REPORT OF THE AICRP ON SORGHUM COORDINATING TEAM
2014-15

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Prelude from Project Coordinator

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Sorghum and other millets are very crucial to the world food economy because they contribute to household food security in many of the world’s poorest, most food-insecure regions. Sorghum is one of the most important cereal crops of India, cultivated in about 8 million hectares annually. Sorghum provides highly nutritious food, feed and fodder and has great potential for industrial use as bio-ethanol for fuel. As principal crop of dryland, it is popular with farmers due to assured grains and fodder yields for low-input cultivation, under harsh weather, especially in drought.

It gives me a great pleasure to announce that the Council (ICAR) has upgraded “Directorate of Sorghum Research” (IIMR) into “Indian Institute of Millets Research” (IIMR), through the integration of mandate and objectives of All-India Coordinated Research Projects on sorghum, pearl millet and small millets under one umbrella of IIMR. As usual, IIMR coordinates and facilitates sorghum research at national level through All India Coordinated Research Project on Sorghum (AICRP on Sorghum), and provides linkages with various national and international agencies. It is also pertinent to reveal here that Indian Institute of Millets Research received an ISO certification for the quality management system in research and development to improve productivity and profitability of sorghum.

IIMR’s utmost priority is ensuring global competitiveness of farming sorghum and other millets in India through enhanced grain production, quality seed production, value-addition and promotion of alternate uses such as health foods, feed, quality stover, green fodder and fuel (bio-ethanol). For this, the institutional mechanisms are in place, and in line with ICAR’s policy on protection of IPR and commercialization. Implementation of this policy creates a common platform with trade, industry and farmers for creating a cooperative and competitive environment for enhanced use of sorghum for food, feed and industrial products like bio-ethanol from sweet sorghum, potable alcohol from molded sorghum grain, and sorghum for poultry and animal feed, in addition to production of ethanol from ligno-cellulose is also envisaged. Licensing and commercialization of nationally developed sorghum cultivars and other technologies are on non-exclusive basis.
Our prime concern is also on developing forage hybrids with higher biomass, better digestibility and resistance to biotic stresses. Strengthening seed delivery systems, greater seed replacement rate, and strengthening of community-based services including seed production, input-supply and marketing support are expected to promote cultivation of sorghum, which in turn supports the cause of millions of dryland farmers livelihoods. On the other side, Rabi sorghum cultivation in recent times has become more remunerative. Research on drought tolerance is now focused on development of early maturing rabi sorghum varieties and identification of QTL for terminal drought tolerance traits.

Now-a-days, sorghum is becoming more popular as a health food, especially in urban areas. Sorghum grain has high fibre content, moderate digestibility and rich mineral content compared to other cereals such as rice and wheat. Hence, sorghum foods are recommended for diabetic and obese persons. Being free from gluten, sorghum is the ideal food for celiac patients. To create greater demand for millets, especially sorghum for foods, we are working through the INSIMP involving public-private partnership by creating value chains.

Sorghum and other millets will very soon find its appropriate place especially in the context of future challenges such as, global warming, scarce water supply, needs for new raw materials, and increasing health awareness among urban and rural public. In this circumstance, we need to reinforce our efforts in sorghum research by innovative research strategies and continue to develop cultivars and technologies suitable for specific end-uses.
1. Genetic resources management & IPR (M Elangovan)

Indian Institute of Millets Research (IIMR) is one of the National Active Germplasm Sites (NAGS) with the responsibility to collect, conserve, evaluate, document, and distribute the sorghum germplasm to the bonafide user within the country. The IP protection of the IIMR is managed under ICAR project on Intellectual Property & Technology Management (IP&TM). The plant variety protection of sorghum genotypes are managed under the DUS test project sponsored by the Protection of Plant Varieties and Farmers Rights Authority (PPV&FRA). The progress made during the reporting period 2014–15 is as follows.

1. Germplasm collection / assembling

- A total of 650 acc. augmented from other national and international centres during 2014 – 15.
- Pearl millet (40 acc.), Finger millet (118 acc.), Foxtail millet (89 acc.), Proso millet (118 acc.), Kodo millet (86 acc.), Little millet (79 acc.), Barnyard millet (93 acc.), Wild sorghum(26 acc.)

2. Evaluation of pre-breeding material

2.1: Kharif 2014:

2.1.1: Evaluation of forage segregating material (F2s): The following eight crosses were found very good viz., CSV 23 X IS 14357, IS 12748 X IS 14357, IS 12965 X IS 23992, IS 37046 X IS 14357, IS 40997 X EJN 41, IS 41003 X IS 14357, IS 40961 X IS 14357, and IS 40957 X IS 12195. A total of 27 crosses were found as very good. There were 7 early flowering crosses, 18 high biomass, 1 high biomass and early flowering, 9 tillering crosses and 1 tillering and early flowering crosses. A total of 146 F2s were selected based on forage traits such as high biomass, long leaves, more number of leaves and advance to F3.

2.1.2: Developing pre-breeding material for forage and high biomass: The mini core collections and indigenous collections were used to develop pre-breeding material for forage and high biomass. A total of 57 crosses were made.

2.2: Rabi 2014-15:

2.2.1: Pre-breeding material for forage and high biomass from mini core collections: A total of 56 F1s were sown for multiplication. 24 F1s were failed to germinate and 33 F1s were harvested. 26 F1s were found very good for forage and biomass traits

2.2.2: Segregating F3 material for forage and high biomass: A total of 146 F3s were evaluated for forage and biomass. 280 selections were made from 52 crosses and advanced them to F4.

3. Sorghum genetic stocks distribution

- A total of 1053 acc. distributed to the bonafide user in the country. In which, 138 acc. distributed to DSR scientists, 116 F2s and 40 F3s of segregating material and 61 germplasm to AICSIP scientists, 10 acc. to University, 180 derivatives to ICRISAT

4. Plant Variety Protection and genetic resources registration

4.1: Sorghum varieties registered with PPV&FRA: A total of 102 applications were submitted to PPV&FRA. 61 sorghum varieties certificates were received from PPV&FRA so far.

4.2: Sorghum varieties registration certificate awaited: Seven sorghum varieties registration certificates are awaited from PPV&FRA.

4.3: Sorghum varieties under DUS testing: Six sorghum varieties are under DUS testing. Two sorghum varieties are in Rabi 2014-15 first year DUS testing and 4 has completed kharif 2014 first year DUS testing.

4.4: Sorghum varieties closed for various reasons: The applications of 8 sorghum varieties were closed due to various reasons. Seven applications were closed due to the completion of 15 years from the date of notification one application closed due to non-availability of seed.

4.5: Sorghum varieties applications pending with PPV&FRA: There are 22 sorghum varieties pending with PPV&FRA. In these, 9 are new varieties.

5. Intellectual property management

5.1: Management of IP portfolio: Applications for 2 patent protection, 1 design protection and 8 trademark applications were made during 2014-15.

5.2: Genetic stocks registration with NBPGR: A total of 21 sorghum genetic stocks applications made for registration with NBPGR during 2014-15, which includes 6 A and 6 B lines. There were 1 shoot fly resistant line, 1 brown midrib line, 6 AB pairs, 5 R lines and 2 varieties.

5.3: Commercialization of technologies: One MoU for sorghum value food products and one MoA for licensing and commercialization of CSH 24MF were signed during 2014-15. Second installment licensing fees from 2 MoAs signed during 2012-13 were received. A total of 10.00 lakhs received as revenue through licensing.
6. Publications during 2014-15
- Four international journal papers, one national journal paper, one abstract, four short communications, five books/technical bulletins and one reports published.
- Two trainings and four ITMU meetings organized, six lectures delivered

2. Forage Sorghum (C Aruna)
Introduction: During 2014-15 three multilocation trials, one 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). Two 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: Initial and Advanced Varietal and Hybrid trial (Single-cut)*
- Sixteen genotypes comprising of 5 hybrids and 11 varieties along with 2 varietal checks (CSV 21F and CSV 30F) and one hybrid check (CSH 13) were evaluated at 15 locations during kharif 2014.
- Among the entries in second year of advanced testing, SPV 2191 and SPV 2185 were promising with about 10% improvement in green (533 q/ha and 528 q/ha) and dry (162 q/ha) fodder yields over the best check, CSV 30F.
- SPV 2191 and SPV 2185 were also promising for per day productivity and forage quality in terms of protein yield and digestible dry matter yield.
- The initial variety, SPV 2315 was the best among all with more than 10% increase in both green (541 q/ha) and dry (163 q/ha) fodder yield and high per day productivity.
- Among single-cut hybrids, SPH 1752 (564 q/ha of GFY, 166 q/ha of DFY) and SPH 1797 (566 q/ha of GFY, 177 q/ha of DFY) were promising for fodder yield and quality.

*Trial 2: Initial and Advanced varietal and hybrid trial (Multi-cut)*
- Twelve entries including 6 test hybrids, 2 test varieties, 2 hybrid checks (CSH 20MF and CSH 24MF) and one variety check (SSG 59-3) were evaluated over 13 locations.
- The hybrid SPH 1768 (1086 q/ha GFY; 281 q/ha DFY) was the most promising hybrid with more than 5% improvement for fodder yield over the checks, CSH 20MF and CSH 24MF.
- Per day productivity of green and dry fodder yields of SPH 1768 was also high. The fodder quality of SPH 1768 in terms of protein yield and DDM was good.
- The multi-cut variety, SPV 2242 recorded superiority for green (1130 q/ha) and dry (276 q/ha) fodder yields compared to the check, SSG 59-3. Its per day productivity of green and dry fodder was also 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 among the varieties.
- SPV 2242 recorded good level of resistance to stem borer and leaf diseases when compared to SSG 59-3 in entomology and pathology trials.

*Trial 3: Advanced seed yield trial*
- Seven genotypes including three single cut test varieties, one multi-cut variety and two single cut national checks (CSV 21F and CSV 30F) and one multi-cut check (SSG 59-3) were evaluated for grain yield potential at five locations.
- The single-cut varieties, SPV 2191 (1734 kg/ha) and SPV 2188 (1718 kg/ha) were found to yield more grain compared to the check, CSV 30F at all India level.

B. Co-ordinated forage sorghum research

*Trial 4: Evaluation of Sudangrass germplasm lines*
- Eighteen sudangrass germplasm lines including the check, SSG 59-3 were evaluated in RCBD with 2 replications in 3 locations.
- The genotypes, IS 14278 and CO(FS)29 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.
- Leaf components like long broad leaves with more leaf-stem ratio were observed in IS 30209, IS 14278 and Pant Chari 9.
- More number of tillers were observed in IS 3266, SGL 87, SGL 70 and CO(FS) 29.
- High protein yield and high DDM were observed in CO(FS) 29, SGL 60 and IS 14278.
- Over two years, CO(FS) 29, IS 14278 and Pant Chari were promising for fodder yield, while SGL 87 and IS 30209 were promising for IVDMD.
Trial 5: Evaluation of brown midrib lines

- Twenty brown midrib lines including three checks (HC 308, CSV 21F and SSG 59-3) were evaluated in RCBD with two replications in three locations for fodder yield and quality traits.
- The brown midrib germplasm line, EC 582508 and the advanced breeding nursery lines, PBMR 4 and PBMR 6 recorded high IVDMD values.
- The advanced breeding nursery lines, PBMR 1 and DSRBMR 1 recorded high fodder yield compared to the checks.
- Over two years, the brown midrib lines EC 582504 and EC 582508 recorded high IVDMD values, while the advanced breeding nursery lines PBMR 1, PBMR 3 and PBMR 4 were promising for fodder yield and quality.

Overall conclusions

- In IAVHT (SC), the advanced varieties SPV 2191 and SPV 2185 were promising for fodder yield with about 10% increase in fodder yield over the best check.
- Over three years, SPV 2191 was promising for fodder yield, per day productivity and fodder quality in terms of protein yield and digestible dry matter yield.
- Among the initial varieties, SPV 2315 was the best for green and dry fodder yields, per day productivity and fodder quality.
- Among the single-cut hybrids, SPH 1752 and SPH 1797 were promising for fodder yield and quality. Their per day productivity was also high compared to CSH 13.
- In IAVHT (MC), the hybrid SPH 1768 was found promising for both green and dry fodder yields over the checks, CSH 20MF and CSH 24MF. Its per day productivity of green and dry fodder yields was also high compared to the checks.
- The multicut variety, SPV 2242 recorded more than 10% increase in fodder yield over the check, SSG 59-3. It had more tiller number and high regeneration potential compared to all entries.
- The per day productivity and fodder quality in terms of protein yield and DDM of SPV 2242 were high compared to SSG 59-3.
- In the advanced seed yield trial, the single-cut variety, SPV 2191 was found to yield more grain among all the single-cut test entries at all India level.
- In the trial on evaluation of sudangrass germplasm lines, the genotypes IS 14278 and CO(FS) 29 were found promising for various fodder yield traits.
- More number of tillers were observed in IS 3266, SGL 98-1 and CO(FS) 29, while good leaf components were observed in IS 30209.
- Over two years, CO(FS) 29, IS 14278 and Pant Chari 8 were promising for fodder yield; IS 869 and IS 3191 for protein; and SGL 87 and IS 30209 for IVDMD.
- In the trial on evaluation of bmr lines, EC 582508 and the advanced breeding nursery lines, PBMR 4 and PBMR 6 recorded high IVDMD values. The improved lines, PBMR 1 and DSRBMR 1 were promising for fodder yield.
- Over two years, the bmr germplasm lines EC 582504 and EC 582508 recorded high IVDMD values, while the improved lines, PBMR 1, PBMR 3 and PBMR 4 were promising for fodder yield and quality.

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 2015

- Promising genotypes from initial trials of both single-cut and multi-cut types will be evaluated in the advanced trials during kharif 2015
- 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)

In 2014, towards grain sorghum improvement basic and applied researches were taken up at DSR and All India Coordinated Sorghum Improvement Project (AICSIP) centers. As part of applied research multi-location yield trials of newly developed varieties and hybrids from the AICSIP centers and private companies were carried out. In basic and strategic researches focus was given towards development of new MS and R lines, breeding for earliness, drought tolerance, cold tolerance, resistance against key insects and diseases among others. Biotechnological tools as well as conventional breeding methodologies were employed towards this direction. Initiatives on inter-institutional hybrid development and testing yielded promising outcomes.

Multi-location AICSIP trials: During kharif 2014 four trials, viz., Advanced Hybrid Trial (AHT), Advanced Variety Trial (AVT), Initial Hybrid Trial (IHT) and Initial Variety Trial (IVT) were conducted across 9 (initial trials) to 24 locations (AHT).
**Advanced Hybrid Trial:** In this trial 4 hybrids and 4 checks were evaluated across 8 and 16 locations in Zone I and Zone II, respectively. Out of 4 test hybrids 3, viz., SPH 1724, SPH 1736 and SPH 1737 were in AHT II.

- In Zone I only SPH 1724 (4110 kg/ha) performed better than best performing check, CSH 23 (3806 kg/ha) in terms of grain yield, while SPH 1748 recorded highest fodder yield (13041 kg/ha). However, none of them recorded more than 10% grain yield superiority.
- In Zone II SPH 1736 out yielded best check, CSH 25 in terms of grain (4577 kg/ha) and fodder yield (13839 kg/ha).

**Advanced Variety Trial:** In this trial only one variety, SPV 2165 along with 5 checks were evaluated across 8 and 14 locations in Zone I and Zone II, respectively. This candidate variety was in AVT II.

- In Zone I for grain yield SPV 2242 (3504 kg/ha) and SPV 2250 (3412 kg/ha) out yielded best performing check, CSV 23 (3028 kg/ha) by more than 10%. However, none of these could out yield CSV 23 in terms of fodder yield.
- In Zone II no test variety could out yield best check, CSV 20 in terms of grain and fodder yield.

**Initial Hybrid Trial:** In this trial 21 test hybrids along with five checks were evaluated in RCBD for grain yield, fodder yield and other agronomic traits across 9 locations, four in Zone I and five in Zone II.

- In Zone I Full maturity test hybrids, SPH 1773 (4810 kg/ha), SPH 1775 (4775 kg/ha), SPH 1776 (5083 kg/ha) and SPH 1791 (4782 kg/ha) out yielded best check, CSH 16 by nearly 10% or more.
- In Zone II SPH 1788 (4320 kg/ha), SPH 1783 (4064 kg/ha) and SPH 1779 (4005 kg/ha) yielded better than best check, CSH 16 but none of them recorded >10% superiority.

**Initial Variety Trial:** In this trial 17 test varieties and 5 checks were evaluated in RCBD for grain yield, fodder yield and other agronomic traits across 9 locations.

- In Zone I SPV 2294 (3486 kg/ha), SPV 2296 (3702 kg/ha), SPV 2299 (3626 kg/ha), SPV 2301 (3767 kg/ha) and SPV 2305 (3442 kg/ha) recorded 10% higher yield over the best check. None of them recorded higher fodder yield.
- In Zone II SPV 2293 (3004 kg/ha), SPV 2298 (3285 kg/ha), SPV 2307 (3039 kg/ha) and 2308 (3010 kg/ha) recorded more than 10% yield superiority than best check, CSV 20 (2704 kg/ha). None of these could out yield CSV 20 in terms of fodder yield.

**Coordinated sorghum breeding research:** During 2014, in inter-institutional hybrid programme 13 experimental hybrids along with four checks were tested at Indore, Parbhani, Akola and Coimbatore. Only one experimental hybrid SHD 6 found to be promising. Towards development of new experimental hybrids 11 CMS lines were collated. Total 19 new experimental hybrids were developed by three centers. From shared segregating populations a total of 91 families were selected at Deesa, Indore and Surat.

**Kharif sorghum breeding at DSR**

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

- Out of 80 experimental hybrids based on 12 ms and 15 R lines 6 hybrids recorded significant improvement for grain yield over the check, CSH 25. Another set of 20 hybrids yielded more than 10% over CSH25 for grain yield. Seven hybrids had bold seed with less grain mould score compared to the check, CSH 25.
- Seventeen advanced breeding lines evaluated for grain yield and quality over the check, CSV20 showed that PVT 13-14 was the highest yielder with 20% improvement over the check, CSV 20 (4402 kg/ha). Two recorded about 10% increase in grain yield over CSV 20.
- Out of 60 germplasm lines evaluated for grain quality traits against the check C 43 for two years 6 lines recorded high 100 seed weigh, some with semolina recovery up to 48%, two with hard seeds. High positive correlation was observed between seed hardness and semolina recovery.

**Genetic improvement of multi-cut forage sorghum**

- Ten new hybrids and ten new hybrid-derivatives (pure lines) were evaluated along with CSH 24MF and SSG 59-3. Two hybrids exhibited more than 20% superiority over check whereas three pure lines were superior to SSG 59-3 in terms of green forage yield.
- New parental lines 335B and MF2068 were evaluated for cyanogenic potential in foliage at 30, 45 and 60 DAS along with that’s of hybrid CSH 24MF and its parents. All lines possessed HCN levels below threshold of 200 ppm indicating that they are safe for feeding to cattle as green forage under normal conditions.

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

- Advanced derivatives from crosses seven crosses were superior and yielded more than 15% green fodder yield compared to checks.
- A total of 253 selections were made from the F3 and F2 generations.
- Seventy germplasm and elite lines were also evaluated for fodder yield and related traits. The lines SC-FS-13, SC-FS-84, EC 582504, HC 136, IS 10302, GFS 5 were superior compared to checks.
Genetic augmentation of parental lines for grain yield and tolerance of shoot pests and hybrid development in kharif sorghum

- Seventy two crosses out of 105 new crosses were made involving promising advance breeding lines and donors for grain yield, seed size and shoot fly tolerance were selected for further advancement.
- Towards development of new MS lines 155 pairs of test crosses were selected for further backcrossing. BC2 are being advanced during the current rabi season. In addition 30 new promising maintainer × maintainer derivatives are in advanced stages of backcrossing and are being used in hybrid development.
- Out of 70 advance breeding lines isolated from maintainer × maintainer crosses, nine genotypes were superior over check 27B. Four advance breeding lines were early
- Nine advance breeding lines were found superior to check CSV20 with 30-60% grain yield advantage, which can be further evaluated.
- Out of the 110 experimental hybrids 10 were superior to check CSH16. Four new cross combinations were tested under high input conditions of rice-fallows.
- Segregating materials in different generations (F3-F7) were advanced and about 275 selections were made for further evaluation.

Molecular tagging of a fertility restoration (Rf6) gene for A1 and A2 CMS systems in Sorghum

- A2 CMS was found to be a better alternative to the widely exploited A1 (milo) CMS in F1 hybrid industry. A new gene for male fertility restoration, Rf6, in sorghum was mapped on chromosome 4 with its ability to restore fertility on both A1 and A2 CMS systems using F2 populations of 27A x M35-1 and A2 x M35-1 crosses. The gene, Sobic.004G004100 is a member of pentatricopeptide gene family.
- Detailed sequence analyses of selected homologous regions of several grass genomes have shown significant conservation of gene order within the grasses. The gene encodes RNA-binding protein with 200 aa chain, and is orthologous to gene GRMZM2G163247 (Zea mays), Si018291 (Setaria italica), Pavir.Aa03572.1 (Panicum virgatum), Pavir.Ab00051.1 (Panicum virgatum), Os02g01480.1 (Oryza sativa) and Bradi3G00804 (Brachypodium distachyon) with same molecular function.
- Sequence comparison of the CDS and peptide sequences of parents showed deletions and insertions in non-restorers leading to truncated peptide. The linked marker, MS-SB04-266 was validated in a set of 37 genotypes and could be employed for selecting potential restorers on both A1 and A2 cytoplasts.

Development of mapping populations

- Towards identifying QTL for various economic traits like charcoal rot, stem borer, shoot fly, 3 recombinant inbred line populations are being developed.

Collation, evaluation, documentation and utilization of sorghum genetic stocks

- In three station hybrid trials 108 experimental hybrids were tested and 19 found promising.
- 74 R lines and 20 B lines were evaluated and 15 and 9 promising R lines and B lines were identified, respectively.
- Towards new R and B line development respectively 61 and 36 families were selected from segregating populations.
- Grain mold derivatives from crosses 296B x RIL 98 (4 Sel.), 296B x RIL 25 (5 Sel.) and GMN 58 x RIL 25 (3 Sel.) were advanced to F5 generation.
- For earliness out of 45 B x B derivatives, five were selected and test crossed to elite A line.
- 10 genetic stocks were blindfold tested for grain mold response and all recorded field grain mold score near to resistant check.
- 75 R lines, 31 B lines and 16 genetic stocks were DUS characterized.

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

- A total of 10 F6 derivatives (B x B and R x R) were evaluated for earliness, plant height (cm), grain yield per plot (kg) and fodder yield per plot (kg). Two genotypes recorded earliness coupled with superior performance for grain yield as compared to the early check (CSV 17).
- A total of 52 BC2 crosses were evaluated and promising 22 pairs were advanced to BC2 generation. About 34 promising and nearly stable AB pairs again backcrossed to advance it to BC4 generation. These 34 B lines were also evaluated along with early duration checks (AKMS 14B and 2219B).

