



REPORT OF THE AICSIP COORDINATING TEAM 2013-14

Contents

Prelude from Project Coordinator	2
Summary of AICSIP research achievements - Kharif 2013	4
1. Genetic resources management & IPR (M Elangovan)	4
2. Forage Sorghum (C Aruna)	4
3. Breeding - Grain sorghum (Sujay Rakshit)	6
4. Sweet sorghum (AV Umakanth).....	13
5. Sorghum agronomy (JS Mishra)	14
6. Sorghum physiology (SS Rao).....	15
7. Sorghum entomology (VR Bhagwat, G Shyam Prasad & B Subbarayudu).....	15
8. Sorghum pathology (IK Das).....	17
9. Sorghum NSP, BSP, MSP & DUS (VA Tonapi & Hariprasanna)	18
Summary of AICSIP research achievements - Rabi 2013-14	19
1. Breeding - Grain sorghum (Prabhakar).....	19
2. Sorghum agronomy (JS Mishra)	21
3. Sorghum physiology (SS Rao).....	21
4. Sorghum entomology (VR Bhagwat, G Shyam Prasad & B Subbarayudu).....	22
5. Sorghum pathology (IK Das).....	24
6. Front-line demonstrations (Rajendra R Chapke)	24
Report on monitoring of AICSIP trials - Kharif 2013	25
Report on monitoring of AICSIP trials - Rabi 2013-14	37
Update on DUS testing in sorghum and new descriptors	47
Sorghum food technology research report 2013-14	53
Compositional grain quality of sorghum varieties & hybrids evaluated under advanced trial.....	58
Appendices	62
Appendix I: AICSIP plan and instructions	62
Appendix II: Proforma for submission of entries for AICSIP trials	64
Appendix III: Information on parental lines / entries submitted.....	66
Appendix IV: New proforma of release and notification proposal - 2014	67





Prelude from Project Coordinator

Dr. JV Patil

*Project Coordinator and Director
Directorate of Sorghum Research, Hyderabad (jvp@sorghum.res.in)*

Sorghum is largely a key dry land crop of resource poor farmers. Therefore, there is a need to develop strategies for increased use of improved technologies in a cost effective manner to realize higher productivity and profitability by the resource poor farmers of the country. Sorghum is resilient to different kind of situations and it can be grown in areas widely differing for climatic regimes. It is also the base crop on which many inter- and sequence-cropping systems are built upon. The major challenge facing sorghum research and development in India is to provide technologies that will enable the agricultural sector to affect transformation of “subsistence farming” to a sustainable “market oriented” enterprise successfully competing with rest of the crops.

DSR and the centres of All India Coordinated Sorghum Improvement Project (AICSIP) are instrumental in developing high yielding varieties and hybrids of sorghum as well as development of improved production, protection and product development technologies. While DSR is mandated to conduct basic and strategic research, it also supports and coordinates development of cultivars and management technologies under AICSIP. The overall goal is to enhance production, productivity and profitability to enable the agricultural sector to accelerate the transformation of “subsistence farming” to “market and income generation oriented” production system.

The sorghum research programmes have developed and tested several technologies for crop production, protection and utilization, all of which are now being adapted to various extent in different parts of the country. The popularity of nationally released sorghum hybrids (CSH 1 to CSH 30), varieties (CSV 1 to CSV 29), forage hybrids (CSH 20MF and CSH 24MF) and sweet sorghums (CSV 19SS, CSH 22SS and CSV 24SS) are a standing testimony of success of Indian sorghum program not only in terms of yield enhancement, but also in terms of diversification of parental lines and progressive advances in the incorporation of resistance against major pests and diseases. One kharif hybrid, CSH 32 (SPH 1674) and one forage variety, CSV 30F (SPV 2057) were identified by the VIC in 2013 for national release and release proposal was submitted to CVRC for consideration.

Now our major thrust is to create demand for kharif grain for non-food sector, particularly for feed, biofuel, starch production and beverage industries, and to provide value addition to kharif grain and stalk. Our past research efforts have been highly rewarding in enhancing the productivity of kharif sorghum. Rabi sorghum cultivation in recent times has become more remunerative, owing to rise in commodity prices for both grain and fodder. The recent focus on



enhancing the productivity of rabi sorghum initiated with the release of new cultivars is expected to give boost to rabi grain production in the years to come. In rabi, focus is given for research on drought tolerance by developing early maturing rabi sorghum varieties and identification of QTL for terminal drought tolerance traits.

We also need to achieve higher productivity of forage sorghum, as the area under this has increased significantly. To meet with the increased fodder demand, emphasis is given on the development of multi-cut sorghum hybrids, single-cut and dual-purpose sorghums which can be grown for quality green forage production in most of the states of India. Our prime concern is on developing forage hybrids with higher biomass, better digestibility and resistance to biotic stresses. For improving forage quality, brown mid-rib lines and lines with high protein and digestibility are being used. Efforts are on for development of sweet stalked sorghums for various specific end-users such as production of alcohol, ethanol, and syrup. Demand for renewable energy sources and biofuel which would minimize pollution are expected to rise rapidly in coming years. Therefore, production and use of domestic energy resources including renewable ones are receiving high priority and sweet sorghum is expected to gain importance in the coming years in bio-energy farming.

During XII plan we organized ourselves to mobilize more resources for meeting future challenges such as sorghum productivity, profitability, nutritional benefits, utilization and climate change to make sorghum the most preferred climate resilient crop. Quality of grain, fodder (green) and stover will be pursued with more vigour. Diversification of both genotypes and end-uses will be continuously emphasized. Success story of sorghum in rice-fallows is commendable. Stem borer resistant Bt transgenic has been tested in the field. Good progress has been made in identifying QTLs for shoot fly resistance, foliar diseases and yield traits. Efforts are on to discover many new potential health benefits from sorghum as health food. Sorghum is becoming popular as a part of multi-grain foods, snacks and sweets. Therefore, to create more demand for millets, especially sorghum for foods, we have been working through the National Agriculture Innovation Project (NAIP) involving public-private partnership. We also provide training to entrepreneurs through our facility, “Centre of Excellence” for food processing and value addition under INSIMP.

We hope to overcome the issue of profitability of sorghum production by research and extension on value addition, marketing research and liaison with the user industries. We are sharply focusing on resolving commodity specific production constraints, matching agricultural and processing technologies with increased market opportunities. This helps in providing additional farm income and creating off-farm employment especially in the semi-arid tropical sorghum growing regions in India and ultimately aims towards achieving food and nutritional security. All these are expected to translate sorghum farming into a healthy and prosperous proposition.



Summary of AICSIP research achievements - Kharif 2013

1. Genetic resources management & IPR (M Elangovan)

Directorate of Sorghum Research (DSR) is one of the National Active Germplasm Sites (NAGS) with the responsibility to collect, conserve, evaluate, document, and distribute the sorghum germplasm to the bonafied user within the country. The following progress has been made during the reporting period 2013 – 14.

A: Characterization / evaluation

- Kharif 2013: Characterization of 110 accessions collected from Uttarakhand (30 acc.), Kutch regions of Gujarat (40 acc.) and Khammam regions of Andhra Pradesh (40 acc.) were evaluated for 30 agro-morphological traits along with the CSV 15, CSV 23 and DSV 5 as checks.
- Maximum variability was available in the plant height and days to 50% flowering.
- A total of 68 potential accessions were identified for different agro-morphological traits
- Rabi 2013-14: A total of 40 accessions collected from Khammam regions of Andhra Pradesh collected during late kharif/maghi were characterized for the following 30 agro-morphological traits. Maximum variability was observed in stem biomass followed by stem dry weight, plant height and grain yield
- Tall plant height, ear head length and leaf length accession IC 0596007 (SE 2) may be used as high biomass sorghum. IC 0596013 (SE 24) may be used as sweet sorghum for its high brix, tall plant height and ear head length. Three accessions viz., IC 0596014 (SE 25), SE 53, IC 0596024 (SE 53) and IC 0596026 (SE 62) may be used in the grain sorghum programme for its good grain yield per plant and 100-seed weight.

B: Pre-breeding

- Kharif 2013: Develop pre-breeding material through crosses among kharif landraces, high biomass germplasm, mini-core collection and wild relatives of sorghum
- A total of 150 high biomass accessions along with 19 wild relatives, 10 B lines, 10 varieties and 115 kharif landraces were used to develop pre-breeding material for the biomass and forage traits.
- 150 hand-crosses were attempted and 109 crosses with seed setting were harvested.
- Rabi 2013-14: Out of 109 F1s sown, a total of 67 hand-crosses were germinated and 65 crosses with seed setting were selected and advanced them to F2.

C: Multiplication

- A total of 26 acc. of indigenous collections from Khammam districts of Andhra Pradesh and 65 F1s are multiplied during rabi (2013 – 14).

D: Distribution

- A total of 679 acc. distributed to the bonafied user in the country.
- In which, 287 acc. distributed to DSR scientists, 205 acc. to AICSIP scientists, 50 acc. to ICAR scientist, 81 acc. to SAU's and 56 acc. to other universities.

E: Registration

- PVP&FRA: A total of 102 applications were submitted 35 sorghum varieties certificates were received from PPV&FRA so far. 27 sorghum varieties under various stages of DUS testing. A total of 11 sorghum varieties applications closed for various reasons. A total of 29 pending sorghum applications are with the PPV&FRA
- NBPGR: Forage mutant line SSG 226 registered for low HCN, high digestibility and high leaf-stem ratio.

F: Licensing and commercialization

- Three MoU's signed for commercialization of sorghum value added products
- One MoU signed for analytical quality testing
- One MoA signed for sorghum seed production
- One MoA signed for popularization of forage hybrid (CSH 24MF)
- A total of 6.5 lakhs revenue generated through licensing our technologies

2. Forage Sorghum (C Aruna)

Introduction: During 2013-14 four multilocation trials, two on single-cut forages, one on multi-cut forages and one advanced seed yield trial were carried out across 15 locations, comprising of two zones (zone I- 9 locations in North India; zone II- 6 locations in rest of India). Three more basic experiments were conducted under co-ordinated forage sorghum research. The most important findings of forage breeding trials for the year are mentioned below.



A. Multi-location trials

Trial 1: Advanced varietal trial (Single-cut)

- Nine genotypes along with 2 checks (HC 308 and CSV 21F) were evaluated at 15 locations during kharif 2013.
- Among the entries in first year of advanced testing, SPV 2191 was most promising with more than 10% improvement in green (461 q/ha) and dry (158 q/ha) fodder yields over the checks, HC 308 and CSV 21F.
- SPV 2191 was also promising for per day productivity and forage quality in terms of protein yield (12 q/ha) and digestible dry matter yield (78 q/ha). It had better level of resistance to shoot pests compared to the checks.
- Other entries, SPV 2186 and SPV 2185 were promising for fodder yield and per day productivity.

Trial 2: Initial varietal and hybrid trial (Single-cut)

- Twelve genotypes along with 2 checks (HC 308 and CSV 21F) were evaluated at 14 locations during kharif 2013.
- Among the hybrids, SPH 1752 was most promising for green (553 q/ha) and dry (181 q/ha) fodder yields and per day productivity over the checks.
- The variety, SPV 2262 recorded superiority for green (515 q/ha) and dry (165 q/ha) fodder yields and per day productivity over the checks.
- SPV 2265 had better level of tolerance to shoot fly (45% shoot fly deadhearts) compared to HC 308 (59%) and CSV 21F (62%)

Trial 3: Initial and Advanced varietal and hybrid trial (Multi-cut)

- Sixteen entries including 12 test hybrids, one test variety, 2 hybrid checks (CSH 20MF and CSH 24MF) and one variety check (SSG 59-3) were evaluated over 13 locations.
- The hybrid SPH 1697 (1037 q/ha GFY; 289 q/ha DFY) was the most promising hybrid with significant improvement in green fodder yield and about 10% improvement in dry fodder yield over the checks, CSH 20MF and CSH 24MF.
- Per day productivity of green and dry fodder yields of SPH 1697 was also high.
- SPH 1697 had performed consistently well over three years in the AICSIP multi-location testing for fodder yield and quality traits.
- The multi-cut variety, SPV 2242 recorded significant superiority for green (969 q/ha) and dry (295 q/ha) fodder yields compared to the check, SSG 59-3. Its per day productivity of green and dry fodder was also significantly superior to SSG 59-3.
- For the quality traits such as protein yield and digestible dry matter also, SPV 2242 is standing in first position.

Trial 4: Advanced seed yield trial

- Eight genotypes including six single cut test varieties and two single cut national checks (HC 308 and CSV 21F) were evaluated for grain yield potential at five locations.
- The single-cut variety, SPV 2128 (24 q/ha) was found to yield more grain compared to the checks at all India level.

B. Co-ordinated forage sorghum research

Trial 5: Evaluation of Sudangrass germplasm lines

- Seventeen sudangrass germplasm lines along with the check, SSG 59-3 were evaluated in RCBD with 2 replications in 3 locations.
- The genotypes, CO(FS)29 and IS 30209 were found more promising for green and dry fodder yields with more than 10% increase for green and dry fodder yields over the check, SSG 59-3.
- More number of tillers were observed in CO(FS) 29, IS 20624, IS 869 and SGL 60.
- High protein yield was observed in CO(FS) 29, SGL 98-M and IS 14278 and high IVDMD in IS 30209 (58%), SGL 87 and IS 607.

Trial 6: Evaluation of brown midrib lines

- Fifteen brown midrib lines along with three checks were evaluated in RCBD with two replications in two locations for fodder yield and quality traits.
- The bmr lines, EC 582504 and EC 582508 recorded high IVDMD values (61 to 63%) compared to the checks.
- The improved lines, PBMR 1, PBMR 3 and PBMR 4 were found promising for fodder yield and quality.

Trial 7: Evaluation of advanced generation progenies of the crosses made across locations

- Ten advanced generation derivatives of the crosses made towards improvement of forage sorghum were evaluated across two locations in RCBD with two replications in order to identify promising derivatives for fodder yield and quality.



- The line, FABN 13-1 was the best genotype for green (719 q/ha) and dry (241 q/ha) fodder yields with 16% and 37% improvement over the check, CSV 21F.
- Among other lines, FABN 13-4 was promising for fodder yield (648 q/ha GFY and 181 q/ha DFY).
- FABN 13-4, FABN 13-3 and FABN 13-1 were promising for leaf traits such as more number of long and broad leaves
- FABN 13-4 and FABN 13-1 had high percent of protein (8.6 and 8.9%) with high protein yield.
- IVDMD was high in FABN 13-2 (55.5%) and FABN 13-4 (54.4%) with high DDM in FABN 13-1 (124 q/ha) and FABN 13-4 (105 q/ha).

Overall conclusions

- In AVT (SC), the varieties SPV 2191, SPV 2186 and SPV 2185 were promising for fodder yield and per day productivity.
- SPV 2191 was promising for fodder quality in terms of protein yield and digestible dry matter yield. It had good level of resistance to shoot fly, stem borer and leaf diseases.
- In IVHT (SC), the entry SPH 1752 among the hybrids and SPV 2262 among the varieties were the promising genotypes for fodder yield, per day productivity and quality. SPV 2265 had better level of resistance to shoot fly.
- In IAVHT (MC), the hybrid SPH 1697 recorded more than 10% improvement for both green and dry fodder yields over the checks, CSH 20MF and CSH 24MF. Their per day productivity of green and dry fodder yields was also high compared to the checks.
- Over three years also, the hybrid, SPH 1697 showed superiority for fodder yield, per day productivity and quality in comparison to both the checks. For pest and disease resistance, it was on par with the checks.
- The multicut variety, SPV 2242 recorded significant superiority for both green and dry fodder yields over the check, SSG 59-3. It had more tiller number and high regeneration potential compared to all entries.
- In the advanced seed yield trial, the single-cut variety, SPV 2128 was found to yield more grain compared to the checks, HC 308 and CSV 21F at all India level.
- In the trial on evaluation of sudangrass germplasm lines, the genotypes CO(FS) 29 and IS 30209 were found promising for various fodder yield traits.
- More number of tillers were observed in CO(FS) 29, IS 20624, IS 869 and SGL 60.
- In the trial on evaluation of bmr lines, EC 582504 and EC 582508 recorded high IVDMD values. The improved lines, PBMR 1, PBMR 3 and PBMR 4 were promising for fodder yield and quality.
- Evaluation of advanced generation progenies of the crosses made across locations showed that the lines FABN 13-1 and FABN 13-4 to be more promising for fodder yield and quality.
- FABN 13-2 had high IVDMD values, while high DDM was observed in FABN 13-1 and FABN 13-4.

Shortfalls

- Regenerability score is very important in multi-cut genotypes and needs to be recorded by all the centres.
- Plant population per plot was not given by some centres.

Follow-up for Kharif 2014

- Promising genotypes from initial trials of both single-cut and multi-cut types will be evaluated in the advanced trials during kharif 2014
- The promising sudangrass germplasm lines and bmr lines identified in the trials will be utilized in the forage sorghum improvement program

3. Breeding - Grain sorghum (Sujay Rakshit)

During 2013, towards improvement of grain sorghum basic and applied researches were undertaken at DSR and All India Coordinated Sorghum Improvement Project (AICSIP) centers. Multi-location yield trials newly developed varieties and hybrids from the centers of AICSIP and private companies were carried out as part of applied research. Basic and strategic researches focused on development of new MS and R lines, breeding for earliness, drought tolerance, cold tolerance, resistance against key insects and diseases etc. Biotechnological tools as well as conventional breeding methodologies were employed towards this direction. New initiatives on inter-institutional hybrid development, testing and multi-location testing of segregating generations from various centers have yielded promising outcomes.

Multi-location AICSIP trials: During kharif, 6 multi-location trials were conducted, out of which 4 (Advanced Hybrid Trial, Advanced Variety Trial, Initial Hybrid Trial and Initial Variety Trial) were conducted during kharif season across 9 (initial trials) to 25 locations (AHT), and 2 trials (Late Kharif Advanced Hybrid Trial and Late Kharif Advanced Variety Trial) were conducted at 6 locations.



Advanced Hybrid Trial (Tables 1, 1A and 1B): In AHT 9 test hybrids (6 in AHT I and 3 in AHT II, respectively) along with 4 checks were evaluated across 25 locations.

- *Zone I (Table 1A):* In Zone I SPH 1702 (4316 kg/ha) and SPH 1703 (4356 kg/ha) performed better than best performing check, CSH 25 (4170 kg/ha) in terms of grain yield, while SPH 1724 recorded superior fodder yield (12905 kg/ha) than best performing check, CSH 30 (11886 kg/ha). However, none of them recorded more than 10% yield superiority.
- *Zone II (Table 1b):* SPH 1736 (4633 kg/ha) and SPH 1702 (4398 kg/ha) performed better than CSH 25 in terms of grain yield and SPH 1724 (12666 kg/ha), SPH 1731 (12665 kg/ha) and SPH 1736 (14462 kg/ha) gave better fodder yield than CSH 25 (11489 kg/ha). SPH 1703 (3966 kg/ha), SPH 1705 (4131 kg/ha), SPH 1724 (4098 kg/ha) and SPH 1737 (3907 kg/ha) were comparable to early check, CSH 23 and recorded more than 10% yield superiority than observed in it (3454 kg/ha).

Advanced Variety Trial (Table 2, 2A and 2B): In AVT 21 test varieties (4 in AVT II and 17 in AVT I) along with 5 checks were evaluated across 22 locations in Zone I and Zone II.

- *Zone I (Table 2A):* In Zone I for grain yield SPV 2122 (3389 kg/ha) and SPV 2110 (3235 kg/ha) in AVT II and SPV 2165 (3229 kg/ha) in AVT I out yielded best performing check, CSV 27 (2925 kg/ha) by more than 10%. However, none of these could out yield CSV 27 in terms of fodder yield.
- *Zone II (Table 2B):* In Zone II SPV 2178 (3322 kg/ha) recorded better yield than CSV 20 or CSV 23 (3197 kg/ha). Only two test varieties viz., SPV 2178 (13367 kg/ha) and SPV 2122 (13258 kg/ha) recorded marginal superiority over checks in terms of fodder yield.

Initial Hybrid Trial (Table 3A and 3B): In IHT 16 hybrids and four checks were evaluated at 9 locations.

- *Zone I (Table 3A):* None of the test hybrids recorded more than 10% grain yield superiority over the check, while SPH 1748 recorded nearly 19% fodder yield superiority over checks.
- *Zone II (Table 3B):* In Zone II SPH 1751 (3916 kg/ha) recorded marginal grain yield advantage over best check CSH 25 (3806 kg/ha). SPH 1748 was highest fodder yielder (14808 kg/ha) with 15.5% superiority over best check.

Initial Variety Trial (Table 4A and 4B): In IVT 15 varieties and 5 checks were evaluated at 9 locations.

- SPV 2243 recorded highest grain yield (3776 kg/ha) but it was marginally superior (4.5%) than the best check, CSV 23 (3613 kg/ha). In terms of fodder yield none were superior than the best check, CSV 23 (12359 kg/ha).
- *Zone II (Table 4B):* SPV 2242 (3209 kg/ha) and SPV 2250 (3081 kg/ha) yielded better than best performing check, CSV 23 (2936 kg/ha), with SPV 2242 recording 9.3% superiority and SPV 2250 with 4.9% superiority. Both these varieties recorded marginal superiority (2.5% and 4.6%, respectively) for fodder yield as compared to best check CSV 27 (13517 kg/ha). SPV 2249 was highest fodder yielder (14671 kg/ha) with 8.5% superiority over CSV 27.

Late kharif

Late kharif Advanced Hybrid Trial (Table 5A): In AHT – LK trial 9 hybrids (3 in AHT) and 5 checks were evaluated across 6 locations.

- None of the test hybrids recorded more than 10% grain yield superiority, while only two hybrids, viz., SPH 1705 and SPH 173 recorded numerical fodder yield advantage over best performing check.

Late kharif Advanced Variety Trial (Table 5B): In IAVT – LK 16 varieties (4 in AVT) and 5 checks were evaluated across 6 locations.

- SPV 2122 (3914 kg/ha) recorded marginal grain yield superiority over best check, CSV 20 (3766 kg/ha). In terms of fodder yield SPV 2175 (9908 kg/ha) ranked first followed by SPV 2181 (9815 kg/ha), SPV 2164 (9772 kg/ha), SPV 1822 (9722 kg/ha), which performed better than the best check, CSV 23 (9015 kg/ha).

Coordinated sorghum breeding research: Inter-institutional hybrids developed through pooled MS lines from different centers were tested at Indore, Parbhani, Akola, Hyderabad and Coimbatore. In this 18 experimental hybrids along with 5 checks were tested. 1158A x C43, 3025A x DSR 1150 and AKMS 30A x AKR 73 found to be promising hybrids as compared to best performing checks, CSH 25. F2 populations of 11 crosses provided by four centers (Kovilpatti, Dharwad, Akola and Parbhani) were evaluated at 8 Akola, Coimbatore, Deesa, Dharwad, Indore, Palem, Surat and Udaipur. A total of 262 single plant selections were made.

Kharif sorghum breeding at DSR

Development of kharif grain sorghum genotypes with improved yield, grain quality and grain mould tolerance

- Eighty experimental hybrids were tested for grain yield superiority and nine hybrids yielded more than 10% over CSH 25. The hybrids based on the MS line 2911A (2911A x R44, 2911A x R48 and 2911A x R50) recorded more than 20% increase over CSH 25.



- Twenty advanced breeding lines were evaluated for grain yield and quality and the genotype PVT 2-13 recorded significant improvement in grain yield over the check, CSV 20 (3783 kg/ha).
- Sixty sorghum genotypes were tested for high semolina recovery along with the other grain quality traits. Semolina recovery ranged from 19.77 to 47.82%. Seven genotypes recorded semolina recovery of more than 45%.

Genetic studies for grain yield and quality traits in elite sorghum genotypes

- Grain protein digestibility and other quality traits in sorghum ~200 experimental hybrids were evaluated. The GCA/SCA ratio was less than unity for most of yield and quality traits indicating preponderance of non-additive gene action in the expression of these traits. Hybrid combinations like C 43 x BN 535, BN 535 x 206B, KR 196 x RS 29, RS 585 x SPV 1775, RS 585 x IS 31706, RS 585 x SPV 462 were superior for grain yield with more than 100g grain yield/plant, and hybrid combinations, viz., IS 31706 x IS 19153, RS 585 x IS 31706, IS 31706 x SPV 462 were promising for 100 seed weight with more than 4.5g/100 seed weight, and cross combinations BN 535 x SPV 1775 and BN 535 x RS 585 were superior for grain protein digestibility (>65%).

Genetic improvement of single cut forage genotypes for fodder yield and quality

- Four genotypes designated as DSR-SC-2 (504q/ha), DSR-SC-7 (454q/ha), DSR-SC-8(470q/ha) and DSR-SC-11(445q/ha) were found to more than 15% superior to HC 308 and more than 20% compared to CSV 21F for green fodder yield. The genotypes were also superior for brix content during flowering and other forage attributes.
- Among 100 germplasm and elite lines evaluated for forage yield and related traits, the lines, viz., IS 27887, IS 27034, IS 28747, SPV 2056, SPV 2058, SPV 2131, HC 260, AKSSV 22, HC 136, Afzalpur local, GFS 5 were found superior for overall forage yield and attributes.
- The cross combinations Rampur Local x CSV 21F, Rampur Local x SSV 74, HC 308 x SSV 74, SSV 74 x IS 23992, CSV 21F x IS 23992 and HC 260 x AKSSV 22 were superior for green fodder yield and related attributes.

Developing early duration and photoperiod insensitive grain sorghum MS and R lines

- Out of a total of 55 F₅ derivatives (B x B and R x R) and 11 checks (AKMS 14B, 2219 B, CS 3541, 467B, CSV 17, 7B, CSV 15, 27B, C 43, 296B and 2077B) evaluated for earliness 33 recorded earliness coupled with superior performance for grain yield as compared to the early checks (CSV 17, AKMS 14B, 2219B, CS 3541 and 467B).
- Fifty four advance breeding lines were used for test crossing with 27A and a total of 95 test cross seeds were harvested during *rabi* 2012-13.

Genetic augmentation of parental lines for grain yield and tolerance of shoot pests and hybrid development in kharif sorghum

- Out of 95 crosses, more than 25 were found to be fertile or partially sterile, while the remaining test crosses were completely sterile and were backcrossed with the resp. maintainer lines for advancement to develop new MS lines.
- 90 superior and genetically uniform advance breeding lines from restorer x restorer crosses were evaluated for performance *per se* performances. Three advance breeding lines viz., DSR 949 (5318 kg/ha), DSR 950 (5023 kg/ha) and DSR 993 (4981 kg/ha) recorded more than 10% grain yield advantage over CSV 216R.
- Comparison of mean performance over *kharif* and *rabi* seasons, showed that DSR 971 (CS 3541 x CB 87) was the highest yielder (3933 kg/ha) closely followed by DSR 926 (RS 29 x ICSR 9) and DSR 908 (RS 673 x ICSR 93001).
- Six entries (DSR 1118, DSR 1175, DSR 1121, DSR 1145, DSR 1128 and DSR 1144) had significantly higher grain yield (25-33%) over the check.
- Forty-six superior derivatives isolated from 22 maintainer x maintainer crosses were evaluated and 13 entries recorded significantly higher grain yield (3689-5355 kg/ha) compared to 27B (2889 kg/ha)

Collation, evaluation, documentation and utilization of sorghum genetic stocks

- 75 established R lines and 21 B lines were evaluated under replicated trials. Out of these 15 R lines and 9 B lines found promising. Promising lines were DUS characterized.
- A total of 109 experimental hybrids were tested under three station trials, and RS1100A2 x RSCN 5028, RS2309A2 x RSCN 5028, RS1215A2 x KR 199, RS1215A2 x RS 4004, RS2313-2A2 x RSCN 5031, RS2309A2 x RS among others found promising.

Studies on sucrose accumulation in sweet sorghum for efficient ethanol production

- Biomass and green cane are maximum in summer season in case of all sweet sorghum genotypes compared to *rabi* and *kharif* seasons. Genotypes Wray, Urja, SSV 74 and CSH 22SS showed maximum biomass in all seasons at maturity stage and these genotypes can be considered as stable genotypes across seasons.
- Five genotypes (Keller, Urja, Wray, BJ 248 and SSV 74) recorded the maximum sucrose content and total fermentable sugars at physiological maturity stage, in all the three seasons.



- Highest brix content was recorded in Wray, Urja, SSV 74, BJ 248 and CSH 22 SS at physiological maturity stage in all the three seasons.
- Sucrose synthase activity is high at milky stage of the crop in all genotypes in all the three seasons. Sucrose synthase activity is expressed equally in all seasons in 4 genotypes (Keller, Wray, Urja and BJ 248).
- Sucrose phosphate synthase activity is highest in milky stage in summer and Indian sweet sorghum genotypes showed highest activity in kharif at milky stage and at physiological maturity in summer season. The invertases are lowest in kharif at physiological maturity stage and in summer season the invertase activity is maximum at physiological maturity stage

Studying the therapeutic properties and establishing sorghum grain as a functional food

- Grain quality of the 127 genotypes analyzed and 10 genotypes were identified with starch content above 69%. Some promising ones are IS2397, SPV1244, EP22, EP64, NSJB6625, IS8348, IS16151, IS19445.
- Amylose content varied from 15.05% in IS 16151 to 28.11% in SPV1471.

Genetic enhancement of sweet and high biomass sorghums for traits related to 1st and 2nd generation biofuel production and shoot pest tolerance

- DSRV8 exhibited significant superiority of 88.8 t/ha (13.52%) for total fresh biomass over the check CSV 19SS (78.2 t/ha).
- Significant and higher brix was observed in DSRV17 (23.2%) over the check (19.2%)
- DSRV7, DSRV13 and DSRV17 and exhibited significantly higher juice yield (10-36%) over the check.
- DSRV17 exhibited significant superior performance for ethanol yield, TSS, TSI and brix (%) and had significant positive heterosis of 33%, 21%, 33% and 21% respectively
- DSRH5 (20.10%) recorded higher brix over the check (14.95%).
- DSRH1, DSRH2, DSRH5, DSRH7 and DSRH10 yielded significantly higher juice and ethanol yields over the check and a standard heterosis of more than 40 per cent.
- The hybrid DSRH5 had a standard heterosis of 93.14% for ethanol yield and 45.17% for juice yield.

Development of novel pre-breeding lines through wide hybridization in sorghum

- De novo variation was created through repeated inter generic pollination between sorghum and maize. A set of variants showed high biomass traits such as juicy thick stems, very tall plants, and greater leaf area. Twenty four such high biomass lines were subjected to in house evaluation in the field along with two checks SSV84 and CSV22S. Significant differences among the genotypes were observed. Comparative evaluation of the data for two consecutive Kharif seasons showed four promising lines, 2114-3, 2127-6, 2288-3 and 2289-1-6. These two are derived from two parental lines.

Kharif sorghum breeding at AICSIP centers

- At Akola total 54 individual plant selections were made in R line development programme while in B line development programme 65 IPS were selected. Total 118 BC pairs were made in grain breeding programme. In grain mold resistance breeding programme, total 45 IPS were selected in R line development programme while in B line development programme 15 IPS were selected. Total 105 BC pairs were made in grain breeding programme. In shoot fly resistance breeding programme, total 3 IPS were selected in R line development programme while in B line development programme 19 IPS were selected. Total 44 BC pairs were made in grain breeding programme. In drought tolerance breeding programme, 7 IPS were selected in two R × R crosses received from the Project under group efforts on sharing of breeding material. Total 6 Station Hybrid/Varietal Trials were successfully conducted. Besides these trials, one Private Hybrid Testing Trial consisting of three hybrids from the private companies were evaluated. Total 7 AICSIP trials were allotted to this centre and were conducted successfully and data submitted to project. One Ph.D. and two M.Sc. students completed their research programme at this unit during the last year. This unit has undertaken four training programmes for the farmers. Total six research papers have been published in the NAAS rated journals. Similarly, 16 abstracts have been published in different international and national seminars during the year 2013-14. Seven popular articles and two books were also published. This centre received two awards, viz., the "Best Performing Centre Award-2012" during the AGM at Hyderabad on 21/04/2013 and the Best Poster Presentation Award during the Global Consultation on Millets on 21/12/2013.
- At Coimbatore in *Grain sorghum breeding* programme in UVT I(S), eight cultures were tested and TNS 644 excelled the check variety CO 30 by recording grain yield of 2854 kg/ha with increased yield of 6.37 percent. In UVT II, Three entries viz., TNS 647, TNS 648 and TNS 649 were found to be superior with grain yield potential of 3457, 3604 and 3669 kg/ha with increased yield of 11, 14 and 16 % over the CO 30. Seven new cultures viz., TNS 651, TNS 652, TNS 653, TNS 654, TNS 655, TNS 656 and TNS 657 selected from non replicated trials were raised and the crop is early seedling stage. Two hybrids ICS12A x ICSR 89020 and ICS90001A x CO 30 recorded highest grain yield of 2839 and 3332 kg of grain yield/ha with fodder yield potential of 7.5 and 9.7 tons/ha respectively. They possessed grain yield



advantage of 14 and 34 per cent over Local Check Co5. The plant heights recorded in these entries were of 188 and 200 cm respectively. Under R line development programme a total of 38 crosses were evaluated under different generation and 260 families has been forwarded. Under trait specific development programmer 4 crosses for drought and 4 crosses for shoot fly has been evaluated in F₂ and 50 families each has been selected for further evaluation. Under B line development programme B x B and B X R crosses has been affected. The resistant entry identified in AICSIP trials viz., CSV 17 for shoot fly, SPV 2175 for mite, SPV 2176 and SPV 2177 for head bug were utilized in making new crosses. A total quantity of 500 kg of CO 30 sorghum TFL seeds were distributed to the farmers. In *Forage and sweet sorghum breeding* programme SPV 2242 promoted to AVT – I, 2014 as it recorded first rank on an average over Zone I and II. Forage sorghum single cut superior cultures namely TNFS 213, 215 identified for testing in AICSIP 2014 as it recorded 9-12 % higher GFY than CO 30 under UVT Trial. Sweet sorghum culture TNSS 214 recorded 11 % higher cane yield than CSV 24 SS with 18 % brix under UVT Trial and identified for AICSIP 2014 Trial. Forage sorghum multi cut superior cultures namely TNFS 210, TNFS 211 found to be 7 % higher than local check CO FS 29 under UVT Trial. 60 Hybrids combination in sweet and forage sorghum evaluated for Hybrid identification and 55 new combinations were synthesized. Four hybrids combinations identified as promising advanced to second year testing. Forage sorghum and sweet sorghum segregating material were evaluated and superior single plants identified in F₅, F₆ families for seed multiplication. A total of 39 new emasculation crosses 17 and 22 in Forage and sweet sorghum and segregating materials F₂ - F₆ were evaluated. Twenty one crosses studied and 315 single plants selected for further evaluation in R line improvement program. Mutation material from Co 11 Variety involving treatments Gamma, EMS and Sodium Azide were developed and M₂ generation evaluated for forage traits. Working germplasm 300 accessions raised for maintenance and utilized in breeding program and a part characterized for qualitative and quantitative traits. All four Forage and sweet sorghum Trial successfully conducted, sucrose analysis done and data loaded.