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

- [(SSV 84 x (SPV 462 XIS 21891)-3-1-1)]-1-1 and (SSV F7-2)-1-3 were promising for most of the sweet sorghum productivity traits and can be tested under multi-locations.
- The entries viz., [(CSV 15 X IS 21891)-6-1-1 X ATLAS )]-1-5 and [(BN 111 X (CSV 15 X IS 21891)-6-1-1)]-1-1 exhibited high fresh and dry biomass yields while [(CSV 15 X IS 21891)-6-1-1 X ATLAS )]-1-3 was promising for brix too apart from biomass yields.
Development of novel pre-breeding lines through wide hybridization in sorghum

- Twenty four high biomass segregants from maize-sorghum crosses were evaluated along with SSV 84 and CSH 22SS as checks. Four genotypes with the high brix were on par with the best check SSV 84. One derivative was also on par with the best check SSV 84 for fresh fodder weight and 6 were superior to CSH 22SS for plant height.

Kharif sorghum breeding at AICSIP centers

Akola

- In grain breeding programme total 40 IPS were selected in R line development programme while in B line development programme 31 IPS were selected. Total 25 BC pairs were made in grain breeding programme. Eight new four way crosses have been made in selected single crosses in F2 Generations during kharif 2014-15.
- In grain mold resistance breeding programme, total 46 IPS were selected in R line development programme while in B line development programme 15 IPS were selected. Total 23 BC pairs were made in grain breeding programme.
- In shoot fly resistance breeding programme, total 1 IPS was selected in R line development programme while in B line development programme 17 IPS were selected. Total 13 BC pairs were made in grain breeding programme. In order to get new recombinations, 12 new four way crosses (Biparental crosses) were made during Rabi 2014-15.
- Total 7 Station Hybrid/Varietal Trials were successfully conducted. Besides these trials, one Private Hybrid Testing Trial consisting of five hybrids from the private companies were evaluated. Total 5 AICSIP trials were allotted to this centre and were conducted successfully and data submitted to project.
- During kharif 2013, the maintenance of A, B, R lines, experimental hybridization programme and varietal selection programme was carried out.
- One Ph.D. and two M.Sc. students are doing their research work at this unit. Total eight research papers have been published in the NAAS rated journals. Nine popular articles were also published. Two scientist form this centre received three awards.

Coimbatore

- The culture TNS623 (2219B x SPV 1390) is dual purpose, short duration, with average grain yield potential is 2742 kg/ha and moderately resistant to shoot fly and stem borer is in third year evaluation in Adative research trial.
- TNS 660 with grain and fodder yield potential of 3892 kg and 15037 kg/ha with increased yield potential of 19.4 and 27.4 percent respectively with favorable plant height of 189 cm has been promoted to multi location trial.
- Among three cultures tested in multi location trial, TNS 648 recorded average grain yield of 2531 kg/ha with yield increase of 12 percent over the check Co 30 has promoted MLT testing in second year.
- Two promising hybrids viz., ICS12A x ICSR 89020 and MS 70A x CO30 with grain yield of 2839 and 3332 kg ha has been identified for UVT trial.
- In forage sorghum breeding the multi cut line TNFS 209 which was selected from the mutant of CoFS 29 was promoted to AVT-II of AICSIP trials. The single cut entries TNFS 204 and TNFSH 205 were evaluated in AICSIP trials and MLT in Tamilnadu. Some of the other promising lines selected from the crosses viz., Co26/IS 4646-3-1-1-2, APK1/M35-1-2-2-3 and Co26/IS 4646-3-3-1-1 are being evaluated in replicated yield trials. These lines recorded the green fodder yield of more than 35t/ha.
- The segregating material of 92 cross combination under R line development programme, 5 in B line development programme and 55 crosses under trait specific development programme are under various stages of evaluation. Published one research paper.

Deesa

- The experimental year showed different temperature regimes, humidity, rain fall and sunshine hours. A total rainfall of 832.6 mm with 21 rainy days was obtained with maximum in September and July and highest rain was observed in the 36 week-03-09 Sept. (462.8 mm) when the crop was in flowering stage. During the crop season the weather was conducive for the crop growth and development.
- Under breeding programme 45 crosses of dual sorghum was attempted and 10 F1s of forage sorghum were evaluated.
- Under the generation advancement progenies of different dual and forage crosses were evaluated and selections were made on the basis of desirable characters viz., earliness, shoot fly resistance, agronomic superiority, forage and dual type.
- Under germplasm maintenance and evaluation programme a total of 392 accessions of forage and dual type sorghum were maintained, 51 accessions evaluated and 136 new germplasm collected during Kharif 2014-15.
- Apart from six coordinated trials two station trials, five state (Multi location) trials, six of dual, grain and forage sorghum were conducted during 2014-15. Twenty three Front Line Demonstrations taken in Sorghum growing area of North Gujarat and 50 demonstrations taken for schedule tribes under TSP programme.
- Produced breeder and truthful seed of different crop varieties by the center. Published three research papers and one popular article.
Dharwad

- The delayed on set of rainfall during kharif 2014 has resulted in late planting of trials leading to realization of poor yield compared with timely sown crop.
- Five ICAR trials (IVT, IHT, IJHT, and AVT & AHT) were conducted & these trials comprised of three varietal & two hybrid entries contributed from Dharwad centre. Apart from this, two multilocation and six station trials were also conducted.
- Among 16 varieties tried, as many as eight varieties recorded significantly superior grain yield over check DSV-6, among these, SVD-722(4473kg/ha), SVD-1212(4139kg/ha) SVD-1203 & SVD-1204 recorded higher grain yield compared to DSV-6(2673.0kg/ha) and further SVD-0722 and SVD-1203 recorded higher seed mass of 3.93g and 3.87g respectively.
- Among 13 hybrid tested, hybrid SHD-6 and SHD-62 recorded significantly superior grain and fodder yield compared to CSH-14 check hybrid(3964kg/ha and 10.6 ton ). The hybrid SHD-6 (17.3 ton/ha) also recorded significantly superior fodder yield with 100 seed mass of 3.33g.
- Among 16 varieties evaluated in AVT I, none of the varieties recorded significantly superior grain yield over DSV-6, however SVD-0714 and SVD-1130 recorded higher grain yield of 1971 & 1960 Kg/ha respectively as against 1644 Kg/ha of DSV-6 and further SVD-0714 recorded significantly superior fodder yield and highest 100 grain weight (3.649g).
- Among 16 hybrids evaluated in SHT I, SHD-71 hybrid recorded higher grain yield of 5612 Kg/ha, significantly superior fodder yield (16.4ton/ha) and higher 100 seed weight (3.07g) compared to CSH-14(4945 Kg/ha, 10.4ton/ha & 2.74g).
- Under National network project on CRP on Agro-biodiversity - Sorghum (Component - I), 750 germplasm lines were characterized as per protocol. As many as 66 crosses were advanced to F2 and 128 IPS/family selections were made in various generations from F2 to F6 and 80 M4 progenies were evaluated for grain size and grain yield. As many as 229 germplasm lines of center were maintained apart from 18 new hybrids were produced using three line methods.
- Published two each research papers and popular articles and one folder.

Hisar

- During kharif 2014 AICSP trials including IAVHT-MC, IAVHT-SC, entomology trials (including sweet sorghum trial, multicut trial, single cut trial and dual purpose trial) and agronomy trials were conducted successfully.
- Among station trials 62 MS based hybrids were evaluated. In Progeny Row Trial and Small Scale Trials 26 and 45 genotypes were tested respectively and among them some promising genotypes were selected. One genotype S 652 has been submitted to DSR for upcoming AICSP-SC trial. Some landraces from Mewat area was collected.
- During kharif 14, four research papers, one popular article and two book chapters have been published. “Farmer Scientist Interaction Meet” was organized in Nuh, Mewat, Haryana on 27th March 2015 to aware farmers about seed production of forage sorghum and good cultivation practices of sorghum production. Hisar center has submitted one genotype for multicut trial 2015 and one more S 692 will be submitted for SC trial in K 2015.

Palem

- In varietal development, CSV 31 (Palamuru Jonna), a high yielding dual purpose sorghum variety with tolerance to grain mold disease, was identified for national release and the proposals were submitted for notification and release by CVRC. One high yielding dual purpose sorghum culture SPV 2242 (PSVGS 316) is in AVT-I stage and two sorghum cultures viz., SPV 2293 (PSVGS 512) and SPV 2294 (PSVGS 520) were evaluated in IVT during Kharif 2014-15.
- In Hybrid development programme, 14 R lines and 17 B lines for various important characters are in F7/F6 stage of development. These lines are derived from the material supplied by Directorate of Sorghum Research under Network Breeding Programme.
- In Station level breeding programme, three trials were conducted during kharif 2014-15. In AVTGS-II – 8 entries, in AVTGS-I – 5 entries and in IVTGS - 3 entries were found to be superior for grain and fodder yields compared to the check PSV-56. Further, all the AICSP breeding trials were conducted during kharif 2014 without any deficiency.

Pantnagar

- Six good single cut/ dual purpose forage sorghum varieties, two multicut varieties and two multicut hybrids with high yield potential, disease resistance and high nutritive value have been released so far. One multicut variety UTMC 539(Pant Chari 9) has been identified for release at State level. The major mandate of the centre to develop high yielding, foliar disease resistant, highly nutritious single cut forage/ dual purpose varieties and CMS based multi cut forage sorghum hybrids. Basic genetic studies are being conducted on inheritance of yield and nutritional quality parameters viz: protein, dry matter digestibility, sweetness/ juiciness of stem and anti-nutritional factors such as HCN, tannin and fiber, for holistic fodder improvement breeding program.
- In view of the great popularity of multi cut forage sorghums hybrids among the farmers and dairymen, the on-going research efforts are mainly focused at the development of high yielding multi cut hybrids. Development of three way cross multi cut hybrids and red grain type cut/single cut hybrids are the new avenues of research being addressed currently. Three new experimental three way cross hybrids with the single crosses viz. ICSA 351 x ICSB 467, ICSA 467 x 104 B and, 2219 A x ICSB 467 ) each crossed with Pant Chari 6 as the pollen parents have been incorporated for multi location testing in AICSP Trial. In view of more popularity of colored grain hybrids of forage sorghum developed and sold
in the market by the private seed companies. They newly incorporated three way cross hybrid (ICSA 351 x ICSB 467) x Pant Chari 6 has dark red color bold seeds.

- A collection of 464 germplasm lines and advanced generations of forage, grain and dual purpose types were maintained at the centre. A core collection of elite germplasm lines and advanced generations was used in hybridization programmes to attempt 40 new inter-varietal crosses for improving foliar disease resistance, fodder yield and nutritional quality. About 23078 single plant progenies (SPPs and progeny bulks) of different generations (F1 onwards to advanced) belonging to 249 crosses were planted for evaluation of which 1569 single plant selections (SPS) and bulk selections (BS) were made from 166 crosses.

- A collection of 146 A/B pairs of CMS lines with fodder attributes were planted for maintenance and use in multi cut hybrid development programmes. Under CMS development/CMS conversion programme, nineteen new B x B crosses have also been attempted to develop early flowering and good combiner CMS lines with coloured grain.

- Progenies of crosses between BMR (brown midrib) x GMR (green midrib) genotypes, having the tan plant color with brown midrib, less disease and other fodder attributes, have been selected in F0 and F1 generations. Several good single cut/dual purpose type BMR derivatives have been identified for their multi location evaluation under AICSIP.

- Guiding four Ph. D. Students and two M. Sc. Students and published 5 research papers.

Chari 6 has dark red color bold seeds.

- For shootfly breeding 96 and 71 SPS were made for R and B line improvement respectively. 42 back cross pairs were attempted in 12 inbred lines of 296 B X PKV 801 cross for developing high yielding grain mold, tolerant A lines.

- 17 hybrids were developed on 7 CMS lines under inter institutional hybrid development programme.

- Total 6 station hybrid / varietal trials were conducted along with private company hybrid trial.

- 9 AICSIP trials were allotted and all were conducted successfully during Kharif 2014.

- Total 5 entries were contributed to different AICSIP trials from this center.

Parbhani

- One hundred fifty six single plant selection were made in R lines from 91 segregating populations. In B line development programme 101 single plant selections were made from 74 segregating populations.

- In grain mold resistance breeding 97 SPS for R line improvement and 114 SPS for B line improvement were made in different generations.

- For shootfly breeding 96 and 71 SPS were made for R and B line improvement respectively. 42 back cross pairs were attempted in 12 inbred lines of 296 B X PKV 801 cross for developing high yielding grain mold, tolerant A lines.

- 17 hybrids were developed on 7 CMS lines under inter institutional hybrid development programme.

- Total 6 station hybrid / varietal trials were conducted along with private company hybrid trial.

- 9 AICSIP trials were allotted and all were conducted successfully during Kharif 2014.

- Total 5 entries were contributed to different AICSIP trials from this center.

Phaltan

- Towards development of promising sweet sorghum varieties and hybrids which yield high biomass and sugar and have tolerance to shoot fly and stem borer F8 progenies were evaluated along with the varietal checks CSV-19-SS and CSV-24-SS. Line (DC-24)-27-1 gave higher total biomass and brix (71.2 t/ha, 18%) than the check CSV-19-SS (62 t/ha, 17%). (DC-24)-17 gave higher brix and juice weight (19% and 3.17 t/ha) than CSV-19-SS (17%, 2.76 t/ha). Total sugar index of (DC-24)-27-1 and (DC-24)-17 (3.9 q/ha, 4.6 q/ha) was also higher than the checks CSV-24-SS (3.18) CSV-19-SS (3.38). (D-118)-69-4 had higher brix (18.5%), juice extraction percentage (37.3 t/ha) than the check CSV-19-SS (17%, 35 t/ha). (D-118)-70-3 and (D-118)-75-7 both showed higher brix values i.e. 18.17% and 18% than both the checks (17%). All three lines were more tolerant to shoot fly damage (5%, 5.33%, 6.67%) than CSV-19-SS (8%) and CSV-24-SS (7%) and also had higher tolerance to stem borer damage (0.67%, 2.67%, 2%) than the check CVS-19-SS (3.67%).

- The F2 populations received from DSR under network breeding programme have been advanced to F8 generation. Thirty four lines were evaluated during Kharif 14 and eight lines showed higher brix values than the checks. The range of values was from 19.33% (10R-SS-20-1-100-6-5) to 20.33% (10R-SS-20-109-2-1) with the brix values for checks being 18.5% and 17.5% for CSV-24-SS and CSV-19-SS respectively. Fifty five lines were evaluated as Pre Varietal Trial entries in four different trials. In Trial 1 the entries (D-91)-29-2, (D-91)-67-5 and (D-169)-50-3 had higher brix values (21.83, 22.25%) than the checks CSV-19-SS (19.5%). In Trial 2 (D-49)-53 showed higher brix value (21.17%) than the check CSV-19-SS (19.33%).

- Towards development of high biomass, high sugar, shoot fly and stem borer tolerant maintainers for hybrid development in sweet sorghum BC8-5-1-3-3-2B showed promising performance with higher biomass (64.02 t/ha), juice weight (38.12 t/ha), juice brix (19%) than the parental lines NARI --SS-5B (46.88 t/ha, 18.47 t/ha, 14%) and NARI-SS-11B (31.38 t/ha, 17.47 t/ha, 14%).

- Towards development of high brix sweet sorghum CMS lines most of the B lines performed better than the parental lines (5A/B; 6A/B and 11A/B) for juice brix, juice yield and juice extraction percentage. Some of the lines (BC8-5-1-1-5-1-3A/B; BC8-5-2-1-3-1-2A/B) showed practically no stem borer damage compared to the parents 5A/B (2%). Brix values of juice for BC8-70-3-3-1-2A/B (21%), BC8-70-3-3-1-1A/B (22%), BC8-59-1-2-3-4A/B (22%) and BC8-3-1-2-1-2-1A/B (22.5%) were higher than that of the parent 5A/B (18%). Juice weight of BC8-70-1-2-1-1A/B (6.05 t/ha) and BC8-3-1-2-1-2-1A/B (6.25 t/ha) was higher than that of the parent 5A/B (4.5 t/ha). Juice extraction percentage of BC8-5-2-2-1-1-1A/B (40%), BC8-3-1-2-1-2-1A/B (36.6%), and BC8-5-1-1-2-5A/B (34.5%) was superior to the parent 5A/B (27%). Total biomass weight of BC8-70-3-3-2-3A/B (34 t/ha) was higher than that of 5A/B (30 t/ha). BC8-70-3-3-2-3A/B had lower stem borer damage (1%) compared to 5A/B (2%).

- Conducted 5 AICSIP trials.
All India Coordinated Research Project on Sorghum, Hyderabad

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Surat

- Satisfactory rainfall was received in 29th STW of July-15, the sowings of different trials were completed in the third week of July. The germination was satisfactory in all the trials. Almost continuous rainfall in 30th to 31st STW hampered the initial growth stage. During the crop growth period, total 886 mm well distributed rainfall was received in 40 rainy days.

- During kharif 2014 total ten project trials were successfully conducted. Out of these, four on grain, two on forage sorghum, each one on sweet sorghum and high biomass were conducted at Surat, while two trials on grain sorghum were conducted at Mangrol. In AHT, the SPH-1737 found significantly superior at Surat and SHP-1736 depicted numerical superiority at Mangrol over better check for grain and dry fodder yield. While in Sweet sorghum trial, SPV-2268 found significantly superior and in High biomass trial SPH-1798 depicted numerical superiority over better check for economic yield. In rabi 2014-15, two grain sorghum trials were successfully evaluated at Tanchha.

- Total four state trials of grain sorghum and three of forage sorghum were successfully conducted at 14 locations during Kharif-2014. In grain sorghum genotypes SR 2872, SR 2819, SR 2950, SR 2983 and SR 2906 while in forage SRF-317, SRF-326 and SRF-332 depicted significantly superiority for economic yield over respective better check. During Rabi 2013-14, four trials on grain sorghum was successfully conducted at five locations.

- Guided 3 M.Sc. and 1 Ph.D. student and published 1 research paper, 4 popular articles and 7 folders.

Udaipur

- During Kharif 14, 2 hybrid (AHT & IHT) and 2 varietal (AVT & IVT) grain trials, 1 Single and 1 multi cut fodder coordinated trials were conducted.

- One each station hybrid trial, station varietal trial and station forage trial were conducted.

- In dual purpose type 70 crosses in different generations were evaluated and 252 progenies/ single plant were selected. In fodder generations 135 single plants were selected from 73 crosses of different generations.

- One hybrid performed well were identified from SHT and 4 entries from SVT. This year 2 entries in IVT-GS and 2 entries in IVT-SC will be contributed.

Publications: During 2013-13 on grain, forage and sweet sorghum improvement all total 37 publications have been made, out of which 2 are in International journals.

4. Sweet sorghum (AV Umakanth)

Trial 1: Evaluation of initial and advanced sweet sorghum varieties and hybrids (IASSVHT)-Kharif 2014

- Eighteen IASSVHT trial entries comprising 13 varieties, 2 hybrids along with 3 checks (CSV 24SS, CSV 19SS & CSH 22 SS) were evaluated at 11 locations during Kharif 2014.

- SPV 2321, SPV 2270, SPV 2319 and SPV 2323 were earliest to flower among the test varieties and were significantly early (7-10%) compared to the check CSV 24SS.

- For total biomass and fresh stalk yields, SPH 1755, SPV 2196 and SPV 2268 were superior to CSV 24SS by >20%.

- With respect to brix content, SPV 2320, SPV 2324 and SPV 2268 recorded a numerical superiority of 5-7% over CSV 24SS.

- For juice yield, SPV 2196 and SPV 2318 exhibited a significant superiority of 44% over the check CSV 24SS.

- SPH 1755 and SPV No’s 2318, 2324, 2196, 2272, 2268 and 2320 were promising for sugar yields and calculated ethanol yields.

Trial 2: Evaluation of initial and advanced sweet sorghum varieties and hybrids (IASSVHT)-Rabi 2014-15

- CSV 19SS, SPV 2268 and SPH 1755 were the earliest to flower among the varieties and hybrids.

- For total biomass and fresh stalk yields, the test hybrid SPH 1755 and all the varieties except SPV 2268 and SPV 2321 showed superiority over respective checks.

- For juice brix, SPH 1754 and all varieties except SPV 2272 were promising.

- With respect to juice yields, the hybrid SPH 1755 and all varieties excluding SPV 2321, SPV 2205 and SPV 2268 were promising.

- For total sugar yields and calculated ethanol yields, SPH 1755 and all varieties except SPV 2205 were promising.

Trial 3: Identification of high biomass sorghums for lignocellulosic biofuel traits-Kharif 2014

- SPH 1798, SPV 2328 and CSH 22SS were promising for total fresh biomass (>60t/ha) and dry biomass (>20t/ha).