- At Deesa during the *Kharif* 2013, total rainfall received 1171.7 mm. The maximum rainfall received in September followed by July. The most of the *kharif* trials was sown in first fortnight of July. Total five state trials, two station trials and seven coordinated trials were conducted during *Kharif* 2013. Under crop improvement programme 317 segregating materials & SPS of dual and forage type sorghum were evaluated and 1096 selections were made on the basis of yield, earliness, shoot fly resistance and agronomic superiority. A total of 392 accessions of forage and dual type sorghum were maintained under germplasm maintenance programme. The summary of research programmes and achievements during *Kharif* 2013 are presented as below.
- At Dharwad sorghum improvement work is carried out with the objective of developing varieties/hybrids with good grain quality; short duration and resistance to biotic stresses like shoot fly tolerance and grain mold resistance. In order to achieve set objectives, as many as five ICAR Viz., AVT, IVT, AHT, IHT and PPHT trials were conducted apart from eight station trials including private hybrid testing. *Multilocation Varietal trial*: In this trial, a total of twenty entries comprising of 15 from Dharwad and five from DSR, Hyderabad were tested at Dharwad centre, out of these, entry from Dharwad SPV-2172 (undergoing AVT) recorded significantly superior grain yield of 4236.00 kg/ha compared to superior check DSV-6 (3212 kg/ha). This was followed by SVD-1203 (3888.0 kg/ha) and SVD-744 entries. The entry SVD-1203 also exhibited highest 1000 seed weight of 32.0 g. compared to 24.0 g. of DSV-6. None of the DSR entries were superior to local check (DSV-6). The trial was also conducted in ARS, Bailhongal, Hanamanamatti, ARS, Bidar and ARS Gulbarga. *Multilocation Hybrid trial*: The six new hybrids along with four checks were tested in multilocation hybrid trial at six locations. The results of Dharwad location revealed superior performance of CSH-30 (3779.0 kg/ha) and SHD-6 (3648 kg/ha) compared to check hybrids like CSH-14 (2298 kg/ha) and CSH-16 (2940.0 kg/ha). *Station varietal trial*: Among twelve entries tested, two entries SVD-1124 and SVD-1130 recorded significantly superior grain yield and on par fodder yield with DSV-6 (2352.0 kg/ha). *Station Hybrid Trial-I*: Among 15 hybrids tested including checks, SHD-34 recorded significantly superior grain yield of 5611.0 kg/ha over high yielding check CSH-16 (3296.0 kg/ha) and numerical superiority over recently released hybrid CSH-30 (4723 kg/ha). *Station Hybrid Trial- III*: Out of 13 hybrids tested, SHD-6 exhibited significantly superior grain yield of 4681.00 kg/ha and on par fodder yield with high yielding check CSH-16 (3431 kg/ha) but highest grain yield was recorded by CSH-30 hybrid (5167.0 kg/ha). *Testing of private hybrids*: Among six entries tested along with two checks, NSH-54 was superior hybrid compared to CSH-14 and CSH-16 check hybrids. *Generation of breeding material*: As many as 18 fresh crosses were made and 123 selections were made in various generations from F₂ to F₆ and 120 M₃ progenies were evaluated for grain mold tolerance and grain size.
- In Indore the season was not favourable due to heavy and continuous rains and after that there was heavy infestation of shoot fly and stem borer. Six AICSIP and four station trials were conducted, and other breeding works taken up.
- In Kovilpatti a high yielding dual purpose sorghum culture TKS_V 0809 developed from this centre has recorded an average grain yield of 2999 kg/ ha over 141 yield trials of different location and registering 16.9% and 24.7% increase over the checks K 8 (Local) and CSV 17 (National) respectively. TKS_V 0809 recorded the dry fodder yield of 11.56t/ ha which is 34.2% and 41.3% increase yield over K8 and CSV 17 respectively. Hence, this culture was proposed for released as K 12 for the winter rainfed vertisol tracts of Tamil Nadu during 2014–15. Two high yielding single cut forage sorghum cultures TKFS 1047 and TKFS 1052 are being proposed to Multilocation testing in the winter rainfed vertisol tracts of Tamil Nadu. During winter 2013-14, a total of 6 fresh crosses were effected with midge resistance donars. In F₂ populations three single plants were selected with grade 1 resistance. Similarly four single plants from F₃ progenies



were selected with grade 1 and two single plants from F₄ progenies were selected with grade 1 resistance. The susceptible check K8 has recorded 90% midge incidence. During the summer 2013 – 14 a total of 16 fresh crosses were effected with Mite resistance donars. In F₂, 4 single plants were selected with grade 1 resistance. In F₃, 6 single plants were selected with grade 1 resistance. In F₄, 5 single plants were selected with grade 1 resistance. The susceptible check K 4 has 95% Mite incidence.

- At Palem towards varietal improvement programme, PSV-56, a high yielding dual purpose sorghum variety with tolerance to grain mold disease, was released in the name of SRISAILA by State Varietal Release Committee, Andhra Pradesh. The notification proposals of the variety were also submitted to Government of India. Two high yielding and grain mold tolerant dual purpose sorghum entries PSVGS-106 (SPV2122) and PSVGS-210 (SPV 2110) are in Advanced Varietal Trial – II stage in Coordinated Trials at All India Level. A high yielding and grain mold tolerant culture, PSVGS-113 is in Advanced Varietal Trial - I stage in Coordinated Trials at All India Level. Two sorghum cultures viz., PSVDP-306 and PSVDP-316 are evaluated in Initial Varietal Trial stage in Coordinated Trials at All India Level. In Hybrid development programme, 14 R lines and 17 B lines for various important characters are in F₆/F₅ stage of development. These lines are derived from the material supplied by Directorate of Sorghum Research under Network Breeding Programme. Further, four yellow pericarp sorghum land races were submitted to National Bureau of Plant Genetic Resources for registration. Of these landraces, PYPS-2 was accepted for registration whereas the other lines viz., PYPS-8, PYPS-13 and PYPS-14, were asked for submitting check performance data. In Grain Sorghum, three Station Trials were conducted during *kharif* 2013-14. In AVTGS – II - 6 entries, in AVTGS-I - 8 entries and in IVTGS - 8 entries were found to be superior for grain and fodder yields compared to the checks PSV-56 and PSV-1. All the All India Coordinated Sorghum Improvement Project breeding trials were conducted during *kharif* 2013 without any deficiency.
- At Pantnagar 346 fodder/dual purpose, sweet sorghum and grain type germplasm lines were maintained. A set of 14 diverse genotypes was planted in crossing block for attempting new crosses through diallel crossing with the objective of improvement in foliar disease resistance, fodder yield and quality. Thirty three CMS lines (A/B pairs) of A₁ and A₂ cytoplasm were maintained. Fifty three new crosses were attempted through emasculation and hand pollination for genetic improvement in terms of fodder yield, quality and foliar disease resistance. Inter generic crosses between sorghum x maize, sorghum x teosinte and maize x teosinte were attempted between three CMS lines of sorghum, one variety (African Tall) of maize and one local variety of Teosinte. A total of 773 SPS/ progeny bulks of 155 crosses/families (from F₁ to F₇ onward generations) were evaluated, of which 740 SPS/progeny bulks of 143 crosses/families were selected for desirable traits. Selected lines will be used as restorers and open pollinated varieties. The multicut experimental hybrid SPH 1697 (UTMCH 1310) which has completed three years of testing showed 10 per cent superiority for green and dry fodder yield and per day productivity, over checks, besides good nutritional quality. The identification proposal of this hybrid will be submitted for its consideration for release in the 44th AGM. The multicut experimental hybrid SPH 1748 (UTMCH 1311) was tested in IVT multicut during Kharif 2013. It had better quality in terms of protein percent, protein yield and DDM yield as compared to both the checks therefore, promoted to AVT I. For evaluation of yield and quality in forage sorghum and sweet sorghum, 8 All India Coordinated Trials, two State Trials, three Station Trials and three Students' Thesis Research Trials were conducted during Kharif 2013. Two entries viz. SPV 2201 (UTFS 71), SPV 2262 (UTFS 74) were incorporated from the centre in IVT single cut. Both these entries showed superiority of 17-18% for green fodder and 20-23% for dry fodder yield over best check CSV 21 F. In the State Varietal Trials single cut varieties UTFS 83 and UTFS 79 showed 26% and 20 % superiority, respectively for green fodder yield and 35% and 29 % for dry fodder yield over check CSV 21F. Whereas multicut varieties UTMCH 545 and UTMCH 548 were better for green as well as dry fodder yield to the tune of 37% and 30%, respectively, than check Pant Chari 6. Amongst the experimental multicut hybrid tested in Station Trials the hybrid EHT 2013-16 was most promising showing dry fodder yield almost *at par* with best check CSH 20 MF. Result of single cut Station Varietal Trial indicated that the entry ESVT 2013-9 was most promising showing numerical superiority over best check CSV 21F. Out of 12 single and three way cross hybrids tested as single cut entry, the most promising was TWCT-2013-5 showing green and dry fodder yield to the tune of 755.48 q/ha and 211.53q/ha, respectively in one cut.
- At Parbhani during 2013-14 total 18 AICSIP project trials, 4 state level trials and 18 station trials were conducted during kharif and rabi season. One kharif based hybrid SPH 1735 and two rabi based varieties SPV 2144 and SPV 2221 from Parbhani are in advance testing trial. Four thousand germplasm lines received from DSR were evaluated during rabi 2014 for shoot fly reaction, grain and fodder yield and yield attributing traits. 122 accessions for shoot fly tolerance, 45 accessions for grain quality and 62 accessions for yield potential and agronomic performance were selected. Eighty five single plant selection/families from 39 crosses of kharif based segregating populations and 205 single plant selection/ families from 57 crosses of rabi based segregating populations were made for R line development. KR 211, KR 225, KR 235 and KR 911 are promising kharif based restorers identified from advance generations. Selections for grain mold tolerance (65 for R lines and 78 for B lines), shoot fly tolerance (83 for R lines and 97 for B lines) and drought tolerance (78) were made in F₂, F₃ and F₄ populations. Thirty eight and 54 marker assisted F₃ and F₄ progenies were evaluated for shootfly tolerance coupled with high grain & fodder yield and 12 & 14 promising progenies



were selected. Five isolines of PMS 20 B genetic background, differ for shoot fly resistant QTLs introgression were crossed with PMS 20A. 29 pairwise crosses were made in BC₁F₁ generation of 5 F₁s.

- At Phaltan different crosses between parents after considering desired traits had been made following diallel mating design in previous years. All the progenies in different generations were evaluated for the characters like plant height, total biomass, stripped stalk weight, juice yield, brix of juice and grain yield. One hundred thirty two F₅ progenies evolved from six different families evaluated in Kharif 2013 were subjected to single plant selection. In all, 197 single plant selections based upon high biomass, brix of juice and grain yield were made in the promising families. In F₇ generation, 20 progenies evolved from six promising crosses were evaluated during Kharif 2013. Among them line DC-32-31 gave significantly highest brix of juice (19 %), total sugar index (3.34 t/ha) and grain yield (2.01 q/ha) as against the check cultivar CSV-24-SS with 17 % brix of juice, 1.71 t/ha total sugar index and 0.43 q/ha grain yield. The same line also exhibited superior performance for the characters like shoot fly damage (36.67 %) and stem borer incidence (16.87 %) compared to the check cultivar CSV-24-SS which showed higher shoot fly (59.93 %) and stem borer (23.74 %) damage. The DSR had supplied F₂ populations to all the centers in Kharif 2010 under network breeding programme and this material has been advanced to F₇ generation at NARI centre. Thirty four advanced F₇ progenies evolved from two different crosses were evaluated during Kharif 2013. Out of these, 10 lines showed significantly higher total biomass and juice brix than the check CSV-24-SS. The line 10R-SS-20-61-8-5 gave the highest biomass (20.71 t/ha) and juice brix (24 %) followed by line 10R-SS-20-61-1-5 which had 20.27 t/ha total biomass and 23.33 % juice brix, line 10R-SS-19-16-5-2 which had 19.76 t/ha total biomass and 20.67 % juice brix as against the check CSV-24-SS which showed relatively lower total biomass (17.04 t/ha) and juice brix (19.67 %). Fifty five uniform lines which are almost stable were tested as PVT (Pre-varietal trial) entries along with two national checks viz., CSV-19-SS and CSV-24-SS in four different trials. In the first trial out of the 13 lines evaluated almost all were numerically higher in plant height, stripping % and brix of juice than both the checks. Line D-91-29-4 recorded the highest value of juice brix (22.83 %) among all the tested entries. Similarly lines D-91-9-2 recorded the highest values of grain yield (4.85 q/ha) and juice brix (21.83%) followed by lines D-91-9-5 (grain yield 2.38 q/ha and juice brix 22.17 %) and D-91-29-2 (grain yield 2.29 q/ha and juice brix 20.50 %) compared to the check CSV-24-SS (grain yield 1.62 q/ha and brix 19 %). In the second trial out of the 15 lines evaluated only four lines recorded greater plant height than the check where line D-141-34 showed significantly highest value for plant height (274.73 cm) with the check CSV-19-SS having plant height of 248.60 cm. Four lines viz., D-18-7-10-2 (Biomass 25.17 t/ha, juice yield 4.79 t/ha and brix 19.17 %), D-77-15-1 (Biomass 21.08 t/ha, juice yield 5.24 t/ha and brix 19.33 %), D-141-33 (Biomass 24.48 t/ha, juice yield 4.46 t/ha and brix 18.50 %) and line D-18-7-8-1 (Biomass 22.44 t/ha, juice yield 4.64 t/ha and brix 19.83 %) reported numerically higher values than the check CSV-24-SS (Biomass 20.49 t/ha, juice yield 4.21 t/ha and brix 18.50 %). Similarly line D-49-53 recorded the highest grain yield (7.10 q/ha) along with a higher brix of juice (19.00 %) than the check CSV-24-SS (Grain yield 2.22 t/ha and brix of juice 18.50 %). In the third trial again 15 entries were evaluated out of which almost all the lines reported greater plant height than the check CSV-24-SS (233.14 cm) with the line D-91-60 reporting maximum plant height (327.40 cm). Line D-94-74 (Biomass 32.35 t/ha, stripped stalk weight 21.54 t/ha and brix 20.50 %) gave numerically higher values than the check CSV-24-SS (Biomass 21.64 t/ha, stripped stalk weight 17.48 t/ha and brix 17.83 %). Almost all the 15 lines reported higher juice brix values than the check CSV-19-SS (17.83 %) with lines D-91-9 and D-91-35 (both 21.83 %) reporting the highest. In the fourth trial, 12 lines were tested out of which four lines were numerically superior in plant height to the check CSV-24-SS (240.27 cm) where line D-23-28-10-2-4 (354.67 cm) reported maximum plant height. Line D-34-20-2-5 (Plant height 286.67 cm, total biomass 30.10 t/ha, stripped stalk weight 20.23 t/ha) exhibited numerically higher values for the mentioned traits than the check CSV-24-SS (Plant height 240.27 cm, total biomass 25.21 t/ha, stripped stalk weight 13.97 t/ha). Almost all the lines which were evaluated in the trial were numerically higher in juice brix than the check CSV-24-SS where lines D-44-3-3 and D-44-3-11 reported the highest brix values (both 21.8 %) and grain yields 5.10 t/ha and 6.04 t/ha respectively compared to the check CSV-24-SS which had juice brix 17.8 % and grain yield 0.96 t/ha. B line development programme at the center was initiated during Kharif 2010 and this material was supplied by the DSR under network breeding programme. Total of 55 F₆ progenies produced from seven different crosses were evaluated in three different trials (Groups A, B & C) during Kharif 2013 (Table: 2). Similarly, another 34 lines which were derived from 11 different crosses and are in F₈ generation were also evaluated under B line development programme during the same season. In the first trial of the 15 F₆ entries evaluated three lines viz. 10B-AGR-46-45-2-4 (7.18 t/ha), 10B-AGR-46-52-5-1 (6.67 t/ha) and 10B-AGR-46-86-3-5 (5.88 t/ha) showed promising performance for stripped stalk weight as compared to the check 296B (4.66 t/ha) while line 10B-AGR-46-45-2-4 reported maximum grain yield (8.16 t/ha), juice yield (2.31 t/ha) and stripped stalk weight (7.18 t/ha) compared to the check CSV-24-SS (Grain yield 1.75 t/ha and juice yield 1.28 t/ha). In the second trial, among 17 F₆ progenies evaluated three lines gave numerically higher plant height than the check 296B (176.33 cm) where line 10B-AGR-47-24-1-1 (225 cm) gave the maximum plant height. Lines 10B-AGR-48-1-5-3 (Stripped stalk weight 9.05 t/ha and juice yield 2.27 t/ha) and 10B-AGR-48-14-4-2 (Stripped stalk weight 8.66 t/ha and juice yield 2.30 t/ha) recorded the highest values for the mentioned traits as compared to the check 296B (7.06 t/ha Stripped stalk weight and 1.24 t/ha juice yield). In the third trial, line 10B-AGR-61-37-1-2 reported the numerically highest total biomass (14.64 t/ha) and stripped stalk weight (5.42 t/ha) compared to the check 296B (13.04 t/ha biomass and 5.41 t/ha



stripped stalk weight). Line 10B-AGR-61-36-1-3 exhibited significantly higher juice yield (3.47 t/ha) as compared to the check 296B (1.38 t/ha). Similarly, lines 10B-AGR-66-49-3-2 showed numerically higher juice brix of 16% followed by the lines 10B-AGR-61-8-2-6 and 10B-AGR-66-49-3-1 (both 15.17 %) than the check 296B (15%). Again under B line development programme during the same season 34 lines which were derived from 11 different crosses and were in F₈ generation were tested for the different characters along with the promising parental lines NARI-SS-5 B and NARI-SS-11 B. Out of the 34 lines evaluated line NARI-54-1-2-3B reported significantly highest biomass of 15.04 t/ha as against that of the check NARI-SS-5 B (13.78 t/ha). Twenty two lines gave significantly higher juice yield as compared to the check NARI-SS-5B (18.05 t/ha). They were NARI-36-5-2-1-1B (53.38 t/ha) followed by NARI-54-1-1-1B (40.77 t/ha). Four lines viz., NARI-36-5-4-2B (21.08 %), NARI-5-1-3-2-1B (21.00 %), NARI-39-7-1-4-2B and NARI-41-5-2-1-1B (both 20.8 %) gave significantly higher juice brix than the check NARI-SS-5 B (17.5 %).

- At Rahuri during kharif season crop condition of sweet sorghum crop was satisfactory. The cane yield and brix % level in all the experiments was recorded satisfactorily. In general kharif season is favorable to sweet sorghum crop. The center has released the forage sorghum variety SPV 2057 under number CSV 30F by 43rd AGM held at DSR Hyderabad for zone I (Haryana, Uttarakhand, Gujarat, Uttar Pradesh, Rajasthan and Punjab) and Zone II (Tamilnadu, Karnataka and Maharashtra) for single cut purpose for kharif season. The notification proposal has been submitted to CVRC, New Delhi on 6/3/2014. Identified the Sweet sorghum Hybrid RSSH-50 for green cane yield coupled with high ethanol and tolerant to shootfly. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This hybrid is proposed for kharif season for western Maharashtra.
- At Udaipur total rainfall received at the center till November was 811 mm against average rainfall 620 mm with continuous drizzling for a long period. More or less the same situation prevailed in all the sorghum growing regions of Rajasthan. Crop growth and yield in general was below satisfactory in all the disciplines. Centre has contributed 10 entries in coordinated trials. Out of these SPV 2061 was for testing of Agronomy & Pathology and SPV 1822 for re-verification of performance, two grain and DP genotypes viz. SPV 2164 and SPV 2165 and two single cut forage genotypes viz. SPV 2185 and SPV 2186 were for advance testing (AVT I), two grain and DP genotypes viz. SU 1426 and SU 1429 and two forage single cut genotypes viz. SU 1454 and SU 1465 for initial testing (IVT). Two varieties CSV 17 and CSV 23 of this centre was also used as check in coordinated trials. One hundred twenty Germplasm were evaluated in augmented RBD. The 20 parents involving agronomically superior, insect resistant, drought resistant, early lines/germplasm were planted in SPT to attempt fresh crosses for different attributes as per mandate. Apart from this 6 parental diallel was attempted between multi cut and single cut genotypes. 16 Hybrids were developed using different MS lines. The 30 F₁s and 3 back crosses were evaluation and advanced. The 152 crosses having 396 progenies including trait specific crosses were evaluated and progenies were identified for evaluation in next generation. Apart from coordinated trials 2 grain varietal, 1 grain hybrid, 3 forage (SC) and 2 forage (MC) trials were conducted during summer and rainy season. Breeder seed production programme for CSV 17, CSV 23 and PC 1080, and nucleus seed production programme of SPV245, CSV15, CSV10, CSV17, PJ1430, CSV23, PC1080, SPV1822, SU45, SU 52, SPV1753, AKMS 14A, AKMS 14B and AKR 150 was under taken.

Publications: During 2012-13 on grain, forage and sweet sorghum improvement all total 32 publications have been made, out of which 3 are in International journals.

4. Sweet sorghum (AV Umakanth)

Trial 1a: Evaluation of initial and advanced sweet sorghum varieties and hybrids (IASSVHT)-Kharif 2013

1. Twenty IASSVHT trial entries comprising 13 varieties, 5 hybrids (including hybrid check CSH 22SS) along with 2 varietal checks (CSV 19SS & CSH 24SS) were evaluated at 11 locations during kharif 2013.
2. SPH 1755 with a flowering of 81 days was the most early test entry in the entire trial and had 7% superiority for early flowering over the check hybrid (88 days)
3. For total fresh biomass, among hybrids, SPH 1755 had a numerical superiority of 13%. SPV 2196 among the varieties recorded a significant superiority of 28% while SPV 2195, SPV 2270, SPV 2268 and SPV 2205 had a numerical superiority ranging from 13-18% over CSV 24SS and these entries were promising for fresh stalk yields too
4. For grain yield, SPH 1738 (6%) and SPV 2267 (7%) exhibited superiority over respective checks.
5. For brix content, the hybrid SPH 1754 and variety SPV 2268 recorded a numeric superiority of 5% over the respective checks.
6. For juice yield, the hybrids SPH 1755 and SPH 1754 exhibited significant superiority over the check while in varieties, significant superiority of 4 to 24% over the check variety CSV 24SS was observed.
7. For total sugar yield and calculated bio-ethanol yields, the hybrids SPH 1754 and SPH 1755 and varieties, SPV 2196, SPV 2270, SPV 2272, SPV 2202, SPV 2205 and SPV 2268 were superior to respective checks.

Trial 1b: Evaluation of initial and advanced sweet sorghum varieties and hybrids (IASSVHT)-Rabi 2013-14

1. The variety SPV 2268 was the earliest to flower in the entire trial



2. SPH 1755 (108 days) among hybrids and SPV 2268 (107 days) among varieties were early maturing.
3. For total fresh biomass, the variety SPV 2271 had a numerical superiority of 23% over the check CSV 24SS.
4. For fresh stalk yields, SPV 2195, SPV 2196, SPV 2200, SPV 2271, SPV 2272, SPV 2202, SPV 2241 and SPV 2201 were superior to the checks.
5. For juice brix, SPV 2268 and SPV 2196 were significantly superior over the check variety.
6. With respect to juice yields, the varieties SPV 2196, SPV 2200, SPV 2195, SPV 2272, SPV 2201, SPV 2202, SPV 2271, SPV 2241, SPV 2205 and SPV 2268 were significantly superior to the check variety CSV 24SS.
7. For total soluble sugars (TSS), the variety SPV 2268 was significantly superior to the varietal check.
8. For calculated ethanol yields, all the hybrids were numerically superior by 16 to 51%. Among varieties, SPV No's 2196, 2195, 2201, 2241 and 2268 were significantly superior.

Trial 3: Identification of high biomass sorghums for lignocellulosic biofuel traits-Kharif 2013

1. RSSH 50, RSSH 18 and CSH 13 were promising for total fresh biomass (>60t/ha). RSSH 50 recorded highest (87 t/ha) fresh biomass and was significantly superior to the check.
2. RSSH 50 recorded the highest dry biomass of 33.5 t/ha.

5. Sorghum agronomy (JS Mishra)

Field experiments were conducted during *kharif* 2013 at different AICSIP centres to evaluate the response of pre-released sorghum genotypes to fertility levels, and to develop improved agronomic practices for higher sorghum productivity and profitability.

1. Response of advanced/pre-released sorghum genotypes to fertility levels under rainfed conditions: Pre-released sorghum genotypes that were promoted to the second year of testing in AVHT under the breeding programme were evaluated for their response to fertility [Control (0:0:0), 50% RDF (40:20:20), 75% RDF (60:30:30) and 100%RDF (80:40:40 kg NPK/ha)] across the sorghum growing zones of the country. The salient findings have been summarized as under (Table 1).

Table 1. Response of promising pre-released sorghum genotypes to fertility levels under rainfed conditions

S. No.	Types of sorghum	Test entries	Checks	Locations	Promising treatments/entries
1KA.	Grain sorghum (Zone-I North)	SPH 1703, SPH 1705, SPV 2110, SPV 2122, SPV2061	CSH 16, CSV 20, CSV 23	Udaipur	Test hybrids SPH 1703 and SPH 1705 produced 25.74 and 32.52 % higher grain yields; higher net returns and B:C ratio over check CSH 16, whereas test varieties were on a par with their respective checks. The SPH 1703 did not respond significantly to increasing fertility levels, but the SPH 1705 produced significantly higher yield with 75% RDF as compared to 50% RDF.
1KB.	Grain sorghum (Zone-I South)	SPH 1703, SPH 1705, SPV 2110, SPV 2122, SPV2061	CSH 16, CSV 20, CSV 23	Coimbatore, Palem	SPH 1703 among hybrids and SPV 2122 among varieties produced 24.56 and 36.55% higher grain yields over respective checks. SPH 1703 at both the locations and SPV 2122 at Palem and SPV 2061 at Coimbatore produced maximum grain yields among the test varieties. The test genotypes responded significantly up to RDF (80:40:40).
1KC.	Grain sorghum (Zone-II)	SPH 1702, SPH 1703, SPH 1705, SPV 2114, SPV 2061	CSH 16, CSV 20, CSV 23	Surat, Dharwad, Akola	Genotypes varied with the locations in response to grain yield. SPH 1703 at Akola, SPH 1705 at Dharwad and SPH 1702 at Surat produced the highest yield and were superior to check. Irrespective of the locations, test varieties (SPV 2114 and SPV 2061) were on a par with the checks. Increasing fertility response up to 100% RDF was noticed at all the locations, however, the F x G interaction was significant at Akola and Dharwad.
1KD	Late Kharif	SPH 1702, SPH 1703, SPH 1705, SPV 2114, SPV 2061	CSH 16, CSV 20, CSV 23	Coimbatore, Madhira	SPH 1703 (6.67% increase) at Coimbatore and SPH 1702 (24.38% increase) at Madhira yielded significantly better than the hybrid check CSH 16. Test variety SPV 2114 recorded significantly higher grain yield at both the locations. The genotypes responded significantly up to 100% RDF.
1KE	Forage Sorghum (Single-cut)	SPV 2128	CSV 21F, HC 308, Local check	Pantnagar, Udaipur, Hisar, Ludhiana	SPV 2128 produced 5.66% and 11.4 % higher green fodder yield over the checks CSV 21F and HC 308. However, at Hisar, the test genotype was significantly inferior to check HC 308. Significant response was observed up to 100% RDF.



S. No.	Types of sorghum	Test entries	Checks	Locations	Promising treatments/entries
1KF	Forage Sorghum (Multi-cut)	SPH 1697, SPH 1698	CSH 20 MF, CSH 24 MF, SSG 59-3	Hisar, Pantnagar, Udaipur, Coimbatore	SPH 1697 being on a par with CSH 20 MF produced significantly higher green fodder yield over SPH 1698, CHS 24 MF and SSG 59-3. At Hisar, both the test genotypes were significantly inferior to checks. Significant response was observed up to 100% RDF.

2 K. Integrated Nutrient Management in *kharif* sorghum-chickpea cropping system: A long-term field experiment was initiated at Dharwad, Indore, Parbhani, Udaipur, Palem and Akola during 2013-14 to find out the effect of integrated nutrient management practices on yield, economics and soil health in sorghum-chickpea cropping system. On mean yield basis, the differences in grain yield among INM treatments were non-significant. However, application of 75% RDN through inorganic fertilizer+25% RDN through vermicompost produced maximum grain yield at Akola, whereas at Dharwad, 50% RDN through inorganic fertilizer+25% RDN through FYM+25% RDN through vermicompost being on a par with 100% RDN through inorganic fertilizer produced the highest grain yield.

3K. Improving Nitrogen-use efficiency through method and time of N application: Field experiments were conducted to improve the N-use efficiency through split application of nitrogen. Results revealed that on overall mean basis, there was no significant difference in grain yields due to variation in N application methods, but the response varied with locations. At Coimbatore, application of 25% N at sowing + 45% at 30 DAS + 5% foliar spray at 45 DAS +15% at BLS +10% GFS produced the highest grain yield of both CSH 16 and CSV 20, whereas at Udaipur, CSV 20 produced maximum grain yield with application of 50% N at sowing and 50% at 30 DAS, where as CSH 16 produced higher yield when 50%N was applied at sowing and 25% at 30 DAS +25% at boot-leaf stage (BLS); and the interaction was significant.

6. Sorghum physiology (SS Rao)

Phenotyping forty promising *kharif* sorghum germplasm for mid-season drought adaptation in dryland condition indicated that entries SSRK13-1, SSRK13-24, SSRK13-26 and SSRK13-30 were found to be the earliest for phenology. Higher total plant leaf area and leaf area index at flowering were recorded by SSRK13-2, SSRK13-13, SSRK13-14, SSRK13-16, SSRK13-18, SSRK13-19, SSRK13-27, and SSRK13-35 (range:4102 to 5471 cm² plant⁻¹) than check CSV23 (2474 cm² plant⁻¹). Significantly higher dry biomass was recorded by SSRK13-2, SSRK13-8, SSRK13-16, SSRK13-21, SSRK13-30 (Range: 853 -1299 g m⁻²) than check CSV23 (595 g m⁻²). Eleven test entries showed very high stalk brix (16.2 to 20.0%) than check CSV23 (4.7%) which include SSRK13-5, SSRK13-7, SSRK13-8, SSRK13-22, SSRK13-24, SSRK13-29, SSRK13-34, SSRK13-35, SSRK13-36, SSRK13-37, and SSRK13-38. SSRK13-29, and SSRK13-2 recorded more grain yields (448 and 342 g m⁻², respectively) than check CSV23 (330 g m⁻²).

7. Sorghum entomology (VR Bhagwat, G Shyam Prasad & B Subbarayudu)

Introduction: Total 126 genotypes were received from AICSIP centers in the form eight trials (AHT-GS, AVT-GS, IHT-GS, IVT-GS, IAVHT-MC, AVT-SC, IVHT-SC and IAVHT-SS) were evaluated for pests for resistance/tolerance at the respective hot-spot locations mainly at Coimbatore, Palem, Rahuri, Indore, Surat, and Hisar for stem borer and Dharwad, Palem, Akola, Parbhani, Indore, Surat and Udaipur for shoot fly. Five checks (IS 18551, IS 2205, ICSV 745, DJ 6514, and Swarna) were incorporated from Entomology. Other than regular trials, pest specific trials two on shoot fly and one on stem borer with a total of 164 lines developed through team efforts of entomology-breeding-germplasm were evaluated. A set of 12 lines were also evaluated for pest and disease resistance through entomology-pathology collaborative efforts. All the entries were evaluated under artificial condition by placing fish meal for shoot fly attractions. Whereas, the lines for stem borer were evaluated under natural conditions except at Hyderabad.