5. Sorghum agronomy (SS Rao)

Field experiments were conducted during kharif 2014 across the dryland semi-arid locations (latitudes) of AICSIP with an objective of 1) quantifying the response of advanced pre-released sorghum genotypes to varying fertility levels, and 2) to develop improved agronomic management practices for higher sorghum productivity, profitability and sustainability.
1. Response of advanced/pre-released sorghum genotypes to varying fertility levels under dryland conditions

Pre-released sorghum genotypes that were promoted from first year to the second year AVHT testing in breeding programme were evaluated for their response to fertility [F: 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

<table>
<thead>
<tr>
<th>S. No</th>
<th>Types of sorghum</th>
<th>Test entries</th>
<th>Checks</th>
<th>Locations</th>
<th>Promising treatments/entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1KA.</td>
<td>Grain sorghum (Zone-I North)</td>
<td>SPH 1736, SPH 1737, SPV 2165</td>
<td>CSH 16, CSV 20, CSV 27</td>
<td>Udaipur</td>
<td>Test hybrids SPH 1736 and SPH 1737 produced 24% and 16% higher grain yields; more net returns and B:C ratio over check CSH 25, whereas test varieties were on a par with their respective checks. SPH 1736 respond significantly to increasing fertility levels producing highest grain yield at 100% RDF followed by SPH 1737 compared to 75% and 50% RDF.</td>
</tr>
<tr>
<td>1KB.</td>
<td>Grain sorghum (Zone-I South)</td>
<td>SPH 1736, SPH 1737, SPV 2165</td>
<td>CSH 16, CSV 20, CSV 27</td>
<td>Coimbatore, Palem</td>
<td>Test hybrid SPH 1736 produced 29% higher grain yields over check. SPH 1737 was on par with check both the locations. Test variety SPV 2165 was not superior to checks at both locations. The test genotypes responded significantly up to 100% RDF (80:40:40).</td>
</tr>
<tr>
<td>1KC.</td>
<td>Grain sorghum (Zone-II)</td>
<td>SPH 1724, SPH 1736</td>
<td>CSH 16, CSV 20, CSV 27</td>
<td>Surat, Indore, Dharwad, Parbhani</td>
<td>Genotypes varied with the locations in response to grain yield. SPH 1724 at Parbhani and SPH 1736 at Indore produced the superior yield than check. Increasing fertility response up to 100% RDF was noticed at all the locations, however, the F x G interaction was significant at Akola and Surat only.</td>
</tr>
<tr>
<td>1KD</td>
<td>1KD. Sweet sorghum</td>
<td>SPV 2196, SPV 2205</td>
<td>CSV 24SS</td>
<td>Palem, Indore, Parbhani, Udaipur, Surat</td>
<td>In general, stalk, grain and stover yields were increased significantly with increasing levels of fertility from 50% to 100% RDF. Differences in grain yield were significant among the genotypes across the locations. Interaction effects were significant for stover yield, brix at Surat and Udaipur only. Among the varieties, none was superior to check CSV24SS for brix content.</td>
</tr>
<tr>
<td>1KE</td>
<td>Forage Sorghum (Single-cut)</td>
<td>SPV 2185, SPV 2191</td>
<td>HC 308, CSV 21F, CSV 30F</td>
<td>Pan Nagar, Udaipur, Hisar, Ludhiana</td>
<td>On overall location mean basis, green and dry fodder yields increased by 33% and 26% due to 100% RDF application as compared to 50% RDF. Test genotype SPV 2185 (49.66 t/ha, and 12.7 t/ha , green and dry resp.) produced 21% and 18.0 % higher green and dry fodder yield respectively over check CSV 31F (40.1 t/ha). Interaction effects between fertility levels and genotypes for green fodder yields were significant at Pantnagar and Ludhiana.</td>
</tr>
</tbody>
</table>

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 Kharif 2013-14 with an objective of quantifying the effect of integrated nutrient management (INM) practices on grain and stover yields, economics and soil health in sorghum-chickpea cropping sequence. All India mean indicate that INM treatment i.e., application (T8) of 75% RDN through IF + 25% RDN through VC + seed treatment with PSB + Azospirillum recorded maximum grain yield (4548 kg/ha) than 100% RDN through IF (4446 kg/ha). On the other hand, application 75% RDN through IF + 25% RDN through FYM+ seed treatment with PSB+ Azospirillum produced maximum 29 % more grain yield at Akola.

3K. Improving Nitrogen-use efficiency through method and time of N application

Field experiments were conducted at eight locations i.e., Palem, Coimbatore, Dharwad, Parbhani, Akola, Indore, Surat and Udaipur to improve the N-use efficiency in grain sorghum through split application of nitrogen. 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 and Akola, application of 25% N at sowing + 50% at 30 DAS +15% at BLS +10% GFS produced the 25 % and 17 % more grain yield respectively, than normal practice (50% N at sowing and 50% at 30 DAS). At Palem, grain N uptake increased when N applied @ 25% of N at sowing + 50% at 30 DAS +25% at boot-leaf stage (BLS) method over normal practice.
4K. Optimization of production factor under resource constraints (Priority inputs in kharif grain sorghum)

Field experiments were conducted at five locations i.e., Palem, Coimbatore, Dharwad, Parbhani, and Surat to find out the priority production inputs needed under resource constraints by the sorghum farmer. Significant differences in grain and stover yields were observed due to variation in production inputs at all locations including overall mean. Full package of practices (FPP) treatment gave significantly higher grain and stover yields and economics at all location and overall mean. Interestingly, significantly highest yield reduction was observed when fertilizer (-76%) was not applied to the sorghum crop followed by weed control (-66%) and plant protection (-46%) indicating that fertilizer, weed control, and plant protection were the important production inputs respectively, on the order of priority.

5K. Intercropping of sweet sorghum fodder with forage legumes under different nutrient management

Field experiments were conducted at five locations i.e., Palem, Coimbatore, Dharwad, Parbhani, and Indore to characterize the sweet sorghum forage intercrop with forage legumes as influenced by fertility levels. Signiﬁcant differences were observed in sweet sorghum equivalent green fodder yields and net returns due to variation in intercropping systems at all locations including overall mean. Mean sweet sorghum equivalent green fodder yield ranged from 34.6 to 62.0 t/ha across the treatments. Intercropping system namely sweet sorghum + fodder cowpea (2:1) replacement recorded 8% more sorghum equivalent green fodder yield. On overall mean basis, application of 100% RDF gave 13% more sorghum equivalent green fodder yields across locations.

6. Sorghum physiology (SS Rao)

Trail 1 K. Phenotyping kharif sorghum germplasm for mid-season drought adaptation: Phenotyping thirty promising kharif sorghum germplasm for mid-season drought adaptation in dryland condition indicated that panicle dry mass at maturity, grain yields, harvest index, and stay green rating decreased by 36%, 13%, 7% and 5% respectively in continuous dryland over limited irrigation during mid-season (PI stage). IS 23514, IS 23579, IS 21083, IS 9108, and CSV 24SS produced higher green leaves and maintained higher leaf area index (source capacity) at flowering. Preflowering drought stress significantly reduced the grain yield by 13%. Genotypes produced higher grain yield and stable under both dryland stress and limited irrigated conditions were IS 13521, SPV 462, CSV 15, S35, NTJ 2, and E 36-1. Genotypes maintained higher visual staygreen rating under drought stress include IS 23579, IS 4698, SPSSV 30, IS 9108, IS 9113, IS29187 (4.0-4.63) than check B35 (4.23).

7. Sorghum entomology (VR Bhagwat, G Shyam Prasad & KS Babu)

Introduction: Total 156 genotypes were received from AICRIP centers in the form seven trials (AHT-GS, AVT-GS, IHT-GS, IVT-GS, IAVHT-MC, IAVHT-SC and IAVHT-SS) were evaluated for pests for resistance/tolerance at the respective hot-pot 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 evaluated under Entomology. Other than regular trials, pest specific trials for shoot fly and stem borer were carried out with a total of 100 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-physiology 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 delayed but moderate rainfall than normal one at 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 incidence in percent particularly in Coimbatore. Very low incidence of midge (<3%) 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: Overall, the shoot fly incidence was low to moderate (20-75%), particularly at Dharwad, Akola, Indore, Udaipur, and Rahuri. At Parbhani and Palem the incidence was relatively low this year. Interestingly, at Coimbatore, first time the shoot fly was recorded up to 70% in susceptible check.

Grain sorghum: In AHT, AVT, IHT and IVT trials, the DH% range was 3176%. Only one test entry SPH 1748 recorded low deadhearts and was on par with resistant check IS 18551. In IHT and IVT trial, test entry SPH 1779 and SPH 1784 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 30 to 66% being an average of 52%. The entries SPH 1769, CSH 24 MF and SPV 2242 recorded low shoot fly damage and was on par with resistant check IS 18551.

Forage (single cut): In IAVVT, the shoot fly damage at peak stage was from 27-55% with an average of 41%. The promising entries SPV 2317, SPH 1752, CSS 21F, ISPV 2311, SPV 2191, SPV 2310 and local check recorded low DH and are on par with resistant check.
Sweet sorghum: In IVAHT-SS, the damage range was 34-68 % with an average of 51% at peak stage. None of the test entries were on par with resistant check.

**AICSIP-SPN:** The entries selected from AICSIP during Kharif 2013 had a range of 26-83% with average of 42%. The entries SPV 2114, SPV 2182, SPV 2265, SPV 2270, SPV 2196, SPV 2203 and SPV 2204 recorded low deadhearts due to shoot fly.

**Elite DP-SF:** Northern based dual purpose sorghum was evaluated for confirmation its tolerance/resistance. Overall, the damage range was from 25-82% with mean of 51%.The entries SPV 2114, SPV 2182, SPV 2265, SPV 2270, SPV 2196, SPV 2203 and SPV 2204 were on par with resistant check IS 18551.

**Shoot pest resistance nursery (DSR-SPRN):** Across the locations, the damage range was from 20-89% with mean of 46%. The crosses (EP 60 x IS 18551), (EC 15 x ICSV 714), (ICSV 700 x IS 2205-1), (M 35-1 x ICSV 714), (M 35-1 x IS 2312-1), (ICSV 700 x ICSV 705) and SUENT 13, PGN 56, ICSV 705, PGN 30 were on recorded low damage and were on par with resistant check IS 18551. The resistant check recorded 29 % DH at peak stage.

**Spotted stem borer (Chilo partellus, Swinhoe):** General trend: The stem borer incidence was low to moderate to high (5-30%). The highest damage was noticed at Surat and Hisar (up to 65%) followed by Coimbatore and Parbhani. The stem tunneling at Coimbatore and Palem is increasing.

**Grain sorghum:** In AHT-GS and AVT-GS, the DH% range was 4-26%. The entries SPH 1748, SPH 1737, SPH 1724, CSH 30 and CSH 23 recorded low deadhearts % at 45 DAE. In IHT (GS) and IVT (GS), the DH range was 0-60 %. None of the test entries recorded low deadhearts/except local check GJ 42 at Surat at 45 DAE.

**Forage sorghum:** The stem borer damage at 45 DAE in IAVHT-multi-cut trial was from 19 to 42% being an average of 28%. The test entries recorded lower deadhearts are: SPV 2242, SPH 1769 SPH 1771 and CSH 20 MF. In single cut trial: the damage was from 19-43 % with a mean of 28%. Only one entry SPH 1752 recorded low DH and was on par with IS 2205.

**Sweet sorghum:** In IVAHT-SS, the damage range was 18-45 % with an average of 32% at 45 DAE. The entries SPV 2205, SPV 2321 and CSV 19SS recorded low deadhearts % and was on par with resistant check.

**Selected entries from AICSIP trials (AICSIP-SPN):** The entries selected from AICSIP during Kharif 2013 had a range of 6-31% with average of 11%. The entries recorded lowest damage is: SPV 2182 and CSV 21Fdue to stem borer.

**Northern based dual purpose sorghum:** (Elite DP-SF): Overall, the damage range was from 11-32% with mean of 18%. The entries POP 52, PGN 39, PGN 4 RED, Lawa, SUENT 13, SUENT 9, PGN 111, Satpani and IS 2146 were on par with resistant check IS 2205. The resistant check recorded 12 % deadhearts at 45DAE.

**Shoot pest resistance nursery (SPRN-DSR):** Across the locations, the damage range was from 7-18% with mean of 9%. The entries EC 15 x ICSV 714)-2-1-2, (EC 15 x IS 2312)-2-1-1, (EP 60 x IS 18551)-3-1-2 and (ICSV 700 x IS 2205-1)-3-2-4 recorded lowest damage due to stem borer. The resistant check recorded 8 % DH at 45 DAE.

**Head bug (Calocoris angustatus):** Damage rating (1-9) due to ear head bugs was recorded at Palem and Indore. The damage rating was ranged from 2 to 6. DJ 6514, SPH 1736, SPV 2297, SPV 2300 and SPV 2301 recorded <2 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 and Coimbatore only. The damage was noticed up to 8 rating. Total 10 test entries from all trials recorded < 3 damage rating.

**Midge (Stenodiplosis sorghicola Coq):** The damage due midge was recorded at Palem and Coimbatore from 2-9 in the scale of 1-9 damage rating. The entries that recorded low damage are: SPH 1768, CSH 25, DJ 56514 and ICSV 745.

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

**Pest-disease resistance trial (PDRN):** Pest-diseases resistance materials were evaluated at hot-spot centers. The entries NRCS-FR09-3, RSSV 9, BS 8566 and SUENT 13 showed promise for multi resistance.

**Multi-pest resistance materials:** The test entries showed resistance to more than one pests particularly to shoot fly and stem borer have been selected from different trials and are listed here: SPHs 1748, 1736, 1769, 1752, 2310, SPVs 2265, 2270, progenies: (EP 60 x IS 18551), (EC 15 x ICSV 714), (ICSV 700 x IS 2205-1), POP 52, Lawa and Rampur local. These lines can be utilized for strengthening breeding pests resistance program.

**Overall conclusions**

- Dharwad, Parbhani, Rahuri, Akola, Indore, Surat and Udaipur centre may be considered for hot spot for shoot fly screening.
- Hisar, Coimbatore, Surat and Indore may be considered hot spot for stem borer.
- A data on selected and few parameters for targeted pest may be required to study mechanism of resistance and correlations for traits.
- There is an increasing damage of stem borer peduncle, midge and mite at Coimbatore, Palem and Surat.
- Interestingly, Coimbatore has witnessed good damage of shoot fly.
Future work plan- Kharif 2015

- Observations on shoot fly should be recorded when deadhearts reaches at 70% in susceptible check or at peak period. If it is more than 70% insecticidal spray may be applied to protect promising entries.
- Dharwad, Parbhani, Akola, Indore, Surat and Udaipur centre may be considered as hot-spot for shoot fly screening.
- Coimbatore, Dharwad, Parbhani, Palem, Hisar and Surat centre to be considered as hot-spot for testing stem borer resistance.
- There is need to find out the causes of outbreak of stem borer incidence at Indore and its management.
- 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 2014-15 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 158 sorghum lines consisting of grain, forage and sweet sorghum entries were evaluated against panicle and foliar and systemic 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 downy mildew.

Disease situations: Among panicle diseases grain mold was predominant in Karnataka, Andhra Pradesh, Maharashtra, Tamil Nadu and Gujarat. Sugary disease (ergot) was severe in Gujarat and downy mildew in Karnataka region. Among foliar diseases anthracnose and zonate leaf spot appeared in moderate to severe form in North India especially in forage growing regions. Leaf blight was common in Gujarat and Rajasthan in North and Tamil Nadu and Karnataka in South. Rust was recorded in Karnataka and Rajasthan and Marathwada region in Maharashtra. Sporadic incidence of sooty stripe, rough, target and grey leaf spots was noted in Maharashtra and Rajasthan. In most host spots centres disease load was optimum as indicated by appearance of disease severity in susceptible checks as well as local checks.

Grain mold: Location severity index for grain mold assessed over all the trials in the location indicated that grain mold pressure was severe in Palem and Coimbatore and moderate in all other locations except Parbhani. Grain mold severity ranged from 2.0 to 9.0 with mean 4.9 in grain sorghum (AHT, AVT, IHT and IVT), 2.6 to 6.0 with mean 3.7 in single-cut forage (IAVHT-SC) and 2.4 to 6.5 with mean 3.4 in sweet sorghum (IAVHT-SS). Among advanced grain sorghum entries SPH 1736, SPH 1737, SPH 1748 and SPV 2250 were moderately resistant to grain mold. Most promising entries in initial grain sorghum trials were SPH 1774, SPH 1778, SPH 1779, SPH 1785, SPH 1786, SPV 2294, SPV 2300 and SPV 2304. Promising sweet sorghum entries for grain mold resistance were SPH 1754, SPV 2272, SPV 2320 and SPV 2324. Among single-cut forage sorghum entries SPH 1797, SPV 2313 and SPV 2315 were promising for grain mold resistances.

Sugary disease/ Ergot: Four grain sorghum (AHT, AVT, IHT & IVT), one sweet sorghum (IAVHT) and one forage sorghum (IAVHT-SC) trials were evaluated for sugary disease resistance in hot spots. During kharif 2014 severe incidence appeared in Surat with location severity index of 42.5%. Mean severity was 44.8% in grain sorghum, 39.6% in sweet sorghum and 37.3% in single-cut forage sorghum. Among grain sorghum entries the hybrids SPH 1775, SPH 1776 and SPH 1783 and the varieties SPV 2300, SPV 2301 and SPV 2305 were promising. Sweet sorghum entries SPV 2322 and SPV 2323 and forage sorghum entries SPV 2313 were promising for ergot resistance.

Downy mildew: Eighty-one grain and sweet sorghum entries consisting of four trials (AHT, AVT, IHT, IVT & IAVHT-SS) were evaluated for downy mildew resistance in endemic locations. Location severity index indicated that downy mildew was moderate in Dharwad (LSI, 14.4). In other locations there was no report of downy mildew incidence during this season. At Dharwad disease incidence ranged from 2% (QL3) to 69.7% (DMS 652) indicating resistant to highly susceptible disease reactions. Among grain sorghum entries the hybrids SPH 1748 and SPH 1786 and the varieties SPV 2242, SPV 2250, SPV 2296, SPV 2298, SPV 2399, SPV 2300 and SPV 2302 were promising for downy mildew resistance. Sweet sorghum entries SPV 2196, SPV 2323 and SPV 2324 were promising.

Foliar diseases: Anthracnose, zonate leaf spot and leaf blight remained major foliar diseases during kharif 2014. 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 Surat, Pantnagar, Udaipur, Coimbatore and Dharwad. Leaf blight incidence was moderate at Surat and low in other locations. Rust was sporadic at Dharwad, Parbhani and Udaipur. Other foliar diseases like rough, gray leaf spot and sooty stripe in Akola, grey and tar 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 1724, SPH 1736, SPH 1737, SPH 1748, SPH 1778, SPH 1783, SPH 1789, SPH 1790 and SPH 1793; varieties- SPV 2165, SPV 2242, SPV 2250, SPV 2294, SPV 2296, SPV 2297, SPV 2299, SPV 2301, SPV 2302 and SPV 2304. Forage hybrid- SPH 1700, SPH 1752, SPH 1768, SPH 1795, SPH 1796 and SPH 1797; varieties- SPV 2185, SPV 2242, SPV 2292, SPV 2313, SPV 2316 and SPV 2317 and sweet sorghum hybrid- SPH 1754 and SPH 1755; varieties SPV 2196, SPV 2268, SPV 2322 and SPV 2324.
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. For forage varieties leaf disease resistance is of utmost importance. SPH 1786, SPV2250 and SPV 2300 were moderately resistant to grain mold and downy mildew; SPH 1775 and SPV 2300 were resistant to grain mold and ergot. Sweet sorghum hybrid SPH 1754 and single-cut forage hybrid SPH 1797 were resistant to grain mold and foliar diseases (anthracnose and zonate leaf spot). In multi-cut forage hybrid SPH 1700 and SPH 1768, there was combined resistance against anthracnose, zonate leaf spot and leaf blight. SPV 2242 had combined resistance to anthracnose and zonate leaf spot. In single cut forage SPV 2316 and SPV 2317 there was combined resistance against anthracnose, zonate leaf spot and leaf blight.

Grain mold pathogen variability: Frequency of fungal infection at milk and physiological maturity stages showed that more than 25% milk stage grains of sorghum were infected by natural fungal inoculum. Infection was increased to more than 85% at physiological maturity. Frequency of infection at physiological maturity compared with milk stage was 2 to 3 times more for Fusarium and 4 to 6 times more for Curvularia. Infection frequency at milk stage of few popular India grain sorghum cultivars were Fusarium (18%), Curvularia (5%), Alternaria (1.3%) and Bipolaris spp. (0.9%).

Anthracnose variability: Anthracnose pathogen Colletotrichum graminicola showed wide variability in their disease causing ability as revealed by disease reactions of nine isolates on nine sorghum genotypes of hot spot location for three seasons. Out of 10 isolates 8 isolates developed moderately resistant reactions and two isolates (CgD and CgE) susceptible reaction on Pant Chari-5 during 2014-15. Against these isolates all other sorghum lines produced susceptible to highly susceptible disease reaction. Results of pooled analysis revealed that susceptibility of few sorghum lines have been changed to few Colletotrichum graminicola isolates over the years. CSV21F and IRTA204 lines which were resistant or moderately resistant to CgA, CgB, CgD and CgL isolates during 2014-15. New resistant lines are to be introduced for virulence analysis.

Grain mold nursery: In advance nursery entries GMR156-1, GMR166-1, GMR84-2, SU 1363 and GMR124 were resistant for PGS and TGS. Entry GMR166-1 was also low in fungal load and recorded less than 15% Fusarium and Curvularia infection. In initial nursery entries GMN14-6, GMN14-7, GMN14-9, PSVGS316, PSVGS105, GMN14-3 and GMN14 were promising for grain mold resistance.

Pest and disease resistant nursery: Of seven entries three were resistant to grain mold (GMR 156, BS8586 and IS 18551 score<3.0) and others were moderately resistant. The entries were also moderately resistant to anthracnose.

Publications and recognitions: The group was involved in publishing 22 articles including five journal papers and 17 other publications including popular articles, bulletin, papers posters in conferences, etc during 2014. Scientists from different centres participated in national and international symposia. One scientist received the best poster award in an international symposium.

9. Sorghum NSP, BSP, MSP & DUS (VA Tonapi & Hariprasanna)
During 2014-15 a total of 320.97 q breeder seed was produced against BSP-I allocation of 93.85 q. A total of 1047 kg nucleus seed was produced against allocation of 978kg. In farmer’s participatory seed production, a total of 660 q seed was produced. The tentative center wise allocation of sorghum breeder and nucleus seed production has been made for 2015-16 across 15 locations based on DAC indent received for the year 2015-16.

During the period under report, two field trials each were conducted during Kharif 2014 and Rabi 2014-15 seasons for examining the DUS in candidate varieties of sorghum as per the PPV&FRA test guidelines. A total of 19 candidate varieties were tested for DUS traits in the kharif season and seven candidate varieties were tested in the rabi season along with the corresponding reference varieties. Maintenance breeding was undertaken for a total of 56 reference and example varieties (varieties/parental lines/hybrids) during rabi 2014-15 season under enforced selfing/controlled pollination.
Summary of AICRP on Sorghum research achievements - Rabi 2014-15

1. Breeding - Grain sorghum (Prabhakar)

During 2014-15, 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.

Multi-location AICSIP trials: During the year 2014-15, the following 4 multi-location yields trials were conducted across locations.

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

Advanced Varietal and Hybrid Trial (Deep soil): In this combined trial of varieties and hybrids, 2 varieties and 7 hybrids along with 5 checks were evaluated for grain and fodder yield and other agronomic traits.

- The hybrid SPH-1741 gave 10.4% more grain yield and 8.0% fodder yield than the hybrid check CSH-15R. Other hybrids which gave more than 5% grain and fodder yields were SPH-1763, SPH-1742, SPH-1765 and SPH-1764.
- The hybrids SPH-1746, and SPH-1763 and varieties SPV-2217 and SPV-2221 were significantly superior to the checks in grain size.
- Performance of the hybrids over 3 years of testing from 2012-13 to 2014-15 indicated that the hybrids SPH-1763 (2663 kg/ha), SPH-1741 (2636 kg/ha) and SPH-1746 (2561 kg/ha) gave 10.59%, 9.47% and 6.35% more grain yield over the check CSH-15R (2408 kg/ha), respectively. For fodder yield, the hybrids SPH-1746 (6755 kg/ha), SPH1741 (6539 kg/ha) and SPH-1742 (6492 kg/ha) gave 10.94%, 7.39% and 6.62% more than the check CSH-15R (6089 kg/ha).
- Performance of the hybrids and varieties over 2 years of testing in Rabi 2013-14 and 2014-15 indicated that the hybrids SPH-1763 (2792 kg/ha) and SPH-1764 (2616 kg/ha) gave 13.5% and 6.4% more grain yield over the check CSH-15R (2459 kg/ha), respectively. For fodder yield, the hybrids SPH-1765 (6811 kg/ha), SPH-1764 (6769 kg/ha) and SPH-1763 (6650 kg/ha) gave 12.1%, 11.4% and 7.8% more than the check CSH-15R (6078 kg/ha).