Pest scenario in sorghum: This year there was relatively moderate rainfall than normal rain fall in all most all centers. Due to longer dry spell, the pest incidence was moderate to higher particularly, shoot fly at Akola, Parbhani, Dharwad, Indore, Udaipur; and stem borer at Dharwad, Hisar, Surat and Coimbatore. The peduncle damage and tunneling damage recorded increase in percent particularly in Coimbatore. Very low incidence of midge (<2%) was recorded in Surat, and Deesa. Among the ear head pests, *Calocoris angustatus* and panicle head worms and *Nezara* infested sorghum up to 5%. The mite incidence seems to be increasing particularly in south Gujarat. *Pyrilla* showed its existence in northern part particularly in Haryana (<5 %).

Shoot fly (*Atherigona soccata*, Rond)

General trend: The shoot fly incidence was moderate to high (40-100%) at Dharwad, Parbhani, Akola, Indore, Surat and Udaipur.

Grain sorghum: In AHT and AVT, the DH% range was 38-82%. Only one test entry SPH 1703 recorded low deadheart and was on par with resistant check IS 18551. In IHT and IVT trial, the range was 49-88%. The test entry SPH 1748 recorded low deadhearts % due to shoot fly at peak stage.



Forage (multi cut): The shoot fly damage at peak stage in IVHT-MC was from 41 to 84% being an average of 61%. No entry was on par with resistant check IS 18551.

Forage (single-cut): In AVT & IVHT, the shoot fly damage at peak stage was from 34-85%. The promising entries SPV 2186, SPV 2258 and SPV 2191 recorded low DH and are on par with resistant check.

Sweet sorghum: In IVAHT-SS, the damage range was 41-85 % with an average of 63% at peak stage. None of the test entries were on par with resistant check.

Selected entries from AICSIP trials (AICSP-SPN): The entries selected from AICSIP during Kharif 2012 had a range of 39-81% with average of 60%. Entries SPV 2196, SPV 2203, SPV 2204 and RSSV 9 recorded low deadhearts due to shoot fly.

Northern based dual purpose sorghum: (Elite DP-SF): Overall, the damage range was from 29-79% with mean of 40%. The entries LDR 238, PGN 39, RSSV 9, SUENT 13, EC 15, ICSB 411, ICSV 705, ICSV 93046, IS 2123 and IS 2146 were on par with resistant check IS 2312. The resistant check recorded 29 % deadhearts at peak stage.

Shoot pest resistance nursery (DSR-SPRN): Across the locations, the damage range was from 39-86% with mean of 59%. The entries M 35-1 x ICSV 714)-3-1-1, (M 35-1 x IS 2312-1)-3-2-2, and (ICSV 700 x ICSV 705)-1-1-1 were on par with resistant check IS 18551. The resistant check recorded 39 % DH at peak stage.

Forage local check (Forage-LC-SF): Across the three locations, the range was 43-89% averaging 62%. The entries CO (FS)-29, CSV 21F, Ramkel, Katakhatav, RSSV 9, Rampur local and Sangoli Hundi recorded low damage.

Pest and Disease resistance (PDRN): The average was 55% ranging from 40 to 80%. The entries NRCS-FR09-3, RSSV 9 and SUENT 13 recorded low shoot fly and were on par with resistant check.

Spotted stem borer (*Chilo partellus*, Swinhoe): *General trend:* The stem borer incidence was moderate to high. The highest damage was noticed at Indore (60 %). At Coimbatore, Surat, and Hisar, moderate population was observed. The stem tunneling at Coimbatore is increasing.

Grain sorghum: In AHT-GS and AVT-GS, the DH% range was 13-26%. The entries SPH 1736, SPH 1731, SPH 1736, CSH 30, LC SPV 2114, CSV 20, SPV 2174, SPV 2178 and SPV 2182 recorded low deadhearts % at 45 DAE. In IHT (GS) and IVT (GS), the DH range was 5-23 %. The test entries SPV 2191 and SPV 2258 recorded low deadhearts % at 45 DAE.

Forage sorghum: The stem borer damage at 45 DAE in IAVHT-multi-cut trial was from 6 to 21% being an average of 10%. The test entries that recorded lower deadhearts due to stem borer are SPH 1695, SPH 1698, SPH 1752, SPH 1753 and SPV 2242. In AVT and IVT, the shoot fly damage at 45 DAE was from 8-37 %. The entries SPV 2191 and ICSV 745, SPV 2258 recorded low DH and are on par with IS 2205.

Sweet sorghum: In IVAHT-SS, the damage range was 9-21 % with an average of 16% at 45 DAE. Only the entry CSV 19SS recorded low deadheart % and was on par with resistant check.

Selected entries from AICSIP trials (AICSP-SPN): The entries selected from AICSIP during Kharif 2012 had a range of 4-11% with average of 7%. The entries SPV 2114, SPV 2122, SPV 2057, SPV 2127, SPV 2130, SPV 2131, SPV 2132, SPV 2186, SPV 2197 and SPV 2198 recorded low deadhearts due to stem borer.

Northern based dual purpose sorghum: (Elite DP-SF): Overall, the damage range was from 13-41% with mean of 22%. The entries P 23, P 45, PGN 30, PGN 39, PGN 61, RSSV 9, Satpani, PGN 111, EC 15, EP 96, ICSV 93046 and IS 2123 were on par with resistant check IS 2205. The resistant check recorded 13.6 % deadhearts at 45 DAE.

Shoot pest resistance nursery (DSR-SPRN): Across the locations, the damage range was from 9-28% with mean of 15%. The progenies (PGN 35 x PGN 30)-3-2,(EC 15 x ICSV 714)-2-1-2, (ICSV 700 x IS 2205-1)-3-1-2 and (ICSV 700 x ICSV 705)-1-1-1 were on par with resistant check IS 2205. The resistant check recorded 9.8 % DH at 45 DAE.

Head bug (*Calocoris angustatus*): Damage rating (1-9) due to ear head bugs was recorded at Palem and Indore. Total 26 test entries from all trials were recorded <3 damage rating.

Shoot bug (*Peregrinus maidis*): No shoot bug damage was recorded at any of these centers.



Spider mite *Oligonychus indicus* (Hirst): The damage rating (1-9) was recorded at Surat only. The damage was noticed up to 8 rating. Total 30 test entries from all trials recorded < 3 damage rating.

Midge (*Stenodiplosis sorghicola* Coq): No recordable incidence was noticed particularly from Coimbatore, Dharwad and Surat.

Sugarcane aphids (*Rhopalosiphum maidis*): The data on aphid population did not recorded since population was inadequate at research station.

Validation of IPM : Some of the AICSIP centers have taken up initiatives for testing newer molecules of insecticides as an alternative to endosulfan. At present, in IPM trial an insecticide, Thiomethoxam (Cruiser) as seed treatment proved effective against shoot fly. While in another preliminary trial, the combined application of carbaryl @ 3g/l+ carbendazim @ 1g/l showed promise for managing ear head damage and ergot disease.

Overall conclusions

1. Dharwad, Parbhani, Rahuri, Akola, Indore, Surat and Udaipur centre may be considered for hot spot for shoot fly screening.
2. Hisar, Coimbatore, Surat and Indore may be considered hot spot for stem borer.
3. A data on selected and few parameters for targeted pest may be required to study mechanism of resistance and correlations for traits.
4. The effective management of head bug damage and ergot can be done with the combined application of carbaryl @ 3g/l+ carbendazim @ 1g/l and also helped in increasing grain yield.

Future work plan- Kharif 2014

1. Observations on shoot fly should be recorded when deadhearts reaches at 70 % in susceptible check. If it is more than 70% insecticidal spray may be applied to protect promising entries.
2. Dharwad, Parbhani, Akola, Indore, Surat and Udaipur centre may be considered as hot-spot for shoot fly screening.
3. Coimbatore, Dharwad, Parbhani, Palem, Hisar and Surat centre to be considered as hot-spot for testing stem borer resistance.
4. Need to find out the causes of outbreak of stem borer incidence at Indore and its management.
5. Transformation method may be adopted during statistical analysis for reducing CV%. It needs further discussion. The data may be considered for interpretation if CV% is <25%.

8. Sorghum pathology (IK Das)

Pathology programme for the year 2013-14 consisted of applied as well as basic research components. Applied research dealt with multi-location testing of breeding materials for resistance against sorghum diseases at hot spot locations. A total 156 sorghum lines consisting of grain, forage and sweet sorghum entries were evaluated against panicle and foliar diseases in endemic areas (Palem, Coimbatore, Dharwad, Akola, Parbhani, Surat, Udaipur and Pantnagar) spread over three sorghum growing zones. Basic and strategic research focused mainly grain mold, anthracnose and charcoal rot disease.

Disease situations: Among panicle diseases grain mold was predominant in Maharashtra, Karnataka, Andhra Pradesh and Gujarat. Sugary disease (ergot) was severe in Gujarat and downy mildew in Karnataka region. Among foliar diseases anthracnose, leaf blight and zonate leaf spot appeared in moderate to severe form in Pantnagar, Udaipur, and Dharwad. Rust was recorded in Dharwad and Udaipur and sporadically in Marathwada region. Sooty stripe was prominent in Vidarbha region. Sporadic incidence of rough, target and grey leaf spots was also noted in Rajasthan, Karnataka and Vidarbha region. In most hot spots centres disease load was optimum as indicated by appearance of disease severity in susceptible checks as well as local checks. Location severity index for various diseases indicated that materials under evaluation exhibited presence of some degree of resistance in them against sorghum diseases.

Grain mold: Location severity index (LSI) for grain mold assessed over all the trials in the location indicated that grain mold pressure was moderate in most of the locations and severe in Dharwad and Palem. Grain mold severity ranged from 2.0 to 9.0 with mean 4.0 in grain sorghum (AHT, AVT, IHT and IVT), 2.3 to 7.0 with mean 3.2 in forage sorghum (IVHT and AVT) and 2.3 to 6.1 with mean 3.5 in sweet sorghum (IAVHT). Among advanced grain sorghum entries SPH 702(2), SPH 1736, SPH 1737, SPV 2174, SPV 2179 and SPV 2181 were moderately resistant to grain mold. Most promising entries in initial grain sorghum trials were SPH 1748, SPH 1751, SPV 2246, SPV 2252 and SPV 2254. Promising sweet sorghum entries for grain mold resistance were SPH 1754, SPV 2200, SPV 2241 and SPV 2271. Among forage sorghum entries SPV 2128(2), SPV 2190, SPV 2261, SPV 2263 and SPV 2264 were promising for grain mold resistances.

Sugary disease: Four grain sorghum (AHT, AVT, IHT & IVT) and one sweet sorghum (IAVHT) trials were evaluated for sugary disease (ergot) resistance in hot spots. During kharif 2013 moderate incidence appeared in Surat. Location severity index (LSI) for ergot indicated that disease severity in Surat was 18.6%. Ergot severity ranged from 8.0 - 40% with mean



18.1% in grain sorghum and 10.4 to 28.5 with mean 19.1% in sweet sorghum. Among grain sorghum entry the hybrids SPH 1731 and SPH 1748 and the varieties SPV 2179, SPV 2182, SPV 2183, and SPV 2246 were resistant to ergot. Among sweet sorghum entries SPV 2195, SPV 2196 and SPV 2271 [range, 10.4 to 13.8%] were promising for ergot resistance.

Downy mildew: Eighty grain sorghum entries consisting of four trials (AHT, AVT, IHT & IVT) were evaluated for downy mildew resistance in endemic locations. Location severity index indicated that downy mildew severity was severe in Dharwad (LSI, 71.1) and sporadic in Coimbatore (LSI, 3.4). In other locations there was no report of downy mildew incidence during this season. At Dharwad disease incidence ranged from 0% (QL3) to 100% (DMS 652) indicating resistant to susceptible disease reactions. Because of severe incidence only two entries *viz.*, SPH 1702 (2) and CSH 25 recorded downy mildew $\leq 25\%$. None of the entries was resistant this season at Dharwad location.

Foliar diseases: Anthracnose, leaf blight and zonate leaf spot remained major foliar diseases during kharif 2013. Location severity index for foliar diseases suggested that anthracnose severity was moderate to high at Pantnagar and Surat and low at Udaipur and Coimbatore. Zonate leaf spot was moderate at Udaipur, Pantnagar, Coimbatore, Dharwad and Surat. Leaf blight was moderate at Surat and low to moderate at Udaipur, Coimbatore and Parbhani. Rust was sporadic at Dharwad, Parbhani and Coimbatore. Other foliar diseases like rough, gray leaf spot and sooty stripe in Akola, target leaf spot in Udaipur and grey leaf spot in Parbhani was recorded in low to moderate form. Most promising entries for foliar disease resistance were as follows; Grain sorghum hybrid- SPH 1703 (2), SPH 1705 (2), SPH 1748, SPH 1749, SPH 1751; varieties- SPV 1822(2), SPV 2122(2), SPV 2183, SPV 2244, SPV 2247, SPV 2248. Forage hybrid- SPH 1753, SPH 2242; varieties- SPV 2128(2), SPV 2259, SPV 2261, SPV 2262, SPV 2264 and sweet sorghum hybrid- SPH 1755; varieties SPV 2205, SPV 2241, SPV 2268.

Multiple resistances: Few entries showed resistance to more than two diseases. In grain sorghum combined resistance against grain mold and downy mildew, grain mold and ergot and grain mold and foliar diseases are required for different growing situations. SPH 1702 (2) was moderately resistant to grain mold and downy mildew, SPH 1748, SPV 2179, SPV 2246 and SPV 2271 were resistant to grain mold and ergot. Sweet sorghum variety SPV 2205, and SPV 2241 and forage varieties SPV 2128 (2), SPV 2261 and SPV 2264 were resistant to grain mold and foliar diseases (anthracnose and zonate leaf spot). For forage varieties leaf disease resistance is of utmost importance. In multi-cut forage hybrid SPH 1753 and SPH 2242, there was combined resistance against anthracnose, zonate leaf spot and leaf blight. In single cut forage SPV 2128(2), SPV 22259, SPV 2261 and SPV 2262 there was combined resistance against anthracnose, zonate leaf spot and leaf blight. Of these, SPV 2128(2) and SPV 2261 also had grain mold resistance combined with multiple foliar disease resistance.

Anthracnose variability: Anthracnose pathogen *Colletotrichum graminicola* showed wide variability in their disease causing ability as revealed by disease reactions of ten isolates on ten sorghum genotypes at hot spot location (Pantnagar). Isolate CgD and CgL were highly virulent that could register 8 susceptible reactions out of 10 lines. Isolate CgB and CgS were least virulent of the ten isolates that could register 6 susceptible reactions. Because of high disease pressure variability was narrowed down. None of the isolates could produce susceptible disease reactions on Pant Chari-5 suggesting the line might have adequate resistant to anthracnose. In terms of aggressiveness CgA was the most and CgS was the least aggressive isolate on this set of sorghum lines.

Grain mold nursery: Entries SGMRN 12-3-1, R10-MP 13, GMR 156-1 and GMR 166-1 were resistant to grain mold. AKMGR 104, AKMGR 103, GMR 84-2, PSGVS 106, GMR 83-1, SU 1363 and GMR 166-1 recorded less than 20% *Fusarium* and PSGVS 106, GMR 166-1, SGMRN 12-3-1, AKMGR less than 15% *Curvularia* infection.

Pest and disease resistant nursery: Out of seven entries four were resistant/ moderately resistant to grain mold (GMR308, GMR156, GMR144-2, GMR309, score<5.0) and others were susceptible. All were resistant to anthracnose but susceptible to downy mildew

Publications and recognitions: The group was involved in publishing 13 research articles during 2013 in national (10) and international (3) journals. Twenty abstracts were presented in different symposia at national and international level. Akola centre received the best poster award in international symposium.

9. Sorghum NSP, BSP, MSP & DUS (VA Tonapi & Hariprasanna)

During 2013-14, 305.04 q breeder seed was produced against BSP-I allocation of 82.90 q. A total of 1047 kg nucleus seed was produced against allocation of 1035 kg. In farmers participatory seed production a total of 810 q seed was produced. The center wise allocation of sorghum breeder and nucleus seed production has been made for 2014-15 across 14 locations based on DAC indent received for the year 2014-15.

During the period under report, two field trials each were conducted during *Kharif* 2013 and *Rabi* 2013-14 seasons for examining the DUS in candidate varieties of sorghum as per the PPV&FRA test guidelines. A total of 23 candidate varieties were tested for DUS traits in the *kharif* season and nine candidate varieties were tested in the *rabi* season along with the corresponding reference varieties.



Summary of AICSIP research achievements - Rabi 2013-14

1. Breeding - Grain sorghum (Prabhakar)

During 2013-14, both basic and applied researches towards improvement of grain sorghum were taken up. Applied researches dealt with multi-location yield trials of finished or near finished products (varieties and hybrids) from the centers of All India Coordinated Sorghum Improvement Project (AICSIP) and private companies. Basic and strategic researches focused on various aspects including new MS and R line development, breeding for earliness, drought tolerance, cold tolerance, resistance against key insects and diseases etc. Efforts were made to use biotechnological tools as well towards improvement of grain sorghum. Efforts were also made to develop inter-institutional hybrids, under which promising MS lines were shared across centers and new experimental hybrids were developed, which were tested under multi-location trials.

Multi-location AICSIP trials: During the year 2013-14, the following 5 multi-location yields trials were conducted across locations.

1. Advanced Varietal and Hybrid Trial-I (Deep soil)
2. Initial Hybrid Trial (Deep soil)
3. Initial Varietal Trial (Deep soil)
4. Initial Varietal and Hybrid Trial-II (Shallow soil)
5. Parental line trial

Advanced Varietal and Hybrid Trial (Deep soil): In this combined trial of varieties and hybrids, 6 varieties and 5 hybrids along with 4 checks were evaluated for grain and fodder yield and other agronomic traits.

- None of the varieties and hybrid was superior to the checks for grain yield. The hybrid SPH-1746 (6780 kg/ha) gave significantly better fodder yield than the check CSH-15R (5778 kg/ha) and was superior by 17.34 %. Other hybrids which gave more than 5% fodder yield than the check hybrid were SPH-1741 (6286 kg/ha), SPH-1742 (6241 kg/ha). Among varieties, the variety SPV-2221 (7148 kg/ha) gave 8.5% more yield than the check CSV-22 (6587 kg/ha). The varieties SPV-2221, SPV-2215 and SPV-2228 and the hybrid SPH-1746 were better in grain size than the checks
- The performance of the varieties and hybrid over 2 years of testing in Rabi 2012-13 and 2013-14 indicated that the hybrids SPH-1741 (2600 kg/ha), SPH-1741 (2607 kg/ha) and SPH-1746 (2534 kg/ha) gave 10.63%, 10.93% and 7.82% more grain yield, respectively, over the check CSH-15R (2350 kg/ha). For fodder yield, the hybrids SPH-1746 (6852 kg/ha), SPH1741 (6217 kg/ha) and SPH-1742 (6184 kg/ha) gave 17.95%, 7.02% and 6.45% more than the check CSH-15R (5809 kg/ha).

Initial Hybrid Trial-I (Deep soil): In this trial of varieties, 6 hybrids along with 3 checks were evaluated for grain and fodder yield and other agronomic traits.

- The hybrids SPH-1763, SPH-1764 and SPH-1762 showed superiority both for grain and fodder yield in the trial. The hybrid SPH-1763 (2846 kg/ha) was significantly superior to CSH 15R (2393 kg/ha) by 18.90% for grain yield

Initial Varietal Trial (Deep soil): In this trial, 14 varieties along with 3 checks were evaluated for agronomic traits

- None of the varieties were significantly superior to check CSV-22. The variety SPV-2277 (7430 kg/ha) was significantly superior to the check CSV 22 (6461 kg/ha) by 14.90% for fodder yield. The varieties SPV-2277 (3.86 g), SPV-2279 (3.72 g), SPV-2280 (3.59 g) and SPV-2282 (3.51 g) were significantly better than the check CSV 22 (3.26 g).

Initial Varietal and Hybrid Trial-I (Shallow soil): In this combined trial of varieties and hybrids, 4 varieties and 2 hybrids along with 5 checks were evaluated for agronomic traits.

- None of the varieties/hybrid was better than the check Phule Anuradha. The hybrid SPH-1768 gave 4.90% more grain yield than the check hybrid CSH-15R. Among varieties, the variety SPV-2291 was better than the check Phule Anuradha by 7.41% for grain yield. For fodder yield, the variety SPV-2289 was better than the check Phule Anuradha by 6.47%.

Parental line trial: A combined (kharif & rabi) parental line trial consisting of 35 parents (14 A lines and 21 R lines) was conducted at Nandyal, Parbhani and Hagari.

- There was good synchronization in parental lines (A/R lines) as the difference between the CMA Lines and restorers ranged from 2 to 4 days. So, they can be sown simultaneously and staggered sowing is not necessary.
- The high yielding CMS lines and R lines were 104A, 32A2, 499A, IMS-9A, SLR-75, SLR-84, SLR-92, SLR-93, AKRB-513, R-204, RSV-269, RSV-1090 and RSV-1130. It was interesting to observe that R lines were more potential than CMS lines.



Coordinated sorghum breeding research: F2 populations of 11 crosses were provided by four centers (Kovilpatti, Dharwad, Akola and Parbhani) and they were sent for evaluation at 9 locations. About 150 single plant selections are made from the crosses.

Rabi sorghum breeding at DSR

- Evaluation of improved breeding lines in shallow-medium and deep soils separately, indicated that 48 promising varieties (12 in shallow-medium and 36 in deep soil) were significantly superior to checks M35-1/Mauli and CSV-22 for grain and fodder yields and grain quality with resistance to insect-pests and diseases.
- Selected varieties for shallow-medium soils were SLV-34, 40, 43, 50, 73, 91, 97, 100, 101, 111, 123 and 135 and for deep soil, the varieties were SLV-97, 118, 123, 130, 131, 133, 145, 166, 169, 172, 180, 188, 199, 202, 207, 209..
- B line improvement for diversifying genetic base led to selection of 17 B lines out of 36 lines with rabi traits. Eleven test hybrids, superior to CSH-15R for grain and fodder yields were selected.
- Selected B lines were SLB-22, 29, 35, 45, 46, 50, 56, 58, 59, 60, 73, 80, 86, 92, 97, 108 and 150.
- Twelve new CMS lines (SLA-9, 19, 29, 35, 45, 46, 56, 59, 60, 73, 82, and 150) better than the CMS 104A in respect of grain quality with resistance to insect-pests and diseases have been stabilized and they are ready for commercial exploitation
- R line improvement for diversifying genetic base led to selection of 54 R lines out of 96 lines with rabi traits. Selected R lines were SLR-27, 31, 34, 46, 57, 67, 68, 70, 80, 87, 97, 130, 133, 136, 146, .
- Twenty five genotypes were evaluated in three reliable soil moisture environments (assured irrigation, water deficit ie.irrigation only upto 50 days after sowing and rainfed ie. receding moisture conditions) along with four checks. Drought susceptible index (DSI) values for grain yield under water deficit condition ranged from 0.13 to 1.32 and under rainfed condition ranged from 0.13 to 1.24. Drought tolerance efficiency (DTE) for yield ranged from 92.84 to 29.84 per cent under water deficit condition and 90.54 to 12.58 per cent under rainfed condition.
- In studies on response of sorghum genotypes towards post-flowering drought stress, four lines, viz., IS 19153, IS 23514, IS 29392 and RS 585 showed consistent better post-flowering drought response over both the years. Out of these four lines identified IS 23514; a red sorghum line recorded lowest DSI in both the years and found to be promising.
- Whole genome and candidate gene-based SNP detection in sorghum: A reference set of 96 sorghum genotypes for drought studies was subjected to Double Digestion Restriction site Associated DNA sequencing (ddRAD-seq). Alignment with the reference genome of BTx 623 led to identification of a total of 235,009 unfiltered SNPs, distributed across 10 chromosomes. Out of these 198,611 (84.5%) were located in inter-genic regions, while 36,398 (15.5%) were localized in intra-genic regions. This led to identification of 10,125 SNPs, 8,313 (82.1%) and 1,812 (17.9%) of which were located in inter- and intra-genic regions, respectively.
- From SNP database 15.1% of unfiltered and 42.5% of filtered SNPs could be confirmed. Out of the identified SNPs 2075 represented 32 reported QTLs, of which, SNPs on chromosome 2, 3, 5 and 8 were mostly associated with drought related QTLs. Sequence alignment of coding (CDS) and promoter regions of 10 candidate genes from six sorghum genotypes led to identification of total of 172 SNPs and 68 in-del mutations in the coding regions, while in promoter regions 159 SNPs and 77 in-dels were identified (Table 3). Forty two identified SNPs were converted to CAPs/dCAPs markers.
- Evaluation of diverse group of breeding material for tolerance to cold stress indicated that date of sowing significantly influenced pollen germinability and the influence of the cooler night temperatures was more than the genetic background. In contrast, pollen viability had less phenotypic plasticity and highly heritable. The loss of grain yield was about 5g/panicle in varieties while it was 1.9g/panicle in restorer lines and about 5.7g/panicle in B-lines. The loss in grain yield was highest in the hybrid at about 22.9g. The germinability percentage was positively associated with selfed panicle weight, grain yield and harvest index while the viability percentage did not show such association. The germinability percentage was more linearly related in R-lines followed by B-lines and varieties.

Rabi sorghum breeding at AICSIP centers

- At Rahuri, rabi sorghum genotype RPASV-3 was identified for papad purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra. Identified the rabi sorghum genotype RSSGV-46 for hurda purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra.
- In Bijapur, under breeding evaluation programme at state level, 3 preliminary varietal trials, one B line trial, one R line trial and one MLT were conducted. A total of 15 lines from PVT, 10 from BLT and 13 from RLt were selected. In station breeding programme, 20 newly derived F6 generation, R lines were evaluated and of them eight were found superior. In B line programme 8 lines were found exceedingly superior to checks. In conversion programme 10 lines are at BC4 stage. In trait specific breeding programme, ten families belonging to BC2&BC1F1 were evaluated for drought stress and four were found promising. In the breeding for charcoal rot tolerance 23 lines derived from BC2F3 and



straight F₃ were evaluated and a total of 20 promising plants were selected. To develop medium dwarf non lodging coupled with CSV216R yielding ability 18BC2F4 families were selected. To develop early maturing lines with maldandi yielding ability 10 F₇ lines were evaluated and a total of 5 families were selected. A total of 33 F₃s derived from different cross combination were grown. Of them a total of 150 plants were selected for different combination of traits.

- At Dharwad, rabi sorghum improvement work is carried out with the objective of developing varieties with good grain quality, resistance to biotic stresses like shoot fly tolerance and charcoal rot resistance. In 3 Station varietal trials, the varieties significantly better than the check DSV-4 were SVD-1251 (3278 kg/ha), SVD-1252 (3260 kg/ha), SVD-1261 (3148 kg/ha), SPV-2217 (3130 kg/ha), SVD-1277 (3852.0 kg/ha), SVD-765 (3463 kg/ha) and SVD-1229 (3389 kg/ha). In 2 station hybrid trials, the hybrids SHD-13-32 (3908 kg/ha) SHD-13-33 (3574.0 kg/ha), SHD-13-34 (3352 kg/ha), SHD-13-57 (4612 kg/ha) SHD-13-53 (4371 kg/ha) and SHD-13-54 (4185 kg/ha) recorded significantly superior grain yield compared to M 35-1 (2093 kg/ha) and DSV-4 (3760 kg/ha). As many as 67 fresh crosses were made and 226 selections were made in various generations from F₁ to F₆ and three M₂ progenies were evaluated for grain size and grain yield.
- At Akola, evaluation of 4000 germplasm received from the Project Directorate, Hyderabad was carried out and observations were made on shoot fly and stem borer and other agronomic characters. In Development of male sterile lines, 31 pairs in BC II, 33 pairs in BC III, 24 pairs in BC IV, 36 pairs in BC V & 21 pairs in BC VI generation have planted. In addition to this, five crosses in F₈ generation have been planted and selections are made. For the development of restorer lines, the centre has already developed 50 restorer lines tolerant to shoot-fly with good *rabi* adaptation. In addition to this, the unit has developed ten restorer lines with earliness. Similarly, the centre developed 25 restorer lines for high yield and its contributing traits. All these lines are being maintained and used in experimental hybrid seed programme. In generation of new material, one diallel set of 8 x 8 parents (half diallel) has been executed. Further, 28 F₃ crosses have been advanced and planted at Washim.

Publications: Twenty four research publications including 7 book chapters, exclusively on rabi grain sorghum have been published during the period.

2. Sorghum agronomy (JS Mishra)

Field experiments were conducted during rabi 2013-14 at different AICSIP centres to evaluate advance sorghum genotypes for fertility response and to develop agronomic practices for higher sorghum productivity and profitability.

1R. Evaluation of advanced sorghum genotypes to fertility levels: Test hybrid 'SPH 1721' was significantly superior to check CSH 15R at Rahuri and Tandur with 17.46 and 34.97% increase in grain yield, and was on a par at Parbhani and Dharwad. Test variety 'SPV 2144' was significantly superior to M 35-1 (15.98% increase) and CSV 29R (52.4% increase) at Rahuri, and to CSV 22R (8.6% increase) and M35-1 (41.07% increase) at Tandur.

2R. Enhancement of *khari*f-fallow *rabi* sorghum productivity through *in-situ* moisture conservation: Compartmental bunding during *khari*f season followed by flat sowing of *rabi* sorghum was the most productive and cost-effective. It produced 36.6% higher grain yield and conserved more soil moisture than that of flat sowing; and gave the highest net returns (Rs 65811/ha) and B: ratio (3.13).

3R. Integrated nutrient management in *rabi* sorghum: Inclusion of *Dhaincha* or greengram (after pod harvest) as green manure and application of 40 kg N/ha enhanced the productivity and profitability of succeeding *rabi* sorghum.

4R. Assessing the performance of sorghum genotypes with increased sowing window: Interaction effect between dates of planting and cultivars indicated that the performance of cultivars varies with dates of planting at different locations. At Parbhani, crop should be sown during first week -3rd week of October whereas at Rahuri 3rd week of Sep sowing was found. At Dharwad, first week of October was the optimum for *rabi* sorghum planting.

5R. Evaluation of plantozyme and plantogranules in *rabi* sorghum: Foliar spraying of plantozyme @2ml/l water at 35 and 60 days after sowing significantly increased (20% increase) the grain yield of *rabi* sorghum compared to RDF alone.

3. Sorghum physiology (SS Rao)

Trial 1R: Preliminary evaluation of diverse germplasm for rabi adaptation: Forty-eight landraces rabi sorghum germplasm along with three checks were evaluated at Parbhani, Tandur, Bijapur, Solapur and Rahuri with an objective of identifying potential donors for rabi adaptation traits such as phenology, physiological traits components of biomass, and grain yield. Entries SSRG 201, RSV-1462, SSRG 202, and SSRG 204 in leaf area index (LAI), and *Honawad*, *Bidar local*, *Pathari local*, SSRG 170, *Halyal local* in SPAD values (54.6-55.9), and RSV 1479, *Aurad local*, *Jhemkhed local* and *Honwad -2* in Photosynthesis rate (Pn) (23.1 to 33.9 μ mol CO₂ m⁻¹ S⁻¹) were superior to check *Phule Chitra*. Landrace germplasm *Pusegoan local* was superior in biomass yields than check, while entries on par with check include *Tikota*, *Gondavle local*, and



Tansoli halli local. In grain yield, genotypes *Gondavle local* (31%), *Pusegoan local* (20%), RSV 1426 (15%) *Tikota* (13%) and *Tansoli halli local* (12% more) produced higher yields than best check *Phule Chitra*.

Trial 2(M) & 3(S): Phenotyping advanced rabi sorghum entries for drought adaptation traits in medium and shallow soils: Sixteen advanced rabi-adapted sorghum entries along with three checks were phenotyped in both medium (≤ 75 cm soil depth) and shallow soils (≤ 45 cm soil depth) at Bijapur, Parbhani, Rahuri, Solapur and Tandur. Average plant height decreased by 12.0 % in shallow soil over medium. *Phule Anuradha* (0.581), CRS 20 (0.636), BJV 114 (0.785), RSV 1420 (0.797) and showed less DSI means more plant height stability under drought. BJV 103 and MSV 71 were stable for Leaf area index (LAI) across the soil depths. Entries CRS 15 and CRS 19 recorded superior crop water status (RLWC) than checks especially in shallow soil stress condition. SPAD declined by 16 % in shallow over medium soils. None was superior check *Phule Anuradha* in shallow soil. Interestingly, higher SPAD units (more leaf staygreen) resulted in realization of higher harvest index as could be seen from significant positive relationship between the two ($r = -0.519$; $P \leq 0.05$) in shallow soil. Entries CRS 19 alone showed 22% higher Photosynthesis rate (Pn) rates in shallow stress than medium followed by CRS 20 (9%) than check *Phule Chitra*. Pn rate had shown significant positive correlation with leaf temperature differential (LTD) and 1000-grain weight ($r = 0.519$, and $r = 0.536$; $P \leq 0.05$) in shallow soil condition. Mean grain yield ranged from 1484 to 2069 kg ha⁻¹ and 787 to 1060 kg ha⁻¹ in medium and shallow soil, respectively. None was significantly superior to check *Phule Chitra* in medium soil, while in shallow soil, BJV 114, and BJV 83 were marginally superior (4-7%) for grain yields. Mean grain yield reduced by 48 % in shallow soils over medium with a range between 35 and 56%. In terms of drought susceptibility index (DSI) for grain yields, RSV 1455 (DSI=0.737), BJV 114 (DSI=0.824), and CRS 15 (DSI=0.825) were relatively more stable than checks.