Initial Varietal and Hybrid Trial (Deep soil): In this trial of varieties and hybrids, 15 varieties and 5 hybrids along with 5 checks were evaluated for grain and fodder yield and other agronomic traits.

- Three hybrids SPH-1801, SPH-1803 and SPH-1799 were significantly superior to the check hybrid CSH-15R and gave 23.3%, 23.1% and 18.1% more grain yield than the check hybrid, respectively.
- The hybrid SPH-1802 was significantly superior to check hybrid CSH-15R for fodder yield and gave 19.1% more fodder yield than the check.
- For grain size, the hybrid SPH-1802 and varieties SPV-2350, SPV-2351 and SPV-2344.

Initial Varietal and Hybrid Trial-I (Shallow soil): In this combined trial of varieties and hybrids, 8 varieties and 2 hybrids along with 6 checks were evaluated for agronomic traits.

- The hybrid SPH-1805 was superior to check CSH-15R for both grain and fodder yield by 11.2% and 23.3%, respectively.
- The varieties which gave more than 10% grain and fodder yields than the check CSV-22 were SPV-2350, SPV-2351 and SPV-2344.

Parental line trial: A combined (kharif & rabi) parental line trial consisting of 38 parents (16 A lines and 22 R lines) was conducted at Nandyal. There was good synchronization between CMS and restorer lines.

Rabi sorghum breeding at IIMR

- Varietal improvement: Evaluation of improved breeding lines in shallow-medium and deep soils separately, indicated that 31 promising varieties (12 in shallow-medium and 19 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.
- Development of new CMS lines and parental lines using exotic/indigenous lines: Conversion programme was continued for 51 pairs in various backcross generations (indigenous and exotic) and out of them, a total of 27 pairs were selected and characterized. The main characters considered for selection were grain color, quality, size, and luster and sterility/fertility reactions.
- Parental lines development: B line improvement for diversifying genetic base led to selection of 12 B lines out of 32 lines with rabi traits. 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 13 R lines out of 36 lines with rabi traits.

- Registration of parental lines and varieties: Thirteen application forms (5 MS lines, 6 restorer lines and 2 varieties) have been submitted for Registration at NBPG, New Delhi.
- For drought tolerance studies, 25 rabi entries were evaluated in 3 reliable soil moisture environments (assured irrigation, water deficit ie. irrigation only up to 50 days after sowing and rainfed ie. receding moisture conditions). Based on drought susceptibility index values (DSI) germplasm accessions IC – 343573, IC – 343584, IC – 392124, IC – 392147, IC – 392150, and IC – 305920 shown lower DSI values under rainfed and moisture deficit conditions hence, were categorized as drought tolerant.
- Identification of high amylopectin lines: Using Rapid iodine staining technique, 13 lines were identified to possess high amylopectin content (90 to 100%). These include IS 23964, Hattigudur cross 2, IS 5624, IS 17994, IS 18020, IS 22119, IS 33815, IS 33887, IS 641, IS 829, IS 2269, IS 24346 and IS 27021.
- About 270 rabi sorghum genotypes were evaluated in two dates of sowing for aphid tolerance. The genotypes BRJ 67, R09 LIP 1884, RS 585, 296A × SPV 1411, R08 BN 195, 49B, AKRB 306, NTJ 2, IS 34722, 104A × C43 and SLV 43 recorded less than 5 aphids per sq cm of leaf area. Aphid count highly correlated with the aphid damage score.
- Promising rabi sorghum genotypes for tolerance to clod across dates of sowing: Photoperiod sensitiveness of rabi sorghum genotypes were evaluated in two dates of sowing for aphid tolerance. The genotypes BRJ 67, R09 LIP 1884, RS 585, 296A × SPV 1411, R08 BN 195, 49B, AKRB 306, NTJ 2, IS 34722, 104A × C43 and SLV 43 recorded less than 5 aphids per sq cm of leaf area. Aphid count highly correlated with the aphid damage score.

Rabi sorghum breeding at AICSIP centers

1. Rahuri

- Released the Sweet sorghum Hybrid RSSH-50 for green cane yield coupled with high ethanol and tolerant to shoot fly. The release proposal of this variety has been submitted to the University RRC meeting during 2014-15. This hybrid is proposed for kharif season for western Maharashtra.
- Released the rabi sorghum variety RPASV-3 for papad purpose under the name Phule Rohini. The release proposal of this variety has been submitted to the University RRC meeting during 2014-15. This variety is proposed for rabi season for western Maharashtra.
- Released the rabi sorghum variety RSSGV-46 for hurda purpose under the name Phule Madhur. The release proposal of this variety has been submitted to the University RRC meeting during 2014-15. This variety is proposed for rabi season for western Maharashtra.
- Identified the good genotypes for hurda and papad purpose: RSSGV 46 for hurda, RPASV 3 for Papad.
- Notification of sorghum varieties: The single cut forage sorghum variety Phule Godhan (CSV 30F) has been notified vide S.O. No. 1919 E dated 31-7-2014 and rabi sorghum variety Phule Suchitra has been recommended for notification in the 70th CVRC, Meeting.

2. Tandur

- In the station yield trial, out of 11 entries tested SVT 3, SVT7 and SVT-9 were promising and out yielded the checks with respect to grain and fodder yields.
- A total of 61 yellow pericarp sorghum germplasm, 50 local collections were evaluated to identify promising entries to be used in crossing programme.
- Promising Rabi adapted, drought adapted advanced breeding entries suitable to the region were identified in the physiology trials.

3. Bijapur

- Out of 17 newly derived back cross advanced generation (BC2F4/BC2F5) R lines evaluated, 7 lines were found superior and retained. In B line programme, 10 lines were found superior.
- In trait specific breeding programme, out of 14 families belonging to BC2F3 evaluated for drought stress, 6 families were found superior. 17 families belonging to F4 were evaluated and 5 families found superior. In the breeding for charcoal rot tolerance 38 families derived from BC2F2, 20 families from BC2F3 and 33 derived from BC2F4 were subjected to evaluation. A total of 37 families were selected.
To develop medium dwarf non lodging coupled with CSV216R yielding ability, 19 BC2F4 families were evaluated along with checks. A total of 5 families were selected.

To develop early maturing lines with maldandi yielding ability 70 BC2F4 generation lines were evaluated and a total of 39 families selected.

To develop high yielding lines with charcoal rot tolerance 25 BC1F3/BC2F3 generation lines were evaluated and a total of 7 families were selected and a total of 9 families were selected.

4. Dharwad
- Station hybrid trial-I: Out of 15 Hybrids, none of hybrids were superior against recently released variety SPV-2217. SHD-62(5084) and SHD-64(4875) were hybrids with higher grain yield among test hybrids.
- Station hybrid trial-II: None of hybrids were superior to check M-35-1 except recently released variety SPV-2217 which recorded significant grain (5093kg/ha) and fodder yield (11.2 ton/ha) over check.
- Station Varietal Trial –I: Among 18 Varieties tried, four entries viz, SVD-1301(4431kg/ha), SVD-0770(4320), SPV-2217(4292) and SVD- 808(4014) recorded significantly superior grain yield over check M-35-1(3292 kg/ha) and similarly these entries recorded superior fodder yield over M-35-1.
- Station Varietal Trial-II: Among 18 entries, 6 entries viz, SVD-1266(4834kg/ha), SVD-1269(4667), SVD-1276(4236) SVD-1270(4139) and SPV-2217(4125) exhibited significantly superior yield over check M-35-1(3195 kg/ha) and one genotype viz., SPV-2217 for fodder yield.
- Station Varietal Trial-III: Four genotypes viz., SPV-2217(4403kg/ha), SVD-806(4403), SVD-765(4098) and SVD-1277(3889) recorded significantly superior grain yield over check M-35-1(2847.0 kg/ha).
- Generation of breeding material: 67 F1 crosses were evaluated & 57 were advanced to next generation and 115 selections were made in various generations from F2 to F4. As many as 214 local germplasm lines along with 64 selected (out of 4000 lines) lines were grown for evaluation/maintenance purpose.

5. Akola
- Development of male sterile lines: About 31 pairs in BC III, 33 pairs in BC IV, 24 pairs in BC V, 36 pairs in BC VI have realized. Besides, 5 crosses in F3 generation were planted and selections were made.
- Development of restorer lines: Desirable restorer lines in rabi programme required earliness, good fertility restoration in winter season, better grain and fodder yield, good grain qualities and good combining ability. The centre has developed 50 restorer lines tolerant to shoot-fly with good rabi adaptation.
- Besides, we have also developed 10 restorer lines with earliness and 25 restorer lines for high yield and its contributing traits.

6. Parbhani
- About 131 single plant selections were made in R lines from 77 segregating populations.
- B line development programme: 141 single plant selections were made from 65 segregating populations. For shootfly breeding, 65 SPS were made each for R and B line improvement.
- For drought tolerance 67 individual plant selections were made in advanced generations. 86 back cross pairs were attempted in 29 inbred lines of MAS progenies of 6 crosses for developing high yielding shootfly tolerant.
- 140 germplasm lines selected from 4000 germplasm stock (2013-14) were screened.

7. Kovilpatti
- A high yielding dual purpose sorghum culture TKSV 0809 recorded grain yield of 2999 kg/ha over 141 yield trials, registering 16.9% and 24.7% increase over the checks K 8 (Local) and CSV 17 (National) respectively.
- TKSV 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. This was released as K 12 for the winter rainfed vertisol tracts of Tamil Nadu during 2015.
- A high yielding grain sorghum cultures TKSV 1036 and single cut forage sorghum TKFS 11109 which consistently performed under rainfed vertisol condition are proposed to Multiocation testing.

8. NAU, Surat
- In LSVT, at Mangrol genotype PKV Kranti (3249 kg/ha) found significantly superior over better check BP-53(2502 kg/ha) for grain yield. In respect to dry fodder yield at Achhalia, genotype PKV Kranti (8577 kg/ha) found significantly superior over better check BP-53(7164 kg/ha).

Publications: Twenty six research publications (5 International and 21 National) including 4 book chapters, exclusively on rabi grain sorghum have been published during the period.
2. Sorghum agronomy (SS Rao)

Field experiments were conducted during rabi 2014-15 at four AICSRIP rabi sorghum research (Rahuri, Parbhani, Dharwad, and Tandur) with an objectives of evaluating advance rabi sorghum genotypes and quantifying their fertility response. Agronomic experiments on planting management, prioritizing production inputs, INM in green gram – rabi sorghum sequence system, and drought management by foliar sprays of nutrients were organized in order to develop best–bet production practices for higher sorghum productivity, profitability and sustainability.

1R. Response of advanced/pre-released rabi sorghum genotypes to fertility levels under receding soil moisture conditions: Field experiments were conducted at Parbhani, Rahuri, Dharwad, and Tandur to evaluate and quantify the response of advance sorghum genotypes to varying fertility levels. 100% RDF increased the grain yield by 21, 49, 17, and 59%, respectively at Parbhani, Rahuri, Dharwad and Tandur over 50% RDF fertility level. Test hybrid ‘SPH 1742 and SPH 1746 were superior to check CSV 15R at Tandur only with 16.0 and 6.0 increase in grain yield, respectively. SPV 2221 was significantly superior to CSV 22R by 19.0%, 11%, 8% at Parbhani, Rahuri, Tandur, respectively.

2R. Assessing the performance of sorghum genotypes with changing climate (increased sowing window): Field experiments were conducted at Tandur evaluate the relative performance of 5 sorghum cultivars (CSH 15R, CSV 22R, Phule Anuradha, Phule Vasudha and Phule Revati) with varying sowing dates (1st week of Sep.; 3rd week of Sep.; 1st week of Oct.; 3rd week of Oct. and 1st week of Nov.) with an objective of identifying best sowing window and genotypes in the current climate change scenario. Interaction effect between dates of planting and cultivars indicated that the performance of cultivars varies with dates of planting. At Tandur, crop should be sown either during 3rd week of September or 1st week of October based on the rainfall distribution and soil moisture availability in the profile. Phule Revati when sown during the 3rd week of September produced higher grain yields (3412 kg/ha), net returns (Rs.92999 Rs/ha) and B: C ratio (5.17).

3R. Optimization of production factor under resource constraints (Priority inputs in kharif grain sorghum): Field experiments were conducted at four locations i.e., Parbhani, Rahuri, Dharwad, and Tandur to find out the priority production inputs needed under resource constraints by the rabi sorghum farmer. Significant differences in grain, stover yields, and net returns were observed due to variation in production inputs at all locations including overall mean. Full package of practices (FPP) treatment gave significantly higher grain and stover yields and economics at all location including overall location mean. Interestingly, significantly highest yield reduction was observed when fertilizer (-43%) was not applied to the sorghum crop followed by plant thinning (-36%) and weed control (-31%) indicating that fertilizer, thinning, and weed control were the key production inputs for Rabi sorghum productivity in above order of priority.

4R. INM in greengram-rabi sorghum sequence: To improve the productivity, moisture conservation and N-use efficiency of rabi sorghum, field experiment were conducted at Tandur on integrated nutrient management with green gram – rabi sorghum sequence. Application of 5 tonnes FYM prior to monsoon, incorporation of green gram during kharif season along with applying 60 or 80 kg N/ha to rabi sorghum produced the highest grain yield (3782 kg/ha) and net returns.

5R. Effect of Seed priming and foliar spray of nutrients in rabi sorghum: Field experiments were conducted at Rahuri, Parbhani, Dharwad and Tandur to evaluate the effect of seed priming treatments and foliar sprays of nutrients on the productivity of rabi sorghum. Among the seed priming treatments, on overall location mean basis highest grain yield was observed with KNO3 seed priming (3182 kg/ha) followed by KH2PO4. In foliar sprays, KNO3 foliar spray @2% gave the highest grain yield (3206 kg/ha). Foliar sprays of KNO3 @2% had increased grain yield by 16% (sign), 6% (on par), and 5 % (on par) over control, Urea @%, and DAP @2%, respectively. By and large, seed priming with KNO3 @2% was superior over others.

3. Sorghum physiology (SS Rao)

Trial 1R: Preliminary evaluation of diverse germplasm for rabi adaptation: Thirty-seven rabi sorghum landrace 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. Five entries recorded superior LAI across locations than check CSV 22R include RSV 1850, SLV 171, SLV 181, SLV 182, SLV 184 and SSSR 13-20. Genotypes produced superior biomass yields than check includes SLV 168, SLV 182, SLV 188, SSSR 13-4, and SLV 190. Genotypes recorded higher yield across locations than check CSV22R (32.0 g/pl) include RSV 1850, RSV 1785, SSSR 13-4, SLV 182, and RSV 1749 (34.2-38.6 g/pl). Interestingly, RSV 1785, SLV 182, and SSSR 13-4 ( IS 4698) produced higher grain yields combining greater biomass production.

Trial 2(M) & 3(S): Phenotyping advanced rabi sorghum entries for drought adaptation traits in medium and shallow soils: Sixteen advanced rabi-adapted sorghum genotypes including 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 14.0 % in shallow soil over medium. As regards DSI, entries BRJ343 (0.571), RSV 1640 (0.606) showed less DSI means more plant height stability under drought. LAI decreased by 15.0 % in shallow soil over medium. BRJ 235 and
BRJ 229 recorded higher LAI while, CRS 49 and CRS 50 showed least reduction in LAI under stress and were stable across the soil depths. Average biomass production at flowering decreased by 29.0 % in shallow soil over medium, and BRJ 229, and RSV 1640 were stable across the soil depths. BRJ 341 alone recorded superior crop water status than checks especially in shallow soil stress condition. Interestingly, higher SPAD units (more leaf staygreen) resulted in realization of higher RWC, grain yield, panicle mass \((r=0.543; 0.557; 0.510; P<0.05 \text{ resp.})\). For grain yield, on overall mean basis, none was significantly superior to check Phlude Suchitra in both soil depths. Grain yield decreased by 34% in shallow soil depth over medium. In terms of DSI for grain yields, RSV 1544 \((DSI=0.617)\), RSV 1572 \((DSI=0.686)\), and RSV 1640 \((DSI=0.727)\) were relatively more stable than checks.

**Trial 4 RF and 4 Irrg: Phenotyping sorghum for key root traits associated with drought adaptation:** Thirteen advanced rabi sorghum genotypes including checks were characterized for key root and shoot traits that contribute survival under flowering and post-flowering drought and heat stress. There was significant decrease in root and shoot related traits under rainfed than in irrigated. Mean plant height, decreased by 11.0 % in rainfed than irrigated. There was 19% decrease in biomass at flowering under moisture mistres less than dryland. Genotypes RSV 1620, RSSGV 46 and CRS 49 recorded higher biomass across the stress and nonstress conditions. The mean root biomass, root length, root volume, and root numbers declined by 31%, 11.0%, 5 % and 16.0 % in irrigated than in rainfed. Entries, RSV 1620, CRS 49 and BRJ 229 were superior to checks across moisture regimes for key root traits under stress and non-stress conditions.

**Trial 5: Drought alleviation of sorghum by using fertilizer nutrients and plant growth substances:** A field experiment was conducted at Bijapur centre during rabi season 2014-15 with an objective of assessing the scope for mitigating drought stress by soil application of potassium and micronutrients viz., Zn and Fe in sorghum besides studying the effects of foliar spray of plant growth substances (PGRs) for mitigating flowering and post-flowering drought stress in rabi sorghum. Recommended dose of fertilizer along with micronutrients \((RD + 30 \text{ kg K2O/ha} + \text{Zn 12kg/ha} + \text{Fe 12 kg/ha})\) significantly \((P<0.05)\) increased the biomass components. There was 7-23 % increase by plantozyme spraying over other treatments in biomass production. Grain yield increased by 2-7 % by RD plus micronutrient application over other treatments. Among the PGR foliar sprays, grain yield continuously increased from T1 to T5. PGR foliar spraying treatment \((\text{plantozyme (seaweed extract)- 2 ml/litre water at 30, 60 & 90 DAS})\) gave 10% , 12%, 20%, 23% and 43% increase in grain yield over Tricornitol 5ppm , GA 25ppm, 6-BA 50ppm, NAA 50ppm, and control respectively.

4. **Sorghum entomology (VR Bhagwat, G Shyam Prasad & KS Babu)**

**Introduction:** In collaboration with AICSIP, total 226 genotypes received from ten trials (AVHT-DS, IVHT-DS, IVHT-SS, AICSIP-DS&SS-SPN, ASFR-DSR, B & R lines, IASFN and ANGSN), two trials on IAPSHN, APShN from DSR (Aphid and shoot bug resistance nursery) were evaluated mainly for shoot fly, stem borer, sugarcane aphids and shoot bugs for resistance/tolerance at respective hot spot locations; Kvilipatti, Dharwad, Bijapur, Rahuri, Parbhani, Tandur, 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 \((\text{Atherigona soccata Rond})\) is a major biotic constraint followed by stem borer \((\text{Chilo partellus Swin.})\), sugarcane aphid \((\text{Melanaphis sacchari Zehntner})\), and shoot bug \((\text{Peregrinus maidis Ashm.})\). They often occur sequentially or together. In most of the parts there were inadequate rains during Kharif as a result, Rabi crop did not receive good moisture. However, the heavy storm and rains during last week of March caused lodging of standing crops and succumbed to loss in grain yield and fodder quality. In Kvilipatti region, interestingly there was 23% shoot fly damage and stem borer damage was up to 49%. Midge incidence was high (35.8%) but low on K-8. In Dharwad region, the incidence of shoot fly was up to 45 %. No incidence of stem borer was recorded. The population of aphids and shoot bug was low. In Bijapur area, the shoot fly incidence was up to 49.6%. Shoot bug damage was recorded about 13.8-46.8% with an average of 31.7%. Aphid damage was recorded up to 56.9%. Coccinellids were observed in the month of January in some of farmer’s field. Since two years the white grub incidence was increasing and recorded up to 9% in this season where sorghum was intercropped with onion. In western Maharashtra, overall incidence of shoot fly was moderate to high (~ 39%). The appearance of sugarcane aphid was high 50-60 aphids/leaf and recorded up to 7 damage rating (55%). The presence of \(\text{Coccinella}\) was sporadic in four fields (3-5/leaf). In Marathwada region, most of the farmers have sown Dagdi, Maldandi \((\text{M-35-1})\) and Parbhani Moti. The incidence of shoot fly was moderate \((5-20 \%)\) with an average of 12.9%. The deadhearts due to stem borer was recorded up to 10%. The infestation of shoot bug was moderate (< 10%). The incidences of Aphid were recorded up to 20%. In Vidartha region, about twenty farms were surveyed in four districts Washim, Akola, Gadchiroli, and Buldhana districts. The shoot fly incidence was low to moderate \((3-15\%)\) averaging about 10%. The stem borer particularly peduncle damage was recorded up to 15%. Aphids damage up to 10% was recorded where sorghum was late grown near wheat farm.

**Shoot fly \((\text{Atherigona soccata, Rond})\)**

**General trend:** The shoot fly incidence recorded moderate to high \((20-90\%)\) at Dharwad, Parbhani, Rahuri and Solapur when evaluated under artificial conditions.
Advanced varietal & hybrids trials (DS): In AVHT-DS trial, the range was from 40.6 to 87.4% DH with an average of 62.1% deadhearts. The entries SPV 2217, CSV 22 and SPH 1746 were on par with resistant check, IS 18551.

Initial hybrids and Initial varietal trial (DS): Across the locations and genotypes the range was from 34.3 to 86.9% deadhearts with an average of 60.3% deadhearts. None of the test entries were superior to resistant check IS 18551.

Initial hybrids and Initial varietal trial (SS): In IAVHT-SS, across the locations and genotypes the range was from 32.0 to 88.9% deadhearts with an average of 60.7% deadhearts. None of the test entries were on par with resistant check IS 18551. Phule Anuradha, the local cultivar recorded < 50% deadheart after resistant check.

AICSIP for deep and shallow soil (AICSIP-SPN-DS & SS): In AICSIP-SPN-DS & SS, total thirty entries were evaluated for resistance to key pests at seven locations. Across the locations and genotypes, the deadhearts % range was from 40.9 to 85.1% being an average of 64.0%. The entries SPVs 2139, 2221, 2231, 2239, 2274 and 2278 recorded relatively low deadhearts (57.4%).