Trial 4 R and 4 Irrg: Evaluation of sorghum plant types for root characteristics: Thirteen advanced rabi sorghum genotypes including checks were characterized for root and shoot traits that contribute survival under flowering and postflowering drought and heat stress. The mean root length, root volume, and root numbers declined by 17.5, 30.0% and 35.0 % in rainfed condition than in irrigated. Mean root length at physiological maturity under rainfed condition varied from 48 to 97 cm/plant. Root number per plant at maturity varied in 34 to 57 and 42 to 92, respectively in rainfed and irrigated conditions. Root mass decreased by 22% (range: 28-63 g/plant) in moisture stress than in irrigated. Entries, CRS 19, MSV 71, and RSV 1098 had recorded significantly superior ($P \leq 0.05$) root traits than checks across moisture regimes.

4. Sorghum entomology (VR Bhagwat, G Shyam Prasad & B Subbaruyudu)

Introduction: In collaboration with AICSIP, total 226 genotypes received from ten trials (AVHT-DS, IHT-SS, IVT-DS, IVHT-SS, AICSIP-DS-SPN, AICSIP-SS-SPN, SFR-F₈, B & R lines, IASFN and NGSN), one trial on APSHN from DSR (Aphid and shot bug resistance nursery) were evaluated mainly for shoot fly, stem borer, sugarcane aphids and shoot bugs for resistance/tolerance at respective hot spot locations; Kovilpatti, Dharwad, Bijapur, Rahuri, Parbhani, Tandur, Hyderabad and Solapur. All the entries were evaluated under artificial condition by placing fish meal for shoot fly attractions. Whereas, the lines for stem borer were evaluated under natural conditions.

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

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



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

Initial hybrids and Initial varietal trial (DS & SS): In IHT-SS, the range was from 33.0 to 78.2% deadhearts with an average of 54.6% deadhearts. However, none of the test entries was superior than resistant check IS 18551. In IVT (DS) trial the range was of deadhearts was from 34 to 79 %. None of the test entries was superior to resistant check IS 18551

Germplasm, B & R lines and IASFN: In IASFN, RSV 1003, NRCSFR09-3, RSV 1315, RSE 03, RSV 1410, RSV 1507, RSV 1635, RSV 1698, RSV 1683, RSV 1687, PBN-ENT-2, PBN-ENT-3 and PBN-ENT-4 were promising. In B & R trial promising entries were SLB 72 and SLV 145 and from germplasm trials NSJB 6596, NSJB 6625, CJV 22, POP 39, SEB 11988 are promising.

SFR (F₃) progenies: The promising progenies that recorded low deadhearts EC 19 x EP 133-2-3, EG 15 x EP 57-6-1, CSV 22 x EC 12-4-1, LG Kumbhari local , EC 19, EC 15.

Spotted stem borer (*Chilo partellus*, Swinhoe)

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

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

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

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

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

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

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

Future work plan Rabi 2013-14:

- Extensive Germplasm accessions may be evaluated at hot spot locations to identify improved sources for major pests through collaborative efforts.
- Shoot fly: Dharwad, Parbhani, Solapur, and Rahuri centre may be considered as hot-spot for shoot fly screening. Observations on shoot fly should be recorded when deadhearts reaches at 70 % in susceptible check.
- Stem borer: Kovilpatti, Bijapur and Parbhani centre to be considered as hot-spot for testing stem borer resistance.
- Aphid/shoot bug: For aphid and shoot bug, Rahuri, Bijapur and Solapur may be considered.
- Midge: It is not regular pest but incidences recorded occasionally at Dharwad, and Kovilpatti. These centers may be considered as testing spots for midge.
- Biopesticides/new molecules: Evaluating of bio-pesticides and new molecules may be taken up on payment basis for conducting in-door and out-door trials.



- Large scale IPM: Large scale IPM trials through on-farm testing (OFT) initiated at Parbhani. Other centers need to follow up.
- Organic IPM: Efforts initiated at Bijapur and Tandur need to make more efforts at other locations too.

5. Sorghum pathology (IK Das)

Disease situation: Rabi season during 2013-14 was overall dry with scanty rainfall. Maharashtra region faced drought. Apart from sporadic incidences of leaf rusts, leaf spots and downy mildew foliar diseases were negligible during rabi. Charcoal rot and lodging incidence was moderate in Solapur, Bijapur and Dharwad and low at Parbhani. Charcoal rot index for sorghum (CRIS) was moderate at Bijapur (18.6) and Dharwad (17.1) and minor at Parbhani (6.8). Downy mildew were noted in Dharwad region (range, 2 to 48%) with mean incidence of 9.8. Rust incidences ranged from 2 to 3 score in farmers field as well as in research plots. Overall diseases incidence was low to moderate during rabi due to less rainfall and rainy days.

Multi-locations varietal and hybrid trials:

Charcoal rot: Fifty-six rabi sorghum varieties and hybrids (AVHT, IHT, IVT & IVHT) were evaluated for charcoal rot resistance in hot spot locations in Maharashtra and Karnataka. Disease incidence ranged from low to moderate. Promising entries for CR resistance in deep soil were SPH 1721(2), SPH 1741, SPH 1744, SPH 1764, SPH 1765, SPV 2284, SPV 2287 and SPV 2281 (CRIS <17). The entries SPV 2289 and SPH 1768 performed well in shallow soil.

Other diseases: Because of dry season foliar diseases incidence was low and sporadic. Among other diseases downy mildew was noted in Dharwad region (range, 2.9 to 32.3%). Entries SPV 2215, SPV 2221, SPV 2288, SPV 2291, SPH 1764, SPH 1765, SPV 2274, SPV 2282, SPV 2283, SPV 2274, SPV 2282, SPV 2283, Maulee and Phule Anuradha were promising for downy mildew resistance during rabi season.

Charcoal rot nursery: Nine entries were evaluated for charcoal rot resistance at host spots. The test entries behaved as resistant to moderately resistant lines for charcoal rot resistance [CRIS, 8.3 to 11.9]. Lodging varied significantly among genotype [range 9.3 to 26.3%]. Entry RSSGV-3 recorded less than 10% lodging and was promising.

Management of charcoal rot: Replicated field trials were laid at Solapur, Dharwad and Parbhani for management of charcoal rot through seed treatments (cv. M35-1). Seven treatments including five bio-agents were used as seed treatment in *M. phaseolina* sick plot. Observations were recorded on CR incidence, severity (nodes crossed by Mp, length of Mp infection in stem), crop lodging, grain yield and fodder yield. Treatments differed significantly for lesion length; mean node crossed and crop lodging. Seed treatment with *T. asperillum* 7316, *Ps chlororaphis* SRB125 and carbendazim significantly reduced lesion length while *T. harzianum* Th4d and *Ps chlororaphis* SRB125 reduced number of node spread by lesion. Bio-agent *T. harzianum* pant, had significantly reduced lodging of the crop.

6. Front-line demonstrations (Rajendra R Chapke)

During rabi 2013-14, 341 frontline demonstrations (FLDs) on sorghum were organized in seven districts across the three different sorghum growing states viz., Maharashtra, Karnataka and Andhra Pradesh. Latest sorghum varieties viz., CSV 22R, CSV 18R, Phule Vasuda, Phule Suchitra, Phule Revati, Phule Anuradha, PKV Kranti, Parbhani Moti, CSV 26R and CSV 29R were demonstrated along with locally popular cultivar as a check in farmers' fields at different locations. The demonstrated sorghum varieties gave 94 per cent higher grain and 75 per cent fodder yields than the local checks. On an average, the demonstrated varieties could earn net returns of Rs.28,979/- on the cost of Rs.16,100/- per ha, which is 90 per cent more than the local check.



Report on monitoring of AICSIP trials - Kharif 2013

Sunil Gomashe and Sujay Rakshit

Introduction: Kharif 2013 AICSIP trials were monitored during September to October, 2013. Twenty one AICSIP and voluntary centers were monitored by DSR and AICSIP scientists for proper conduct of the trials, monitoring biotic and abiotic stresses and other relevant issues. Composition of the monitoring team and their dates of visit are presented in Table 1.

Table 1. Details of the monitoring teams for AICSIP trials during kharif 2013

Centers	Team members	Date
Palem	K Hariprasanna, ZN Patel, RK Choudhary	Sept. 05, 2013
Coimbatore, Bhavanisagar	G Shyam Prasad , HV Kalpande, Pushpendra Singh	Sept. 19-21, 2013
Dharwad	C Aruna , NS Thakur , Kalaisekar	Sept. 17-18, 2013
Mandya	Ganapathy KN, R. Kalpana	Sept. 26, 2013
Solapur, Rahuri, Phaltan	VR Bhagwat, G Shyam Prasad , Ravi Kumar , YD Narayana	Oct. 03-05, 2013
Akola, Parbhani	VA Tonapi, HS Talwar, Kalaisekar	Oct. 18-20, 2013
Indore	JS Mishra, BR Ranwah, Shekharappa	Oct. 10-11, 2013
Surat, Mangrol, Deesa, Udaipur	IK Das	Sept. 25-29, 2013
Jhansi, Pantnagar	B Subbarayudu, SK Jain , RW Deshmukh	Oct. 03-07, 2013
Hisar, Ludhiana, Meerut	V Bhat, C. Sudhakar , K Srinivasa Babu, GR Bhandari	Oct. 25-28, 2013

The monitoring teams visited the respective centers and submitted their reports, which have been summarized center-wise below:

1. PALEM

AICSIP trials conducted and observations

- RARS Palem is the lead centre for dryland agriculture research in the Southern Telangana zone, representing one of the nine agro-climatic zones of AP, covering three districts viz., Mahabubnagar, Ranga Reddy and Nalgonda. The zone includes 14 research schemes, two RARS, three polytechnic colleges, five KVKS, and 3 DAATT centers.
- During the kharif 2013 season, the southern Telangana zone received well distributed rainfall, though water tanks were not recharged fully. Palem received 466 mm rainfall till 5th Sept. with 34 rainy days. The normal rainfall of the region is around 750 mm. It was told that maize and sorghum crops have come up nicely this year in the Mahboob Nagar district. Farmers who have sown yellow jowar during 2nd week of June have started harvesting

Plant breeding trials

- There were 5 AICSIP breeding trials and 9 station trials apart from a public-private hybrid trial. Expression of the entries was good in IHT-GS, IVT-GS and IAVHT-SS, while plant population and expression was very poor in AHT-GS and AVT-GS and some station trials. The trials were sown on 24th and 25th June.
- Some of the general observations are as follows:

IVT-GS: 4016 – good, tall; 4020 – good; 4007 – very late; 4001 – very very late, tall; 4012 – good, early; 4013 – good, very tall; 4015 – Dwarf, early; 4006 – good, medium height; 4004, 4014, 4010 4008 – many off type plants (local check used – PSV 56)

IHT-GS: 3003 – good, long panicle; 3004 – good; 3005 – good; 3058 – good, 3055 – good, long panicle (local check used – PSV 56)

IAVHT-SS: 8003 – tall, very late; 8017 – early; 8001 – medium duration, good; 8011 – goose neck type; 8016 – early, big panicle, 8012 – good, dual type; 8014 – good, tall, uniform; 8008 – very tall, very late; 8007 – very tall, good; 8005 – medium height, late

Station trials/programmes were:

- Evaluation of pre-release sorghum varieties IVT-I: 21 entries + PSV 56 as check
- Evaluation of pre-release sorghum varieties IVT-II: 16 entries + PSV 56 as check
- Evaluation of pre-release sorghum varieties AVT-I: 9 entries + PSV 56 as check
- Evaluation of pre-release sorghum varieties AVT-II: 9 entries + PSV 56 as check
- Evaluation of pre-release dual purpose sorghum varieties: 7 entries + PSV 56 as check
- Evaluation and maintenance of segregating material: 64 entries
- Maintenance of yellow pericarp sorghum germplasm lines; No. of lines - 21
- Development of dual purpose sorghum hybrids using new A/R lines: A/B lines - 23; R lines - 11
- Evaluation of DSR advance breeding lines: 5 entries

- In case of AHT-GS and AVT-GS the crop stand and expression was severely affected because of poor site and previous crop taken. Plant stand was very poor in some of the entries and overall expression was very poor. Hence, the trials are vitiated and no meaningful data are expected. In AVT-GS some of the entries did not flower.
- Advancement of segregating material and maintenance of yellow sorghum collection was good.

Plant pathology trials

- There were seven Pathology trials viz., IHT-GS, AHT-GS, IVT-GS, AVT-GS, IAVHT-SS, NGN and PDRN. A station trial on biological approach for the management of sorghum grain mold was also conducted.
- Trial management was very good in all the trials and foliar disease incidence was very low even with artificial inoculation for anthracnose and leaf blight (single row each in every entry) in most of the trials.
- All the trials were sown on 15.6.13, except PDRN trial. In PDRN trial, which was sown on 12.7.13 plant stand was poor due to heavy shoot fly damage.
- Grain mold development had started in Bulk Y check. Some of the entries which were completely disease free were 2014, 2007, 2017, 2005, 2013, 2021, 2008, 2006, 2002 (AVT-GS); 3005, 3008, 3001, 3004, 3003, 1, 3, 2 (IHT-GS); 4003, 4020, 4007, 4002, 4015, 4001, 4009, 4004, 4005 (IVT-GS); 1, 8014, 2, 8007 (IAVHT-SS).
- In NGN trial the grain mold incidence will be low as most of the entries had very loose panicles.



Very loose panicles in entry 5 (NGN trial)



Grain mold development in Bulk Y

Agronomy trials

- The centre had conducted three AICSIP trials (1KB-Response of pre-release grain sorghum genotypes to different fertilizer levels, 2K-INM in kharif sorghum-chickpea cropping system, 3K-Improving Nitrogen-use efficiency through method and time of N application) and two station trials (Response of pre-release yellow sorghum genotypes to different fertilizer levels and Integrated weed management in sorghum). All the allotted AICSIP trials and station trials were managed very nicely.
- Data booklets were maintained properly. Sowing of the trials was also most appropriate. The trials were sown during 11th to 14th June. Plant population was also maintained satisfactorily.
- Intercultivation, weeding, plant protection measures, etc. were done properly.
- Battery operated bird scaring appliance was installed the working was very satisfactory as no bird damage was observed.
- Shootfly and stem borer damage was very less in all the trials
- The entry SPH 1703 performed better followed by SPV 2112 in the trial 1KB.
- Treatments T2 and T4 were found to be better followed by T7, T8 and T9 in the trial 2K
- Under the trial 3K, hybrid CSH 16 was better over CSV 20, while among the Nitrogen application methods, N1 method (50% N at sowing + 50%N at 30 DAS) was better with CSH 16 and N3 (25%N at sowing + 50%N at 30 DAS + 25%N at BLS) was better with CSV 20.
- Overall, the Agronomy trials conducted by the centre were excellent and the team work is appreciable.



CSH 16 in Trial 3K

Entomology trials

- There were seven Entomology AICSIP trials viz., IHT-GS, AHT-GS, IVT-GS, AVT-GS, AICSIP-SPN, DSR-SPRN and ISIPRSN and two station trials viz., evaluation of certain foliar sprays against stem borer and evaluation of certain management practices against ear head bug and ergot diseases.
- All the trials were sown on 30.6.13. Overall the trial management was very good and note book maintenance was proper.
- Crop condition in response to biotic and abiotic stresses is satisfactory. Excessive rains affected the crop growth phase (both vegetative and reproductive).
- Low lying field areas be avoided for field trials. Some of the general observations are as follows:

AHT-GS: 1005, 1051, 1055, 1062, 1108, 1102, 1106, IS2205, IS 18551 showed pest damage below 50%.

AVT-GS: 2003, 2006, 2056, 2051, 2058, 2120, 2106, 2103, 2119, 2112 and IS 2205 showed pest damage below 50%.

IHT-GS: 3004, 3058, 3106 showed pest damage below 50%.

IVT-GS: 4004, 4017, 4018, 4068, 4069, 4066, 4105, 4111, 4116 showed pest damage below 50%.

AICSIP-SPN: 111, 118, 144, 163, 164, 182, 183, 188, 191, 193, 202, 203, 206, 209 showed pest damage below 50%.

DSR-SPRN: 544, 539, 554, 555, 564, 571, 575, 579, 583, 585, 586, 587 showed pest damage below 50%.

ISIPRSN: IS 2146, ICSV 25026, ICSV 700, IS2123 showed pest damage below 60%.

Front Line Demonstrations

- Visited a farmer's field (Sh Sekhar Reddy, Cherlathirumalapur, Gangaram) who has planted PSV 56 in 4 ha area. The crop was sown on 3rd June and was in the physiological maturity stage. Crop was very good. The previous year the farmer had obtained 5 t/ha yield with the same variety.
- Visited FLDs taken up under TSP at Erakunta Tanda, Lattupally village. Total 28 demonstrations were taken up with PSV 56 + RDF in the village. Local yellow sorghum variety was used as check. The crop was very good and had reached physiological maturity stage.

Recommendations/suggestions made:

- Only the actual plot yield has to be reported for all breeding trials along with final plant stand. No single plant data have to be extrapolated for the entire plot.
- It was suggested to take up the AICSIP trials only in good plots, preferably without any preceding crop in the rabi/summer season..
- From the Yellow sorghum trial, good genotypes may be registered with NBPGR and also may be used in hybrid development after testing the restoration reaction.
- Farmers in the region may be encouraged to apply for the registration of farmers' varieties, especially the yellow sorghum varieties and RARS may provide all the support for filing the applications.

2. COIMBATORE

General observations:

- The center has conducted six breeding trials (AVT(GS), AHT (GS), IVT (GS), IHT (GS), Hybrid nursery, Public private hybrid trial. Four under forage sorghum (IAVHT (MC), AVT (SC), IVT (SC), Seed yield forage trial); one under sweet sorghum (IAVHT-SS). Under Agronomy three trials (I KB, I KF, T3 and I KD); Eleven under entomology AHT (GS), AVT(GS), IHT (GS), IVT (GS), IAVHT(SS), IAVHT(MC), AVT (SC), IVT(SC), Elite DP-SF & SB, AICSIP-SPN, DSR-



SPRN- F 9); seven under Pathology (AHT (GS), AVT(GS), IHT (GS), IVT (GS), IAVHT(MC), AVT (SC) and IVHT (SC) totaling 32 trials were conducted at Coimbatore.

- At ARS, Bhavanisagar, two breeding trials AVT (GS), AHT (GS) were conducted.
- All the trials were well laid out as per the technical program, field maintenance by and large satisfactory.
- Overall there was upto 60 % shoot fly infestation while stem borer infestation was 12 %. sorghum midge infestation leading to loss in yield. The incidence of shoot fly was low whereas the incidence of borer was 10-12 % DH.
- In none of the entomology trials fish meal was applied resulting in insufficient infestation.

BREEDING

SN	Trial	DOS	Promising lines	Remarks
1	AVT(GS&DP)	20.6.13	2010, 2007, 2001, 2005; 2067, 2052, 2057, 2053; 2114, 2119, 2104, 2116	Dwarf entries: 2066, 2108
2	AHT (GS)	20.6.13	1001, 1058, 1060, 1107	--
3	IVT(GS)	20.6.13	Most of the entries are agronomically good	Off types: 4004, 4007, 4059 Very tall entries: 4013, 4060, 4102
4	IHT(GS)	20.6.13	3001, 3002, 3003, 3006, 3054, 3051, 3052, 3055, 3108, 3107, 3103, 3104	-
5	Hybrid nursery	20.6.13	7, 1, 32, 35, 61, 76	Moderate intensity sugary disease noticed
6	Public private hybrid trial	20.6.13	9003, 9059, 9104	Poor entries: 9008, 9011; 9056, 9053; 3101, 9110, 9106
Forage sorghum				
7	IAVHT-MC	3.5.13	Harvested	The harvested multicut is in second ratoon
8	AVT-SC	13.6.13	Harvested	-
9	IVT (SC)	13.6.13	Harvested	-
10	Seed yield forage trial	13.6.13	7058, 7055, 7107, 7109	Crop suffered bird damage.
Sweet sorghum				
11	IAVHT (SS)	13.6.13	8019, 8008, 8003, 8067, 8058, 8056, 8103, 8108, 8102	
ENTOMOLOGY: The incidence of shoot fly was low (5- 60% DH), whereas the incidence of borer was 0-12 % DH. In all trials data on shoot fly and stem borer have been recorded. Incidence of head bugs has started. Data on tunneling, yield etc are to be recorded. The promising lines trial wise are detailed below:				
SN	Trial	DOS	Promising lines	Remarks
1	AHT (GS)	20.6.13	1004, 1057, 1052, 1101	1. The incidence of shootfly is low hence, fishmeal may be applied henceforth. 2. Labeling was faulty.
2	AVT(GS)	20.6.13	2016, 2003, 2120, 2111, 2104	
3	IHT (GS)	20.6.13	3006, 3007, 3052, 3101	
4	IVT (GS)	20.6.13	4009, 4016, 4066, 4105, 4111	
5	IAVHT(MC)	20.6.13	5009, 5002, 5106, 5015	
6	AVT(SC)	20.6.13	6003, 6006, 6058, 6104	
7	IVHT(SC)	20.6.13	5005, 5002, 5006, 5115	
8	IAVHT-SS	20.6.13	8008, 8014, 8002, 8115	
9	AICSIP- SPN	20.6.13	112, 97, 132, 167, 176, 195, 206	
10	SF & SB Elite DP	20.6.13	212, 231, 247, 237, 253, 245, 243, 273	
11	DSR& SPRN F8-F9	20.6.13	505, 509, 512, 529, 532, 539, 585, 556, 576	
PATHOLOGY: The diseases noticed were sugary disease and some leaf marginal drying was there. Low intensity of downy mildew was noticed.				
1	AHT (GS)	20.6.13	As such experiments were laid as per technical program. Trials are well maintained. No data has been recorded.	1. After the crop was sown no observations were recorded till date in the absence of pathologist. 2. The data on foliar disease has to be recorded immediately. 3. The center incharge is requested to record data on grain mold at physiological maturity with the help of pathologist from TNAU which was agreed to.
2	AVT(GS)	20.6.13		
3	IHT (GS)	20.6.13		
4	IVT (GS)	20.6.13		
5	IAVHT(MC)	20.6.13		
6	AVT(SC)	20.6.13		
7	IVHT(SC)	20.6.13		
AGRONOMY				
1	Trial Response of pre-release sorghum genotypes to different fertilities (I KB)	2.07.13	Some of the genotypes were severely affected by shoot fly and downy mildew.	The pest and disease incidence is due to its close proximity to the field of MC fodder experiment.
2	1 KF	18.4.13	Two cuts have been taken till date. SSG 59-3 performed better others in both cuts	Third cut in sprouting condition Early sowing is suggested.
3	T 3	2.07.13	Nitrogen use efficiency on visual basis revealed treatment T5 was better over others.	
4	1 KD	---		Yet to be laid out



3. BHAVANISAGAR

The trials were sown on 5.7.13. There was moderate infestation of, shoot fly borer. Crop is in flowering stage. Trials need to be weeded

AHT (GS):

Early entries: 2012, 2008, 2016, 2058, 2053, 2106, 2110

Late entries : 2007, 2017, 2011, 2018, 2064, 2069, 2109, 2104, 2105

Dwarf entries: 2019, 2066, 2108

AVT (GS & DP):

Good entries: 1010, 1001, 1052, 1060, 1106, 1108, 1104

Recommendations including follow-up action:

- The monitoring dates were fixed well in advance with the consent of center in charge, in spite of that the scientists of the center were absent causing inconvenience to monitoring team members and had to rely on technical's.
- Though pathology trials are planted data is yet to be recorded. The center incharge was requested to get the data recorded by requesting services of pathologists from University. DSR needs to make some arrangement for data recording henceforth as pathologist is not posted.

4. DHARWAD

General report:

- The rainfall received was more than normal years. There was deficit in June and August while excess in the months of May, July and September.
- Different field experiments were in milky to maturity stage and the crop stand was good.
- The crop was observed to be free from pests and diseases and all experiments were well maintained

Discipline wise report:

Breeding:

- Five breeding experiments were allotted to the centre under AICSIP and all the five were sown on 12-6-13 and 13-6-13. Crop stand was good and crop was free from pests and diseases.
- The trials include AVT (GS), AHT (GS), IVT (GS), IHT (GS) and Private public hybrid trial.
- Four station trials one on varieties and three on hybrids and two trials under university multilocation testing were sown
- A trial on M3 generation progenies of DSV 6 and CSV 15 was also planted
- The segregating material at different stages of development and the seed production plots were also visited.
- The promising genotypes in each of the trials include
 - AVT- code nos. 2003, 2008, 2009, 2015, 2006, 2068, 2055, 2054, 2102, 2119, 2107, 2112
 - IVT- Code nos. 4008, 4016, 4017, 4065, 4062, 4051, 4115, 4119, 4120
 - AHT- Code nos. 1014, 1004, 1008, 1005, 1007, 1013, 1001, 1063, 1055, 1059, 1058, 1053, 1057, 1060, 1109, 1111, 1102, 1104, 1103, 1107
 - IHT- code nos. 3002, 3003, 3004, 3008, 3057, 3053, 3054, 3058, 3103, 3105, 3102, 3101
 - PPHT- 9005, 9002, 9009, 9004, 9006, 9054, 9058, 9053, 9051, 9055, 9103, 9105, 9109, 9108, 9110

Agronomy:

- There were three AICSIP Agronomy trials being conducted at UAS Dharwad center
- The agronomy trials were sown on 15 and 16th June 2013. In the first trial (1K) on response of pre release sorghum genotypes to fertilizers, clear cut response of fertility levels was observed among the treatments. SPH 1702 and SPH 1703 were better.
- In the INM trial (2K), 50% RDN through organic + 50% RDN through vermicompost; and 75% RDN through vermicompost + 25% FYM was found better but not much visible differences.
- In the trial on Top dressing (3K), 50% N at sowing + 25% at 30DAS + 25% at BLS was found to be better.

Entomology:

- Twelve entomology trials were taken under the AICSIP program targeting different pests such as shoot fly, stem borer and aphids.
- Sowings of entomology trials were done on 20-7-13
- Shoot fly incidence was high with more than 80% shoot fly deadhearts in susceptible check and about 25% deadhearts in resistant check. Promising lines with shoot fly resistance on par with resistant check were noted.

Pathology:

- Twelve pathology trials were taken under the AICSIP program targeting different diseases such as grain moulds, downy mildew.
- Sowings of pathology trials was done on 25-06-13
- Uniform pathogen pressure was ensured with proper inoculation methods.



Station programme:

- The station trials involve the state level varietal and hybrid trials like MLVT, MLHT etc. All the trials are being maintained well.
- The team had visited the station breeding program consisting of F1s (14 crosses), early generation breeding material (F3 to F6), A/B/R line program and a trial of M3 progenies of DSV 6 and CSV 15. Emphasis was mainly on grain mould and downey mildew resistance along with yield.

Suggestions/general comments:

- It was suggested to note the sterility/ fertility of the hybrids in all the trials.
- While noting the plot yield, the stem borer infested plants to be taken care
- In agronomy trials, ridge and furrow method should be adopted if possible for conserving moisture and drainage of excess water.

5. MANDYA

Main observations and work done:

- Monitored three forage trials (IAVHT, AVT-SC and IVHT-SC).
- In IAVHT multicut trial there were 17 entries and harvesting were made during 26-07-2013 to 11-08-2013. The entries 5013, 5007, 5315 and 5112 were reported to be promising for forage attributes. The entries 5311, 5006, 5015 were reported for rust incidence and 5305, 5008, 5006 for downey mildew incidence
- In AVT-SC, 10 entries were sown and the harvesting was made during 14-09-2013. The entries, 6052, 6058, 6051 were reported to be promising for forage yield. The entry 6056 was reported with rust infection and 6004, 6105, 6057 for Downey mildew incidence
- In IVHT- SC there were 16 entries. The entries 5009 and 5013 were promising for forage attributes. Entries 5058, 5051 and 5053 showed rust incidence, 5115, 5063 recorded Downey mildew incidence.

6. RAHURI

General:

- The total rainfall received till September, 2013 was 363 mm.
- The trials were managed satisfactorily.
- Shoot fly was the major biotic stress & there were not any abiotic stresses.
- The incidence of rust and Zonate leaf spot were just initiated. The incidences of stripe and mosaic diseases were also noticed.

Breeding trials:

IAVHT SS trial: Visual best performing lines: 8001, 8003, 8005, 8010, 8011, 8012, 8013, 8014, 8017, 8056, 8057, 8066, 8065, 8060, 8101, 8101, 8112, 8114, 8103.

High biomass trial: Visual best performing lines: RSSV 350, 351, 369 & RSSH 18, 50.

NFBSFARA project: Drs Ratnavathi (DSR) and UD Chavan (MPKV) are studying the sucrose accumulation for efficient ethanol production form sweet sorghum under NFBSFARA project. There were 18 genotypes with two replications.

The promising entries: RSSV 313, SPV 2135, RSSV 167 that were found to be higher sucrose accumulation with efficient ethanol production.

Entomology trials: The shoot fly damage was from 27 to 89%. The objective was met.

AVT GS: Best performing entries on visual observations: 2020, 2009, 2018, 2053, 2120 and local check Phule Amrita.

IVT GS: Best performing entries on visual observations: 4062, 4070, and 4105.

AHT-GS: Best performing entries on visual observations: 1002, 1014, 1061, and 1109.

IAVHT SS: Best performing entries on visual observations: 8002, 8016, 8051, 8053, 8102, 8109, and 8112.

IHT GS: Best performing entries on visual observations: 3058, 3051, and 3106.

ICRISAT trial: Best performing entries on visual observations: ICSV 25019, ICSV 25026, ICSV 93046, ICSB 413, ICSV 700.

Station trials: *In varietal trial:* Best performing entries on visual observations: RSSV 323, RSV 351, and RSSV 376. *In hybrid trial:* Best performing entries on visual observations: RSSH 89, RSSH 100 and in multi-location trial, the best performing entries on visual observations are: RSSV 350, RSSV 351, and RSSV 369.

- The Physiology program related to identification of physiological traits associated with high biomass accumulation in sweet sorghum was in progress at Rahuri.
- The ICAR funded biochemistry program on accumulation of sugars in sweet sorghum was also in progress.

Recommendations:

- In breeding trial: Seed treatment with Imidacloprid is recommended so as to manage shoot fly and fulfill the objective of the trial.



- In entomology trial: Observations on stem borer damage may be recorded. The promising entries may be selfed for further use in breeding programme.
- In AICSIP trials: Suggested to take the help of pathologist to record observations of diseases in ACSIP trials and also station trials.

8. PHALTAN

General:

- There was 565 mm rainfall up to last week of September. Recorded 7% excess rainfall.
- Germination was up to 85% in all trials.
- The trials were also affected with severe shoot fly infestation 20-90%.
- The incidence of downy mildew (5%), sorghum stripe and maize mosaic virus incidences were recorded up to 3%.
- The incidence of rust was initiated in these trials.

Breeding and Physiology trials:

Pheotyping kharif sorghum for mid-season drought: Mid-season drought objective was not visible. The variety SSRS 20, SSRK 13-19 found promising.

IAVHT-SS trial: The promising entries were: 8001, 8002, 8003, 8019, 8005, 8010, 8063, 8066, 8057, and 8109.

High Biomass trial: RSSV 325, RSSV 350 RSSV 369 and RSSH 50, RSSH 18 were promising.

Recommendations:

Pheotyping Kharif sorghum for mid-season drought: Reduce the number of germplasm entries & changing the objective to disease screening during this year (K 2013) will be more appropriate. A help from safflower pathologist, NARI, may be sought for scoring the intensity of diseases. Reading on chlorophyll content with SPAD meter is suggested.

IAVHT-SS and Biomass trial: Seed treatment with Imidacloprid is recommended so as to manage shoot fly which reduced the plant population in many plots. Thus objective of the trials will be served.



Downy mildew and pest infestation in experiments at Phaltan



Monitoring team along with Rahuri AICSIP officials

9. AKOLA

Breeding trials:

In AHT the entries 1003, 1004, 1008, 1010 were promising, and in AVT 2004 and 2007 were promising. In IHT 3001, 3002, 3006; in IVT 4001, 4007, and 4019 were promising. In Public Private Hybrid Trial 9004, 9058, 9060 were promising. Along with these trials, Hybrid Nursery Trial was also monitored.

Following two trials of Agronomy were monitored; the third trial was already harvested.

- Response of advanced/pre-released genotypes to different fertility levels under rainfed conditions
- Improving NUE through method and time of N application

Entomology:

- The trials were treated with insecticide similar to that at Parbhani.
- The conduct of trials and data recording were handled lightly and there was no seriousness. The station needs to be sensitized about the importance and seriousness of the AICSIP programme.

Pathology:

- Screened for foliar diseases and grain mold. The disease causing pathogens were cultured and inoculated. The data collection was not satisfactory.



Major observations are as follow:

- Both the trials were having attack of Shoot-fly upto 25-30%. The plant population was also not satisfactory may be 60-70%.
- In the first trial, "Response of advanced/pre-released genotypes to different fertility levels under rainfed conditions" The hybrid SPH 1702 was looking very promising under both 50 and 75% RDF and on par with 100% RDF.
- In the trial "Improving NUE through method and time of N application" the treatment N3 (25% at sowing+50% at 30DAS+25% boot leaf stage) and N4 ((25% at sowing+50% at 30DAS+15% boot leaf stage +15 at grain filling stage) were promising. Variety (CSV 20) was particularly responding to N4 treatment of nitrogen application

10. PARBHANI

Breeding trials: In AVT (GS) trial the entries 2006, 2104, 2110, 2113, 2118 were promising, ; in AHT (GS) the entries 1001, 1003, 1010, 1053, 1060, 1061 were promising, In IVT (GS) the entries 4012, 4013 were promising; in IHT (GS) the entries 3001, 3002, 3054 were promising, in Public Private Hybrid Trial (AICSIP) 9006, 9055 were promising. The Initial Varietal cum Hybrid Trial & Advanced Hybrid Trial (SC) were not monitored as they were already harvested..