Advanced shoot fly resistance lines (ASFR): Across the locations and genotypes, the deadheart % range was from 32.2 to 82.77% being an average of 50.7%. The progeny that recorded lowest deadhearts (<45%) was EC 19 x EP 133-2-3 and the parental lines that recorded lowest (<45%) deadhearts % were, POP 52, LG Kumbhari local, EP 133 and EC 15

Screening of B & R lines-SF: The shoot fly was varied from 33.7 to 79.9 % with an average of 51.9%. The entries that recorded lowest deadhearts % are SLB 135, SLB 72 and SLB 138 and were on par with resistant check IS 18551.

Initial and Advanced lines for shoot fly resistance (IASFN): Across the locations and genotypes, the deadheart % range was from 34.2 to 87.0% the average being 50.5%. The entries AKSV 155R, PBNENT-2, RSV 1687, RSV 1710, NRCSFPR09-3, RSE 03, SLV 145, SLV 131, low deadhearts (< 45.0%) and were on par with IS 18551.

Advanced Germplasm for shoot fly resistance (ANGSN-SF): A total of 25 germplasm accessions were selected from five hundred germplasm lines after rigorous evaluation through last three seasons. The entries NSJB-6596, EP 121, and ELG 4 had low deadhearts (< 35%) due to shoot fly and were on par with IS 18551.

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, Bijapur, and Parbhani. Stem tunneling was very high in Kovilpatti (up to 80%).

Advanced varietal & hybrids trials (DS): The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 6.89 – 31.47 % DH the average being 13.62 %. Across the locations and genotypes, SPV 2221, CSH 15R, SPH 1763, SPH 1746 and SPH 1762 recorded low deadhearts (<10%). The stem tunneling data was recorded at Kovilpatti and Tandur and had high CV%. The damage ranged from 16.9 – 85.1 % with mean tunneling of 29.7 %.

Initial hybrids and Initial varietal trial (DS): The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 7.0 – 21.9% the average being 12.5%. The test entries SPV 2330, SPV 2336, SPV 2340 CSV 29 R and M 35-1 recorded lowest deadhearts (10%). The peduncle tunneling (%) ranged from 14.3 – 52.4 % with an average of 31.3%. The least damage was recorded in SPH 1802.

Initial hybrids and Initial varietal trial (SS): The overall mean of deadhearts % due to stem borer at 45 DAE was ranged from 6.68 to 13.70% with an average of 9.26%. It was interesting to note that Swarna, the susceptible check recorded lowest deadhearts (6.68%) followed by SPH 1805 (7.37%). The peduncle tunneling (%) ranged from 11.7 – 57.7 % with an average of 31.3%. The least damage was recorded in SPH 1802.

AICSIP for deep and shallow soil (AICSIP-SPN-DS & SS): Overall, the leaf damage ranged from 1.83 – 5.83 with an average of 3.16 in the scale of 1 to 9. The lowest leaf injury was recorded in SPV 2330, SPV 2336, SPV 2340 CSV 29 R and M 35-1 recorded lowest deadhearts (10%). The peduncle tunneling (%) ranged from 14.3 – 52.4 % with an average of 3.16. The least damage was recorded CSV 26 followed by SPV 2351.

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 trials are SPH 1746, SPH 1803, SPH 1805, SPV 2221, SPV 2334, SPV 2343, SPV 2345 and SPV 2346.

Sugarcane aphids (Rhopalosiphum maidis): The data on aphid damage rating (1-9) was recorded at Bijapur, Parbhani 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 SPH 1742, SPH 1765, SPV 2217, SPV 2247, SPV 2348, SPV 2349, SPH 1805, CSV 29, TAM 428, SPV 2220, SPV 2236 and SPV 2281. The entries that recorded low aphid damage rating in aphid and shoot bug nursery trial are SLB 81, KR 191, Long SPS 43 and SLR 37.

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 at Bijapur. The entries IS 18551, SPH 1742, SPV 2217, TAM 428, SPV 2338, CSV 26, SPV 2274, SPV 2290m SPV 2322, SPV 230, SPV 2231 and SPV 2225 performed well in AICSIP trials. Whereas, The entries that recorded low shoot bug damage in aphid and shoot bug nursery trial SLB 19, SLB 50, SLB 80, CRS 11, DJ 6514, ICSV 93046, ICSV 745, ICSV 700, IS 2205, Local check (M 35-1), KR 191 and SLR 37.

Eco-friendly and organic IPM: Two IPM trials one at Bijapur and another at Tandur were conducted with varied treatments.

At Bijapur center: An IPM module was attempted on a one acre plot each for IPM and Non-IPM plot. IPM plot consists of soil application with Vermicompost + Neem cake, seed treatment with Thiamethoxam, application of poison bait and spraying of NSKE 5%. In Non-IPM plot, RDF with one spray each of chlorpyriphos and cypermethrin was applied. The shoot fly incidence at 28 DAE was 24.2% in IPM and 38.4% in non-IPM plot. The aphid damage rating was 5 in IPM and 8 in Non-IPM plot. The mean SPAD meter reading recorded 47.5 in IPM and 33.6 in Non-IPM plot. There was increasing in grain yield and fodder in IPM plot. The cost benefit ration was 1:1.19.

At ARS, Tandur center: Integrated management of sorghum pests was attempted during Rabi 2014-15 comprising of use of organic manure (Vermicompost). Application of Vermicompost @ 7.5q/ha+ 50% RDF recorded 15.5 % deadhearts due to shoot fly at 28 DAE and followed by the application of deoiled Neem cake @ 6.25q/ha+ 50% RDF (18.2%). The data were recorded on deadhearts (%) due to stem borer. Application of deoiled Neem cake @ 6.25q/ha+ 50% RDF recorded lowest deadhearts (9.5%) followed by application of Vermicompost @ 7.5q/ha+ 50% RDF (9.7%). There were significant differences between treatments for fodder yield and grain yield. The application 100% RDF recorded highest fodder yield (42.6 q/ha) and application of deoiled neem cake @ 6.25q/ha+ 50% RDF recorded highest yield (27.1 q/ha) followed by Application of Vermicompost @ 7.5q/ha+ 50% RDF 25.2 q/ha

Future work plan Rabi 2014-15:
- 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**

Low to moderate incidence of charcoal rot was reported from most locations. Incidence was high in Bijapur, moderate in Dharwad and low in Solapur and Parbhani. Charcoal rot index, a measure based on multiple factors of charcoal rot, were 39-73 in Bijapur, 10-27 in Dharwad and 2-13 in Parbhani. Apart from charcoal rot, rust and downy mildew were diseases on rabi sorghum in Karnataka. Lodging per cent ranged from 15-35% in farmers fields with mean lodging of 29%. Downy mildew incidences were noted only in Dharwad region (range, 0 to 32%). Rust incidences ranged from 3-6 (1-9 scale) in farmers field and as well as in research plots. Overall diseases incidence was low to moderate due to less rainfall and rainy days during rabi. Foliar diseases were sporadic in incidence due to dry weather conditions. Moderate incidence of leaf rusts and sporadic incidence of downy mildew were reported.

**Multi-locations varietal and hybrid trials**

**Charcoal rot:** Fifty-six rabi sorghum varieties and hybrids (AVHT-DS, IVHT-DS & IVHT-SS) were evaluated for charcoal rot resistance in hot spot locations in Maharashtra and Karnataka. Disease incidence ranged from low to high. Promising entries for CR resistance in deep soil were SPH 1742, SPH 1801, SPV 2217, SPV 2221, SPV 2343, SPV 2337, SPV 2339, SPV 2342 (CR index <25). The entries SPV 2349, SPV2350, SPV2346, SPV2348 and SPH 1804 performed well in shallow soil.
Other diseases: Foliar diseases incidence was low and sporadic due dry climates. Among other diseases leaf rust appeared in moderate from in Dharwad region (range, 2.0 to 5.0 in 1-9 scales). Entries SPH 1765, SPV 2340, SPV 2336, SPV 2337, SPV 2335, SPV 2348 and SPV 2349 were promising for leaf rust resistance during rabi season.

Stay green: Stay green is an important character that imparts charcoal rot resistance to sorghum genotype. Top five leaves were observed for greenness at the time of maturity. Number of green leaf per plant was counted entry wise and data were analyzed. Number of green leaf varied from 1.2 – 1.9 (out of max 5) (Table 1.1). SPH 1765, SPV 2331, SPV 2348 and SPV 2350 recorded stay green score of around two at maturity.

Flowering time: Number of days taken to 50% flowering varied from 68 to 80 among entries. Among the test entries none flowered before 70 days or after 80 days. Few earliest to flower entries were SPH 1763, SPH 1799, SPV 2339, SPV 2346 and Maule (71-73 days). There were variations in flowering time at different locations as shown by location means. At Dharwad mean flowering time was around 70 days and at Parbhani it was around 80 days.

Charcoal rot nursery: Eight entries were evaluated for charcoal rot resistance at host spots. CR index varied from 20.1 (RSR 991) to 26.7 (RSR 1016) suggesting moderately resistant CR reactions for entries. Entry RSSGV-3 recorded less than 10% lodging and was promising. Entries were moderately resistant to leaf rust.

Management of charcoal rot: Replicated field trials were laid at Dharwad and Parbhani for management of charcoal rot through seed treatments (cv. M35-1). Six treatments including four 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), grain yield and fodder yield. Treatments differed significantly for CR incidence, mean node crossed CR index, grain yield and plant height. At Dharwad treatments were at par in all charcoal rot parameters except plant height (Table S1). At Parbhani treatments significantly reduced CR index, MNC and MLS. All bio agent significantly reduced CR index and best performance was given by Pseudomonas fluorescens 21. This treatment also gave highest grain yield among bio-control agents. Seed treatment with Carbendazim, however, gave best control of charcoal rot.

6. Front-line demonstrations (Rajendra R Chapke)
During rabi 2014-15, 334 frontline demonstrations (FLDs) on sorghum were organized in 7 districts across three different sorghum growing states viz., Maharashtra, Karnataka and Andhra Pradesh. Latest sorghum varieties viz., CSV 22R, CSV 18R, Phule Suchitra, Phule Revati, Parbhani Moti, Phule Anuradha, 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 38 per cent higher grain and 43 per cent fodder yields than the local checks. On an average, the demonstrated varieties could earn net returns of Rs. 31,863/- on the cost of Rs.17,278/- per ha, which is 64 per cent more than the local check.
Report on monitoring of AICRP on Sorghum trials - Kharif 2014

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**Introduction:** Kharif 2014 AICSIP trials were monitored during September to October, 2014. Twenty three AICSIP and voluntary centers were monitored by DSR and AICSIP scientists for proper conduct of the trials, monitoring the prevalence of biotic and abiotic stresses and other relevant issues. Composition of the monitoring team and their dates of visit are presented in Table 1.

<table>
<thead>
<tr>
<th>Center</th>
<th>Team members</th>
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<td>Palem</td>
<td>RK Das, UN Alse, P Sanjana, KA Patil</td>
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<td>Solapur, Phaltan &amp; Rahuri</td>
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<td>VR Bhagwat, Yogendra Singh, SK Pahuja, Ravi Kumar</td>
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<td>Hisar, Pantnagar &amp; Ludhiana</td>
<td>AV Umakanth, YM Narayana, RK Choudhary, KN Ganapathi</td>
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The monitoring teams visited the respective centers and submitted their reports, which have been summarized center-wise below:

1. **PALEM**

   **General observations:**
   - RARS Palem, located in Mahabubnagar district, is one of the important centres for kharif sorghum research under AICSIP Programme. It is the zonal head quarter for Southern Telangana Zone, where sorghum is grown over an average area of 1.00-1.20 lakh ha. The mandate of this centre is to enhance productivity of sorghum through development of high yielding and dual purpose sorghum cultivars with resistance to biotic and abiotic stresses.
   - During last 30 years (centre started in 1982-83), this centre has released two high yielding dual purpose sorghum varieties (PSV-I and Palem-2) and two hybrids (PSH-I and ASH-I). Recently another variety CSV-31 has been identified for release.
   - Rainfall during this season was almost normal (Jun-Aug total rainfall received 319mm in place of 338mm normal). However, there was dry spell in July causing moisture deficiency which was made up by supplementary irrigation. Trials were sown during 2nd to 3rd week of June and crop conditions were quite good.

   **Breeding**
   - Five trials (AHT, IHT, AVT, IVT, IAVHT) were taken up under breeding programme.
   - The entry 1005 in AHT, 3014, 3018, 3007, 3006, 3012, 3016 in IHT, 2003 and 2004 in AVT, 4051, 4106, 4022, 4063, 4058, 4067, 4068, 4072, 4071, 4101, 4111, 4102, 4105 in IVT and 7005, 7017, 7013, 7011, 7001, 7009, 7012 in IAVHT were promising.
   - There were uniformity problem in some of the hybrids and varieties.
   - Self-restoration testing for hybrids was done properly for the entries. It should be done strictly in future in hybrid trials.
   - Some of the advanced varieties were quite short (AVT- 2006, 2055, 2106; IVT-4014, 4002, 4070, 4056, 4115, 4104, 4114) and may not be suitable as varieties.

   **Agronomy**
   - Six Agronomy trials were conducted and sowings were taken up during last week of June and crop was in flowering stage.
   - 100% RDF (80:40:40 kg/ha NPK) was observed superior than other lower doses of nutrient on pre-release grain sorghum genotypes.
   - Entries in INM trial (sorghum – chickpea cropping system) were in flowering stage and no treatment difference was observed. Clear defences were observed in T1 and T4 treatments i.e. control and FPP-weed control respectively. Due to late sowing trial was not up to the mark.
   - Intercropping of sweet sorghum with fodder horse gram observed to be a good intercropping. The local cultivars were tested for fertility levels for farmers. The variety PYPS-2 observed prominent at 100% RDF level.
Pathology
- There were total 8 trials in Pathology (six trials on breeding materials, one each on grain mold nursery and biological management). Crop was in dough stage and plant stands were good.
- Grain mold was major disease which was visible even on immature grains of few hybrids and varieties. Entries 1003, 1001, 1055, 1053, 1051, 1056, in AHT; 3013, 3018, 3006, 3012, 3002, 3060, 3069, 3055, 3062 in IHT were affected by grain mold. Entries 1005, 3007 and 3010 seemed good for mold tolerance. Mold incidence was comparatively less on varieties.
- Among foliar diseases leaf blight and anthracnose were prominent. Artificial inoculation with leaf blight pathogen helped develop the disease. Few entries developed upto 7.0 score for LB in 1-9 scale. Sporadic incidence of zonate leaf spot and rust were recorded.
- Biocontrol of grain mold has been attempted using *Pseudomonas fluorescens* and other chemicals. Following biological treatments accumulation of defense related bio-chemicals are being studied to know the nature of defense.

Entomology
- Entomology had total six trials which were sown during last week of June except one trial (F9-F10 trial was sown during 1st week of July).
- In all entomological trials the infestations of shoot fly and stem borer was negligible except in susceptible check. So there may not be reliable results on resistance from the entries. Artificial infestation of pests may be emphasized.

Suggestions
- Fertility restoration of hybrids should be noted in the breeding trials.
- Artificial infestation of shoot pests, shoot fly and stem borer may be adopted for building enough pressure.

2. COIMBATORE

**General Information:** This was a drought year. The Centre received total rainfall of 121 mm during July to August and hence the experiments were irrigated when required. In general, Coimbatore receives North-east rains during Sep-Oct. and hence, the rabi is considered as rainfed and kharif is irrigated. In general midge problem was severe during this year. The crop was at grain filling stage.

Agronomy
- All the four trial allotted were conducted as per the technical programme. All the experiments were sown on 2nd July, 2014.
- In Trial 1KB, significant response was observed up to 75% RDF. SPH 1736 was 8-10 days early for days to flowering, but there was problem of shootfly and midge. SPV 2165 was comparatively better.
- In 3K. Split application of nitrogen was sowing better results in terms of crop growth and panicle appearance. In trial 4 K, selection of plots was not appropriate; hence the treatment effects were not proper. In 5K, there was general infestation of stem borer in sweet sorghum. Fodder intercrops were harvested.

Entomology
- The crop is weed free and plant populations were well maintained in all the experiments.
- Total nine trials were allotted to TNAU, Coimbatore centre, all were conducted.
- Sorghum crop was sown on 27.06.2014. Crop was at milky stage.
- Midge and mite infestation was moderate to severe in all the trials but more severe in IVT entries
- Under high and uniform level of infestation of shoot fly and stem borer reliable evaluation of entries of AHT-GS, AVT-GS, IHT-GS, IVT-GS, IAVHT-MC, IAVHT SC, IAVHT-SS, Elite DP, SPRN were tested.
- Entries which were found promising were given in tabular form

<table>
<thead>
<tr>
<th>Trial</th>
<th>Promising entries</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Shoot fly</td>
</tr>
<tr>
<td>AHT-GS</td>
<td>1106</td>
</tr>
<tr>
<td>AVT-GS</td>
<td>2104, 2053</td>
</tr>
<tr>
<td>IHT-GS</td>
<td>3101, 3008</td>
</tr>
<tr>
<td>IVT-GS</td>
<td>4063</td>
</tr>
<tr>
<td>IAVHT-MC</td>
<td>5032, 5065</td>
</tr>
<tr>
<td>IAVHT-SC</td>
<td>6113, 6069</td>
</tr>
<tr>
<td>IAVHT-SS</td>
<td>7056, 7065</td>
</tr>
<tr>
<td>Elite-DP</td>
<td>247, 212, 282</td>
</tr>
<tr>
<td>SPRN</td>
<td>503, 591, 575</td>
</tr>
</tbody>
</table>

* Data was not taken by the time of monitoring since they were planted late.

Pathology: All the six trials were conducted as per the technical programme. All the experiments were planted on the 30th June 2014. The crop was in milking stage. There was moderate infestation of leaf diseases.
Breeding: There were 5 grain sorghum and 4 forage and sweet sorghum AICSIP breeding trials and some station trials. The crop had reached maturity in almost all the trials except sweet sorghum trial. Midge and severe bird damage was observed in all the grain sorghum trials. Some of the general observations are as follows:

IVT-GS: The trial was sown on 16.06.2014. There were 22 entries including a local check (Co 30). Some of the early entries were 4004, 4070 and 4115, while 4005, 4015, 4053, 4061 and 4114 were late. Some of the good entries were 4021 and 4012, while poor seed set due to midge attack was observed in 4006, 4016, 4011, 4001, 4017, 4019, 4020, 4055, 4064, 4065, 4063, 4119, 4112, 4110, 4106 and 4107. Very severe shoot fly damage was also recorded in 4058.

IHT-GS: The trial was sown on 16.06.2014. There were 26 entries including a local check (CoH 5). Some of the early entries were 3007, 3071, 3065, 3108 and 3103, 3021, 3019, 3052, 3070, 3067 and 3111 were late to flower. Some of the good entries were 3017, 3024, 3006, 3018, 3016, 3025, 3058, 3057, 3068 and 3013. Poor seed set was observed in 3010, 3007, 3021, 3009, 3050, 3014, 3011, 3076, 3054, 3075, 3065, 3053, 3116, 3118, 3107 and 3115 due to midge attack.

AVT-GS: The trial was sown on 16.06.2014. There were 8 entries including a local check (Co 30). High variation was observed in some of the test entries. Some of the good entries were 2001 and 2008. 2006, 2055 and 2106 were early while 2007, 2053 and 2105 were late.

AHT-GS: The trial was sown on 16.06.2014. There were 9 entries including a local check (CoH 5). Some of the early entries were 1001, 1051 and 1103, and late entries were 1003, 1055 and 1102. 1002 was a good hybrid.

IIHT: The trial was sown on 30.06.2014 with 17 entries. Some of the early entries were 101, 103, 106, 113, 154, 161, 164, 214, 201 and 205. 104 and 107 were good hybrids.

IAVHT-SC: The trial was sown on 16.06.2014. There were 20 entries including a local check (K 0550). The trial was harvested at 50% maturity. Some of the promising entries were 6018, 6017, 6010 and 6002 which had high yield, juice content and brix. Entries 6016 and 6014 had high yield but not juicy.

IAVHT-MC: The trial was sown on 16.06.2014. There were 12 entries including a local check (Co(FS) 31). First cut was taken at 50% flowering. Some of the entries which had high green fodder yield were 5013, 5007, 5038, 5033, 5042, 5040 and 5066. Regeneration was poor in almost all the entries except 5006. Local check Co (FS) 31 is a gamma ray mutant of Co(FS) 29, non-shattering type and released in 2013.

IAVHT-SS: The trial was sown on 16.06.2014. There were 18 entries including a local check. Foliar disease was severe in some of the entries like 7012, 7002, 7055. Some of the good entries were 7014, 7006, 7007, 7010, 7017, 7011 and 7013 with good biomass.

SYT: The trial was sown on 30.06.2014 with 8 entries. Entries with good seed yield were 102 and 105.

DHARWAD General observations:

- Total rainfall received during kharif season was 680 mm, which was 38% excess of average rainfall of over 60 years. Summer rain of 196.6 mm received in the month of May helped in land preparation. The month of June received deficit rainfall of 81.1 mm. Thus, timely sowing of experiments could not be taken up. Excess rainfall of 88.1 mm was received during the month of July helping in sowing but it got delayed by almost one month. With sufficient rainfall in July germination and crop establishment was satisfactory. Further the August month received excess rainfall of 57.6 mm, which helped in good crop growth. In general excess rain led to much weed growth and inter-cultural operations could not be taken up timely. Untimely rainfall from Oct 24-26 with accompanied wind has led to extensive lodging of crop. In general there was heavy incidence of stem borer and ergot.
- All the five allocated trials in breeding, 8 in entomology, 7 in pathology and 5 in agronomy were conducted successfully. In general in majority of trials weed control got affected due to rains.
- Large-scale demonstration was conducted with 10 elite hybrids and varieties. Out of these SHD 6 and SHD 36 looked promising and did not lodge at all, while other varieties/hybrids have lodged.

Breeding: Lack of uniformity in some entries in IVT and IHT was reported. Since there was severe lodging exact extent of admixture could not be recorded but the center has already recorded the information and has been asked to furnish the data. All trials could not be seen meticulously as majority entries lodged. Severe ergot infection was noticed in 3004, 3014, 3016, 3019, 3021, 115, 2014-21 among others. Some promising entries are as follows:

IVT GS: 5057, 4058, 4059, 4064 and 4065
AVT GS: 2101, 2105 and 2103
IHT GS: 3001, 2011, 3012, 3020 and 3025
AHT GS: 1102, 1105 and 1107
IIHT GS: 117, 112, 106, 104 and 111
Besides allocated AICSIP breeding trials, the station has conducted two state trials, viz., MLVT and MLHT with 16 and 13 entries, respectively. One MLT on foxtail millet with 13 entries was also conducted. They had two SVTs and two SHTs with 16 entries each. One State Private Hybrid testing trial had 7 entries.

A CRP-NBPGR/DSR germplasm trial with 870 entries was also conducted. Besides they had 66 F1s, 12 F2 populations, 35 F3 families, 6 advanced lines in F3 and 11 in F5, 35 R lines, 28 A/B pairs and 229 germplasm for evaluation and multiplication.

One evaluation trial with 80 M4 families from DSV6 and CSV15, showed some promising entries for seed weight.

**Entomology:** Eight allocated entomology trials were well managed. Some of promising entries are as follows:

- **AHT GS:** 1001
- **IHT GS:** 3064, 3125
- **IVT GS:** 4063
- **PDRN:** 622, 630, 636
- **IAVHT SC:** 6008, 6012, 6065
- **IAVHT MC:** 7104

**Pathology:** Seven allocated pathology trials were conducted properly. Crop condition was good but in general shoot fly damage was high. Some of promising entries are:

- **AHT GS:** 1008, 1007, 1052, 1103
- **AVT GS:** 2001, 2002, 2054, 2107
- **IHT GS:** 3007, 3011, 3055, 3103, 3109
- **IVT GS:** 4004, 4055, 4115
- **IAVHT SS:** 7011, 7059, 7110, 7102
- **PDRN:** 348, 607, 639
- **NGN II:** 809, 812, 853, 870

**Agronomy**

- Among all 5 agronomy trials stem borer incidence was more otherwise crop management was good. In ‘Response of pre-release sorghum genotypes to different fertility levels’ SPH 1736 and CSH 25 at 75% and 100% RFD performing better.
- In ‘Integrated nutrient management in kharif sorghum-chickpea cropping system’ trial treatments T4, T5 and T6 appear good.
- In ‘Improving N use efficiency through method and time of N application’ T2 and T4 appear good. In ‘Priority inputs in kharif sorghum’ T4, T6, T7 and T8 appear good. In ‘Intercropping of sweet sorghum fodder with forage legumes under different nutrient management’ the crop was already harvested.

**Recommendations:**

- Across discipline maintenance of data books was meticulous. They followed given technical programme and sowing plans. Weed control was not appropriate, which might have happened due to occasional rains during the cropping season. Interaction across discipline was satisfactory.

4. **CRS, SOLAPUR AND NARI, PHALTAN**

- The AICSIP Trials were monitored at CRS Solapur and NARI phaltan
- All the trials were perfectly conducted at CRS Solapur.
- There was severe damage due to midge in all the trails. Hence place is not suitable for grain sorghum trials.
- It is a best hot spot for midge screening

5. **RAHURI**

- At Rahuri, initial advanced varietal and hybrid trail and High biomass trail, along with university trails were monitored
- All the experiments were perfectly conducted and had very good growth and expressions
- The promising entries in initial advanced varietal and hybrid trail were 7017, 7013, 7011, 7018, 7062, 7065 and 7110
- The promising entries in High biomass trail were 309, 307, 305, 357, 356, 355, 408, 409 and 402
- Promising entries in Entomology trails were: **IAVHT- SS:** 7017, 7018DJ6514, Swarna, IS 18551, 7105,7103; **AHT- GS:** IS 2205, Amrutha, IS 18551, DJ 6514, IS 2205; **AVT-GS:** 2101, 2052, IS 2205, IS 18551, Swarna, Amrutha, DJ 6514, 2057, 2102

6. **PARBHANI**

**General information:**

- The kharif sorghum trials were sown during the second week of July 2014. The total rainfall received during the cropping period was 383.0 mm which is far lower than normal rain fall of about 755 mm.
- Prolonged drought spells occurred both in July and August. The distribution of rainfall indicated that there was delay in onset of monsoon by a more than three weeks in June-July. Thus sowing was postponed to July second week in all trials.
- The rainfall received during second fortnight of July was just adequate to sow the kharif crops. Hence, most of the sowings were done in the 2nd week of July 2014.
- The crops experienced more than two weeks of severe early seedling drought followed by mid-August. Because of initial prolonged drought, the seedling establishment and crop height decreased in some trials.
Single protective irrigation was given as per necessity to avoid severe desiccation. The crops are at soft-dough stage and likely to face severe terminal drought unlike rains are not received.

**Breeding:** All the trials were organized as per the technical program allotted. The conduct of the trials was very good including field management. No significant biotic stresses observed. The promising entries in various trials are listed below.

* AHT-GS: 1005, 1006, 1002- for biomass and high grain yield
  * AVT-GS: 2054, 2056, and 2052
  * IVT-GS: 4017, 4021, and 401
  * IAVHT-SS: 7113, 7118, and 7117
  * IHT-GS: 3016, 3018, 3006, 3011, 3024 and 3020
  * IIHT-GS: 105, 112, 115, 117, 111, 104

- **High biomass trial:** Genotypes planted to assess the biomass quantity and quality is under evaluation. The entries with high cellulose and low lignin content will be known after harvest and processing only
- **Evaluation of kharif grain sorghum for mid season drought:** Phenotyping sorghum germplasm for mid and terminal drought tolerance indicated that the entries exposed to both mid season and terminal drought stress and promising entries identified based on visual field scoring include Trno. T11, T13, T27, T15.

**Agronomy**
- The trials on grain and weed management are planted in July Second week. In general, the crop stand and agronomic superiority are good. The crop exposed to prolonged dry spells during pre- and post-flowering stages.
- In trial 1KC i.e., response of pre-released sorghum to fertility levels, apparent differences were seen among fertility levels and genotypes based on visual agronomic rating.
- In trial 2K i.e., INM (sorghum-chickpea cropping), marked differences were observed among the treatments.
- In trial 3K i.e. use efficiency too, apparent differences were observed among the treatments.
- In trial 4K i.e., prioritizing of inputs the conduct of the trial is good but plant population is relatively less.
- A trial 5K i.e., Evaluation of post-emergence herbicides for kharif sorghum is planted and in good condition. The relevant data are being collected.

**Entomology:** The trials were sown from 22 to 24 July 2014. However, the trials were managed properly and expression of crop was good. Shoot fly infestation was ranged from 13(resistant) to 75% (susceptible). The promising entries are listed below.

* AHT-GS: SF Res.nos.1003, 1008, 1007; SB tol: 1001, 1003, 1006, 105
  * IAVHT-SS: SF: 4020, 4009; SB: 4020, 4009, 4068.
  * SPRN: SF: 502, 519, 521, 532; SB: 502, 511, 527.

- The two sowings were not carried out to assess the damage caused by shoot fly and stem borer separately. The stem borer infestation was also very low and it ranged only less than 17%.

**Pathology**
- All the trials were planted on 30 June 2014 and the crop management and data collection are good. In view of drought conditions, there was no significant incidence of foliar diseases, while the incidence of grain mold was too absent.
- **Observations:** The AICSIP trials namely AHT-GS, IHT-GS, AVT-GS, IVT-GS, IAVHT-SS, NGN-1 were planted as per plan and the observations of postflowering are yet to receive by pathologist.
- **Conclusions:** The grain mold incidence was not seen due to late sowings and there was no sufficient rainfall in the month of August and September. Advised them to arrange sprinklers to induce grain mold if there is no rains in October. Sowings should be completed during the first week of June.

The team also met Dr B. Venkateswarlu, Hon’ble Vice Chancellor and Director Research of VNMKV and highlight the progress of sorghum research at SRS. The VC suggested exploring the possibility of arresting the reduction of kharif sorghum area by promoting value added health food. There is a serious concern for harvesting machinery sorghum due to labor problem. The VC suggested that DSR should organize a brain storming session of developing Sorghum harvester in collaboration with CIAE, Bhopal and VNMKV, Parbhani with other SAUs.

7. **AKOLA**

**General information:**
- The rainfall received during June to September end was 565mm against a normal (long-term) rainfall of 661 mm during the corresponding period. The total rainfall deficit was about -15.0%.
- The rainfall distribution was highly erratic with severe drought conditions prevailing in June and early July. Although the rainfall was near normal in July, the sowing was done in the last week of July only. Again dry spells occurred in mid-August too.
- Because of this late sowing, the crops were exposed to severe terminal drought which coincided with booting to flowering. If there is no rainfall in GS 3 stage, there is depressed grain filling and it is difficult to produce grain by some late entries.
Breeding: All the trials were conducted as per the technical program of AICSIP. Entries in most of the trials were between flowering and soft-dough stage showing good growth and biomass production. Promising entries identified based on visual rating on biomass, agronomic superiority, etc., (plant height 1.5 - 2.0 m) are listed below.

AHT-GS: There is less plant population than normal. Promising one include 1051, 1053, and 1056. Due to sparse population, caution should be exercised while pooling the data.

AVT-GS: Some entries showed poor expression due to improper thinning. The promising one include 2001 and 2006(dwarf)

IHT-GS: Most of the entries showed good expression with optimal plant population. Entries showing good growth and biomass production include 3014, 2024, 3009, 3025, 3011, and 3006, while entry 3010 is mixture.

IVT-GS: Most of the entries showed good expression. Entries showing vigorous growth and biomass production include 4019, 4001, 4010, 4009, while entry 3013 is mixture.

IIHT-GS: Entries showed stunted growth with relatively poor performance. Promising ones include 116, 106, 117, and 115

Agronomy:
- The trials on grain sorghum and weed management were planted in July last week. In general, poor crop stand observed in some trials. The crop was exposed to prolonged dry spells during pre- and post-flowering stages. The promising treatments are listed below trial-wise.
  - In trial 2K i.e., INM (sorghum- chickpea cropping), the trial was said to be planted in the first week of June 2014. The team had not seen the crop as we were told that the trial was already harvested. Caution should be exercised to include this data in pooling with other centers at AICSIP HQ.
  - In trial 3K i.e. use efficiency, there was suboptimal plant population was observed. The split application of N was not done at boot-leaf stage and hence, caution should be exercised to include this data in pooling with other centers at AICSIP HQ.
  - In another station trial i.e., effect of BBF on soil moisture conservation, the crop condition is good. The plant population was relatively high in flat-bed treatment. There is need to maintain optimal plant population to observe the treatment effects uniformly.

Entomology: The incidence of shoot fly in all the trials is very low due to drought conditions. The symptoms of spotted stem borer damage observed in some entries. Promising entries identified based on symptoms for different pests are listed below.

Shoot fly infestation was ranged from 0 (resistant) to 87% (susceptible). The promising entries are listed below.

AHT-GS: SF Res.nos.1004, 1058,1052, IHT-GS: SF: 2,1, 3025,3053,3064,3074,3069


IAVHT-SS: 7013,7018,7003,2,1,7065 SPRN: SF: 514, 521, 538, 578, 604.

Plant Pathology:
- All the trials were plated late (August last week 2014). In view of late planting, the entries showed symptoms of severe drought stress at pre-and postflowering stages.
- 9 trials namely AHT-GS, AVT-GS, IHT-GS, IVT-GS, NGN-II, PDRN, IAVHT (MC), IAVHT-SS, IAVHT-SC were planted.
- Due to terminal drought conditions, the incidence of grain mold was absent at the time of visit (flowering to soft-dough) even on the susceptible entry i.e., Bulk-Y.
- There is no significant foliar disease incidence was noticed at this stage due to drought conditions. The evaluation needs to be continued in anticipation of late rains prior to physiological maturity (November). It was suggested that sprinklers may install to induce grain mold if there is no rains and also sowings should be completed during the first week of June.

Crop Physiology: In “phenotying sorghum germplasm for mid and terminal drought tolerance” trial, the entries exposed to both mid-season and terminal drought stresses and promising entries identified based on visual field scoring was SSRK-13-1.

8. BULDHANA

General information:
- Plantings were done during 3rd week of July. The rainfall received during June to September end was 680mm against a normal (long-term) rainfall of 744mm. The rainfall distribution was highly erratic with severe drought conditions prevailing in June and early July and mid-August. Sowing was delayed by one month due to non occurrence of rainfall in June.
- Despite this late sowing the crop conditions is very good with full plant population. The crops are at late flowering to soft-dough stages showing good growth and biomass production.
- Symptoms of drought stress i.e., leaf folding was seen in some late entries. Promising entries identified based on visual rating on biomass, agronomic superiority, etc., (plant height 1.8 - 2.0 m) are listed below.
- AHT-GS: No significant biotic and abiotic stresses were observed. Promising ones include 1007, 1008, 1003, and 1001, while entry 1006 is an admixture. Variety SPV 669 which included as local check in AHT trial should not be compared with experimental hybrids.
- AVT-GS: No significant biotic and abiotic stresses were observed. Minor incidence of stem borer (~10%) foliar damage was seen. Promising ones identified include 2001, 2006, and 2004.
Recommendations (for Parbhani, Akola and Buldhana)

- The rainfall quantum and its distribution are highly erratic during kharif 2014 both at Parbhani and Akola. There is an opportunity to evaluate and identify the genotypes for pre-and postflowering drought and heat stress conditions prevailing during the current kharif season.
- At Parbhani plant protection sprays should have been minimal and need based.
- In high biomass trial prior planting information of cellulose, hemicelluloses lignin should needed for effective field evaluation and utilization for 2G biofuels rather than visual plant vigour and plant height.
- In Initial hybrid trials, some entries are looking like B-lines not like hybrids in terms of height, vigour and biomass production. Care should be taken that they should be evaluated at the station trials before entered in AICSIP trials.
- In all Agronomy trials, NPK status of soil prior to sowing and at harvest should be done for estimating nutrient uptake and use efficiency.
- At Akola, incidence of foliar diseases under drought and heat stress should be recorded. If necessary, using sprinklers for screening for grain mold tolerance to be explored in the absence of natural infection.
- The centre scientists requested that all the PIs should decide the number of genotypes and treatments at the workshop so as to make necessary indents for resources to the university authorities.
- Entomologist was suggested to evaluate sweet sorghum trials for shoot bug infestations.
- Dr B. Venkateswarlu, Hon’ble Vice- Chancellor suggested to explore the possibility of arresting the reduction of kharif sorghum area by promoting value- added health food products. The VC also suggested that DSR should organize a brainstorming session of developing Sorghum harvester in collaboration with CIAE, Bhopal and VNMKV, Parbhani with other SAUs.

9. INDORE

General information:

- The rainfall received was 842.8 mm during June to September with 27 rainy days. The rainfall was received late in July. Even though normal quantity of rainfall was received, the distribution was not uniform.
- 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.

Breeding:

- Five breeding experiments were allotted to the centre under AICSIP and all the five were sown on 8-7-14. Crop stand was good and crop was free from pests and diseases.
- The trials include AVT (GS), AHT (GS), IVT (GS), IHT (GS) and IIHT.
- Five station trials two on varieties, one on hybrids and one on restorer evaluation were sown.
- Male sterile development, improvement, evaluation and maintenance program was also planted. Crossing work is being attended.
- There were two experiments on germplasm evaluation, maintenance, characterization and documentation.
- The segregating material at different stages of development and the seed production plots were also visited.
- Sterility was noticed in some entries of AHT (1054), IHT (3004, 3006, 3013, 3016, 3067, 3052, 3055, 3111 etc) and IIHT (115, 151, 216 etc).

- The promising genotypes in each of the trials include:
  - AVT- code nos. 2006, 2056, 2101, 2104
  - AHT- Code nos. 1002, 1009, 1057, 1059, 1105
  - IVT- Code nos. 4021, 4010, 4118, 4122, 4064, 4116, 4106
  - IHT- code nos. 3007, 3015, 3020, 3022, 3021, 3023, 3026, 3057, 3051, 3058, 3072, 3074, 3117, 3103, 3123, 3102, 3109
  - IIHT- 102, 108, 110, 211

Agronomy:

- There were five AICSIP Agronomy trials being conducted at Indore center.
- All trials were sown on 21st June 2014 as dry sowing but first effective rains came on 8th July 2014 therefore, effective date of sowing considered as 8th July 2014. In general crop conditions in all trials were good and weed free. The crop was at grain filling stage and dough stage. The crop faced small dry spell of about 18 days during crop growth stage.
- In general the quality of experimentation, plant population and maintenance of data booklet of all the experiments were proper and at satisfactorily level.

1K (C). Response of pre-released sorghum genotypes to different fertility levels (grain type) - On visual basis the test genotypes performance can be ranked in the order of SPH-1736, SPH-1724 and CSH 16. At higher fertility i.e. 100% and 75% RDF performance of SPH- 1736 observed better than other test genotypes. Fertility response can be observed visually.

1K (D). Response of pre-released sweet sorghum fodder genotypes to different fertility levels (sweet sorghum fodder) - On visual basis the test genotypes performance can be ranked in the order of SPV-2205, SPV-2196 and CSV 24 SS. Fertility response was observed between 50% RDF and 100% RDF in all replications.
2K: Integrated Nutrient management in kharif sorghum- chick pea cropping system- The kharif 2014 season was second year of this trial. The visual performance of treatment no. T5 : 75% RDN thru chemical fertilizer+ 25% RDN thru vermicompost and T8: 75% RDN through chemical fertilizer+ 25% RDN through vermicompost+ seed treatment with PSB & Azospirillum proved superior over other treatments under test. Application of recommended dose of nitrogen through vermicompost proved superior over FYM.

3 K: Improving N use efficiency through method and time of N application - N application method comprising of 25% N at sowing+ 50% N at 30 DAS+15% N at boot leaf stage+10% at grain filling stage looked better than other N application methods in both the cultivars.

5 K: Intercropping of sweet sorghum fodder with forage legumes under different nutrient management - This experiment was harvested before the monitoring team visited the centre, however Dr N.S. Thakur reported that intercropping of sweet sorghum fodder + fodder cowpea(2:1) and sweet sorghum + fodder cowpea(2: 2) row ratio found good in terms of green fodder yield.

Entomology:

- Five AICSIP trials and two station trials targeting different pests such as shoot fly and stem borer were taken up under Entomology discipline.
- Sowings of entomology trials were done on 30-6-14.
- Shoot fly incidence was high with about 80% shoot fly deadhearts in susceptible check and about 10% deadhearts in resistant check in different trials. Promising lines with shoot fly resistance on par with resistant check were noted.

Station programme:

- The station trials involve the state level varietal trials like SVT I, SVT II and SSTetc. All the trials are being maintained well.
- The team had visited the station breeding program consisting of early generation breeding material (F3 to F6), A/B/R line program and nucleus seed and breeder seed production.

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.

10. SURAT

General information:

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. However, this year 844.8 mm rains were received with 38 rainy days. Crop growth and field management in general was good. Most of the trials were sown during end of July and multicut fodder was sown in May end. As a result, the sowings were delayed due to late arrival of monsoon and hence, the crop was at either flowering or boot leaf stage.

Breeding:

- In total there were six grain sorghum and two forage sorghum trials were sown. In addition to this some state trials were also planted. There were other trials such as public private trial, high biomass trial, and a trial on A/ B lines.
- Few of the promising lines were 4018, 4020, 4004, 4002 (IVT-GS), 2006, 2052 2106 (AVT-GS), early flowering in 3003, 3014 3024, 3020 (IHT-GS). In AHT (GS) entries 1006, 1007, 1001 were promising.
- The entries 7018, 7016, 7008, 7003 (IAVHT-SS) and 5006, 5009, 5003 in IAVHT –MC) were founding good. 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 four trials allotted were conducted as per prescribed information. The trials were planted on 16th July, 2014. Most of the entries in trials were either at vegetative or flag leaf stage.
- Foliar application of 5% urea at boot leaf stage was better as seen differences in leaf color and growth. A trial on CAN obtained from private sources was also conducted to test its efficacy on sorghum.

Entomology

- All the AICSIP allotted eight trials were carried out in 2 m row length for shoot fly resistance screening. There were three station trials in addition to AICSIP trials.
The trials were sown on 16th July, 2014. Shoot fly incidence was moderate (up to 60% DH) whereas, leaf damage due to stem borer and armyworms was high (up to 7 damage rating). Overall, the crop condition and field maintenance was good.


Pathology

All the allotted eight trials were planted on 16th July, 2014. The crops were in grain filling stage. There were three state trials.

Disease incidence was low to moderate (2-5) predominantly 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. The entries that were performed better against anthracnose and leaf blight are 1007, 1105, 1056 in AHT-GS, entry nos 2004, 2001, 2008, in AVT-GS; 4001, 4063, 4066, 4106 in IVT-GS; 6018, 6011 in IAVHT-SC, 7015 in IAVHT-SS and 819, 843, 856, in NGMN-II trial. GJ 38 was used as local check in these trials.

11. MANGROL

The crop condition in Mangrol was very good and the trials were managed nicely (Plate 1). In total, 1418.5 mm of rainfall was received in Kharif 2014 in 40 rainy days. There were two coordinated trials on sorghum and few state trials including LST, LSVT and SSVT were also planted. The trials were conducted successfully. In AVT (GS), the promising entries were 2006, 2054, 2055 and 2106. In AHT (GS), the promising entries were 1008, 1007, 1005, 1001, 1053, 1051, 1052, 1103, 1104 and 1106.

12. DEESA

The experiments at Deesa were also laid in proper design and crop condition was also good. Total 847.5 mm rainfall was received in 30 days during kharif season.

There were six breeding trials and two station trials. In IVT (GS) the promising entries were 4009, 4007, 4011, 1012, 4017, 4057, 4058, 4051, 4055, 4102, 4108, 4112, 4121, 4101 and 4117. The good entries 2006, 2004, 2003, 2051, 2054, 2057, 2103, 2107 in AVT (GS). In IHT (GS), the promising entries were 3007, 3017, 3014, 3025, 3065, 3056, and 3071. The impurity was observed in 3019, 3017, 3010 and 3055. In AHT (GS), the promising entries were 1006, 1005, 1001, and 1106.

In IAVHT (MC), the promising entries were 5006, 5005, 5032, and 5065. Whereas, in IAVHT (SC), entry nos 6007, 6002, 6006, 6018, 6004, 6059, 6069 and 6053 were found better.

13.UDAIPUR

General information: The centre received 600 mm rainfall till September. Pest and disease incidence was moderate. The crop condition was good. All trials were sown in 1st week of July except entomology. The crop was in grain filling stage.

Breeding: There were six breeding trials and two station trials. The trials were planted on 15-19th July, 2014. In IVT (GS), the promising entries were 4009, 4007, 4011, 1012, 4017, 4057, 4058, 4051, 4055, 4102, 4108, 4112, 4121, 4101 and 4117. The good entries 2006, 2004, 2003, 2051, 2054, 2057, 2103, 2107 in AVT (GS). In IHT (GS), the promising entries were 3007, 3017, 3014, 3061, 3056 and 3113. In AHT (GS) the promising entries were 1006, 1052 and 1106. The local check used was SPH 837. In IAVHT (MC), the promising entries were 5008, 5036, 5032, 5036, 5070 and 5065. Whereas in IAVHT (SCI), the promising entries were 6065, 6002, 6058, 6056, 6052, 6119, 6111 and 6116. In State trials, in F2 population, the crosses IS 12965 x IS 23952, GGUB 21 x EJN 71, GGUB21x IS 18850 and IS 19859 x IS 19831 recorded promising plant growth and earhead formation.