General observations:

- A complete new team has joined. Newly joined team including Breeder (station incharge), Agronomist and Pathologist are shifted from Teaching to Research, and have negligible research experience. Further, entomologist (Dr Daware) is also going to retire soon.
- In general the sorghum crop was heavily infested by shoot fly attack and mostly re-growth of tillers are seen in all the trials. The team informed that all the necessary precautions of plant protection were taken care, even than the shootfly /stem borer attack could not be controlled.
- Monitoring team suggested that one of the factors for heavy infestation of shoot fly may be because of double cropping (two seasons) and use of same land for two seasons. This may be avoided, if possible, by exchanging the land with other schemes in one of the season. The station incharge agreed to explore this

Following three trials of Agronomy were monitored.

- Response of advanced/pre-released genotypes to different fertility levels under rainfed conditions
- Improving NUE through method and time of N application
- INM in kahif sorghum-Chickpea cropping system

Entomology:

- Objective was to screen for shoot fly, stem borer and shoot bug. There were 8 trials with two different sowing dates (15.07.2013 and 22.07.2013). The field layout and maintenance were proper.
- The natural shoot fly pressure was heavy during the season and therefore the trials were treated with insecticide to avoid severe fly infestation. This practice of insecticide protection to the trials which are supposed to produce inherently tolerant/ resistant plants is totally counter to the very objective of the screening. The plants that need chemical protection against the onslaught of a pest cannot be categorized as tolerant/resistant or even susceptible. Therefore the data from such trials would be misleading. The matter may be discussed in a larger forum like AGM for better clarity.
- The data for stem borer and shoot bug were in progress as per the station entomologist at the time of monitoring.

Pathology:

- The objective was to screen for foliar diseases. There were 8 trials with sowing dates of 19-20. 06.2013. There were two observations one was at boot leaf emergence and the other at harvest time.
- There was no clarity on scoring for disease rating as the rating may differ person to person. A standard scoring procedure needs to be developed for generating better data sets.

Major observations: All the three trials were having a very severe attack of Shoot-fly. The population was very poor may be ranged between 40-50%. Whatever plants were having panicles; these were from the re-growth of tillers. In my opinion, no meaningful inference can be drawn and further recording of data may not be of much use. Hence these trials may be vitiated. But final decision may be taken by PI (agronomy).

11. INDORE

General information: Indore Centre received very high rainfall (1501.4 mm till 8th October 2013) during current *kharif* season as against the average rainfall of 950 mm. This continuous excessive rainfall resulted in water stagnation, stunted crop growth, severe infestation of shoot fly, high plant mortality and heavy weed growth. The Madhya Pradesh has 3.9 lakh ha area under sorghum, with total production of 6.1 lakh tones and average productivity around 1583 kg/ha. Khargaon, Barwani, Khandwa, Chhindwara, Shajapur, Betul, Rajgarh, Sidhi are the major sorghum growing districts.

Discipline wise status

Agronomy: All the three trial allotted were conducted. The germination was very good. However due to continuous rains



from June onwards resulted in water stagnation, stunted crop growth, severe infestation of shoot fly, high plant mortality and heavy weed growth. The plant population was very poor. Hence, all these 3 trials are vitiated. Regarding cataloguing of weed flora of sorghum in different agro-ecological regions, weed density and weed photographs are being recorded.

Entomology: All the 9 allotted AICSIP trials were conducted along with 4 station trials. The trials were sown timely. The initial plant population was good and observations on shoot fly at 21 and 28 DAS were recorded. However, due to continuous rains, there was severe infestation of shoot fly and weeds. Plant stand was also very poor. Trials may be vitiated.

Breeding: All the 6 allotted AICSIP trials were conducted along with 8 station trials. They were sown on 25-6-2013. Initial plant population was very good. Severe infestation of shoot fly, stem borer and weeds due to excessive rains resulted in poor plant population and stunted plant growth. Trials may be vitiated.

Others

- FLDs under TSP were also conducted through University KVVs located in Jhabua, Dhar and Barwani districts. Proper records and field books were maintained.
- Collected the membership fees (5 members @ Rs 3000/- per member) for Indian Society of Millet Research and Development and deposited to the treasurer of the Society.
- Discussed with the HOD Agronomy and other scientists regarding sorghum improvement research, collaboration of other disciplines like soil science and area of adaptation.
- Also suggested to come up with good publications in sorghum research.

Recommendations: Since the plant population was very poor and crop growth was also stunted in all the trials due to excessive rains, these trials may be vitiated.

12. SURAT

Main observations and work done:

- Unusually heavy rain in western Gujarat and eastern Maharashtra during last week of September caused water logging in the area and also in the sorghum fields. Otherwise, crop growth and field management in general was good. Most of the trials were sown during end of June and multicut fodder was sown in May end. It was not possible to enter into the fields because of water logging and lodging of crops due to flooding.
- **Breeding:** A total of eight trials were allotted (4 grains, 3 forage and 1 sweet sorghum) and conducted. There were other trials such as public private trial, high biomass trial, and a trial on 63 A & B lines from ICRISAT. Some of early flowering entries (<65day) were 4006 (IVT), 2014, 2005, 2016, 2019 (AVT) and 3004 and 3008 (IHT).
- The state trials included small scale varietal trial, large scale varietal trials, multi-location varietal trials, on grain and fodder sorghum. Presently there was not much work on station trials but they have planned new breeding programme to develop genotypes having roti quality of the most popular Nizar goti variety. Beside this the centre has undertaken seed production programme of the release variety CSV 21F.
- **Agronomy:** All the three trials allotted were conducted as per prescribed information and crop conditions were good. Foliar application of 5% urea at boot leaf stage was found giving visual difference in leaf color and growth. Dr. ZN Patel has catalogued about 30 weeds observed in sorghum field in the region of which 6 were of common types across fields. A trial on CAN obtained from private sources was also conducted to test its efficacy on sorghum.
- **Entomology:** All the allotted nine trials were carried out in 2 m row length using two different dates of sowing. Shootfly and stem borer incidence were quite high (SF max 90%). Few entries in AVT-GS such as 1003, 1005, 2005 were tolerant to SF. Mite incidence was notable in some entries in IHT-GS. Checks DJ6514 and IS18551 were highly susceptible to mite.
- **Pathology:** All the allotted trials were planted and crops were in grain filling stage. The Pathologist was on monitoring tour and not present. Disease incidence was low to moderate with incidence of anthracnose and leaf blight. Grain mold was yet to appear and grains were not mature. The fodder variety CSV21F was affected with sooty stripe disease.

13. MANGROL

Two trials were allotted and one was executed successfully. AVT-GS trial was vitiated /washed away due to heavy rain just after sowing.

14. DEESA

- Deesa centre was allotted 7 breeding trials and all were carried out as planned. Trials were sown in 1st week of July and crops were in grain filling stage. Scanty rainfall during 1st to 3rd wk of September caused the crop to experience drought like conditions. Soil was sandy and lodging was there especially in forage trials for high wind and late rainfall. Few good yielding entries were, 2004, 2001, 3006, 3008, 3054, 3051, 1003, 1011, 1102, 1052, 1055, 1001 and 1010.
- Multicut forage trial was sown in May. Few entries recorded good regeneration of tillers such as 5016, 5310, 5005, 5006 and 5015.
- Top borer damage was conspicuous in few entries and almost 50% plants in such entries were affected and produced late tiller without main head. Some of the affected entries were 4059, 4053, 4019, 1111, 1062 and 1002.



- Among diseases sporadic incidence of leaf blight and stripe virus were noted. Few entries were susceptible to mid-season drought (2055, 2002, 4055, 4057, 4070, 4056, 4020, 4007, 4017, 40013002 and 3003) and produced leaf burning symptoms.

15. UDAIPUR

- The centre received more than normal rainfall (658 mm up to September). Continuous rain hampered the intercultural operations during vegetative growth and all the fields were full of weeds (except pathology trials that were sown early and managed well). The centre was allotted 7 breeding, 13 entomology, 10 pathology and 6 agronomy trials and all were conducted. Pest and disease incidence was moderate. Whole day of the visit there was heavy rain and the fields which were otherwise full of weed could not be entered.
- **Breeding:** All trials were sown in 1st week of July and crop was in grain filling stage. A few hybrids 2005, 3004 and 3008 seemed early and almost reach physiological stage. Apart from coordinated trials, the centre took some station trials that included varietal and hybrid trials, germplasm trials, segregating materials (around 150 crosses from F1 to F7) for fodder attributes, maintenance of A & B lines, breeder seed production of CSV17, CSV23 and PC1080 etc.
- **Agronomy:** Six trials were conducted and sown on 6th July. Fertilizer response was visible on SPH1703, SPH1705 and CSH16. In N₂-use efficiency trial N₁ treatment (50% n at sowing and 50% at 30 DAS) looked good.
- **Entomology:** Dr. Lekha, Assistant Entomologist, is looking after entomology trials. Total 14 trials have been sown on 15th July. For shootfly a set was late planted. General crop growth was poor due to weed infestation and inadequate management. Shootfly observations are completed and waiting for earhead emergence for recording earhead pests.
- **Pathology:** All nine trials were sown on 27th June. Foliar disease incidence particularly anthracnose, target & zonate leaf spot and leaf blight were moderate in incidence. Screening was done using infector row and artificial inoculations that developed good disease pressure. Due to heavy rain during last week of September crops lodged severely and recording of observations on diseases are pending.

Recommendations including follow-up action:

- Research activities at Surat related to sorghum improvements keeping in mind the requirement of the location peoples should be further strengthened in the form of on-station activities. At present very little is there to show as station trial.
- Udaipur centre reported scarcity of fund required for handling on-farm activities like harvesting threshing etc. It may be looked into.

16. JHANSI

AICSIP Breeding Trials :

- **IAVHT Multi cut Trial:** D/S on 13-05-2013. Entries 5106, 5313 and 5305 were resistant to shoot fly and foliar diseases. 5008, 5116 and 5309 were good fodder yielders.
- **IVHT Single cut Trial:** D/S on 11-07-2013. The crop was harvested on 26-09-2013. 5015, 5013, 5011, 5008 were good fodder yielders.
- **AVT Single cut Trial:** D/S on 12-07-2013. The crop was harvested at 27-09-2013. 6004, 6059, 6058 and 6102 were good fodder yielders.

17. PANTNAGAR

Main observations and work done :

Kharif fodder and sweet sorghum breeding : AICSIP trials: GBPUAT, Pantnagar

- **Single Cut Advanced Varietal Trial:** D/S on 29-06-2013. Crop is in harvesting stage. Shoot fly and stem borer incidence ranged between 22-29% DH. *Anthracnose* and *Zonate* leaf spot diseases incidence was ranging from 4 to 6. The best entries for the fodder yield viz.; 6001, 6009, 6008, 6005, 6055 and 6052.
- **IVHT SC:** D/S on 04-07-2013. Crop is in harvesting stage. Shoot fly and stem borer incidence was ranging from 20 to 31. . *Anthracnose* and *Zonate* leaf spot diseases incidence was ranging from 3-5 score. The best entries for the fodder yield viz.; 5002, 5013, 5007, 5056, 5051 and 5052.
- **IVHT MC:** D/S on 08-05-2013. Crop is in harvesting stage. Shoot fly incidence 20-25% DH most of entries harvest at 60 days after sowing disease rating below-4. The best entries for the fodder yield viz.; 5007, 5016, 5013, 5112 and 5115.
- **IAVHT SS:** D/S on 12-06-2013. Crop is in harvesting stage. Shoot fly and stem borer incidence was ranging from 22-60% DH. The best entries viz.; 8010, 8062, 8053, 8113.
- **SYT Forage:** D/S on 20-06-2013. Crop is in harvesting stage. The flowering ranged between 71-103 days. Most of the data will be recorded at maturity.

AICSIP Pathology Trials :



- AHT-GS: D/S on 15-06-2013. First observations on disease severity of *Anthraco*se and Zonate leaf spot recorded at boot leaf emergence. Second recorded at before harvesting. The best entries viz.; 1012, 1058 and 1105.
- AVT-GS: D/S on 15-06-2013. First observations on *Anthraco*se, Zonate Leaf Spot at boot leaf emergence. 2nd recorded at before harvesting. The best entries viz.; 2018, 2069 and 2101.
- IHT-GS: D/S on 15-06-2013. First observations on *Anthraco*se and Zonate Leaf Spot diseases are recorded at boot leaf emergence. 2nd observations recorded at before harvesting. The best entries viz.; 3005, 3056 and 3015
- IVT-GS: D/S on 15-06-2013. 1st observation on *Anthraco*se recorded at boot leaf emergence. 2nd recorded at before harvesting. The best entries viz.; 4011, 4064 and 4110.
- IAVHT-SS: D/S on 15-06-2013. 1st observation on *Anthraco*se, Zonate Leaf Spot diseases are recorded at boot leaf emergence. 2nd recorded before harvesting. The best entries viz.; 8014, 8058 and 6108.
- IAVHT-MC: D/S on 15-06-2013. Observation on severity of foliar disease recorded at the time of first cut. The best entries for the fodder yield viz.; 5017, 5109 and 5308.
- AVT-SC: D/S on 15-06-2013. 1st observation on Anthracnose, ZLS recorded at boot leaf emergence. 2nd at recorded before harvesting. The best entries for the fodder yield viz.; 6053 and 6102.
- IVHT-SC: D/S on 15-06-2013. 1st observation on Anthracnose, ZLS recorded at boot leaf emergence. 2nd recorded at before harvesting. The best entries for the fodder yield viz.; 6009, 6053 and 6102.
- FMV(Field monitoring of anthracnose virulence) : D/S on 26-08-2013. Observation on disease severity has to be recorded.

18. HISAR

General observations: The season was characterized by poor to very heavy and erratic rain fall. Moderate to higher incidence of stem borer and foliar diseases were observed. On the day of monitoring it was observed that fields were inundated with rainwater due to heavy rains received a couple of days ago. Generally plants were stunted in stature. All the allotted trials were conducted.

The observations pertaining to the trials taken up at the centre discipline-wise are as follows:

- In the IVHT (MC), best entries were 5016, 5017, 5002, 5106, 5110, 5112, 5306, 5310 and 5315. Whereas 5001, 5313 and 5309 were poor fodder yielders. Entry 5009 noticed most promising for anthracnose resistance. While, entries 5008 and 5014 were highly susceptible to anthracnose.
- In AVT (SC) trial- 6003 and 6102 were early. 6002, 6051, 6104 and 6105 were poor in growth and biomass. Notable tall entries were 6057, 6059, 6106 and 6052. Entry 6003 was found highly susceptible to anthracnose whereas entry 6106 was observed promising for anthracnose resistance. The leaf blight was found in entries 6002 and 6051
- In IVHT (SC), entry 5110 was taller whereas 5109 was a poor yielder
- Severity of anthracnose in all AICSIP trials was observed and was ranged from 20 to 25%
- The infestation of other leaf diseases viz, leaf blight, zonate leaf spot, grey leaf spot etc. was noticed
- The seed production programme of HJ-541, HJ-513 and HC-308 was disease free, but high incidence of anthracnose was found in seed production programme of HC-136

19. LUDHIANA

General observations: The season was characterized by poor to very heavy and erratic rain fall. Crop growth as well as stand was good in all the trials.

Observation:

- Severity of anthracnose in all AICSIP trials was observed and range was 15 to 18%
- In all AICSIP trials, other leaf diseases incidence was very low
- In IAHT(MC) trial: Promising entries were 5004, 5001, 5003, 5105, 5108, 5102, 5309, 5307 and 5315, based on the data from two cuts. Entries 5112, 5113, 5005, 5002, 5301 and 5302 were poor yielders. Good regeneration was seen in 5107 and 5111, besides the local check (SGL 87). Entry 5003-Promising for anthracnose resistance. Whereas entries 5004, 5007, 5008, 5011 and 5012 were highly susceptible to anthracnose.
- In IVHT (SC), several entries were already harvested as they had flowered. 5014 and 5112 were promising. 5002, 5003, 5004, 5006, 5014, 5015, 5102, 5109, and 5112 were early. Anthracnose Severity was noticed and was ranged from 10 to 15%. Whereas incidence of leaf blight was 10-12%. 5005 and 5006 were susceptible to anthracnose, like 5101. 5005, 5014, 5015, 5051, 5054, 5064, 5101, 5102 and 5115 were highly susceptible to shoot fly.
- Local Ramkel variety was highly susceptible to anthracnose. The variation in severity of anthracnose was found high when Ramkel cross with 2077A. Local check Ramkel was highly susceptible when treated with 75% N
- In the seed trial, most entries had flowered. Foliar diseases were observed on 7001, 7005, 7007, 7052 and 7055.
- Regeneration was noticed in the sorghum sudangrass trial after the first cut.
- In the seed trial, most entries were susceptible to shoot fly.



20. KAPURTHALA

General observations: The season was characterized by poor to very heavy and erratic rain fall. Crop growth as well as stand was good in the sweet sorghum trial. Promising taller entires were 8017, 8018, 8013, 8064, 8066, 8051, 8059, 8014, 8105, 8107 and 8117.

Leaf diseases like anthracnose, pakka boeing, zonate leaf spot and leaf blight were found in this sweet sorghum trial. Severity of anthracnose was high which was ranged between 15 – 20%. But pakka boeing, zonate leaf spot and leaf blight were found in some entries only. Promising entries for anthracnose resistance were 8010, 8056, 8062, 8103, 8104 and 8105.

21. MEERUT

General observations: The season was characterized by poor to very heavy and erratic rain fall. Crop growth as well as stand was good in all the trials. Sowings IVHT (SC) was delayed due to heavy rains in June. IVHT (MC) was already harvested as per recommended schedule.

In AVT (SC) trial, entries 6104, 6108 and 6101 were early to flower; 6106 and 6109 were taller as well.

In the IVHT (SC), entries 5013, 5059, 5060 5063, and 5009 were taller and promising. 5052, 5064, 5054, etc. had poor crop stand. 5062 was late flowering. Anthracnose incidence was observed in 5009. Stem borer incidence was high in the entry 5066.

A perusal of the data from IVHT (MC) revealed that entries 5002, 5010, 5004, 5303, 5304 and 5307 were superior to the rest based on the green forage yield from 2 cuts. Entry 5003, 5007, 5305, 5311, etc. performed poorly for grain forage yield.

Severity of anthracnose was recorded and range from 10 to 15%. Zonate infestation was ranged from 5-10%. Promising for anthracnose resistance were 5004, 5007, 5008, 5012, 6101, 6107 and 6109. Entries 5005, 5009, 5059, 5066 and 6105 were highly susceptible for anthracnose. Entries promising for zonate leaf spot resistance were 5004 and 5012. Highly susceptible for zonate leaf spot were 5007, 5009 and 5015. Pakka boeing disease was found in entry 5015.

Station trials on germplasm evaluation and breeding experiments were in flowering stage.



Report on monitoring of AICSIP trials - Rabi 2013-14

Sunil Gomashe and Sujay Rakshit

Introduction: Rabi 2013-14 AICSIP trials were monitored during January-February, 2014. Eleven AICSIP centers were monitored by DSR and AICSIP scientists for proper conduct of the trials, monitoring biotic and abiotic stresses and other relevant issues. Composition of the monitoring team and their dates of visit are presented in Table 1. The monitoring teams visited the respective centers and submitted their reports, which have been summarized center-wise below:

Table 1. Details of the monitoring teams for AICSIP trials during Rabi 2013-14

Centers	Team members	Date
Solapur and Bijapur	JS Mishra, C. Sudhakar, HS Gahukar , Prabhakar	Jan. 28-29, 2014
Rahuri	GS Prasad, Chandrkant D Soregaon, Y.D.Narayana , Ravi Kumar	Jan. 22-24, 2014
Parbhani	C Aruna, AP Biradar, V.S.Kubsad , S. Ameer Basha	Jan. 20, 2014
Tancha	IK Das, P. Anandhi , P. Sujathamma , R. W. Deshmukh	Jan. 30, 2014
Tandur	Prbhakar , SR Gadakh, SV Nirmal,	Feb. 16, 2014
Nandyal	VR Bhagwat, K Hariprasanna, UN Alse	Jan.20, 2014
Mohol and Phaltan	AV Umakanth, Aswathama, P Sanjana Reddy	Feb. 04-05, 2014
Dharwad	Sujay Rakshit, Srinivasa Babu , Sunil Gomashe , G. R. Bhanderi	Jan. 28-30, 2014
Kovilpatti	SS Rao, HV Kalpande	Jan. 26-27, 2014

1. SOLAPUR

A. ZARS, Solapur:

Two experiments were allotted, one each for shallow and deep soils to evaluate the performance of IVT lines in shallow soils and AVHT lines in deep soils. The station received 598 mm rainfall during *kharif* as against normal rainfall of 723 mm.

IVT Shallow soils: Shallow soils faced severe moisture stress as there were no rains received during cropping season. Soil depth was 15-22.5 cm. total 14 genotypes in 6 rows plot as per the technical programme were evaluated. The crop was sown on 29th September 2013. Code no. 442 was looking better. The crop was severely damaged by birds as the site was surrounded by trees.

AVHT Deep soils: 16 genotypes were evaluated as per the technical programme. Sowing was done on 3rd Oct. 2013. In general, genotypes suffered with low temperature stress and there was lodging/breaking of plants. The promising entries were Code nos. 174, 163 and 170. Code no. 378 was more susceptible to shoo fly.

B. CRS Solapur

The Centre received 655.7 mm rainfall as against 753 mm during January to December, 2013, which was around 13% less than the normal rainfall. The crop was sown during 24-25th September, 2013. The crop received 67.8 mm rainfall during its growth period, but the cold temperature prevailed during seed filling stage from 6th-22nd December, 2013 resulted in cold stress under shallow to medium soils. Discipline wise monitoring report is as under.

Plant Breeding: At Mulegaon farm, the breeding trials conducted in shallow/medium soils include: VT I, VT II, VT III, EHT I, EHT II, BLT I, BLT II, BLT III, RLT I and RLT II. The number of entries included ranged from 18-22. The trials were conducted in RBD with 3 replications and there were 6 rows of 4 m length in each plot. As the crop was already matured, the trials were harvested. The other breeding trials were the conversion programme and crossing block in irrigated condition. These include evaluation of 5 to 38 pairs in different generations (BC1 to BC 7) with 2-4 rows in each plot. The crop was sown on 30th Sept. 2013. Besides there were trials on CRS restorer lines, Hybrid development programme, Maintenance of A/B lines of CSh 15R, Hybrid seed production of CSH 15 R and evaluation of CRS elite lines, Evaluation of breeding materials for genetic enhancement for drought tolerance in rabi sorghum. All these trials were in maturity stage.

Agronomy: The agronomy trials included were: Evaluation of advanced sorghum genotypes to fertility levels, efficacy of plantozyme granules, Assessing the performance of rabi genotypes to sowing dates and increasing NUE. The performance of 'SPH 1721' was better than the check CSH 15 R in terms of ear head size. Nitrogen placed at 30 cm depth depth was looking better than surface application. September sown crop performed better and there was no ear head emergence in November and December sown crop. In plantozyme trial, there was no visual difference among the treatments. It was suggested to record soil moisture content while placing the N at different depths. It was also suggested to keep 45 cm row distance.

Seed Technology: The trials conducted under seed technology include: Study of flowering and seed setting behavior in rabi sorghum genotypes in response to cold temperature, Seed invigoration studies and studies on genetic variability for seed longevity of advanced breeding lines. All these experiments were conducted as per the technical programme. The crop was in maturity stage.



Pathology: Six trials including evaluation of AVHT-DS, IHT-DS, IVT-DS, IVHT-SS, CR management and CR Nursery were conducted as per the programme.

Entomology: Total 13 trials on evaluation of parental lines, advanced hybrids and varieties, initial hybrids and varieties, B&R lines for shoot fly, APSHN, IPM and pest survey and surveillance, etc were conducted.

FLD: Also visited FLD at Ulegaon, around 15 km away from Solapur. The crop variety 'Phule Revati' was raised with one irrigation. The crop performance was excellent and farmers were very happy. The crop was approaching towards physiological maturity stage.

2. BIJAPUR

The total rainfall received at the Bijapur station was 772 mm from Jan-Dec 2013 as against the normal rainfall of 595 mm. The experiments were sown during 21-24th Sept 2013 as per the technical programme. The crop was under severe cold stress during grain filling stage and hence, the grain filling was adversely affected in some cases. Discipline wise report is as under:

Plant Breeding:

Name of trial	Promising entry codes
IVT DS	RI-312, 318, 316, 317, 302, 306, 311
	RII-332, 344, 336, 341
	RIII-371, 362, 376, 366, 373
IHT DS	RI-202, 206, 210
	RII-235, 237
	RIII-263, 267
AVHT DS	RI-113, 108, 110, 103, 115
	RII-140, 136, 139, 137, 133
	RIII-164, 165, 171, 176
IVHT SS	RI-408, 406, 401, 404
	RII-442, 432, 441
	RIII-462, 469, 466, 471
CRS Hybrid trial (EHT)	RI-104AxSLR28, 104AxSLR81
	RII-104AxSLR125, 104AxSLR91, 104AxSLR88
	RIII-104AxSLR130

Besides, there were 17 Station trials in sorghum breeding. These trials were sown during 24th Sept to 22nd October 2013. The October sown trials were in maturity stage and crop expression was very good.

Entomology: There were 10 AICSIP trials and some station trials in entomology on various key pests. All the trials were conducted as per the technical programme. The promising entries against different pests were as follows.

Name of trial	Promising entry codes
IVT DS	Shoot fly-303,306, 342, 375, 331
	Shoot bug-304, 303, 375, 338, 313
	Aphid-313, 317, 318, 375, 378, 336, 338
IVHT SS	Shoot fly-409, 402, 403, 466
	Shoot bug-409, 403, 405, 412
	Aphid-409, 410, 440, 471, 462
ICRISAT Nursery for screening resistance to pests	Shoot fly-1013, 1019, 1015, 2020, 3008
	Shoot bug-1012, 1009, 1018, 20043018
	Aphid-1013, 1005, 3014, 3020
IAVT- DS- SPN	Shoot fly-502, 508, 513, 522, 532, 536, 541
	Shoot bug-504, 505, 511, 517, 543, 553
	Aphid-501, 505, 514, 527, 522, 553, 554
IAVT-SS-SPN	Shoot fly-602, 603, 607, 628, 634, 643, 644
	Shoot bug-605, 609, 648, 627, 626
	Aphid-602, 607, 611, 647, 646
IHT-DS	Shoot fly-202, 208, 210, 261, 262, 263, 265
	Shoot bug-207, 208, 209, 263, 265, 233
	Aphid-206, 210, 203, 232, 234, 233
AVHT-DS	Shoot fly-115, 112, 105, 109, 140, 137, 139
	Shoot bug-113, 103, 102, 141, 135, 139
	Aphid-101, 104, 140, 137, 145, 175, 170
APSHN	Shoot fly-1104, 1113, 1115, 1132, 1148
	Shoot bug-1101, 1114, 1124, 1136, 1150
	Aphid-1101, 1104, 1115, 11351184, 1182

Physiology: There were 7 trials including evaluation of advanced germplasm for drought tolerance in shallow and medium soils, preliminary evaluation of sorghum germplasm for rabi adaptation, drought alleviation using fertilizers (KNO₃), and PGR, an Industry trial on evaluation of plantozymes, root characters study and quantifying the impact of climate change with different dates of sowings and genotypes. All the trials were conducted as per the technical programmes. The effect of PGRs/nutrients (KNO₃) and plantozymes were not much visible in the field. Low temperature during Nov-Dec adversely affected the growth and development.



Pathology: Four trials namely IVT DS, IHT DS, AVHT DS and IVHT SS were conducted properly and sown on 19th October, 2013. Besides there were 8 station trials on PVT, --I, PVT-II, PVT-III, RLT, BLT, MLVHT, PPHT and maintenance of germplasm line.

Recommendations including follow-up action:

- At Bijapur, there is need to post one Agronomist in AICSIP to conduct the Agronomy trials.
- The post of Pathologist is also vacant at Bijapur. It needs to be filled urgently.
- It was suggested to record soil moisture content in Agronomy/Physiology trials at Solapur and Bijapur

3. RAHURI

General observations:

1. The center has conducted following trials supplied by DSR.

Sl. No.	Discipline	No of Trials	Name of the experiment	Date of sowing
1	Breeding	6	AVHT-DS, IHT-DS, IVT-DS, IAVHT-SS, Germplasm and CRS Hybrid trial	13.9.13 & 26.9.13
2	Entomology	11	AVHT-DS, IHT-DS, IVT-DS, IAVHT-SS, AICSIP-DS SPN,	10.10.13
3	Agronomy	4	<ul style="list-style-type: none"> • Evaluation of advanced sorghum genotypes to fertility levels • Enhancement of Kharif fallow rabi sorghum productivity through in situ moisture conservation • Assessing the performance of rabi sorghum genotypes in changing climate • Efficacy of plantozyme and planto granules in rabi sorghum. 	13.9.13
4	Physiology	4	<ul style="list-style-type: none"> • ADA germplasm trial • PE of diverse germplasm • Evaluating the sorghum plant for root characteristics (rainfed/ irrigated) • Evaluation of sorghum lines for terminal drought tolerance (stress/ no stress)[NICRA] 	10.9.13 to 12.9.13

2. Apart from above trials the team had look at the

- State level multilocation varietal cum hybrid trials (under irrigated, rainfed condition)
- University multilocation trials for soil depths (shallow, medium, deep) and alternate uses.
- Station varietal, hybrid trials for drought, shallow, medium, deep soils, hybrids
- Segregating material of MPKV, DSR, Mohol centers
- Crossing program for high yield coupled with drought, shoot fly tolerance for soil depths (shallow, medium, deep); sweet sorghum.
- Hybrid development program (maintenance of CMS lines, B, R lines, seed production)

S.N	Trial	DOS	Promising lines	Remarks
1	AHT(GS&DP)	16.6.11	1002, 1004, 1011, 1012, 93, 1001, 1006, 1031, 1047, 1036, 1069, 1075, 1077	Moderate midge incidence was observed
2	AVT(GS&DP)	16.6.11	2048, 2022, 2024, 2025, 2007, 2008, 2020	The local check CO30 was better. Heavy midge infestation was noticed.
3	IVT(GS&DP)	16.6.11	4014, 4020, 4006, 4002, 4040, 4033, 4034, 4035, 4048, 4072, 4075, 4066, 4068.	The entries 4004, 4050, 4071 were highly susceptible to midge. The incidence of midge was moderate
4	IHT(GS&DP)	16.6.11	3042, 3052, 3046, 3050, 3026, 3032, 3028, 3027, 3003, 3009, 3007, 3008	The local check CO H 5 was better. Moderate midge incidence noticed
5	Hybrid nursery-I	30.6.11	9016, 9009, 9021, 9022, 9036, 9043, 9045, 9066, 9067, 9069, 9081.	Moderate midge incidence observed.
6	Hybrid nursery-II	30.6.11	10001, 10005, 10009, 10011, 10012, 10021, 10025, 10028, 10030, 10032, 10045, 10049, 10051	Moderate midge incidence observed
7	Stability of micronutrients	30.6.11	None of the entries were performing better for grain yield.	There was heavy midge infestation
Genetic resources				
1	Evaluation of DSR Sorghum germplasm	19.7.11	182 germplasm lines failed to germinate (list attached).	The was 25-30 % midge infestation
Forage sorghum				
1	IAVHT-MC	13.6.11	5010, 5008, 5003, 5031, 5021, 5029, 5048, 5044, 5051,	The harvested multicut is in second ratoon
2	IAVT-SC	30.6.11	6007, 6011, 6010, 6033, 6031, 6028, 6052, 6044, 6049	-
3	Evaluation of local checks	13.6.11	MP chari, Sangoli Hundi, Rampur local, SSV 84, RSSV 9	-
4	Seed yield forage trial	19.6.11	8004, 8008, 8027, 8026.	The plant stand was very poor in 8005, 8017, 8028, 8023, 8024
Sweet sorghum				
1	IAVHT (SS)	30.6.11	7019, 7013, 7005, 7012, 7046, 7039, 7047, 7035	
ENTOMOLOGY: Overall there was 25-30% sorghum midge infestation leading to loss in yield in the trials. The incidence of shoot fly was low (12-16% DH), whereas the incidence of borer was 10-12 % DH. In all trials data on shoot fly and stem borer have been recorded. Data on tunneling, yield etc are to be recorded. The promising lines trial wise are detailed below:				
S.N	Trial	DOS	Promising lines	Remarks
1	AHT (GS & DP)	19.7.11	1003, 1031, 1050, 1046, 1047	-



2	AVT(GS& DP)	19.7.11	2001, 2002, 2008, 2010, 2025, 2029, 2042, 2049	-
3	IHT (GS & DP)	19.7.11	3011, 2007, 3005, 3023, 3031, 3049, 3052	Poor plant stand in 4063, 4066, 4079, 4081, 4015, 4016
4	IVT (GS & DP)	19.7.11	4010, 4067, 4018, 4039, 4042, 4051	-
5	IAVHT(SS)	19.7.11	5011, 5028, 5024, 5006,	-
6	IAVHT(MC)	19.7.11	7013, 7009, 7045, LC (CO FS 20),	Poor germination and plant stand in 7003, 7006, 7002, 7007, 7080, 7074, 7068, 7071, 7076, 7077
7	IAHT(SC)	19.7.11	6003, 6013, 6010, 6009, 6011, 6026, 6045, 6053	No germination in 6021, 6031
8	DP-SB	19.7.11	133, 151, 161, 165, 266, 263, 261, 253, 246, 241, 237, 231, 202	-
PATHOLOGY: The diseases noticed were zonate leaf spot, leaf blight, downy mildew, anthracnose and rust. The observations trial wise are detailed below:				
1	AHT (GS & DP):	19.7.11	Incidences of zonate leaf spot, leaf blight were observed on entries 1015, 1008, 1050, 1031.	-
2	AVT(GS& DP):	19.7.11	There was no incidence of diseases	-
3	IHT (GS & DP)	19.7.11	CO 30 (Local check), 3030 were infected with Zonate leaf spot	-
4	IVT (GS & DP)	19.7.11	No incidence of disease was observed.	Poor germination/ low plant stand was observed in 4006, 4001, 4067, 4017, 4077.
5	IAVT(SC)		Slight incidence of rust was observed in 6003, downy mildew in 6001, anthracnose in 6006 & 6032.	-
AGRONOMY				
1	Trial Response of pre-release sorghum genotypes to different fertilities (I KB)	28.6.11	CSH 23 was earlier among all varieties and fertilizer response was better at 150 RDF visually.	Three irrigations given.
2	Integrated weed management	28.6.11	The treatment Atrazine 0.25 PE +2 HW was best for controlling grassy weeds while T9 (and T11 were best to suppress broad leaved weeds.	Oxyfluorfen alone (T4) and as tank mix with atrazine (T7) exhibited phyto toxic severe symptoms. There was a suggestion that intercultivation should be compulsorily used in all treatments.
3	Evaluation of sweet sorghum genotypes for single cut fodder at different N levels	28.6.11	SSV 84 and SSV 74 were the best. The fodder has been harvested	The seed rate factor was dropped due to insufficient seed in consultation with PI

4. Parbhani:

General report:

- The rainfall received was normal.
- The field experiments under different disciplines were in milky to maturity stage and the crop stand was good.
- The crop was observed to be free from pests and diseases and all experiments were well maintained

Discipline wise report:

Breeding:

- Seven breeding experiments were allotted to the centre under AICSIP and all the seven were sown during 7th to 9th Oct 2013. In general the crop stand was good and crop was free from pests and diseases.
 - The trials include AVHT (DS), IVT (DS), IHT (DS), PLT, AVT drought, PEDG and IAVHT (SS).
- Two state level trials and four station trials were also there in the field.
- Germplasm trial with 4000 lines along with the checks was sown in augmented design. There was good stand in almost all the entries and good variability was observed for maturity, height, panicle traits, grain colour etc.
- The station trials include one preliminary varietal trial, and three preliminary hybrid trials. The hybrid trials include material from kharif x rabi and rabi x rabi crosses
- The segregating material at different stages of development and the seed production plots were also visited.
- The promising genotypes in each of the trials include
 - AVHT (DS)- code nos. 104, 101, 111, 114, 113, 143, 133, 145, 146, 144, 139, 166, 161, 163, 165, 174
 - IVT (DS)- Code nos. 302, 307, 316, 308, 313, 301, 311, 342, 337, 335, 365, 371, 373, 368, 378, 369, 375
 - IHT (DS)- Code nos. 203, 209, 210, 201, 239, 238, 232, 234, 261, 267, 268, 264
 - PLT- code nos. 1034, 1003, 1019, 1012, 1033, 1021, 1358, 1355, 1374, 1710, 1716, 1722, 1730
 - AVT drought- 4, 9, 8, 2, 7, 9, 10, 12, 15, 8, 9, 12, 13, 16

Agronomy:

- Out of allotted three Agronomy trials as per the rabi technical programme, 2013-14, only two trials on, "Evaluation of advance sorghum genotypes to fertility levels and Assessing the performance of rabi sorghum genotypes in changing



climate” were conducted at the centre. The trial on, “Integrated nutrient management in rabi sorghum” was not conducted

- In first trial on Evaluation of advance sorghum genotypes to fertility levels, application of 100% RDF to all genotypes appears to be better. Among the genotypes, SPV-2144 and SPH-1721 were looking comparable to checks.
- In second trial on assessing the performance of rabi sorghum genotypes in changing climate, sorghum sown on 1st week of October found promising. Among genotypes, Phule Revathi and Phule Vasudha appear at par with checks.
- The chickpea was sown as preceding crop to kharif sorghum in trial on , “Integrated nutrient management in kharif sorghum-chickpea cropping system”. There were no visible differences between treatments.