Agronomy: Six trials were conducted and sown on 17th July. Fertilizer response was visible on SPV 2185, SPH 1736, SPH 1737 and CSH16. In N2-use efficiency trial N1 treatment (50% n at sowing and 50% at 30 DAS) appeared better. Application of Vermicompost with normal dose of fertilizer was found better. In intercropping trial, 2 rows of sorghum with one row of cowpea had greater compatibility.

Entomology:

Dr. Lekha, Assistant Entomologist, is looking after entomology trials. Total 11 trials have been sown during 2-3 August, 2014. General crop growth was poor due to weed infestation and inadequate management.
The trials were poorly managed however, the record maintenance was good. The incidence of shoot fly was 5-60% and stem borer infestation was very meager, however, the damage due to *Mythimna* was severe up to 90%.

The entries which had lesser damage due to shoot fly were recorded. They are: AHT-GS: 1003, 1004, 1052, 1058, 1103; AVT-GS: 2108, 2101; IVT-GS: 4017, 4007, 4119; IAVHT-SC: 6001, 6015, 6008, 6018, 6007, 6059, 6065, 6058, 6069, 6061, 6018, 6103; IAVHT-MC: 5008, 5009, 5040, 5043, 5033, 5039, 5037, 5035, 5065, 5070; IAVHT-SS: 7003, 7005, 7018, 7013, 7008, 7061, 7060, 7056, 7103, 7009, 7017; FORAGE: 903, 905, 915, 919, 942, 943, 95, 952, 942, 939; IHT-GS: 3023, 3051, 3069; ELITE-DP: 205, 212, 213, 225, 267, 264, 259, 255, 252, 248, 259, 271, 287, 288, 297; PDRN: 602, 606, 610, 627, 630, 625, 624, 628 and ISPRN-ICRISAT: 101, 102, 119, 104, 112, 205, 212, 217, 301, 306, 308, 319. The plant growth was stunted due heavy weeds and hence ear head formation will be delayed.

Pathology:

All nine trials were sown on 16th July, 2014. Foliar disease incidence particularly anthracnose, target & zonate leaf spot and leaf blight had less (1-3) in incidence. Screening was done using infector row and artificial inoculations that developed good disease pressure. Crop was in good condition.

The disease is expected to increase further as some entries were still in flowering stage. However, some of the promising entries were recorded. AHT-GS: 1005, 1003, 1007, 1056, 1057, 1053, 1105, 1102, 1108, 1104; IAVHT-SS: 7001, 7011, 7010, 7004, 7063, 7066, 7059, 7056, 7108, 7107, 7111; AVT-GS: 2004, 2001, 2002, 2003, 2056, 2051, 2057, 2053, 2103, 2101, 2104; IVT-GS: 4010, 4017, 4016, 4019, 4066, 4071, 4062, 4057, 4018, 4009, 4102, 4103, 4112; IAVHT-SC: 6010, 6016, 6017, 6062, 6060, 6051, 6053, 6104, 6118, 6107, 6102 and IAVHT-MC: 5004, 5007, 5010, 5040, 5033, 5063, 5066, 5069.

Recommendations:

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.

Timely planting of respective trials need to be taken for each disciplines at Surat.

There was stem borer problem in all trials in Surat. Respective control measures need to be taken in yield oriented trials.

Fish meal technique for shoot fly screening should be followed in Entomology trials at Surat.

Damage of *Mythimna* is required to be recorded. Since damage was severe.

Plant stand need to be maintained properly at Udaipur.

Proper drainage system particularly in Agronomy trials is needed.

The interdisciplinary collaboration need to be strengthened.

Visit to the centers need to be scheduled based on the sowing date at a given center.

Centre reported scarcity of fund for handling on-farm activities like harvesting threshing etc. The audit unit DSR may be looked into it.

The centers need to inform DSR Hyderabad the dates of sowing of all experiments across different disciplines.

14. JHANSI

General observations:

The center has conducted two trials IAVHT- SC and IHT- MC, the later has been harvested twice on 26.7.14 and 17.9.14. The trials were sown on 24.7.14 and 8.5.2014, respectively.

The IHT- MC trial was harvested twice on 26.7.14 and 17.9.14 and concluded. The data on green and dry fodder yields have been recorded. The data on other qualitative traits like IVDMD is yet to be recorded.

The trial IAVHT is in boot leaf stage. The field was not thinned sufficiently. There is incidence of foliar disease in some entries which are reported.

Based upon visual observation and raw data following entries are worth reporting

<table>
<thead>
<tr>
<th>Trial</th>
<th>DOS</th>
<th>Promising lines</th>
<th>Remarks/ suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAVHT- SC</td>
<td>24.07.2014</td>
<td>6004, 6013, 6008, 6063, 6058, 6053, 6102, 6108</td>
<td>The trial was not thinned properly. Entries susceptible to leaf spot: 6020, 6006, 6002, 6117, 6120</td>
</tr>
<tr>
<td>IHT- MC</td>
<td>08.05.2014</td>
<td>1st cut: 5004, 5038, 5073 highest GFY/plot&lt;br&gt;lind cut: 5004, 5043, 5065 highest GFY/plot</td>
<td>Only data on green and dry fodder/plot has been recorded. Other qualitative data are not recorded.</td>
</tr>
</tbody>
</table>

Recommendations:

The kharif crop was in good condition in spite of scanty rainfall and all the trials were laid out satisfactorily and labeled properly.
The trial IAVHT-SC was not thinned properly resulting in poor crop expression.
The data on HCN, IVDMD are not recorded which are must for fodder trials.

15. PANTNAGAR
- Though there were not enough rains in the initial stages of crop growth, the crop expression was satisfactory.
- In the multicut trials, two cuts were taken and the entry number 5005, 5007, 5008, 5010 were promising based on the two cuts yield.
- In the IAVHT single cut, the entries 6004 and 6010 were having high biomass and were promising.
- In the sweet sorghum and BMR trials incidence of foliar diseases was quite high.
- The entry numbers, 16, 19, 20 were stable for BMR trait.
- The entries 7060 and 7107 were found promising with high biomass in sweet sorghum trials (IAVHT).
- In the prebreeding F2 material shared by DSR, the cross numbers 569, 570, 582 and 583 were throwing segregants with more leafiness.
- The incidence of anthracnose and zonate leaf spot was seen in lower leaves in most of the pathology trials.

Recommendations
- Timely selfing of the BMR genotypes is required so as to prevent segregation in the advanced generations.

16. LUDHIANA
- Shootfly infestation was quite high in most of the trial
- In the IAVHT (Multi-cut), two cuts were completed and the entries 5011 and 5035 and 5070 were promising for fodder yield
- In the IAVHT (single-cut) the entry number 6004 was tall with broad leaves and was promising
- The local check SL 44 was quite early (65 days) to flower.
- The sweet sorghum trials has severe attack of shootfly and poor stand was observed in some of the plots
- The agronomy trial (SS + legume mixture) was vitiated due to shootfly attack
- In the trial 1 KE SPV 2185 showed relatively less leaf diseases.

Recommendations:
- To include ICSV 93046 in stem borer resistance breeding programmes
- To liaise with the sugar industry in Punjab for promoting sweet sorghum as biofuel crop

17. HISAR
- Similar to Ludhiana, most of the trials has high incidence of shootfly and stem borer due to late sowing (60 % deficit in rainfall)
- In multicut trials, the promising genotypes based on GFY were 5040, 5042, 5034.
- In IAVHT single cut trials the entry numbers 6104, 6105, 6119 and 6120 appeared to be promising.
- In Agronomy trials, SPV 2191 appears promising compared to SPV 2185 at all fertility levels

Recommendations: To provide an entomologist to this centre as it is a hotspot for shoot pests.
Report on monitoring of AICRP on Sorghum trials - Rabi 2014-15

Aruna C.
ICAR-Indian Institute of Millets Research, Hyderabad - 500030

Introduction: Rabi 2014-15 AICSIP trials were monitored during January-February, 2015. The 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 2014-15

<table>
<thead>
<tr>
<th>Center</th>
<th>Team members</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solapur, Bijapur, Mohol</td>
<td>VR Bhagwat, P Sanjana, VS Khubsad, RW Deshmukh</td>
<td>Jan 6-7, 2015</td>
</tr>
<tr>
<td>Rahuri</td>
<td>AV Umakanth, AP Biradar, P Satish, V Bhat</td>
<td>Jan 21, 2015</td>
</tr>
<tr>
<td>Parbhani, Akola</td>
<td>Prabhakar, SJ Trivedi</td>
<td>Jan 28-29, 2015</td>
</tr>
<tr>
<td>Surat</td>
<td>SS Rao, HV Kalpande</td>
<td>Jan 21, 2015</td>
</tr>
<tr>
<td>Tandur</td>
<td>Aruna C., P Sujathamma, Kalaisekar, Aswathama, Sunil Gomashe</td>
<td>Jan 28, 2015</td>
</tr>
<tr>
<td>Phaltan</td>
<td>Sujay Rakshit, UN Alse, YD Narayana, Sonalkar</td>
<td>Jan 31, 2015</td>
</tr>
<tr>
<td>Dhawad</td>
<td>GS Shyam Prasad, Gowri Sajjanar</td>
<td>Jan 20-22, 2015</td>
</tr>
<tr>
<td>Kovalpatti</td>
<td>IK Das, Shekharappa, R Kalpana</td>
<td>Jan 30, 2015</td>
</tr>
</tbody>
</table>

CRS- SOLAPUR

During the year, the total rainfall received from January to December 2014 was 450.3 mm as against the normal rainfall of 753.0 mm which shows a deficit of 59.8%. However the distribution of rainfall during July to November was quite good. The sowing of major trials was completed during 26th September to 4th October, 2014. Post-sowing rains (98 mm) was quite helpful for good germination. The soil moisture was conserved by following compartmental bundings technique during kharif that helped a lot for Rabi crop (Plate 1).

Breeding: One AICSIP trial i.e. IVHT-SS was taken up at CRS-Solapur. The material was sown on 26th September, 2014. The entries that recorded good performance were 3006, 3057, 3063, 3066, 3104, 3107, 3109 and 3110. The entries recorded as kharif type were 3010, 3051 and 3052. The entries 3101, 3108, 3106, 3114 and 3116 showed lodging. In addition to this, some Institute trials on evaluation of parental lines, varieties, hybrids were taken up (Plate 2). Apart from this conversion program had B-lines in different stages of back crossing. In germplasm trial which had 37 lines and 3 checks, the entries RSV 1767, RSV 1516 and SLV 188 were promising.

Agronomy: There were two institute trials on the effect of placement of fertilizers for the better use efficiency. The performance will be judged after collecting the yield, fodder data and other parameters harvesting. However the initial observations at flowering stage reveals that irrespective of four test treatments there was increase in leaf area and fresh weight biomass per plant (Plate 3). Since maize was grown during kharif, it may affected soil moisture and might reduce germination and growth of rabi sorghum. However no AICSIP trial was allotted to Agronomy at Solapur. Field of uniform soil depth should be selected for precise trials

Entomology: Three AICSIP and five Institute trials were planted on 30th September, 2014 at Mulegaon farm. The eight trials were carried out in 2 m row length for shoot fly resistance screening. The fish meal was applied at 10 DAE. Infester rows of Swarna were planted 20 days before test materials. This year shoot fly incidence was relatively low (12-56%) and the leaf damage rating due stem borer was 1-6. Deadhearts due to stem borer was very meager ( < 3%). The promising entries that recorded low shoot fly deadhearts (%) < 20%. AVHT-DS: 1008, 1056, 1058. IVHT-DS: 2004, 2071; IVHT-SS: 3011, 3014, 3101, 3110; AICSIP-SPN: 403, 404, 406, 407, 410, 445, 446, 478, 479, 487, 490; B & R: 625, 637, 657, 660; ANGSN: 832, 840, 843, 856, 884, 896 900; ASFR-DSR: 509, 514, 515, 518, 523, 537, 546 and IASFN: 752, 790, 731, 741, 779. No other incidences of pests were recorded. The Institute project trials on aphids were sown on 17th November, 2014. The experimental crop is 40 days old. At flowering stage, one irrigation will be given and the crop will be covered with full net so that moisture can be retained for aphid population build up (Plate 4).

Pathology: The foliar disease incidences were low to sporadic. However, rust disease appeared to be severe in trials. The charcoal rot symptoms were yet to be developed. Artificial inoculation of charcoal rot with tooth peak technique will be initiated for the evaluation of test materials. Three trials (AVHT-DS, IVHT-DS, and IVHT-SS) were allotted and sown on 26th September, 2015. The crops were in boot leaf stage. No foliar diseases were noticed. The tooth peak treatments will be subjected during 11-12 January, 2015 for charcoal rot infections. At this stage no selections were made since there was no incidence of charcoal rot.
Physiology: In CRS Solapur, three trials were planted on 26-27 October, 2014. The trials were well managed with good crop stand. There was lodging in some of the plots due to recent rains. Aphid incidence was sparsely seen. In preliminary evaluation trial, SSRK 13-2, 13-2, 13-20, 13-1, RSV 1772, BRJ 19914 were promising. In phenotyping of advanced lines for drought adoption trial in medium soil, the entries, RSV 1544, CRS 50, BRJ 341, 343 and RSV 1572 were promising. The same trial under shallow soil, the lines BRJ 341, PUR 930, RSV 1620, CRS 50, and RSV 1640 were promising. However, there was growth variation in replication to replication. There is need to check uniform soil depth for desirable result.

ADR, SOLAPUR
General observation: The sowing of AICSIP trial was quite late (11th October, 2014) and as a result the germination was affected. About 449 mm rainfall was received from June and about 16.43% deficit rainfall is observed. The In-charge was told that the soil moisture was conserved by following compartmental bundings technique during kharif. However, the advantage could not be reached to the experiment since there was delay in sowing. Most of the entries are in flowering and experiencing severe drought stress.

Breeding: Three trials IVHT-DS, AVHT-DS and IVHT-SS were sown on 8-11th October, 2014. The crop was in is under severe drought condition. Getting yield from such conditions is doubtful. In IVHT-DS, entries 2058 and 2062 were observed to be good performing. The entry 2051 showed segregation while the entries 2051 and 2069 were kharif type. In the entries 2059 and 2068, smut incidence was observed. In AVHT-DS, the entries 1053, 1054, 1057, 1062 showed good agronomic performance. The entry 1069 showed poor panicle emergence. IVHT-SS was sown on 8th October. The entries 3001, 3005, 3007, 3003, 3054 and 3058 were good. The entries 3057, 3059, 3060 and 3062 were susceptible to drought. The entry 3063 showed good panicle emergence while 3051 & 3052 were of kharif/adaptation. Stations trials were in good conditions (Plate 5).

MOHOL
At Mohol center, the total 600 mm rainfall was received throughout the year. Thus there was 8% deficit of rainfall. There was only one trial (IVHT-SS) on shallow soil. The condition of crop was good. The entries that were promising are: 3003, 3005 and 3053. However some of the entries (3012, 3013) were short and poor. The experimental plot was differed from the regular practice. The row to row distance was maintained 60 cm. There were multi-location trials from the University and seed production plot (Plate 6).

BIJAPUR
The centre received 650 mm rainfall mostly during July-September. The frequency of rainfall was evenly distributed and as a result the Rabi crop was good. Aphid and shoot bug incidence was moderate. The crop condition was good. All trials were sown during September-October. The crop was in grain maturing stage.

Breeding: There were three breeding trials and fourteen state/station trials. The AICSIP trials were planted on 19-21 September, 2014. In IVHT (DS), the promising entries were 2010, 2015, 2020 and 2023. The entries 2009, 2017, 2103 2024 and 2053 did not perform well. The entries 1013 and 1010 were found good in AVHT (DS). The entries 1004, 1003, 1007, 1012, 1009 and 1059 were either segregated or sterile. In IVHT (SS) trial, the entries 3013, 3010 and, 3005 were Kharif type. However, the entries 3001, 3011, 3009 and 3112 recorded good performance. Among other trials, 17 hybrids contributed from CRS-Solapur were evaluated in EHT. While few entries were promising, some of the hybrids showed sterility under bagging. Among the station trials, preliminary varieties were evaluated in 6 trials, B-lines, R-lines and germplasm (90 lines) were evaluated in separate trials. The material showed good diversity. The entries for diverse end uses were evaluated in specialty production plot (Plate 7).

Agronomy: Six trials were conducted and sown on 17th July. Fertilizer response was visible on SPV 2185, SPH 1736, SPH 1737 and CSH16. In N2-use efficiency trial N1 treatment (50% at sowing and 50% at 30 DAS) appeared better. Application of Vermicompost with normal dose of fertilizer was found better. In intercropping trial, 2 rows of sorghum with one row of cowpea had greater compatibility.

Entomology: Dr. AP Biradar, Sorghum Entomologist, is looking after entomology trials. Total nine trials have been sown during 8 October, 2014. The crop in general was good. The shoot fly incidence was up to 40% in susceptible check. The shoot bug incidence was high (3-7 damage rating) and aphid population build up was moderate to high. The entries that performed well against aphid incidence are AVHT-DS: 1007, 1011, 1004, IVHT-SS: 3015, 3014, 3009, 3011, IVHT-DS: 2004, 2014, 2009, 2013, 2015, AICSIP-SPN: 402, 405, 415, 416, 422; IAPHN: 918, 919,923, 932, 936, APSHN: 1122, 1121, 1105; ANGSN: 847, 813, 842, 839,836, IASFN: 752, 790, 731, 741, 779. The shoot bug incidence was heavy up to 8 damage rating in all trials (Plate 8).
Pathology: The foliar disease incidences were low to sporadic. The leaf blight was severe at Bijapur appeared to be severe in trials. The charcoal rot symptoms are yet to be developed. Artificial inoculation of charcoal rot with tooth peak technique will be initiated for the evaluation of test materials. Three trials (AVHT-DS, IVHT-DS, and IVHT-SS) were allotted and sown on 26th September, 2015. The crops were in boot leaf stage. No foliar diseases were noticed. The tooth peak treatments will be subjected during 11-12 January, 2015 for charcoal rot infections. At this stage no selections were made since there was no incidence of charcoal rot.

Physiology: There were five trials mostly for drought evaluation from AICSIP collaborations. In preliminary evaluation trial, RSV 1345, 1749, 1767, 1785, 1786, SLV 169, 184, 188, 190, 193, BRJ 3121, SSRK 13-15 appears promising. In advanced drought adaptation trial in shallow soil, RSV 167, CRS 50 and BRJ 229 were promising. The same trial in medium soil, the entries RSV 1544, 1620, 167, CRS 49, BRJ 343, 235, 376, and 341 found promising. In root characterization studies, the plant growth was poor. Trial can be vitiated. In drought evaluation trial, although the crop growth was good, there were no visible differences between treatments. Aphid incidence was more. In general, the trials were well maintained.

Recommendations (for Solapur, Bijapur, Mohol):
- Research activities at Bijapur related to Rabi sorghum improvements keeping in mind the requirement of the location peoples should be further strengthened in the form of on-station activities.
- Timely planting of respective trials need to be taken for each disciplines at Bijapur and ADR, Solapur.
- There was good attack of aphids this season at Solapur and Bijapur, observations on leaf angle, leaf thickness, SPAD reading, aphid populations/sqcm and damage rating at proper time need to be recorded.
- Based on the data, Kharif types, lodging plants and sterile hybrids should be removed from the advancement.
- More care may be taken while planting to avoid shading effect of trees around on the crop growth at ADR, Solapur.
- Mohol and ADR, Solapur centre were requested for timely receipt of fund. However, there was growth variation in replication to replication.
- There is need to check uniform soil depth for desirable result at Solapur.
- At Bijapur, in Physiology, in root characterization studies, the plant growth was poor; therefore the trial may be vitiated.
- At Bijapur, rodent management is necessary in some of the trials.

RAHURI
General information: The rainfall received till December was 409 mm and the number of rainy days were 18. Approximately 56% of the area was sown.

Breeding:
- Three breeding trials under AICSIP were laid out.
- The AVHT (Deep soil) was sown on 8th Oct and the expression of the crop was good,. The entries 1013, 1008, 1058, 1010, 1105 and 1111 were found promising.
- The trial IVHT (Deep soil) was sown on 8th Oct and the entries 2023, 2019, 2073, 2054, 2108 and 2117 were found promising.
- In IAVHT (SS), the entries viz., 7004, 7007, 7018, 7006 were found promising with good biomass and no lodging

Physiology:
- Under physiology trials, four trials are being conducted. In the A.D.A germplasm trial, the entries RSV 1544, RSV 1640 and RSV 167 were found promising.
- In the P.E of diverse germplasm trial, the entries RSV 1542, RSV 1516, RSV 1786 and SLV 193 were promising.
- Under the evaluation of sorghum plant types for root characteristics, the promising entries with good root characteristics were RSV 1572, CRS 49, BRJ 229 and PVR 930.
- Under A.D.A (shallow soil) trial, the entries RSV 1544, RSV 1572, RSV 1640 and RSSV 167 were found promising.

Entomology:
- Under entomology programme, all the allotted nine AICSIP trials (ANGSN,APSNN ASFR-DSR, SPN, B&R lines IASFN, IVHT-SS and DSand AVHT-DS) as per the rabi technical programme, 2014-15, were conducted at the centre.

Promising Entries in different trials for different pests (Shootfly, Stem borer and Aphid)

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<tr>
<td>Bc and AP</td>
<td>3053,3053,3106</td>
<td>AVHT-DS: 1110, 1101,1108</td>
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<td>621,646,647</td>
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</tr>
</tbody>
</table>
Agronomy:

- Under agronomy, three trials were conducted. Under the evaluation of advanced sorghum genotypes to fertility levels trial, SPH 1746 was observed to be responsive with the 100% RDF (60 30 0 NPK/ha).
- Under the effect of seed priming and foliar spray of nutrients in rabi sorghum trial, the foliar spray at 55 days after sowing crop with 2% urea treatment plot observed to be tall with aphid infestation than other treatments. Overall the trial was good.

Recommendations:

- Very dwarf entries are being contributed into the AICSIP rabi trials (For e.g., entry no 2017 in IVHT). This practice may be discouraged as rabi sorghum needs dual-purpose types
- The germplasm trial under physiology actually consists of genetic stocks or advanced breeding derivatives and not any novel germplasm. The trial may be renamed accordingly.
- It was suggested to record natural enemies populations in entomology experiments
- It was also suggested to use standard yardstick in assessing the performance genotype in the entomology trials

AKOLA

General information: At Akola and Parbhani, the Rabi season experienced drought like situation. Only the important breeding materials were maintained at Akola, whereas in Parbhani, the AICSIP trials in all disciplines were conducted with one irrigation.

At Akola, the breeding programmes of the centre for Rabi season are in progress. The programme included established AB Lines (46 Pairs), restorer lines (34), station trials (2 Varietal and 1 hybrid), 2 sets of line x testers (4 lines x 15 testers), rabi varietal multiplication (15), HSP Programme and demonstration (17 varieties and 2 hybrids). The expression of the breeding materials was excellent and evaluation of new parental lines for rabi traits were carried out.