Entomology:

- All the allotted ten AICSIP entomological trials (AVHT-DS, IVT-DS, IVHT-SS, IHT-DS, SFR-F8, IAVT-DS, IAVT-SS, IASFN, APSHN and Survey of major sorghum pests in Parbhani district) as per the rabi technical programme, 2013-14, were conducted at the centre.
- The laying out of trials, their management, maintenance of field book and register were satisfactory.
- All the trials (except survey) were sown on 10-10-2013 and the treatment effects were spectacular.

Pathology:

- Five pathology trials were allotted to Parbhani under AICSIP, and all were conducted
- Sowings were taken up on 7th Oct and the crop was about 3 months age
- Foliar disease incidence was very less (less than 2 scale) in all the entries, whereas pokah-boeng disease was noticed in all the experiments.
- Knife cut symptoms were present on the 3-4th node of the stem, due to this lodging of the crop may occur.
- In AVHT (DS) entry no. 106 in R1 has high incidence of pokah-boeng disease.
- In IHT (DS) entry no. 270 in R3 has maximum plants infected with pokah-boeng disease
- In charcoal rot management experiment, the pathogen *Macrophomina* was artificially inoculated in five plants

Station programme:

- The station trials involve the state level varietal and hybrid trials like MLVT, MLHT and the station varietal and hybrid trials etc. All the trials are maintained well.
- The station breeding program consisted of F₁s for grain and fodder yield and shoot fly tolerance, and drought tolerance.
- F₂ population of 15 crosses targeting grain and fodder yield were raised
- 110 F₃ progenies from 19 crosses are being evaluated for yield and quality traits
- A/B/R line improvement program
- In Entomology, two station trials have been conducted namely, i) Population dynamics of Rabi sorghum pests and ii) Estimation of avoidable losses due to major sorghum pests.

Suggestions/general comments:

- It was suggested to note the sterility/ fertility of the hybrids in all the trials.
- In Entomology trials, it was suggested to record natural enemies populations in experiments

5. TANCHI

General report:

- Tanchi centre is located in south Gujarat and was established in 1959 for research work on sorghum, wheat, and pulses under rainfed conditions. The location is having dry climate (550-750 mm rainfall), deep black cotton soil which is alkaline (pH 7.7-8.7) in nature. The location is used as testing centre for dry land crops.
- Salinity seemed to be major problem as it is located in low altitude (15.5m above MSL). Salinity and alkalinity partly affected seed germination and plant stand. This year unusually heavy rain in western Gujarat during last week of September, 2013 caused water logging in the area and also in the sorghum fields.

Discipline-wise report:

- The voluntary centre conducted three breeding trials (AVHT-DS, IHT-DS and IVT-DS) in all. Sowing of the trials were delayed to mid to end of October due to unusually heavy rain in western Gujarat during last week of September, 2013 and water logging in the area and also in the sorghum fields.
- Agronomy: Fifteen entries in AVHT-DS, nine in IHT-DS and seventeen in IVT-DS were planted in October 23 and 24 in flat bed using 45 x 15 cm spacing. Plant stand in all AICSIP trials in general was poor and patchy as gap filling could not be done due to less seed. In all three trials average plant stand was around 1 lakh/ha which was well below the recommended stand of 1.8 lakh/ha for rabi. Though recommended dose of fertilizer (40:20:0) was applied plant growth was lanky and patchy. During the visit crop was at dough/grain filling stage. Seed germination problem was there in all trials.



- **Breeding:** In AVHT-DS flowering duration ranged from 63 to 85 days. Average plant stand was well below the recommended stand for rabi. Plant growth was lanky and none of the entries expressed better than the local check BP-53. Few relatively good looking entries were 109, 114, 116, 142, 146, 161 and 162. In IHT-DS nine entries along with local check (BP-53) were planted on 24 October. Flowering duration ranged from 70 to 85 days. Few promising entries were 210, 231, 232, 266, and 269. In IVT-DS seventeen entries along with local check (BP-53) were planted on 23 October. Flowering duration ranged from 66 to 85 days. Average plant stand was low and in patches especially in replication 2 and 3. Few promising entries were 309, 310, 335, 338, 342, 371, 373, 361 and 374.
- **Pathology:** The location was not having considerable disease problem. Disease incidence was low and sporadic. Due to heavy soil charcoal rot was not observed. In AVHT-DS sporadic incidence of *pokkah boeng* and leaf diseases was noted. In IHT-DS and IVT-DS sporadic incidence of *pokkah boeng* diseases was noted.
- **Entomology:** Among the insect pests shoot fly and mite were noted other pests were negligible. Shoot fly and mite incidence was around 20% in AVHT-DS. Mite incidence was around 10% in IHT-DS. Shoot fly incidence was around 60% and mite incidence was around 30% in IVT-DS. Pests pressure was not suitable for evaluation and comments.

Suggestions/general comments:

- The centre has alkalinity and salinity problems that affect seed germination. The location can be effectively used by the physiologist for salinity and alkalinity screening.
- Considering poor plant stand and crop growth this year's data on AVHT, IHT and IVT from this centre may be avoided for release purpose.

6. TANDUR

General observations:

- The centre has received 824.5 mm rain fall and excess rains during sowing made the scientists to re-sowing of some the trials. However, the plant populations were good in Agronomy trials. In some of the breeding trials the populations were less. Also, there was pig damage.
- The center has conducted two breeding trials, four agronomy trials, four entomology trials under AICSIP. Apart from this preliminary evaluation of diverse germplasm for rabi adaptation, advanced drought adaptations germplasm trial-medium soil, trial on drought and Rabi germplasm evaluation were taken up.
- The Agronomy experiments were neatly maintained, labeled and well conducted. The expressions in Agronomy trials were excellent. The data books were up to date.

Following are the observations trial wise:

Breeding and physiology trials

S. No.	Name of the trial		Promising entries codes/genotypes
1	Initial Varietal Trial – Deep soil (IVT-DS)	R-I	304, 312, 302, 303, 313, 305
		R-II	345, 334, 338, 339, 337
		R-III	373, 376, 371, 367, 369
2	Advanced Varietal Hybrid Trial – Deep soil (AVHT-DS)	R-I	105, 101, 104
		R-II	140, 143, 135
		R-III	166, 165, 175
3	Initial Hybrid Trial – Deep soil (IHT-DS)	R-I	203, 209, 210, 206, 208, 207
		R-II	238, 239, 233, 232
		R-III	262, 265, 263, 266, 261, 269
4	Preliminary evaluation of diverse germplasm for rabi adaptation	R-I	SSRG-206, RSV-1468, RSV-1425, Pusegaon local, Kavalgunda mungaru
		R-II	Pusegaon local, RSV-1425, RSV-1458, Dharampur local
		R-III	Pusegaon local
5	Advanced drought adaptation germplasm trial – Medium soil	R-I	BJV-116, CRS-15, BJV-103, CRS-20
		R-II	CRS-19, CRS-15, BRJ-204, BJV-114
		R-III	RSV-1098, BJV-114, CRS-20, BJV-103
6	Station Trial		
	Experimental Hybrid Trial	R-I	ICSA-29003 X SFART-1
		R-II	ICSA-422A X SFART-1

Agronomy Trials:

S.No.	Trial Name	Better Treatment
1.	Evaluation of Rabi Sorghum Genotypes to fertility levels (Continuous)	Better performance at 100% RDF CSV-29R and SPH-1721 appeared better
2.	Enhancement of kharif fallow – Rabi Sorghum productivity through in-situ moisture conservation. (3 rd year of study)	Compartmental bunding during kharif and flat sowing rabi sorghum (T-1) <i>In-situ</i> mulching with green gram during kharif (T-5)
3.	Integrated Nutrient Management Rabi Sorghum. (3 rd year of study)	Main Plots: incorporation Dhaincha (<i>Sesbania acculeata</i>) and fodder cowpea Liner response to application of N upto 60 kg N/ha
4	Assessing the performance of rabi Sorghum under changing climate. (2 nd year of study).	The subsequent sowings couldn't be taken up due continuous and heavy rains since 3 rd week of September, 2013. The trial was treated vitiated.



5.	Efficacy of Plantozyme and Planto granule (Bio-extract organic product) in Rabi Sorghum (New Paid-up trial assigned by DSR).	RDF + Seed treatment with plantozyme @ 2ml/kg Seed (T-5) RDF + plantozyme 2ml/lit. at 35 and 60 DAS (T-4)
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Entomology trials

S. No.	Trial	Target Pest	Promising entries
1	AVHT-DS	SF & SB	109, 110, 144, 135146162, 173, 169
2	IHT-DS		202, 210, 201235, 240237, 232261, 264, 262
3	IVT-DS		317, 302, 306, 315, 316, 305, 346, 334, 344, 367, 370
4	IVHT-SS		407, 412, 409, 408, 402, 439, 437, 440, 471, 467, 462
5	IAVT-DS-R12		501, 504, 515, 517, 516, 520, 537, 535, 540, 541, 554, 552
6	IAVHT-SS-R12		601, 603, 604, 614, 616, 628, 629, 645, 646, 639, 636

Recommendations

- Breeder post is vacant at present and ANGRAU is to be requested to fill up the post in order to conduct the sorghum breeding and physiology trials precisely. At present, additional charge has been given to the Breeder of Red gram (Mrs. Pushpavalli).
- For conduct of plantozyme trial, rabi variety should be used. The seeds for conducting the trial may be obtained from the concerned breeder of the variety well in advance.
- The crop needs to be protected from Pig damage by erecting strong fence around the field. They can also request the authority for compound wall.

7. NANDYAL**Main observations and work done:**

Introduction: Dr. Y Padmalatha, ADR, RARS Nandyal and other scientists discussed the agricultural profile in the command regions of RARS. RARS Nandyal is the Head quarters of scarce rainfall zone covering Kurnool, Ananthpur and Kadapa districts. The zone includes many research schemes, ARS, a polytechnic college, KVKS, and DAATT centers. The normal annual rainfall of the region is 675 mm. The gross cropped area of the region is about 10 lakh ha with net area of 5.5 lakh during kharif and 4.5 lakh during rabi. The major crops are cotton, groundnut, chickpea, rice, sorghum and maize.

About the region: In the Rayalseema region of AP, sorghum is an important dryland crop and is grown in an area of approximately 1.0 lakh ha. The sorghum is mainly grown in the late kharif (Mahi) season and during rabi season with irrigation. The average area is about 50-60, 000 ha each in both the seasons. Seed production is mainly taken up during rabi season and black cotton soils are preferred. There is no reduction in the sorghum area over the years. Yellow sorghum is grown in some pockets and it fetches a premium compared to white sorghum.

Contributions by Station: The millet scheme at RARS, Nandyal has contributed many white as well as yellow pericarp sorghum varieties like N-13 (striga resistant), N-14, NTJ-2, NTJ-3, NTJ-4, etc. Drought tolerant white pericarp entry (NJ 2647) and yellow pericarp entry (NJ 2446) are under minikit trials at farmers' field and will be proposed for AICSIP testing. The centre is also working on small millets and foxtail millet is very famous among the farmers of the region.

Rainfall status: During 2013, the total precipitation in the region was 730 mm in 47 rainy days with fairly good distribution. But there was no rain during November and December which led to moisture stress during grain filling stage in sorghum.

Pest status: The stem borer damage was severe during this mahi season with up to 20-22% incidence during post-flowering stage. Aphid infestation was also severe and farmers usually spend Rs 10-12, 000/ha on plant protection in sorghum.

AICSIP trials: There were three AICSIP breeding trials and few station trials. The crop had reached maturity and there was heavy lodging in most of the entries due to moisture stress during December.

Some of the general observations made by the monitoring team are as follows:

AVT-GS: The trial was sown on 24.9.13. There were 20 entries + local check (NTJ-2). Plant height varied between 157 and 289 cms. Panicle length ranged from 21 to 29 cms. The days to maturity ranged from 84 to 99 days. Less lodging was noticed in 2012, 2019, 2065, 2069, 2066, 2101, 2106, 2112, 2117 and 2121. Some of the good entries based on panicle size were 2020, 2008, 2015, 2021, 2070, 2051, 2053, 2064, 2057, 2059, 2056, 2104, 2102, 2116 and 2119. Bold grains were observed in 2058, and 2008 had stay green character.

AHT-GS: The trial was sown on 24.9.13. There were 13 entries + local check (NTJ-2). Plant height varied from 107 to 253 cms, and panicle length from 21 to 37 cms. The days to maturity ranged from 88 to 106 days. Less lodging was noticed in most of the entries except 1006, 1001, 1011, 1007, 1062, 1053, 1055, 1052, 1109 and 1104. Good entries were 1005, 1002, 1006, 1007, 1053, 1052, 1114, 1110, 1104 and 1105. Entries 1013, 1059, 1057, 1061, 1054, 1101, 1107 and 1103 had stay green character. Bold grains were observed in 1063.



PLT: Total 35 entries were sown on single row plots on 10.10.2013 in 3 replications. Data on plant population, days to flowering, plant height and panicle length have been recorded and reported. Some of the good entries were 1024, 1355, 1351 and 1722.

Station trials & programmes: The mandate of the centre is to develop early, high yielding and quality type (both white and yellow pericarp) sorghum varieties suitable for rainfed conditions during late *kharif* season. As farmers prefer grain type varieties currently, development of semi-dwarf drought tolerant high yielding varieties is focused. Under RKVY drought and shootfly tolerant varietal development has been targeted. Screening of drought and shootfly tolerant proven ICRISAT material has been carried out along with NTJ series as checks. ICRISAT bred CMS lines along with popular A lines like 296A, 27A and IMS 9A are being used for hybrid development and evaluation. Segregating material have been advanced. Advance breeding lines NJ 2446 (yellow pericarp) and NJ 2647 (white) are promising end-products and will be proposed for AICSIP *rabi* trials.

Recommendations including follow-up action:

- Looking at the potential of the centre and interest shown by the ADR and scientists the centre may be proposed as a regular centre instead of a voluntary centre.
- Farmers' varieties of yellow pericarp sorghum may be proposed for registration with PPV&FRA. Communities or individual farmers who have conserved or contributed towards varietal development may be nominated for different awards of PPV&FRA.
- In the station trials apart from NTJ-2, national checks may also be used for evaluation of entries before proposing to AICSIP.
- Lodging due to non-uniform field or uneven irrigations may be avoided.
- Interdisciplinary collaborative work may be strengthened.
- The ADR expressed concern over late receipt of funds from DSR and has requested for timely release of funds.

8. MOHOL

Observations on various trials:

- The IVHT (SS) was sown on 21st Sep 2013 and the trial suffered from severe moisture stress
- The rainfall received during September was 249 mm followed by 42 mm in October. Later on no rains were received.
- The entries 401, 402, 434, 435, 440, 461, 464, 466 and 471 were promising under IVHT (SS).
- In the research station's demo plot, the entries Phule Suchitra, Revati and Vasudha performed extraordinarily in medium-Deep soils

9. PHALTAN

- The trial IVHT (SS) was sown on 23 Sep while IAVHT (SS) was sown on 9th Oct 2013.
- The crop expression was excellent on account of receipt of substantial rains during the crop period
- In IVHT (SS), the lines 403, 410, 412, 434, 440 and 442 were tolerant to shoot fly
- In IAVHT (SS), the entries viz., 8006, 8052, 8053, 8058, 8060, 8068, 8069, 8113, 8110 and 8118 were found promising with good biomass and no lodging
- Under breeding for *rabi* improvement, 39 new crosses using local landraces are being evaluated
- Under segregating generation advancement, new F₂'s are being screened for *rabi* adaptation traits
- A total of 114 F₆ progenies are being evaluated for *rabi* traits
- Under PVT, 51 new entries are being evaluated
- Under parental line improvement, 36 new B lines are being maintained
- Under network sweet sorghum breeding, a total of 140 advanced progenies are being tested
- Under germplasm maintenance, 273 locally collected and 141 IS lines are being maintained.

Recommendations of the team: The IVHT (SS) trial may be replaced by IVHT (Deep) at Phaltan because of soil type.

10. DHARWAD

Main observations: During the *rabi* season there was a deficit of about 21% against normal rainfall of 62 years. During the season, only September month received an excess rainfall of 28.3 mm. However, October month received a deficit of 45 mm as against average rainfall. Although the expression of trials were not to the full potential but overall crop condition was satisfactory. There was high infestation of shoot fly in agronomy trials. Minor incidence of downy mildew was also reported in breeding trials.



Breeding trials: All the trials were sown as per the AICSIP Rabi 2013-14 programs. Three AICRP trials (IVT, IHT and AVHT) and seven station trials were planted during the season (12th – 17th October 2013). In addition to this the centre has nucleus seed production and various breeding material trials. Promising entries for agronomic traits in different trials are as below:

IVT (Rabi) DS: 302, 308, 305, 336, 338, 342, 345, 363, 368, 376. Entry no. 309 was of kharif type whereas, 317 exhibited mixed population (for traits: plant height, panicle type, grain colour etc.). Sr. # 333 was very tall and late.

IHT (Rabi) DS: 202, 210, 232, 235, 239, 262, 268, 269. Sterility reported in few entries (206 & 240). Entry no. 209, 238, 265 were kharif types and dwarf.

AVHT (Rabi) DS: 106, 108, 112, 131, 136, 139, 141, 161, 166, 172, 173. Entry no. 175 recorded 5 sterile plants.

Germplasm evaluation trial: A total of 4000 germplasm accessions were sown in last week of October 2013 along with five checks in augmented design. The overall plant stand and expression was very good. A very high level of variability was observed for various agronomic traits.

Agronomy trials: Six agronomic trials were sown during rabi 2013-14 programme. Out of these one trial on "Integrated nutrient management in kharif sorghum (CSH 14) – chickpea cropping system" not taken up due to late harvesting of kharif sorghum crop (Chickpea crop not sown).

Trial 1: Evaluation of pre-released sorghum genotypes to varying fertility levels: 100% RDF was observed promising.

Trial 2: Enhancement of kharif fallow = rabi sorghum (CSV 22R) productivity through in-situ moisture conservation-

Promising treatments:

- Compartment bunding> tied ridging> opening of furrows at 45 cm

Trial 3: Integrated nutrient management in rabi sorghum (CSV 22R):

Promising treatments:

- Application of 33 and 50 kg N/ha in Mungben/cowpea –rabi sorghum sequence cropping
- All N levels on par in sunhemp –rabi sorghum sequence cropping

Trial 5: Assessing the performance of rabi sorghum genotypes in changing climate:

- Sowing in 3rd week of sept. appeared promising

Trial 6: Efficacy of plantozyme and plant granules:

- Soil application of plantogranules @20kg/ha, foliar application of plantozyme @ 2 ml/l water at 35 & 60 DAS and CaCl₂ (2%) seed treatment appeared promising.

Recommendations including follow-up with due dates, and name of person responsible:

- Some entries in IVT resembled like kharif types. Kharif types especially varieties are not preferred by farmers from rabi sorghum growing areas and moreover these showed more susceptibility to aphids. These should not be tested in rabi trials.
- In germplasm trials at least five plants should be selfed to get pure seeds.

11. KOVILPATTI

- The monitoring team consisted of Drs SS Rao and H.V.Kalpande visited and evaluated the trials organized in Breeding, and Entomology and other station trials. Kovilpatti is a semi arid region with an annual rainfall of 737 mm. The normal max.and min. temperatures recorded are 35° C and 22° C res., and the major soil type is Vertisol.
- In general, Kovilpatti receives an average annual rainfall of 703 mm from last week of August to 1st week of December. The average rainfall received in SW monsoon (June to Sept.) is about 159 mm and is inadequate to grow the kharif season crops including sorghum. Highest rainfall is coincides with October 2nd fortnight. The average rainfall received is about 390 mm during NE monsoon (October –Dec) which is enough to grow rabi crops. Due to the occurrence assured rainfall during rabi season, most of the cropping including sorghum is done in rabi season at this location.
- The monsoon ceases by the middle of December. Hence, terminal drought is the major production constraint for sorghum planted in early October. The average farm yields realized are about 1.0 t/ha, while the experiment station yield are ~2.5 t/ha (check K8) . Most of the plantings were done on 17 and 18 October 2013.
- The actual rainfall received from October to December end was just 253 mm as against a normal (long-term) rainfall of 390 mm during the corresponding period. Terminal drought conditions were prevailing due to the deficit rainfall in GS3 due to which lodging occurred in some entries. The promising entries in different trials are given below.

Breeding: All the trials were conducted as per the program assigned. Entries in all the trials were between hard-dough to physiological maturity. The crop grew to a height of about 1.5 to 2.0 m. Lodging occurred (> 50%) in some entries due to moisture stress especially in early maturing ones. Observation on lodged stalks (by splitting of stem at the base) showed



some incidence of charcoal rot symptoms may be due to high temperature. Plant Pathologists help may be taken to assess the charcoal rot incidence. Promising entries identified based on visual agronomic superiority, biomass etc., are listed below trial wise.

AVT-GS late kharif: Sr # 2007, 2009, 2013, 2017, 2011, 2102, 2014, 2018, 2014 (lodging occurred in 2005, 2010, K8). Difference in maturity is seen among the trial entries. It is necessary to formulate the trial with almost similar maturity. The ideal maturity needed for this location is ~ 95 days (60 d flowering duration). Anything later to this maturity is subjected to severe terminal drought results in low yields. The flowering should complete by 15 December for better yields.

AHT-GS late kharif: Sr #1001, 1003, 1059, 1053, 1010, 1112, 1109

AVT-SC forage: 6104, 6102, 6054, 6101. Some entries have already harvested as per the maturity date. The promising variety namely TKSV0809 (SPV 772 x S35) identified by the station is showing good growth and the seed multiplication is in progress.

Station trials: Five station trials including MLTs on grain sorghum, forage sorghum are planted. Besides, crossing materials involving R*R, A*R and other segregating breeding materials are under evaluation.

Entomology: The incidence of shoot fly in all the trials is very low ($\leq 10\%$). The infestation even in the susceptible check, DJ6514 is also very low ($\leq 10\%$). This reflects low level of infestation than expected/recommended (70%) for inclusion in State/All India averages. The resistant checks (IS2205) had exhibited high degree of resistance ($<10\%$). The symptoms of spotted stem borer damage observed among the entries varied (dead hearts at 45DAE: 0 to 30%). Symptoms of damage by head bug were low to moderate in some entries. Promising entries identified are listed below:

- AVHT-DS: Entry # for SB tolerance: 103, 135, 166, 175, 136, 140, 167.
- IHT-DS: Entry # for SB: 206, 204, 210, 233, 267, 262.
- IVT-DS: Entry # for SB: 313, 308, 339, 364, 375, 368.
- IVHT SS: Entry # for SB: 401, 406, 440, 431, 408.
- AICSIP DS-SPN: Entry nos: 504, 505, 508, 520, 519.
- AICSIP SS-SPN: Entry # 617, 623, 624, 626, 630.

Screening for Midge tolerance: Sorghum midge is the problem when crop planted under late conditions especially in the late October, which usually occurs in once in three or four years. Research program on evaluation of segregating materials (F2, F3, F4) for midge tolerance is planted on 11 Nov.2013 and evaluated by providing humidity through overhead sprinklers. The segregating materials are selected from different cross combination such as IS 7034 x K8, IS 2663 x CSV 17, TKSV 0809 x DJ 6514, etc. Recoding the observation is in progress.

Recommendations including follow-up with due dates, and name of person responsible:

- As the rainfall condition at Kovilpatti suitable for growing rabi season crop, the trial data should be interpreted on location specific basis and should not merge with other kharif location data.
- The crop maturity required for this location is ~95 days, and there is a need to formulate AICSIP entries with almost similar maturity for effective screening.
- The team recommends that the need for a separate trial with early maturing cultivars from both kharif (CSH 16, CSH27, CSH30) and rabi (Selection 3, Phule Maluee, Phule Anuradha, CSV 26 R) to identify best ones that can be popularized in that area in relation to local check.
- The team felt the need for fortnightly measuring soil moisture status in selected trials up to at least up to 60 cm profile to assess the stage at which the permanent wilting occurs that enable quantification of drought effects and identification of higher water use efficient genotypes.
- For monitoring charcoal rot symptoms, the help of plant pathologist from other schemes is to be taken in the coming years.



Update on DUS testing in sorghum and new descriptors

Hariprasanna K. and Aruna C.

Directorate of Sorghum Research, Hyderabad - 500030; (hari@sorghum.res.in)

Introduction: Sorghum is one among the first set of 12 crop species notified by Govt. of India for registration under the Protection of Plant Varieties and Farmers' Rights Act, 2001 (PPV&FRA, 2007a). The general and specific guidelines for DUS testing in sorghum was published by the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), New Delhi in Plant Variety Journal of India, the official journal of PPV&FRA on 20th February, 2007 (PVJ, 2007) paving the way for registration of new varieties of sorghum and grant of Plant Breeders' Rights. The PPV&FRA started receiving applications for registration of varieties from May, 2007. Presently registration can be done for 57 crop species and the DUS testing guidelines notified for these crop species have been provided in the website of the Authority and can be freely downloaded (<http://www.plantauthority.gov.in/crop-guidelines.htm>).

DUS testing guidelines in sorghum: The DUS test guidelines notified for sorghum includes 33 descriptors (PPV&FRA, 2007b). Out of these, 21 traits are assessed visually while 12 are measured traits (Table 1). The visual assessment is of two types: VG (visual assessment by a single observation of a group of plants or parts of plants) and VS (visual assessment by observation of individual plants or parts of plants). Similarly, assessment through measurement is of two types: MG (measurement by a single observation of a group of plants or parts of plants) and MS (measurement of a number of individual plants or parts of plants). The characteristics, which are known from experience not to vary, or to vary only slightly within a variety and which in their various states are fairly evenly distributed across all varieties in the collection are used for grouping of candidate varieties. The characteristics used for grouping of sorghum varieties for DUS testing are (1) *kharif* or *rabi* adaptation, (2) time of panicle emergence (50% of the plants with complete panicle emergence), (3) total height of plant at maturity, (4) panicle shape, and (5) colour of caryopsis after threshing. The grouping of candidate variety facilitates the assessment of distinctness as well as choice of appropriate reference variety for comparison. The DUS test guidelines for sorghum involves 15 essential characteristics, *i.e.*, characteristic that should be observed during every growing period on all varieties and shall always be included in the description of variety. These are denoted by (*) legend in the table of characteristics. Seven essential characteristics are of VG type, 5 are of VS type and rest 3 are of MS type. Nine characteristics out of 33 are descriptive type denoted by (+) mark and these characteristics are illustrated by explanation or drawing in table of characteristics in section VIII. Seven of the descriptive characteristics are of VG type and one each is of VS and MS type. Altogether there are 14 VG, 11 MS, 7 VS and one MG characteristics.

Table 1. DUS characteristics in sorghum

DUS #	Characteristics	States (Note)	Type
1 (+)	Seedling: anthocyanin coloration of coleoptiles	Yellow green(1), Grayed purple(2)	VS
2 (*)	Leaf sheath: Anthocyanin colouration	Yellow green(1), Grayed purple(2)	VS
3	Leaf: Mid rib colour (5 th fully developed leaf)	White(1), Yellow green(2), Grayed yellow(3), Grayed purple(4)	VS
4 (*)	Plant: Time of panicle emergence (50% of the plants with 50% anthesis)	Very early(1), Early(3), Medium(5), Late(7), Very late(9)	VG
5	Plant: Natural height of plant up to base of flag leaf	Very short(1), Short(3), Medium(5), Tall(7), Very tall(9)	MS
6 (*)	Flag leaf: Yellow colouration of midrib	Absent(1), Present(9)	VS
7 (*)	Lemma: Arista formation	Absent(1), Present(9)	VS
8 (*)	Stigma: Anthocyanin colouration	Absent(1), Present(9)	VS
9 (*)	Stigma: Yellow colouration	Absent(1), Present(9)	VS
10	Stigma: Length	Short(3), Medium(5), Long(9)	MS
11 (+)	Flower with pedicel: Length of flower	Very short(1), Short(3), Medium(5), Long(7), Very long(9)	VG
12	Anther: Length	Short(3), Medium(5), Long(7)	MS
13	Anther: Colour of dry anther	Yellow orange(1), Orange(2), Orange red(3), Grayed orange(4)	VG
14 (*)	Glume: Colour	Green white(1), Yellow white(2), Grayed yellow(3), Grayed orange(4), Grayed red(5), Grayed purple(6)	VG
15 (*)	Plant: Total height	Very short(1), Short(3), Medium(5), Long(7), Very long(9)	MS



DUS #	Characteristics	States (Note)	Type
16	Stem: Diameter (at lower one third height of plant)	Small(3), Medium(5), Large(7)	MS
17	Leaf: Length of blade (the third leaf from top including flag leaf)	Short(3), Medium(5), Long(7), Very long(9)	MS
18	Leaf: Width of blade (the third leaf from top including flag leaf)	Narrow(3), Medium(5), Broad(7), Very broad(9)	MS
19 (*)	Panicle: Length without peduncle	Very short(1), Short(3), Medium(5), Long(7), Very long(9)	MS
20	Panicle: Length of branches (middle third of panicle)	Short(3), Medium(5), Long(7), Very long(9)	MS
21 (*)	Panicle: Density at maturity (ear head compactness)	Very loose(1), Loose(3), Semi loose(5), Semi compact(7), Compact(9)	VG
22 (*) (+)	Panicle: Shape	Reversed pyramid(1), Panicle broader in upper part(2), Symmetric(3), Panicle broader in lower part(4), Pyramidal(5)	VG
23 (*)	Neck of panicle: Visible length above sheath	Absent or very short(1), Short(3), Medium(5), Long(7), Very long(9)	MS
24 (+)	Glume: Length	Very short(1), Short(3), Medium(5), Long(7), Very long(9)	MS
25 (+)	Grain: Threshability	Freely threshable(1), Partly threshable(5), Difficult to thresh(7)	VG
26 (*)	Caryopsis: Colour after threshing	White(1), Grayed white(2), Yellow white(3), Yellow orange(4), Grayed orange(5)	VG
27	Grain : Weight of 1000 grains	Very low(1), Low(3), Medium(5), High(7), Very high(9)	MG
28 (+)	Grain: Shape (in dorsal view)	Narrow elliptic(1), Elliptic(2), Circular(3)	VG
29 (+)	Grain: Shape (in profile view)	Narrow elliptic(1), Elliptic(2), Circular(3)	VG
30 (+)	Grain: Size of mark of germ	Very small(1), Small(3), Medium(5), Large(7), Very large(9)	VG
31 (*)	Grain: texture of endosperm (in longitudinal section)	Fully vitreous(1), $\frac{3}{4}$ vitreous(3), Half vitreous(5), $\frac{3}{4}$ farinaceous(7), Fully farinaceous(9)	VG
32	Grain: Colour of vitreous albumen	Grayed yellow(1), Grayed orange(2), Grayed purple(3)	VG
33 (*)	Grain: Lustre	Non-lustrous(1), Lustrous(5)	VG

The 33 DUS characteristics are recorded on six plant parts *viz.*, seedling, stem, leaf, panicle, flower and seed or grain. Further, the different characteristics are recorded on eight different stages of the crop. The characteristics recorded on different plant parts and growth stages, and types of assessment are given in Table 2 & 3. Perusal of the tables show that each stage of the crop is important and thus, DUS testing requires complete attention starting from sowing till harvesting.

Table 2. DUS characteristics on different plant parts

Plant part	Characteristics (DUS#)	Type of assessment				
		VS	VG	MS	MG	Total
Seedling	1	1	-	-	-	1
Plant / stem	4*, 5, 15*, 16	-	1	3	-	4
Leaf	2*, 3, 6*, 17, 18	3	-	2	-	5
Panicle	19*, 20, 21*, 22*, 23*	-	2	3	-	5
Flower	7*, 8*, 9*, 10, 11, 12, 13	3	2	2	-	7
Seed / grain	14*, 24, 25, 26*, 27, 28, 29, 30, 31*, 32, 33*	-	9	1	1	11
	Total	7	14	11	1	33

Table 3. DUS characteristics on different growth stages

Stage of Observation	Characteristics (DUS#)	Type of assessment				
		VS	VG	MS	MG	Total
Seedling (7-8 DAS)	1	1	-	-	-	1
5th leaf	2*, 3	2	-	-	-	2
Panicle emergence	4*, 5, 6*	1	1	1	-	3
Flowering	7*, 9*, 10, 11, 12	2	1	2	-	5
End of flowering	8*, 13	1	1	-	-	2
Physiological maturity	14*, 15*, 16, 17, 18, 19*, 20, 21*, 22*, 23*, 24	-	3	8	-	11
Maturity	25	-	1	-	-	1
Post-maturity / threshing	26*, 27, 28, 29, 30, 31*, 32, 33*	-	7	-	1	8
	Total	7	14	11	1	33

Status of DUS testing: DUS testing in sorghum for the purpose of registration of varieties under PPV&FRA started in 2008. So far 99 candidate varieties have undergone DUS testing since 2008. Out of these, 41 candidate varieties have come from public sector breeders and 57 are from private sector breeders, and one is a farmers' variety. Out of total candidate varieties tested 59 are under the category of new varieties and 39 are under the category of extant/varieties of common knowledge (VCK) (Table 4). Further, parental lines constituted more than half of the candidate varieties tested (54.5%) and rest were either open pollinated varieties (28.3%) or hybrids (17.2%) (Fig.1).

Table 4. Candidate varieties undergone DUS testing since 2008

Year	New	VCK	FV	Total	Remarks
2008 (Kh)	9	0	0	9	All Pvt.
2008 (Rabi)	1	0	0	1	Pub.
2009 (Kh)	6	0	0	6	5 Pub.+ 1 Pvt.
2010 (Kh)	8	2	0	10	6 Pub. + 4 Pvt.
2011 (Kh)	6	8	0	14	All Pvt.
2011 (Rabi)	5	0	0	5	3 Pub. + 2 Pvt.
2012 (Kh)	7	20	1	28	20 Pub. + 7 Pvt. + 1 FV
2012 (Rabi)	5	2	0	7	1 Pub. + 6 Pvt.
2013 (Kh)	9	6	0	15	4 Pub. + 11 Pvt.
2013 (Rabi)	3	1	0	4	1 Pub. + 3 Pvt.
Total	59	39	1	99	41 Pub. + 57 Pvt. + 1 FV

VCK: Variety of Common Knowledge; FV: Farmers' Variety

Frequency of reference varieties used: For comparing the 99 candidate varieties tested for DUS traits since 2008, a total of 59 reference varieties were used. Some of the reference varieties were used more frequently compared to others (Fig. 2). For example, the short duration CMS line AKMS 14A has been claimed as reference variety for maximum number of candidate varieties. The fertility restorer line C 43 has been claimed as reference variety in case of 13 candidate varieties, while restorers RS 29 and CS 3541 have been claimed for 12 and 11 candidate varieties, respectively. The hybrid CSH 14 was used as reference for 10 candidate varieties while another hybrid CSH 9 was used as reference for nine candidate varieties. Among the OPVs CSV 15, CSV 216R and M 35-1 have been claimed as reference varieties maximum number of times. Out of 59 reference varieties, 24 were used in case of single candidate variety only.

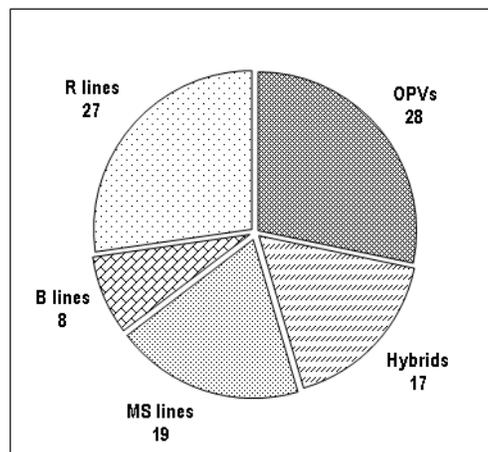


Figure 1. Classification of candidate varieties undergone DUS testing since 2008

Most commonly claimed distinct traits: The claimed distinct characteristics in the 99 candidate varieties tested so far for assessment of distinctness in comparison to the reference variety varied from 2 (AKR 150, BGS 802) to 16 (KSR 6310) with a median and mode of 6, and mean of 7. The more commonly claimed characteristics were panicle shape and panicle density followed by total height of plant, caryopsis colour after threshing and glume

colour (Table 5). Among these, three traits were used for grouping of the varieties (DUS #22, DUS #15 and DUS #26) also. It is also interesting to note that the deviation from the claims (by the applicant) was mostly observed in case of panicle shape and density, plant height and time of panicle emergence. The characteristics that were claimed less in general were stem diameter and colour of vitreous albumen in grain (Table 5). Very less variation in these traits as well as difficulty in characterization of some of the traits or more subjectivity would be the reason behind minimum claims.

Table 5. More common (> 40%) and less common (< 10%) claimed distinct traits

DUS #	Characteristics	Claimed (%)
22.(*) (+)	Panicle: Shape	54
21.(*)	Panicle: Density at maturity (ear head compactness)	54
15.(*)	Plant: Total height	49
26.(*)	Caryopsis: Colour after threshing	47
14.(*) (+)	Glume: Colour	46
8.(*)	Stigma: Anthocyanin colouration	7
12.	Anther: Length	7
20	Panicle: Length of branches (middle third of panicle)	7
25.(+)	Grain: Threshability	7
16	Stem: Diameter (at lower one third height of plant)	2
32	Grain : Colour of vitreous albumen	2

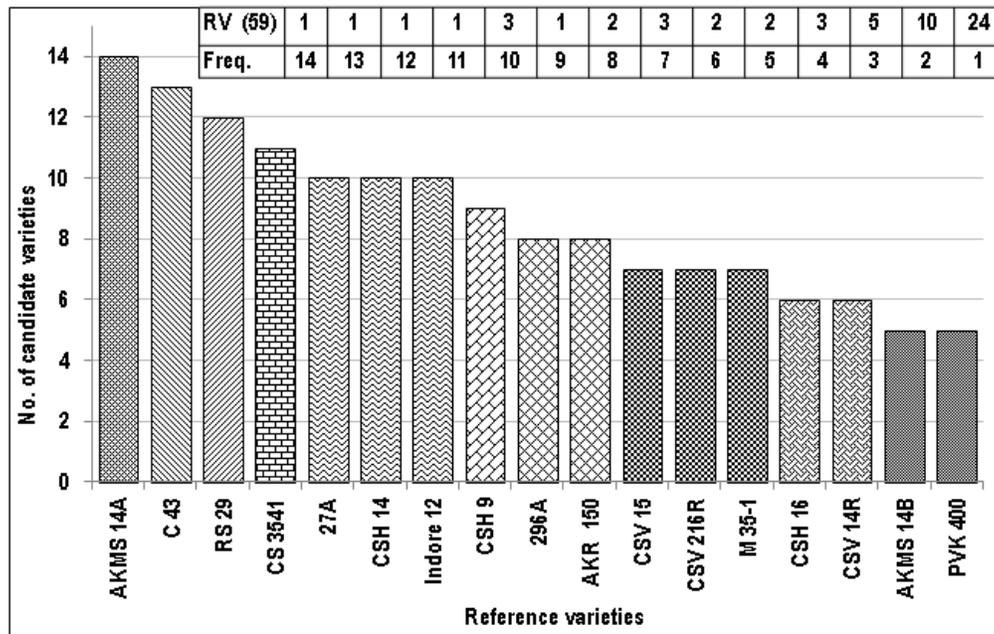


Figure 2. Frequency of reference varieties used in DUS testing

Status of applications filed and certificates granted: Since the very beginning of establishment of PPV&FRA both public and private sector agencies were actively involved in filing applications for registration of sorghum varieties. Till date 221 applications have been filed and sorghum stands 4th in terms of total number of applications received by PPV&FRA so far under cereals and millets, next only to rice, maize and pearl millet (Table 6). Among the applications, 107 are from public sector and 85 are from private sector, and 29 are farmers' varieties. Overall, 54 sorghum varieties have been registered and certificate of registration have been issued (PPV&FRA, 2014). Out of 54, 35 are public sector bred varieties and 19 are private sorghum varieties (Table 7).



Table 6. Status of applications received by PPV&FRA (till April, 2014)

Crop	Public	Private	Farmers' var.	Total
Dicoccum wheat	3	0	0	3
Durum wheat	7	1	0	8
Maize	112	249	53	414
Pearl millet	59	165	3	227
Rice	230	227	2673	3130
Sorghum	107	85	29	221
Wheat	120	16	19	155
Total (46 crops)	1255	2417	3087	6759

Table 7. Sorghum varieties registered in the Plant Varieties Registry (till April, 2014)

Sl.No.	Registration No./date of grant	Denomination of the candidate variety	Category	Name of applicant
1.	3 of 2009/12.02.09	JKSH-22 (JKSH-161)	Extant	JK Agri Genetics Limited
2.	32 of 2009/12.02.09	CSH-13	Extant	ICAR
3.	33 of 2009/12.02.09	CSH-16 (SPH 723)	Extant	ICAR
4.	34 of 2009/12.02.09	CSH-18 (SPH-960)	Extant	ICAR
5.	55 of 2009/16.04.09	CSV 216 (Phule Yashoda)	Extant	ICAR
6.	102 of 2009/20.07.09	CSH-15R (SPH 677)	Extant	ICAR
7.	103 of 2009/20.07.09	CSH-17 (SPH-660)	Extant	ICAR
8.	109 of 2009/20.07.09	CSV-15	Extant	ICAR
9.	132 of 2009/21.12.09	CSH-22SS (NSSH-104)	Extant	ICAR
10.	133 of 2009/21.12.09	CSH-20-MF (UPMCH-1101)	Extant	ICAR
11.	144 of 2009/21.12.09	RSSV-9 (CSV-19SS)	Extant	ICAR
12.	163 of 2009/21.12.09	Pant Chari-5 (UPFS-32)	Extant	ICAR
13.	38 of 2010/20.10.2010	Haryana Chari-308	Extant	ICAR
14.	43 of 2011/24.06.2011	AKSSV-22	Extant	Dr. PDKV, Akola
15.	44 of 2011/24.06.2011	AKSV-13R (PKV-Kranti)	Extant	Dr. PDKV, Akola
16.	105 of 2011/01.11.2011	J 1126	New	MAHYCO
17.	106 of 2011/01.11.2011	J 1062	New	MAHYCO
18.	109 of 2011/01.11.2011	JKSH 574	New	JK Agri Genetics Limited
19.	113 of 2011/07.12.2011	MIJ-007	New	Devgen N.V., Belgium
20.	7 of 2012/16.01.2012	APK-1	Extant	TNAU, Coimbatore
21.	16 of 2012/04.04.2012	Pant Chari-4	Extant	GBPUA&T, Pantnagar
22.	17 of 2012/04.04.2012	Jawahar Jowar 1041	Extant	RVSKVV, Gwalior
23.	18 of 2012/04.04.2012	Parbhani Moti (SPV-1411)	Extant	MAU, Parbhani
24.	19 of 2012/04.04.2012	BSR-1	Extant	TNAU, Coimbatore
25.	20 of 2012/04.04.2012	CO(S)-28	Extant	TNAU, Coimbatore
26.	21 of 2012/04.04.2012	K-11	Extant	TNAU, Coimbatore
27.	22 of 2012/04.04.2012	Paiyur-2	Extant	TNAU, Coimbatore
28.	73 of 2012/02.07.2012	Pratap Jawar-1430 (SPV-1430)	Extant	MPUA&T, Udaipur
29.	74 of 2012/02.07.2012	Uttara (RSSGV-3)	Extant	MPKV, Rahuri
30.	75 of 2012/02.07.2012	Vasudha (RSV-423)	Extant	MPKV, Rahuri
31.	76 of 2012/02.07.2012	Parbhani Sweta (SPV-1333)	Extant	MAU, Parbhani
32.	77 of 2012/02.07.2012	RSLG-262 (Maulee)	Extant	MPKV, Rahuri
33.	88 of 2012/02.07.2012	J1127	New	MAHYCO
34.	136 of 2012/19.09.12	CSH-21 (SPH-1342)	Extant	Devgen N.V., Belgium
35.	101 of 2013/17.06.2013	MRS 4094	Extant (VCK)	MAHYCO
36.	106 of 2013/01.07.2013	JKSH-234	Extant (VCK)	JK Agri Genetics Ltd.
37.	107 of 2013/01.07.2013	JKSH-434	Extant (VCK)	JK Agri Genetics Ltd.
38.	108 of 2013/02.07.2013	Co(FS)29	Extant	TNAU, Coimbatore
39.	113 of 2013/17.07.2013	MRS 4649	New	MAHYCO
40.	119 of 2013/14.08.2013	MIJ-005	Extant	Devgen N.V., Belgium
41.	135 of 2013/02.09.2013	CSV 17	New	ICAR
42.	136 of 2013/02.09.2013	CSH 23	New	ICAR
43.	268 of 2013/16.12.2013	SPH-1567	Extant	ICAR
44.	269 of 2013/16.12.2013	Nandyal Tella Jonna-3 (NTJ-3)	Extant	ANGRAU
45.	29 of 2014/21.1.2014	Phule Panchami (RPOSV3)	Extant	MPKV, Rahuri
46.	31 of 2014/22.1.2014	NSH-54	Extant	Nuziveedu Seeds Ltd.



Sl.No.	Registration No./date of grant	Denomination of the candidate variety	Category	Name of applicant
47.	38 of 2014/23.1.2014	CSV 20	New	ICAR
48.	41 of 2014/24.1.2014	Phule Revati (SPV 1830)	Extant	MPKV, Rahuri
49.	52 of 2014/12.2.2014	DGJ-015	New	Devgen N.V., Belgium
50.	53 of 2014/12.2.2014	HT-GS-3201	New	Hytech Seed India Ltd.
51.	54 of 2014/12.2.2014	DGJ-018	New	Devgen N.V., Belgium
52.	55 of 2014/3.3.2014	DGJ-017	New	Devgen N.V., Belgium
53.	56 of 2014/3.3.2014	KSR 6195	New	Kaveri Seed Comp. Ltd.
54.	59 of 2014/3.3.2014	DGJ-020	New	Devgen N.V., Belgium

New descriptors for sorghum: The PPV&FRA is propounding the idea of review of existing DUS test guidelines for the crops for which DUS testing was started in 2008 and the need for amendments, if any, for strengthening the plant variety protection system further. Based on the experience gained over the years, some of the descriptors which are currently being used can be obliterated while some other new descriptors may be added to the list of DUS test guidelines. Some of the new descriptors that can be considered in case of sorghum are given in Table 8. These characteristics can be easily examined at field level. Some other special characteristics which can also form part of sorghum DUS descriptors are contents of seed protein, lysine, tannin, total phenols and micronutrients; HCN content in case of forage sorghum; anti-nutritional factors like phytate, fibre, trypsin inhibitor and cyanogens; and tolerance to various biotic and abiotic stress factors. However, most of these characteristics require specialized laboratories and test conditions and shall be essential for protection of special quality sorghums like pop sorghum, quick cooking sorghum, quality protein sorghum, etc. Promotion of sorghum as health enhancing food through development of new value-added food products shall require breeding of appropriate specialized varieties and identification of suitable special DUS tests will be necessary for protection of such special sorghum varieties. All the sorghum researchers are hereby requested to share their views and provide suggestions on new descriptors that can be considered in case of sorghum for further strengthening the plant variety protection system in India.

Table 8. New descriptors that can be considered for sorghum DUS testing

Category	Characters	States	Stage of observation	Type of assess't	Caution
Grain sorghum	Stem/leaf: Waxy bloom (epicuticular wax)	1-Absent 3-Slightly bloomy 5-Mostly bloomy	Flowering / End of flowering	VG	Can vary with moisture stress?
-do-	Foliage: intensity of green colour	1-Light 3-Medium 5-Dark	Flowering	VG	-do-
-do-	Plant : pigmentation	1-Yellow green 5-Greyed purple	Physiological maturity	VG	<i>Kharif</i> types are mostly tan; <i>rabi</i> types are mostly purple
Sweet sorghum	Stem: Field brix (%)	1-low (<12) 3-Medium (12-15) 5-High (15-18) 7-Very high (>18)	Physiological maturity	MS	Can vary with growing condition
-do-	Plant: Biomass (g/plant)	1-Low (<250) 3-Medium (251-350) 5-High (351-450) 7-Very high (>451)	Physiological maturity	MS	Can vary with growing condition / season
Forage Sorghum	Plant: Tillering ability	1-Absent 3-Few (1-3) 5-Many (>4)	Flowering	MS	Can vary with growing condition / location
-do-	Plant: Biomass (g/plant)	1-Low (<150) 3-Medium (151-250) 5-High (251-350) 7-Very high (>351)	Flowering	MS	Can vary with growing condition / season

Suggested references

- PPV&FRA, 2007a. <http://www.plantauthority.gov.in/pdf/contents.pdf>
 PVJ, 2007. Plant Variety Journal of India, 1(1): 192-201 (<http://www.plantauthority.gov.in/pdf/EnglishPart.pdf>)
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Sorghum food technology research report 2013-14

Dr. UD Chavan

Senior Cereal Food Technologist, Sorghum Improvement Project, Mahatma Phule Krishi Vidyapeeth, Rahuri

Nutritional quality evaluation of *rabi* sorghum genotypes of dough, *roti* and nutritional parameters

A. Results: *Rabi*– 2012-2013, sorghum genotypes received from Dharwad Center

Roti and grain quality of sorghum: In India sorghum is traditionally consumed in the form of unleavened pan cake / *Roti* / *Bhakari*. Because of sorghum is a staple food in many parts of the country. Though sorghum grains are nutritious, the consumption of this cereal is decreasing due to non-availability of easy cooking raw materials from the sorghum. The other major reasons are; dying traditional food habits, requirement of special skill for preparing sorghum *rotis*. For many years sorghum eating population particularly in *rabi* growing areas, the *roti* made from Maldandi (M 35-1) is preferred for taste and softness, over other genotypes. But now days some new genotypes of *rabi* sorghum are developed which gives better nutritional as well as organoleptic quality of the *roti* than the M 35-1. A study done on the dough, *roti* and nutritional quality of 10 sorghum genotypes grown at Dharwad to identify superior genotypes.

a) Flour and dough quality

- **Hectoliter weight:** The hectoliter weight gives the soundness of the grain as well as higher recovery of the flour. It is a unit weight of the grain in a specific volume. The hectoliter weight ranged from 71.84 (SVD-0770) to 79.67 (DSV-4) kg/hl. The check DSV-4 genotype gave higher hectoliter weight than rest of the genotypes studied.
- **Water absorption capacity:** The water absorption capacity is positively correlated to the *roti* quality. The higher the water absorption capacity the superior was the quality of the *roti*. The water absorption capacity of flour ranged from 90% (Annigeri-1) to 120% (SVD-0813).
- **Water required for the dough:** The water required for the preparation of dough was estimated for different genotypes and presented Table 2. The genotypes differed significantly for the water requirement for dough preparations. Higher water requirement for dough preparation is a good character for softness of the *roti* for longer period. The water required for dough preparation ranged from 80 ml/100g flour (Annigeri-1) to 100 ml/100g flour (Phule Revati, BJV-44, SDV-0813, SDV-0768, and DSV-4).
- **Kneading quality:** The kneading quality of dough is measured on 1-3 scale (score 1 is the best and 2 score is good and 3 score is poor). The kneading quality of dough gives cohesiveness of the dough which is good sign for better quality of the *roti*. All genotypes studied were found best kneading quality of the dough as compare to the checks.
- **Spreading quality:** The spreading of the dough while preparing *roti* was studied and all genotypes scored ranged 1.0. All genotypes were found comparable to the local check for spreading quality of the *roti*.
- **Crude protein:** The crude protein content ranged from 8.73% (BJV-44) to 10.78% (Local check DSV-4). None of the new genotype was found superior over local check studied.
- **Soluble protein:** The soluble protein content in the flour mostly responsible for the holding more water and developing smoothness to the *roti*. The soluble protein content in the flour ranged from 0.79% (Annigeri-10) to 1.90% (Phule Revati).
- **Total soluble sugars:** The total soluble sugars ranged from 1.55% (BJV-44) to 2.08% (SDV-0768). All the genotypes studied were significantly different. The higher sugar percentage in sorghum flour representing good amylolytic activity while preparation of *roti*. It also responsible for good taste of the *roti*.
- **Starch:** Starch content ranged from 48.22% (SDV-0813) to 61.39% (SDV-0808). Higher starch content mostly responsible for gelatinization properties of the *roti* and keeping smooth for longer time.
- **Free amino acids:** The free amino acids in the studied genotypes ranged from 73.33 mg/100g flour (SVD-0808) to 90.48 mg/100g flour (DSV-4). The advanced sorghum genotypes were significantly different in the free amino acid content.



b) *Roti* quality: A test panel consisting of 10 semi-trained judges for testing and scoring *rotis* for their organoleptic quality parameters was constituted. The evaluation was performed on a hedonic scale 1 to 9 range, like extremely (Excellent) 9 to dislike extremely (not acceptable) 1. The results of the organoleptic quality of *roti* were presented below.

- *Colour and appearance*: The colour and appearance attribute is very important for immediately affect the acceptance of the product. The colour and appearance index ranged from 7.4 (Annigeri-1) to 8.6 (DSV-4). The studied genotypes were significantly different in their colour and appearance score.
- *Flavour / aroma*: For judging the *roti* quality flavor is one of the parameter mostly responsible to give their acceptance. The score ranged from 7.3 (Anni-1) to 8.8 (DSV-4).
- *Texture*: The texture of the *roti* gives the smoothness or roughness of the product. The texture score ranged from 7.5 to 8.8.
- *Taste*: Taste parameter is very important for the acceptance of any food product. It gives direct feelings of the consumer for that particular item. The taste score ranged from 7.4 (Annaigeri-1) to 8.9 (DSV-4).
- *Overall acceptability*: The overall acceptability score is based on the average score of all other four characters (colour and appearance, flavor, texture and taste). The overall acceptability score ranged from 7.40 (Annigeri-1) to 8.80 (DSV-4).
- *Storage study*: Storage study was under taken to study the loss in weight of *roti* during storage. The storage quality of the *roti* was evaluated for a total period of 24 hrs. The genotypes were significantly different. During this experiment three samples were drawn after 4 hrs, 8 hrs and 24 hrs at room temperature to see the loss in weight of the *roti*. The genotype SVD-0813 showed minimum loss in weight after 24 hrs storage at room temperature (Tables 2).

Conclusions: During *Rabi*-2012-2013 (Dharwad center) 10 sorghum genotypes were evaluated for *roti* and nutritional quality using above quality parameters. *Roti* quality judges by the semi-trained judges and nutritional quality based on some of the important nutrient present in sorghum grain. On the basis of these characters among the new sorghum genotypes from SVD-0813 was found comparable to Check DSV-4 followed by SVD-0768 and SVD-0808.

Table 1: Nutritional constituents responsible for *roti* quality prepared from different *Rabi* cultivars of sorghum (Dharwad Center 2012-13)

Genotype/ Entry code	Colour of the grain	Appearance / shape of the grain	Hecto-liter weight (Kg/hl)	Water absorption (ml/100g)	Crude Protein (%)	Soluble proteins (%)	Total sugars (%)	Starch (%)	Free amino acids (mg/100g)	Phenolics (%)
Phule Revati	CW	R	75.59	115	10.19	1.90	1.95	58.02	85.44	1.04
SVD - 0803	W	R	75.47	100	10.57	1.16	2.04	56.39	82.23	1.55
M 35 - 1	W	R	77.57	100	9.29	1.29	1.88	54.39	79.87	1.95
BJV- 44	W	R	77.39	110	8.73	1.05	1.55	53.98	84.90	1.57
SVD - 0808	W	R	74.75	110	9.33	1.19	2.03	61.39	73.33	1.47
SVD - 0770	DW	R	71.84	90	9.63	1.23	1.79	57.74	89.73	1.74
SVD - 0813	CW	R	77.23	120	9.09	1.14	1.73	48.11	88.31	1.48
SVD - 0768	W	R	78.16	105	9.77	1.31	2.08	56.34	78.98	1.65
Annigeri - 1	DW	R	76.49	90	10.38	0.79	1.77	48.44	79.65	1.75
DSV - 4	CW	R	79.67	120	10.78	1.58	1.76	49.56	90.48	1.33
Range	-	-	71.84-79.67	90-120	8.73-10.78	0.79-1.90	1.55-2.08	48.11-61.39	73.33-90.48	1.04-1.95
Mean	-	-	76.42	106	9.78	1.26	1.86	54.44	83.29	1.55
S.E. +	-	-	2.04	10	0.64	0.28	0.15	4.23	5.19	0.23
C.D. at 5 %	-	-	6.14	31	1.94	0.85	0.48	12.71	15.57	0.71

Replications: 3, Grain colour: Creamy = C, Creamy White = CW, Dull White = DW, White = W, Brown = B, and Dull Brown = DB. Grain Shape: Round = R, Oval/Oblong = O and Wrinkle = W.



Table 2: Organoleptic quality of roti prepared from different Rabi cultivars of sorghum (Dharwad Center, 2012-13)

Genotype/ Entry code	Water required for dough (ml)/100g	Knea- ding quality	Spread- ing quality	Organoleptic quality parameters					Rank by DMRT	Loss in weight during storage (%)		
				Colour & appea- rance	Fla- vour	Tex- ture	Taste	Overall accept- ability		4 hrs	8 hrs	24 hrs
Phule Revati	100	1	1	7.8	8.4	8.3	8.5	8.25	5	2.23	4.18	12.23
SVD - 0803	90	1	1	7.6	7.8	7.6	7.6	7.65	6	2.61	4.45	12.45
M 35 - 1	90	1	1	7.4	7.6	7.8	7.5	7.58	7	2.63	4.16	12.25
BJV- 44	100	1	1	8.6	8.4	8.5	8.6	8.53	4	2.32	4.12	12.35
SVD - 0808	100	1	1	8.5	8.5	8.6	8.6	8.55	3	2.38	4.13	12.56
SVD - 0770	80	1	1	7.5	7.4	7.6	7.6	7.53	8	2.92	4.87	13.42
SVD - 0813	100	1	1	8.8	8.7	8.8	8.9	8.80	1	2.85	4.24	12.13
SVD - 0768	100	1	1	8.5	8.4	8.6	8.8	8.58	2	2.16	5.37	12.37
Annigeri - 1	80	1	1	7.4	7.3	7.5	7.4	7.40	9	2.24	4.38	12.84
DSV - 4	100	1	1	8.6	8.8	8.9	8.9	8.80	1	2.32	3.35	12.23
Range	80-100	-	-	7.4-8.6	7.3- 8.8	7.5- 8.8	7.4-8.9	7.40- 8.80	-	2.16- 2.92	3.35- 5.37	12.13- 13.42
Mean	94	-	-	8.1	8.1	8.2	8.2	8.16	-	2.46	4.33	12.48
S.E. +	8	-	-	0.54	0.52	0.51	0.59	0.53	-	0.25	0.49	0.36
CD at 5 %	24	-	-	1.64	1.57	1.54	1.80	1.61	-	0.77	1.50	1.10

Kneading quality of dough, Score: Good = 1, Fair = 2, Poor = 3. Spreading quality of roti, Score: Easy spreading without crack = 1, Slightly difficult to spread with minute cracks = 2, Difficult to spread with cracks = 3.

Sensory score: Like extremely (Excellent) - 9, Like very much (Very good) - 8, Like moderately - 7, Like slightly-6, Neither like nor dislike - 5, Dislikes lightly - 4, Dislike moderately - 3, Dislike very much - 2, Dislike extremely-1.

B. Rabi 2013-14 (AVHT) sorghum genotypes from Rahuri center for dough *roti* and nutritional quality evaluation

During *Rabi* - 2013-14, 18 sorghum genotypes from AVHT were evaluated for flour, dough, *roti* and nutritional quality. While the *roti* quality was evaluated using colour and appearance, flavour, texture, taste, overall acceptability and the storage quality after 4, 8 and 24 hrs storage at room temperature. The *roti* quality was judged by the semi-trained judges and nutritional quality based on some of the important nutrient present in sorghum grain. On the basis of these above characters among the new sorghum genotypes from SPH 1721(2), SVT (R)-1310, CSV 29R, SPV 2144(2) and CSV 22 were found promising and superior for *roti* as well as nutritional quality (Table 3 & 4).

Considering the flour, dough, *roti* and nutritional quality parameters, among the AVHT *rabi* sorghum genotypes SPH 1721(2), SVT (R)-1310, CSV 29R, SPV 2144(2) and CSV 22 were found to be promising and superior.

Table 3: Nutritional constituents responsible for *roti* quality prepared from different *Rabi* (AVHT) cultivars of sorghum (Rahuri Center 2013-14).

Genotype	Colour of the grain	Appear- ance/ Shape of the grain	Hecto- liter weight (Kg/hl)	Water absorp- tion (ml/100g)	Crude Protein (%)	Soluble proteins (%)	Total sugars (%)	Starch (%)	Free amino acids (mg/100g)	Phenolics (%)
SPV 2144(2)	CW	O	77.51	110	8.70	1.13	1.57	47.71	77.26	2.05
M 35-1	CW	O	78.08	96	9.12	1.15	1.54	45.06	75.57	2.18
SPV 2215	CW	O	75.95	106	8.84	1.25	1.51	50.97	75.54	1.96
SPV 2228	CW	O	76.50	112	8.97	1.07	1.40	46.24	80.31	1.77
SPH 1746	CW	O	78.84	114	9.97	1.96	1.58	41.76	81.46	2.50
CSH 15R	CW	O	78.42	119	9.70	1.10	1.82	46.19	86.78	2.29
CSV 29R	CW	O	77.14	116	8.66	1.04	1.57	49.11	87.85	2.05
SPV 2225	CW	O	78.89	120	9.16	1.04	1.56	44.65	83.22	2.11



Genotype	Colour of the grain	Appearance/ Shape of the grain	Hecto-liter weight (Kg/hl)	Water absorption (ml/100g)	Crude Protein (%)	Soluble proteins (%)	Total sugars (%)	Starch (%)	Free amino acids (mg/100g)	Phenolics (%)
SPH 1721(2)	CW	O	78.02	109	9.65	1.16	1.94	48.61	81.00	2.14
CSV 22	CW	O	77.11	108	8.81	1.02	1.24	48.01	83.69	1.80
SPH 1741	CW	O	77.25	119	7.86	1.16	1.99	47.01	78.83	1.75
SPH 1744	CW	O	77.04	117	8.43	1.06	1.10	45.87	81.20	1.90
SPV 2221	CW	O	78.32	105	10.04	1.79	1.53	45.42	87.12	1.88
SPH 1742	CW	O	77.54	121	10.02	1.00	1.61	42.28	82.61	2.44
SPV 2227	CW	O	77.88	110	8.74	1.75	1.12	41.51	80.81	1.90
RSV-423	CW	O	76.09	108	9.06	1.93	1.40	47.90	90.69	1.89
SVT (R) 1310	CW	O	76.79	118	9.58	1.12	1.80	52.96	86.27	2.01
RSSGV-46	W	O	67.92	120	7.77	1.08	1.86	46.01	32.96	1.64
Range	-	-	67.92-78.89	96-121	7.77-10.04	1.00-1.96	1.10-1.94	41.51-52.96	32.96-90.69	1.75-2.50
Mean	-	-	76.96	113	9.06	1.27	1.56	46.52	79.62	2.01
S.E. ±	-	-	2.34	6.54	0.65	0.32	0.24	2.90	12.03	0.22
C.D. at 5 %	-	-	7.04	19.62	1.97	0.98	0.74	8.71	36.10	0.68

Grain colour: Creamy = C, Creamy White = CW, Dull White = DW, White = W, Brown = B, and Dull Black = DB.

Grain Shape: Round = R, Oval/Oblong = O and Wrinkle = W.

Table 4: Organoleptic quality of *roti* prepared from different hybrid/varieties of *Rabi* (AVHT) cultivars of sorghum (Rahuri Center, 2013-14).

Genotype	Water required for dough (ml)	Kneading quality	Spreading quality	Organoleptic quality parameters					Rank by DMRT	Loss in weight during storage (%)		
				Colour & appearance	Flavour	Texture	Taste	Overall acceptability		4 hrs	8 hrs	24 hrs
SPV 2144(2)	90	1	1	7.33	6.67	6.83	7.00	6.96	4	2.43	4.28	9.95
M 35-1	80	1	1	5.00	5.83	5.50	6.33	5.67	17	2.78	4.76	11.08
SPV 2215	90	1	1	6.83	6.50	6.33	7.33	6.75	5	2.73	4.86	10.71
SPV 2228	100	1	1	6.17	5.83	6.33	6.17	6.13	13	2.64	4.23	9.45
SPH 1746	100	1	1	6.50	5.67	6.50	6.50	6.29	12	4.15	6.38	10.82
CSH 15R	110	1	1	6.17	5.83	5.67	6.33	6.00	14	2.78	6.74	11.91
CSV 29R	100	1	1	7.83	6.50	7.33	7.17	7.21	3	2.43	4.62	11.55
SPV 2225	110	1	1	6.17	6.67	5.67	6.67	6.30	11	2.56	4.67	9.89
SPH 1721(2)	100	1	1	7.17	7.17	7.50	7.83	7.42	1	2.30	4.23	9.86
CSV 22	90	1	1	6.83	7.50	6.33	7.17	6.96	4	2.21	4.81	13.24
SPH 1741	110	1	1	6.17	6.33	6.83	6.67	6.50	9	2.62	4.42	12.60
SPH 1744	110	1	1	6.17	6.33	6.67	6.33	6.38	10	2.36	4.15	12.65
SPV 2221	90	1	1	6.83	6.50	6.67	6.83	6.71	6	2.21	4.15	12.15
SPH 1742	110	1	1	5.67	5.83	5.67	6.00	5.79	16	2.32	4.10	12.23
SPV 2227	90	1	1	6.83	6.67	6.50	6.33	6.58	7	2.95	4.78	12.33
RSV-423	90	1	1	6.67	6.67	6.33	6.50	6.54	8	2.83	4.42	12.65
SVT (R) 1310	100	1	1	7.00	7.33	7.33	7.83	7.37	2	2.18	6.73	12.57
RSSGV-46	100	1	1	5.83	6.00	6.00	5.67	5.88	15	2.23	4.83	12.42
Range	80-110	-	-	5.00-7.83	5.67-7.33	5.67-7.50	6.00-7.83	5.67-7.42	-	2.18-4.15	4.10-6.74	9.45-13.24
Mean	98.33	-	-	6.51	6.44	6.44	6.70	6.51	-	2.59	4.84	11.56
S.E. ±	8.97	-	-	0.64	0.52	0.53	0.57	0.51	-	0.44	0.83	1.14
CD at 5 %	26.93	-	-	1.94	1.58	1.61	1.73	1.53	-	1.34	2.51	3.45

Kneading quality of dough, score: Good = 1, Fair = 2, Poor = 3. Spreading quality of *roti*, score: Easy spreading without crack = 1, Slightly difficult to spread with minute cracks = 2, Difficult to spread with cracks = 3.

Sensory score: Like extremely (Excellent) - 9, Like very much (Very good) - 8, Like moderately - 7, Like slightly-6, Neither like nor dislike - 5, Dislikes lightly - 4, Dislike moderately - 3, Dislike very much - 2, Dislike extremely-1

Research publications and extension activities

Research papers/articles/conferences

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3. Gadakh, S. R., Shinde, M. S., Gaikwad, A. R., Nirmal, S. V. and Chavan, U. D. (2013). Phule Suchitra: A new *rabi* sorghum variety for medium soils. Crop Res. 45 (1, 2 & 3): 136-140.
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13. Chavan, U. D. (2013). Presented a research paper on "Role of Polyphenols in Nutrition and Prevention of Disease" in the "Global Consultation on Millets Promotion for Health and Nutritional Security" Conference held at Directorate of Sorghum Research, Rajendranagar, Hyderabad (AP) during 18th to 20th December, 2013.

Books

1. Chavan, U. D. (2014). Question bank on Food Science and Technology. Daya Publishing House, A Division of Astral International Pvt. Ltd. New Delhi. 1-563. ISBN: 978-81-7035-882-4.
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Compositional grain quality of sorghum varieties & hybrids evaluated under advanced trial

CV Ratnavathi, A Mahender, U Lavanya, B Ranga, & JV Patil
Directorate of Sorghum Research, Hyderabad - 500030; (ratnavathi@sorghum.res.in)

Introduction: Sorghum and millets have been important staples in the semi-arid tropics of Asia and Africa acting as principal sources of energy, protein, vitamins and minerals. Sorghum is considered as a nutritious coarse cereal grain that is almost on par or richer than rice and wheat for many nutritional components, especially dietary fiber, vitamins and minerals. Sorghum grain starch is slow digestible and is important attribute for recommending the cereal in the diet for diabetic population. The grains produced during rainy season attract low market value because of physical quality deterioration due to mold, but chemical quality does not always get affected significantly. Hence, grain quality evaluation of new sorghum varieties and hybrids assume significance apart from superiority for grain yield. However the deterioration of the grain occurs due to the water activity present in the grain. Slow starch digestibility is correlated to amylose content in the grain. Grain samples from varieties and hybrids evaluated under the advanced trial of AICSIP were analyzed for chemical quality parameters. The percent starch, amylose and protein are the three major constituents of grain affecting the quality in sorghum. There is no much significant difference in fat content was observed over the years and hence this year it was not analyzed. Therefore, starch, amylose and protein were determined in the randomly collected replicated grain samples from the entries evaluated during *khariif* 2013 at three locations *viz.*, Coimbatore, Akola, and Udaipur. The results of advanced hybrid trial are presented in Table 1A & 1B and advanced varietal trial is presented in Table 2A & 2B.

Advanced Hybrid Trial (Table-1A & 1B): The data on water activity and percent Protein in 9 test hybrids along with 4 check hybrids and one local check genotype from Coimbatore, Akola, and Udaipur locations is presented in Table 1A. The data on percent starch and amylose in 14 genotypes which include 9 test genotypes from the above three locations is presented in Table 1 B. Nine grain sorghum hybrids were compared for all four grain quality parameters with five checks including one local check.

Water activity: In general water activity was found higher at Coimbatore compared to other locations. Grain at Coimbatore is effected by grain mold. There is no significant variation across genotypes while across locations variation was observed.

Protein: The mean protein content varied from 10.30% (SPH 1736) to 11.85% (CSH 23). At Coimbatore location higher protein content was observed compared to other locations and it varied from 11.18 (SPH 1737) to 12.01% (Local Check). At location Akola, the range of protein was 10.18 (SPH 1736) to 12.59 (CSH 16). In Location Udaipur the protein content ranged from 9.21 (SPH 1736) to 11.79 (CSH 30). In Udaipur most of the samples showed less protein as compared to the other 2 locations. Five test entries SPH 1703, SPH 1705, SPH 1730 SPH 1731 and SPH 1733 are having protein content above 11.00%, but not superior to check genotypes. Remaining four entries recorded low protein content (Table-1A)

Starch: The mean starch content of the three locations varied from 58.02 (CSH 30) to 62.92 % (SPH 1731). The starch content significantly varied across locations. At Udaipur location, the starch content was observed to be low and Percent starch is more at Coimbatore location. The starch content at Coimbatore location ranged from 59.25 (SPH 1703) to 64.3% (SPH 1731). In Akola the range for starch was 56.40 (SPH 1705) to 63.65 % (SPH 1724) and in Udaipur the range was 53.5% (SPH 1737) to 63.05 (SPH 1731). Out of 9 test hybrids six test hybrids (SPH 1702, SPH 1703, SPH 1724, SPH 1731, SPH 1733 and SPH 1736) are superior to all 5 check genotypes with mean starch content (Table-1B)

Amylose: The mean percent amylose ranged from 15.52 (CSH 25) to 17.79 (SPH 1724). Across locations there is no significant difference in Amylose content. The range of amylose % in Coimbatore location was 14.71 (Local Check) to 17.89 (SPH 1733) while in Akola the range was 15.99 (CSH 25) to 18.41 (SPH 1730). Two test entries



SPH 1724 and SPH 1730 are superior to all the check genotypes for amylose content. All the genotypes showed less amylose compared to sorghum Indian average amylose content (20%). (Table-1 B)

Advanced Varietal Trial (Table-2A &2B):

The data on water activity and percent protein in 16 genotypes from Coimbatore, Akola, and Udaipur locations is presented in Table 2A. The data on percent starch and amylose in 16 genotypes from the above three locations is presented in Table 2B. Sixteen varieties of grain sorghums were compared for all four grain quality parameters with five checks including one local check.

Water activity: In general water activity was found higher at Coimbatore followed by Akola and Udaipur locations. There is no significant variation across genotypes while across locations variation was observed only between Coimbatore and other two locations. There is no significant variation for water activity between Akola and Udaipur locations. Water activity in the grain was an indicator for the shelf life of the grain.

Protein: The mean protein content varied from 10.22% (CSV 27) to 11.76% (SPV 2179). The range of protein is very narrow. At Coimbatore location higher protein content was observed followed by Udaipur and Akola and it varied from 10.99 (CSV 27) to 13.47% (SPV 2175). At location Akola, the range of protein was 9.69 (SPV 2174) to 11.77 (SPV 2183). In Location Udaipur the protein content ranged from 9.78 (CSV 27) to 12.34 (SPV 2178). In Udaipur most of the samples showed slightly lesser protein as compared to the other 2 locations. Thirteen test entries showed protein content above 11.00%, but all are not superior to the check genotypes.. Remaining three entries (SPV 2114, SPV 2174 and SPV 2184) recorded low protein content (Table 2A).

Starch: The mean starch content of the three locations varied from 58.53% (SPV 2179) to 63.18 % (SPV 2114). The grain samples collected at Udaipur location showed grain starch content relatively low and it ranged from 54.85 (SPV 2179) to 62.30 % (CSV 20). Three test varieties (SPV2114, SPV 2110, and SPV 2178) are superior to all the check genotypes including local check. Except two genotypes SPV 2179 and SPV 2181, remaining 14 genotypes were superior to local check (59.72) in the mean starch content.

Amylose: Amylose content in the grain indicates the amount of resistant starch present in the grain. The digestibility of the starch is dependent on the amylose content. Genotypic variability for amylose content is very low. The mean percent amylose ranged from 15.54 (SPV 2181) to 17.01 (SPV 2182). Amylose content is slightly lower in Coimbatore location compared to Akola. Test entries SPV 2182 and SPV 2178 are superior or on par with check genotypes. The amylose content is relatively low at all locations compared Kharif season 2012 produce.

Conclusion

The results of pooled analysis of data across all three locations and the conclusions drawn from the grain quality analysis are enumerated below.

1. The mean protein content varied from 10.30% (SPH 1736) to 11.85% (CSH 23)
2. The mean starch content of the three locations varied from 58.02 (CSH 30) to 62.92 % (SPH 1731).
3. Five test entries SPH 1703, SPH 1705, SPH 1730 SPH 1731 and SPH 1733 are having protein content above 11.00%, but not superior to check genotypes
4. Thirteen test entries showed protein content above 11.00%, but all are not superior to the check genotypes.
5. Genotypic variability for amylose content is very low.



Table 1A: Grain quality of grain sorghum hybrids in Advanced Hybrid Trial –Kharif 2013

Sl. No	Entry	WATER ACTIVITY								PROTEIN%							
		COI	R	AKO	R	UDA	R	Av.	R	COI	R	AKO	R	UDA	R	Av.	R
1	SPH 1702	0.577	4	0.396	2	0.381	1	0.451	1	11.64	6	11.48	7	9.35	13	10.82	12
2	SPH 1703	0.551	12	0.356	13	0.353	9	0.420	13	11.80	5	12.36	4	9.43	12	11.20	8
3	SPH 1705	0.557	9	0.345	14	0.359	6	0.420	12	11.58	8	12.48	2	9.77	9	11.28	7
4	SPH 1724	0.589	1	0.377	5	0.349	10	0.438	4	11.26	10	10.86	12	10.71	5	10.94	11
5	SPH 1730	0.552	11	0.362	11	0.347	11	0.420	11	11.85	4	11.83	6	9.64	11	11.11	10
6	SPH 1731	0.555	10	0.402	1	0.340	12	0.432	6	11.61	7	12.32	5	10.00	8	11.31	6
7	SPH 1733	0.579	3	0.358	12	0.376	2	0.438	5	11.26	11	11.33	9	11.53	2	11.37	5
8	SPH 1736	0.563	8	0.367	8	0.365	4	0.432	7	11.52	9	10.18	14	9.21	14	10.30	14
9	SPH 1737	0.566	7	0.363	10	0.358	7	0.429	9	11.18	13	11.26	10	9.68	10	10.71	13
10	CSH 16	0.569	6	0.387	3	0.365	5	0.440	3	11.25	12	12.59	1	10.61	6	11.49	3
11	CSH 23	0.541	14	0.368	6	0.337	13	0.415	14	11.97	2	12.45	3	11.11	4	11.85	1
12	CSH 25	0.570	5	0.366	9	0.357	8	0.431	8	11.64	6	11.37	8	10.32	7	11.11	9
13	CSH 30	0.583	2	0.383	4	0.358	7	0.441	2	11.90	3	11.17	11	11.79	1	11.62	2
14	Local Check	0.542	13	0.368	7	0.370	3	0.427	10	12.01	1	10.78	13	11.52	3	11.44	4
	LOC. MEAN	0.564		0.371		0.358		0.431		11.61		11.61		10.33		11.18	
	C.D. (5%)	0.047		0.032		0.041		0.022		0.89		1.29		1.23		1.16	
	C.D. (1%)	0.063		0.043		0.056		0.029		1.21		1.74		1.66		1.57	
	C.V. (%)	4.960		5.070		6.840		2.980		4.59		6.62		7.09		6.17	
	F (Probability)	0.000		0.000		0.000		0.086		0.00		0.00		0.00		0.49	

Table 1B: Grain quality of grain sorghum hybrids in Advanced Hybrid Trial – Kharif 2013

Sl. No	Entry	STARCH %								AMYLOSE %							
		COI	R	AKO	R	UDA	R	Av.	R	COI	R	AKO	R	Av.	R		
1	SPH 1702	60.65	9	61.85	2	59.90	2	60.80	4	15.85	11	16.63	10	16.24	11		
2	SPH 1703	59.25	14	61.35	5	59.40	5	60.00	6	17.04	3	17.01	8	17.03	6		
3	SPH 1705	61.15	8	56.40	14	57.50	9	58.35	13	16.38	4	17.08	7	16.73	7		
4	SPH 1724	63.45	4	63.65	1	59.75	3	62.28	2	17.61	2	17.96	4	17.79	1		
5	SPH 1730	60.50	11	60.20	9	54.65	13	58.45	12	16.16	8	18.41	1	17.28	2		
6	SPH 1731	64.30	1	61.40	4	63.05	1	62.92	1	16.04	9	16.04	13	16.04	12		
7	SPH 1733	64.25	2	61.70	3	59.45	4	61.80	3	17.89	1	16.39	11	17.14	5		
8	SPH 1736	64.10	3	60.95	6	56.65	10	60.57	5	16.03	10	16.88	9	16.45	9		
9	SPH 1737	61.85	6	60.55	7	53.50	14	58.63	11	16.35	5	16.25	12	16.30	10		
10	CSH 16	62.50	5	59.75	10	55.65	12	59.30	9	15.58	12	17.36	6	16.47	8		
11	CSH 23	60.55	10	60.40	8	58.25	8	59.73	8	16.31	6	18.11	3	17.21	3		
12	CSH 25	61.50	7	59.50	11	58.95	6	59.98	7	15.04	13	15.99	14	15.52	13		
13	CSH 30	60.30	12	57.20	13	56.55	11	58.02	14	16.20	7	18.13	2	17.16	4		
14	Local Check	59.50	13	59.20	12	58.30	7	59.00	10	14.71	14	17.38	5	16.04	12		
	LOC. MEAN	61.70		60.29		57.97		59.99		16.23		17.12		16.67			
	C.D. (5%)	5.39		5.93		8.30		2.80		2.04		2.14		1.71			
	C.D. (1%)	7.29		8.02		11.22		3.78		2.76		2.89		2.39			
	C.V. (%)	5.20		5.86		8.53		2.78		7.49		7.44		4.76			
	F (Probability)	0.00		0.00		0.00		0.02		0.00		0.00		0.36			



Table 2A: Grain quality of grain sorghum Varieties in Advanced Varietal Trial – Kharif 2013

Sl. No	Entry	WATER ACTIVITY								PROTEIN%							
		COI		AKO		UDA		Av.		COI		AKO		UDA		Av.	
			R		R		R		R		R		R		R		R
1	SPV 1822	0.566	8	0.407	13	0.384	10	0.452	14	11.92	17	10.43	13	11.87	2	11.41	9
2	SPV 2110	0.553	18	0.429	5	0.393	8	0.458	8	11.86	18	10.43	13	10.86	10	11.05	16
3	SPV 2114	0.567	7	0.414	8	0.401	5	0.461	4	11.34	20	10.82	8	10.80	11	10.99	18
4	SPV 2122	0.559	14	0.397	20	0.367	18	0.441	20	12.18	13	11.00	7	10.08	19	11.09	15
5	SPV 2164	0.564	9	0.400	18	0.387	9	0.451	16	12.34	9	11.45	2	10.37	18	11.38	10
6	SPV 2165	0.550	19	0.414	9	0.408	3	0.457	10	12.11	16	10.57	10	10.46	15	11.05	17
7	SPV 2170	0.561	11	0.449	2	0.365	21	0.458	7	13.16	3	10.07	17	10.62	13	11.28	11
8	SPV 2172	0.554	16	0.416	7	0.365	20	0.445	18	12.12	15	11.02	5	11.79	4	11.64	6
9	SPV 2174	0.599	1	0.405	15	0.378	14	0.461	5	12.23	12	9.69	20	10.64	12	10.85	20
10	SPV 2175	0.593	3	0.404	16	0.377	15	0.458	9	13.47	1	10.29	14	11.34	8	11.70	3
11	SPV 2178	0.567	6	0.435	4	0.381	11	0.461	3	12.47	7	9.69	19	12.34	1	11.50	7
12	SPV 2179	0.560	12	0.390	21	0.419	1	0.456	12	12.31	10	11.12	4	11.86	3	11.76	1
13	SPV 2181	0.558	15	0.411	10	0.395	6	0.455	13	12.14	14	11.40	3	11.41	6	11.65	5
14	SPV 2182	0.546	21	0.406	14	0.417	2	0.456	11	12.78	4	10.53	12	10.45	16	11.25	12
15	SPV 2183	0.560	13	0.401	17	0.395	7	0.452	15	12.66	6	11.77	1	9.86	20	11.43	8
16	SPV 2184	0.549	20	0.408	12	0.378	13	0.445	19	12.29	11	10.18	15	10.42	17	10.97	19
17	CSV 17	0.571	4	0.409	11	0.404	4	0.461	2	13.17	2	10.56	11	11.25	9	11.66	4
18	CSV 20	0.570	5	0.400	19	0.366	19	0.445	19	12.35	8	10.61	9	10.47	14	11.14	14
19	CSV 23	0.595	2	0.451	1	0.371	17	0.472	1	11.84	19	10.14	16	11.70	5	11.22	13
20	CSV 27	0.554	17	0.416	6	0.378	12	0.449	17	10.99	21	9.90	18	9.78	21	10.22	21
21	Local Check	0.561	10	0.444	3	0.375	16	0.460	6	12.76	5	11.01	6	11.41	7	11.72	2
	LOC. MEAN	0.565		0.415		0.386		0.455		12.31		10.60		10.94		11.29	
	C.D. (5%)	0.037		0.053		0.057		0.029		1.41		1.31		1.65		1.02	
	C.D. (1%)	0.049		0.071		0.077		0.039		1.88		1.76		2.21		1.37	
	C.V. (%)	3.940		7.780		9.020		3.910		6.92		7.51		9.13		5.49	
	F (Probability)	0.000		0.000		0.000		0.951		0.00		0.00		0.00		0.40	

Table 2B: Grain quality of grain sorghum Varieties in Advanced Varietal Trial – Kharif 2013

Sl. No	Entry	STARCH %								AMYLOSE %							
		COI		AKO		UDA		Av.		COI		AKO		Av.			
			R		R		R		R		R		R		R		R
1	SPV 1822	61.00	10	61.60	13	60.25	9	60.95	8	15.08	16	16.62	11	15.85	14		
2	SPV 2110	59.00	16	67.75	2	60.90	4	62.55	2	15.77	6	16.64	10	16.21	7		
3	SPV 2114	65.25	1	63.00	8	61.30	2	63.18	1	14.92	19	16.22	17	15.57	20		
4	SPV 2122	59.55	14	61.45	14	58.35	12	59.78	16	14.95	18	16.25	16	15.60	18		
5	SPV 2164	60.75	12	68.55	1	55.20	19	61.50	6	15.22	14	16.61	12	15.92	13		
6	SPV 2165	59.25	15	62.10	11	61.15	3	60.83	9	16.02	4	16.04	19	16.03	12		
7	SPV 2170	60.55	13	59.30	20	59.25	10	59.70	18	15.22	14	15.96	20	15.59	19		
8	SPV 2172	61.30	9	62.80	9	57.85	15	60.65	12	15.54	12	15.67	21	15.61	17		
9	SPV 2174	62.20	5	60.00	17	58.95	11	60.38	13	15.67	9	16.86	6	16.27	6		
10	SPV 2175	61.80	7	61.10	16	57.75	16	60.22	15	15.90	5	16.96	4	16.43	5		
11	SPV 2178	63.80	2	64.70	4	57.90	14	62.13	3	16.85	2	16.87	5	16.86	2		
12	SPV 2179	58.45	17	62.30	10	54.85	20	58.53	21	15.66	10	17.36	1	16.51	4		
13	SPV 2181	55.65	20	63.75	5	57.20	17	58.87	20	14.26	20	16.82	7	15.54	21		
14	SPV 2182	63.05	3	61.10	16	58.25	13	60.80	10	17.86	1	16.15	18	17.01	1		
15	SPV 2183	62.15	6	59.35	19	60.55	6	60.68	11	15.59	11	16.53	13	16.06	11		
16	SPV 2184	60.95	11	66.05	3	56.20	18	61.07	7	15.69	7	16.68	8	16.19	8		
17	CSV 17	57.00	19	59.65	18	60.75	5	59.13	19	15.05	17	16.52	14	15.78	16		
18	CSV 20	57.40	18	61.30	15	62.30	1	60.33	14	15.18	15	16.51	15	15.85	15		
19	CSV 23	61.50	8	63.05	7	60.50	7	61.68	5	15.69	8	16.68	9	16.18	9		
20	CSV 27	61.50	8	63.50	6	60.35	8	61.78	4	16.49	3	17.06	3	16.77	3		
21	Local Check	62.30	4	62.00	12	54.85	20	59.72	17	15.26	13	17.10	2	16.18	10		
	LOC. MEAN	60.69		62.59		58.79		60.69		15.61		16.58		16.09			
	C.D. (5%)	6.46		5.75		5.32		4.11		1.21		1.84		1.27			
	C.D. (1%)	8.65		7.69		7.12		5.50		1.62		2.46		1.74			
	C.V. (%)	6.45		5.57		5.48		4.11		4.71		6.72		3.79			
	F (Probability)	0.00		0.00		0.00		0.82		0.00		0.00		0.48			



Appendices

Appendix I: AICSIP plan and instructions

Zone-wise testing during the year will have all test-entries coded. Besides field performance and, screening for resistance to major biotic and abiotic stress factors, the additional data on grain and stover quality, market-price, and wherever possible even on food quality will be collected and documented.

A. The trials and nurseries

1. Kharif: IHT, AHT, IVT, AVT (If number of entries are less we will be clubbing hybrid and varietal trials like last year as IVHT and AVHT)
2. Sweet sorghum: IHT, AHT, IVT, AVT (If number of entries are less we will be clubbing hybrid and varietal trials like last year as IVHT and AVHT)
3. Forage sorghum (both single and multi-cut): IHT, AHT, IVT, AVT (If number of entries are less we will be clubbing hybrid and varietal trials like last year as IVHT and AVHT)
4. Late kharif: IHT, AHT, IVT, AVT (If number of entries are less we will be clubbing hybrid and varietal trials like last year as IVHT and AVHT)
5. Rabi: IHT, AHT, IVT, AVT (If number of entries is less, we will be clubbing hybrid and varietal trials like last year as IVHT and AVHT) and Parental line trials.
6. Parental line trials: All those from public sector need to submit all three parents of each hybrid sent for testing (min. 0.5 kg seed).
7. Agronomy and physiology trials: For grain, dual purpose, sweet and forage sorghums as per the experimental plans
8. Single-cut, multi-cut forages and any special purpose types: Discuss with PC.

All the entries will be included in breeding, pathology and entomology trials.

B. Calendar

Activities	Tentative dates
Submission of trial entries	01 April (Multi cut); 15 April (Kharif & Late kharif); 05 August (Rabi)
Dispatching of seeds to centers	15 April (Multi cut); 15 May (Kharif); 30 July (Late kharif); 20 August (Rabi)
Report on sowings and plant stand	15 July (Kharif), 20 September (Late kharif) and 15 October (Rabi)
Shoot fly data	As per plan provided by PI, Entomology
Submission of final data	30 November (Kharif), 30 January (Late kharif) and 15 March (Rabi)
Completion of statistical analysis of the data	10 January (Kharif); 07 February (Late kharif); 20 April (Rabi)
Completion of all reports in bound form	25 February
Next AGM	April
Proceedings of AGM	30 April



C. Special instructions and specific actions (*a calendar is separately issued*)

- Periodic reports are needed from the Centres so that the PC is able update the ICAR Hqs. on sorghum situation in the country.
- Calendar of activities: The program is suffering because of non-adherence to the schedule, especially to dispatch data on coordinated trials. This calls for immediate remedial action.
- SOEs and AUCs must be very promptly submitted. (So far, compliance on this ground is very poor).
- Uniformity in reporting and data recording is a matter of concern, in spite of guidelines being circulated repeatedly. Please use standard format, terminology and SI units.
- Detailed pedigree of a test entry is a must: Without which no entry will be included in trials.
- Submission of all parental lines (A, B and R) of all advanced entries with their pedigree details: is a must for conducting parental line trials. Without parental lines for PLT trials, entries for hybrid trials will not be accepted. Ideally, you need to gather DUS data as soon as a good line is identified.

D. Sources of errors and how to avoid them

- Don't treat the seeds of any entries: Seed treatments influence the outcome of pest and disease resistance trials. All treated entries will be summarily rejected.
- Please fill all the fields in your data sheets: Absence of information creates problems for interpretation.
- Please follow suggested plan strictly: Your own modified plans for experiments are impediments for uniformity in trials. Always plant in time, and plant enough border rows.
- Seeds should have good germination: The seeds with low germinability and vigour leads to poor plant stand and vitiates the experiment and even the ranking of top most hybrids. Seeds having less than 80% germination will be straight away rejected.

E. Pedigree information, and source of original breeding stocks

- There must be compulsorily checked by all public sector institutions. Breeding schemes may also be mentioned such as MABC, derived from RM populations, etc., with all essential details.
- From private sector also we invite all above information. Detailed pedigree and breeding scheme is compulsory for any repeated test (like AVHT).
- We urge all to collect data on DUS characteristics even before submitting seeds.



Appendix II: Proforma for submission of entries for AICSIP trials

(2 pages)

To

The Project Coordinator (AICSIP)
Directorate of Sorghum Research
Rajendranagar
Hyderabad- 500 030

Sub: Details regarding submission of entries for AICSIP Trials

1. Kindly find attached here with the details, in the enclosed proforma, of our entries (*including detailed pedigree for all centres, and Testing fees# @ Rs. 60,000/- plus service tax per entry per season for all private company entries as per ICAR norms*) for testing in AICSIP Kharif / Late Kharif/ Rabi* multi-location trials (IVT/AVT/IHT/AHT)** of kharif grain / rabi grain / single-cut forage / multi-cut forages / sweet sorghum. It is certified that the information submitted is true to the best of my knowledge.

Thanking you,

Sincerely,

(Signature of Station I/c./DR/CEO /
authorized signatory of the company)

2. Name : _____
Designation : _____
Institute/ : _____
Company : _____
Address : _____
: _____
Tel/Fax/E-mail : _____

(Seal/ Stamp)

*Strikeout which is not applicable

(Turnover to next page (landscape))



3. Name and address of the scientist submitting entries

Name : _____ Designation : _____
Telephone: _____ Fax: _____ E-mail : _____

S. No	Name of the entry (station code)	Name of the trial and the Zone for which it is a entry§	Detailed Pedigree of hybrid/ variety**	DUS characteristics	Breeding method & stage (F7 etc.)	Quantity of seed submitted(Kg)	Seed germination (%) at the time of submission of entry	Testing fees total (Rs.)	DD No. and date; Name of bank on which DD is drawn#
<p>1. Please note that entries should not be treated with any chemicals. Treated seeds are summarily rejected.</p> <p>2. Seed quantity to be submitted without fail: IVT-10 Kgs. IHT-10 Kgs. AVT-15 Kgs. AHT-15 Kgs. For large plot agronomy trials of advanced entries: 25 Kgs.</p> <p>3. Your entries may not be accepted if:</p> <ol style="list-style-type: none"> Quantity is less than specified; Germination after receiving is less than 85%; Seed is a mixture, or treated with chemicals; Not received before deadline. <p>4. Please do not ask for extension of date for submission of seeds (date on which it reaches DSR only will be considered).</p> <p style="text-align: right;">IVT - Initial Varietal Trial; AVT - Advanced Varietal Trial; IHT - Initial Hybrid Trial; AHT - Advanced Hybrid Trial</p>									

4. Name of the entry and detailed pedigree

*Strikeout which is not applicable; § Trials: IVT, IHT, AVT, AHT, preliminary DUS Testing; Zones: I/II/III/All Zones

** Entries without detailed pedigree are not accepted from public sector; parental lines (min. 500 g seeds) of hybrids must also be provided;

Private companies entries are accepted only along with DD for testing fees @ Rs.60,000/-plus service tax per trial/season as per ICAR norms; Even for private, providing pedigree details is compulsory from 2nd year of testing.

(Signature & date)

(Seal / Stamp)



Appendix III: Information on parental lines / entries submitted

*(AICSIP centre scientists to note: Without parental lines no hybrid will be accepted as entry in trials)
(minimum quantity to be submitted: 100g)*

S. No.	Name of the parental line	Pedigree	Year/Season of production	Seed grading done? Yes/No	Seed treatment done? If yes, with what chemical and concentration? Why this was done in spite of instructions to the contrary?

Certified that the above information is true to the best of my knowledge and I hereby confirm the same.

Signature : _____
Name : _____
Centre/company : _____
Address : _____
_____ Pin: _____
Telephone : _____
Fax : _____
E-mail : _____

(Authorized signatory & date)

Name & e-mail of authorized signatory: _____

**Appendix IV: New CVRC proforma of release and notification proposal**

S.No.	Item	Page no.
1	Title page	
2	Provide clear photographs of: A. Field view of crop B. Plant close-up C. Ear-head/Panicle (close-up) D. Grain (close-up)	
3	Summary of Proposal	
4	Proforma	
5	Summary yield data of coordinated varietal trials	
6	Adaptability to agronomic variables	
7	Reaction to major diseases	
8	Reaction to insect pests	
9.	Data on quality characteristics	
10.	Data on other important characters	
11.	Parentage and pedigree	<i>Annexure I & II</i>
12.	DNA profile of variety*	<i>Annexure III</i>
13.	DUS - Descriptors of variety	<i>Annexure IV</i>
14.	Copy of allotment of IC numbers from NBPGR*	<i>Annexure V</i>
15.	Copy of recommendation of workshop*	<i>Annexure VI</i>
16.	Package of practice	<i>Annexure VII</i>

* This proforma can be used for VIC also, except for the marked ones.

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