The AICSIP Breeding trials were conducted at Ekarjuna. Since, the crop could not be established due to drought situation, the team did not visit Ekarjuna.

The team visited Buldana on 28-1-2015 and Washim on 29-1-2015, where the Akola centre conducted station varietal and hybrid trials. At Buldana, the expressions of the entries in the trial were excellent. But, in Washim, the crop was affected due to moisture stress. As the crop at Buldana completed 85 days, real assessment of entries could not be made. However entries 1256, 1258, 1261, 1266, 1267, 1272 and 1274 in State varietal –I and entries 1304, 1295 and 1289 in State varietal –II were promising.

PARBHANI

Breeding and Physiology trials: The breeding and Physiology trials were conducted satisfactorily. The promising entries in the trials were as follows.

<table>
<thead>
<tr>
<th>Name of the trial</th>
<th>Promising entries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>R-II: 2068, 2057, 2056, 2070, 2064, 2054, 2075 (LC)</td>
</tr>
<tr>
<td></td>
<td>R-III: 2120, 2117, 2101, 2102, 2109, 2108, 2125 (LC)</td>
</tr>
<tr>
<td>Advanced Varietal cum Hybrid Trial (DS)</td>
<td>R-I: 1012, 1010, 1009, 1011, 1002, 1005, 1004, 1008, 1014 (LC)</td>
</tr>
<tr>
<td></td>
<td>R-II: 1061, 1062, 1051, 1055, 1059, 1064 (LC)</td>
</tr>
<tr>
<td></td>
<td>R-III: 1111, 1106, 1102, 1101, 1104, 1110, 1114 (LC)</td>
</tr>
<tr>
<td>Phenotyping Advanced rabi sorghum entries for Drought adaptation</td>
<td>3, 4, 5, 6, 10, 14 and 16</td>
</tr>
<tr>
<td>Preliminary evaluation of diverse germplasm for rabi adaptation</td>
<td>10, 14, 19, 31, 34, 5, 20, 11, 37, 12, 29, 24, 25 and 26</td>
</tr>
</tbody>
</table>

Agronomy: In Agronomy, totally 4 AICSIP Rabi experiment were conducted as per Program. All experiments are in good condition, even though they are having adverse condition on rabi. Observations experiment-wise are as follows:

a) Evaluation of advanced sorghum genotypes to fertility levels: 100% RDF (40 20 20 kg NPK/ha) is superior to 75% RDF and 50% RDF. Among the different varieties/hybrids SPH-1746, SPY-2221, SPH-1742 are better in descending order,

b) Priority inputs in Rabi sorghum: Priority inputs like fertilizer, weed control, thinning has major effects than other inputs

c) Effect of seed priming and foliar spray of nutrients in rabi sorghum: Effect of priming with KnO3, KH2PO4 and ZnSO4 was found in time of germination (early) in case of foliar spray. Spraying with KnO3 @ 2% was the best. Two other sprays like DAP @ 2% and Urea @ 2% were also good.

Integrating Nutrient Management in Kharif grain sorghum chickpea cropping system: The better treatments were treatment T6 (50% RDF through organic fertilizer) T2 (25% RDF through FYM + 25% RDF through vermicompost), T4 and T2 have somewhat beneficial effort on second crop or grain.
Pathology: In all, 5 AICSIP Pathology trials as conducted as per Program. All experiments are in good condition even though they are having adverse condition. Yet treatments are yet to be given in all experiments. They have shown us disease on pokka boeing. Crop condition is good.

Entomology: All the Entomology trials were nicely conducted as per the programme. The data on shoot fly were sent to PI.

SURAT
In Gujarat, sorghum is primarily grown as grain crop in south Gujarat, dual purpose in north Gujarat, Kutchh, and Saurashtra. The fodder is primarily used for milch animal population. The crop is planted over and area of about 0.2 m ha. The research on kharif sorghum improvement is done at Main research station, Surat, while rabi sorghum research is concentrated at ARS, Tanchha. The major goals are improving sorghum for both grain and fodder, incorporating biotic stress tolerance traits, develop improved sorghum based production technology and value addition. The station served as a research testing centre for Bara tract of South Gujarat Agro-climatic Zone II. This ARS Tanchha mandate is to promote and develop technology on sorghum, wheat and pulses under rainfed condition of Bara tract.

Climatic situation and crop condition: The cropping pattern at Tanchha is primarily Rabi production oriented. The soils are deep vertisols with an average rainfall of 800 mm. Because of the heavy rains in kharif, sowing of sorghum in kharif is not practiced in this area. The rabi sorghum trials were planted with stored soil moisture on September 26, 2014. The rainfall received during kharif season was enough to plant the rabi sorghum under stored soil moisture. The crop condition and growth and biomass production are good. All the entries grew to a height about 2.0-2.5 m.

ARS, TANCHHA
Two trials namely AVHT–DS and IVHT-DS were organized as per the technical program allotted to the centre. The conduct of the trials was very good including field management. The crop is at hard dough stage to physiological (110 days old) stage and ready for harvest. Incidence of shoot fly was observed in some entries as could be seen from the plant population at maturity. No significant other biotic stresses were observed. The crop was lodged in some entries due to terminal drought resulting in soil cracking. The promising entries in various trials are listed below.

AVHT–DS: This trial was planted on 26 Sept, 2014 with 14 entries. The crop growth and development is very good. There were some gaps in plant population due to the initial shoot fly attack followed by terminal moisture stress. Promising entries identified based on phenology and apparent grain and stover yield and quality include 1011, 1006, 1004,1012,1013,1107, 1105 and 1053. There was some lodging in some entries due to the non –adoption of intercultivation operation in the GS1 stage.

IVHT–DS: This trial was planted on 26 Sept, 2014 with 25 entries. The crop grew to a height of about 2.0-2.5 m. There were some gaps in plant population due to the initial shoot fly attack followed by terminal moisture stress. Promising entries identified based on phenology, vigor and apparent grain and stover yield and quality include 2022, 2112, 2114, 2108, 2102,2121, and 2103. There was some lodging in some entries due to the non –adoption of intercultivation operation in the GS1 stage.

At ARS, Tanchha other station trials are under evaluation include small scale varietal trial (SSVT-1) and SSVT-2, Large scale varietal trials (LSVT) preliminary evaluation trial (PET). Entries include materials from kharif and rabi are compared with locals such as BP53 and Wani for better grain and stover productivity. These trials are tested at five state locations.

Main Sorghum Research station, Athwa farm, Surat: At Surat, crossing program on L* T involving five lines and five testers were planted. There were other seven trials are planted in rabi and Late rabi at Surat include multiplication and maintenance of kharif rabi released and promising materials, germplasm seed multiplication and evaluation, A, B, and R seed multiplication and maintenance. The team discussed with all sorghum team at AICSIP Surat on the possibility of increasing sorghum yield and value addition.

Recommendations:
- Since the rainfall quantum and its distribution may be erratic during kharif in some years at Tanchha, this leads low crop growth in rabi due to insufficient soil water storage. There is a need to develop and evaluate sorghum genotypes with rabi adaptation traits such as bold and pearly white grains with high grain and stover yields and quality. Besides, incorporation of postflowering drought and heat stress tolerance traits will stabilize the rabi sorghum productivity.
- Simple agronomic practices such as intercultivation should be followed immediately after final thinning (25-35 DAS) in all rabi sorghum trials to prevent end season lodging.
- Shoot fly control should be done with soil application of Furadon granules at the time of sowing. Other plant protection measures should be undertaken based on the need.
TANJAVUR

General information: The rainfall received was less than normal and the distribution was not uniform. Two grain sorghum breeding trials, 5 agronomy trials, 2 physiology and 3 entomology trials were sown under AICSIP during rabi. The crop is in milky to physiological maturity stage. In general, the crop is well maintained and crop stand is good.

Breeding: There were two AICSIP breeding trials and five station trials under sorghum program. The trials were sown on 21st October, 2014. In both IVHT-DS and AVHT-DS lodging was observed in most of the entries because of the heavy rain received during first week of January.

Agronomy: Under AICSIP Agronomy five trials are conducted during rabi 2014-15
- Evaluation of rabi sorghum genotypes to fertility levels: Among the test entries SPH 1746 and SPV 2221 are appears to be good and showing positive response to fertilizers. Crop is well managed.
- Assessing the performance of rabi sorghum under changing climate: Plant population is maintained well. Crop sown on 11-09-2014 & 26-09-2014 was severely damaged by birds.
- Studies on optimization of production factors in rabi sorghum under resource constraints: In a Full package of practices minus thinning treatment, crop is totally laid down on the ground.
- Integrated nutrient management in greengram- rabi sorghum cropping system: Effect of main plot treatments and sub plot treatments are not visible, but the sub-sub plot treatments (Nitrogen levels) having noticeable influence on the crop growth.
- Effect of seed priming and foliar spray of nutrients in rabi sorghum: Crop is well maintained, effect of treatments are not noticeable.

Physiology: Sorghum physiology trials viz., ADGT (medium soils) and Preliminary evaluation germplam for rabi adaption trial plots were taken up by Tandur station. Experiments were sown according to plan of layout. The rain fall received during cropping season was 212.5 mm. In September 2014 there was 113 mm rainfall. Rain received in the subsequent months was less and there were no rains in December. Even though plots were managed properly, more than 50 per cent lodging was observed in ADGT medium soil trial.
1. ADGT (Medium soil): Date of sowing: 21-10-2014 - The ear head size was small in all the entries. Among then treatments, the entries found promising were CRS 49, RSSV 1640, RSV1572 and BRJ 343.
2. Preliminary evaluation of diverse germplasm for rabi adaption: Date of sowing: 21-10-2014 - In this trail the population was good and uniform. Among the 40 entries, SLV 181, RSV 1542, SLV 184, SSRK13-7, RSV 1850 and BRJ 29914 were found promising.

Entomology: The entomology plots were harvested before the monitoring team visit because of wild boar damage. Hence the trials could not be visited by the monitoring team.

Recommendations:
- Care should be taken while recording yield data, since lodging was observed in many plots.
- Lot of bird damage was noticed especially in agronomy plots, and proper care should be taken in future
- Sterility in the rabi hybrids should be noted in the breeding trials.

PHALTAN

General information: Presowing rainfall was satisfactory, 239.7 mm in the month of August (12 rainy days). The month of September received 26.4 mm rainfall (3 rainy days). After sowing the center received total 8 rainy days, 4 in October (45.7 mm) and 2 in November (33.2 mm). Maximum temperature ranged from 30.8 C -33.7 C, and minimum temperature ranged from 13.5 C -20.7 C. Relative humidity during cropping season ranged from 41.0%-95.1%.

Breeding:
- Two trials, viz., IAVHT SS and IVHT SS were provided to NARI Phaltan center and trials were taken up satisfactorily. Dates of sowing were 15.09.14 and 02.1014, respectively.
The crop was at late maturity stage leading to lodging of entries in number of cases. In IAVHT SS trial promising entries in RI were 7013, in RII 7055 and 7067, and in RIII was 7114. Maximum brix values (>15.0%) were recorded in entry nos. 7013 and 7109, while stripped stalk weight (>2.0 kg) in 7017, 7054, 7113 among others. TRS% ranged from 2.87 (in 7060) to 1.3 (7054), and juice weight ranged from 0.075 kg (in 7010) to 1.969 kg (in 7067).

In IVHT SS stay green entries were 3013, 3060 and 3104. Plant height ranged from 150.8 cm (in 3013) to 301.2 cm (in 3102), flowering dates ranged from 58 (in 7016) to 79 in (7002, 7053 and 7115). Shoot fly and stem borer damage was moderate to height. Best entries recorded are 3010, 3004, 3064 and 3102.

Field management was good and data book management needs to be improved. The station has a total of 27 station trials and breeding materials are very vast being handled very effectively. Two promising entries for sweet sorghum, D10212 and D9474 were noticed in their station demonstration. They are in possession of some high fiber sorghum lines, which may be used in pulp making.

DHARWAD
General information:
- The center has conducted two breeding trials (IVHT, AVHT), four Agronomy three trials (1R, 2R, 3R, 4R); eight entomology trials (AVHT-DS, IVHT-SS, B & R lines, IVHT-DS, SPN-DS & SS, MLVT, Mutant material evaluation for shoot fly and Pest surveillance, five under Pathology (AVHT –DS, IVHT-DS, IVHT-SS, CRN nursery, Charcoal rot management. totaling 19 AICSIP trials were conducted.
- The total rainfall was 278.4 mm which was more than last year figures by 7.6 mm. During Sept, October there was deficit in rainfall but during Nov 43.8 mm rainfall was received resulting in good crop expression.
- All the trials were well laid out as per the technical program, field, data book maintenance was good.
- There was moderate incidence of rust in breeding, entomology trials about 20 %, 5 – 10 % downy mildew incidence..
- The shoot fly infestation ranged from 30 – 70 %, borer incidence was negligible whereas there was low to moderate incidence of aphids.

Breeding:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Trial</th>
<th>DOS</th>
<th>Promising lines</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>AHT (GS)</td>
<td>7.10.14</td>
<td>1010, 1002, 1058, 1106, 1101</td>
<td>Suffered rust damage</td>
</tr>
</tbody>
</table>

Entomology: The shoot fly infestation ranged from 30 – 70 %, borer incidence was negligible whereas there was low to moderate incidence of aphids. 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:

<table>
<thead>
<tr>
<th>S. No</th>
<th>Trial</th>
<th>DOS</th>
<th>Promising lines</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AVHT DS</td>
<td>2.10.14</td>
<td>1006</td>
<td>SF infestation ranged from 30–70 %</td>
</tr>
<tr>
<td>2</td>
<td>IVHT SS</td>
<td>2.10.14</td>
<td>3011,3003,3115</td>
<td>The crop suffered rust damage in all trials</td>
</tr>
<tr>
<td>3</td>
<td>B &amp; R lines</td>
<td>2.10.14</td>
<td>601, 602, 625, 646</td>
<td>Negligible borer damage</td>
</tr>
<tr>
<td>5</td>
<td>SPN DS &amp; SS</td>
<td>2.10.14</td>
<td>461, 427</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Mutants</td>
<td>20.10.14</td>
<td>2,4,15,16,17,20,31,42,44,47,53,56,69</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>MLVT</td>
<td>2.10.14</td>
<td>MLT 6, MLT 1</td>
<td></td>
</tr>
</tbody>
</table>

Pathology: The diseases noticed were sugary disease and some leaf marginal drying was there. Low intensity of downy mildew was noticed.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Trial</th>
<th>DOS</th>
<th>Promising lines</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AVHT DS</td>
<td>20.6.13</td>
<td>As such experiments were laid as per technical program. Trials are well maintained. The data on charcoal rot and rust will be recorded at maturity.</td>
<td>The data on charcoal rot and rust will be recorded at maturity. At present crop is in milky stage. The crop will ne inoculated with charcoal rot pathogen and data recorded at maturity.</td>
</tr>
<tr>
<td>2</td>
<td>IVHT SS</td>
<td>20.6.13</td>
<td></td>
<td>The rust score is 3 ie. 20 %. The late sown trials escaped rust whereas breeding and entomology trials suffered rust infestation.</td>
</tr>
<tr>
<td>3</td>
<td>CRN nursery</td>
<td>20.6.13</td>
<td>20.6.13</td>
<td>5 – 10 % downy mildew infection was noticed mainly as localized lesions on leaves.</td>
</tr>
<tr>
<td>4</td>
<td>Charcoal rot management</td>
<td>20.6.13</td>
<td>20.6.13</td>
<td></td>
</tr>
</tbody>
</table>

Agronomy: The total rainfall was 278.4 mm for the season which was more than last year figures by 7.6 mm. During sept, October there was deficit in rainfall but during Nov 43.8 mm rainfall was received resulting in good crop expression.

<table>
<thead>
<tr>
<th>S.No</th>
<th>Trial</th>
<th>DOS</th>
<th>Promising lines</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 R</td>
<td>Evaluation of pre released rabi sorghum genotypes to carrying fertility levels</td>
<td>12.10.14</td>
<td>SPH 1746, CSH 15R, CSV 22R, M 35-1</td>
<td>100% RDF appears to be optimum to all genotypes visually.</td>
</tr>
</tbody>
</table>
**S.No** | **Trial** | **DOS** | **Promising lines** | **Remarks** |
---|---|---|---|---|
2 R | Integrated nutrient management in Kharif sorghum chickpea cropping system | 28.11.14 | 1. Chickpea crop was late sown owing to late harvest of Kharif sorghum. 2. Chickpea is at flowering stage and at present visually no differences are seen. |
3 R | Priority inputs in Kharif grain sorghum | 12.10.14 | 1. Full package of practice in M 35-1 with all inputs appeared promising. |
4 R | Effect of seed priming and foliar spray of nutrients in rabi sorghum | 12.10.14 | 2. Seed priming with water or spray of 2 % DAP at 55 DAS was promising |

**Recommendations including follow-up action:**
- The monitoring dates were fixed well in advance but DR Gahukar (Akola) and Dr. Verma (Udaipur) could not attend leaving only a breeder and Entomologist in team.
- The data on charcoal rot and rust in pathology trials is pending as data has to be recorded at maturity, at present crop is in milky stage.

**KOILPATTI**

**General Information:**
- Kovilpatti centre is located in south Tamil Nadu and was established in 1901 for research work on sorghum, cotton, soil system and dryland agriculture. The location is having dry rabi climate (around 400 mm rainfall during October to December) under deep black as well as red soil. This rabi season experienced low (rainfall around 300 mm during October to December) The location is used as testing centre for dry land crops. Prevalence of high areal humidity brought about by scanty but frequent rainfall seemed to be major contributing factor for many foliar diseases on sorghum particularly forage cultivars. The centre has released forage varieties such as K2, K4 and K12 for that area.
- **AICSIP Trials:** Kovilpatti centre sown all allotted trials in between 16 to 27 October 2014. The centre conducted five AICSIP trials that included one forage trial (AVHT-SC), and four entomology trials (AVHT-DS, IVHT-DS, IVHT-SS, and DS-SPN). Apart from AICSIP trials the centre were involved in station trials. In brief, main aim of the station was to develop short duration (<100 days maturity) shootfly and midge resistance sorghum cultivars for forage production. Germination and plant stand seemed good. However, shootfly damage in some entries caused thin stands.

**Discipline-wise report:**

**Breeding (Single cut forage, AVHT-SC):** The trial had 20 entries and was sown on 16 October after receiving some rain. Entries flowered between 60-75 days. Barring two boarder rows the crop was harvested at 50% flowering for recording green and dry fodder yield. In these two rows grain filling, in almost all entries, was negligible or completely absent due to heavy attack of midge. Among foliar diseases rust was very common and affected almost all the entries. 3062, 6107, 6118 were promising for rust resistance. Entries 6012, 6052, 6067, 6062, and 6102 were promising for fodder yield. Stem borer infection was moderate and multiple areal tillers were noted on many entries.

**Entomology (AVHT-DS, IVHT-DS, IVHT-SS, and DS-SPN):** Entomology trials were sown late on 27 October, and attracted huge midge infestation. None of the entries in the above trials had grain formation and bore chaffy panicles only. Shootfly incidence ranged from 0 to 23% in AVHT-DS, 0 to 67% in IVHT-DS, 2 to 80% in IVHT-SS and 0 to 81% in DS-SPN trial. Shootfly promising entries were 1006, 1012, 1013, 1063, 1060, 1108, 1109, 2003, 2061, 2063, 2064, 2108, 3057, 3115 etc. Stem borer incidence ranged from 3 to 22% in AVHT-DS, 3 to 56% in IVHT-DS, 4 to 53% in IVHT-SS and 3 to 43% in DS-SPN trial. Stemborer promising entries were 1005, 1063, 1103, 2051, 3066, etc.

**Station Trials:** The centre conducted few rabi trials (PET-I, segregating materials for yield and pest resistance, crossing programme etc.) based on materials from the state programme. Trials were mostly sown on 2nd week of October, and crop was in mature stage. One eco-friendly trials where various plants extracts were used for management of shootfly and stem borer incidentally managed midge infestation well. This may be noted for further experiments.

**Recommendations:** Earhead midge is a huge problem in this location. The facility of the centre should be used for screening materials for midge resistance. Yield trial materials should be protected from midge infestation to get grain yield for record and comparison.
Status of distinctiveness, uniformity and stability testing in sorghum

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Introduction
Consequent upon enactment of ‘Protection of Plant Varieties and Farmers’ Rights Act’ by the Indian Govt. in 2001 and establishment of Protection of Plant Varieties and Farmers’ Rights Authority (PPV&FRA) in 2005, an effective system for protection of plant varieties, the rights of farmers and plant breeders, and for encouraging the development of new varieties of plants came into being. To start with, 12 crop species were notified by Govt. of India for registration under the Act; sorghum was one among them. The general and specific guidelines for DUS testing in sorghum was published by the 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. The PPV&FRA started receiving applications for registration from May, 2007. Presently registration can be done for 92 crop species and the DUS testing guidelines notified are available on the website of the Authority (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, 2007). Out of these, 21 traits are assessed visually while 12 are measured traits. There are four characteristics used for grouping of sorghum varieties for DUS testing apart from kharif or rabi adaptation. They are (1) time of panicle emergence (50% of the plants with complete panicle emergence), (2) total height of plant at maturity, (3) panicle shape, and (4) 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.
Out of 33 characteristics, 15 are essential traits, 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. 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. Overall there are 14 VG (visual assessment by a single observation of a group of plants or parts of plants), 11 MS (measurement of a number of individual plants or parts of plants), 7 VS (visual assessment by observation of individual plants or parts of plants) and one MG (measurement by a single observation of a group of plants or parts of plants) characteristics (Table 1).

<table>
<thead>
<tr>
<th>Category of characters</th>
<th>Type of assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grouping (Kh/Rabi + 4)</td>
<td>VS  VG  MS  MG   Total</td>
</tr>
<tr>
<td>Essential (*) marked</td>
<td>3    -  1    -  5</td>
</tr>
<tr>
<td>Descriptive (+ marked)</td>
<td>5    7    3    1   15</td>
</tr>
<tr>
<td>Others</td>
<td>1    2    7    1   11</td>
</tr>
<tr>
<td>Total</td>
<td>7    14  11    1  33</td>
</tr>
</tbody>
</table>

The 33 DUS characteristics in sorghum are recorded on six plant parts viz., seedling, stem, leaf, panicle, flower and seed or grain, and on eight different stages of the crop, namely seedling (7-8 DAS), 5th leaf, panicle emergence, flowering, end of flowering, physiological maturity, maturity and post-maturity/threshing. Therefore, every stage of the crop is important with respect to enumeration of DUS traits, and complete attention on the crop starting from sowing till harvesting is highly necessary for successful DUS testing.

Present status of DUS testing
DUS testing in sorghum for registration of new varieties under PPV&FRA started in 2008. So far 113 candidate varieties have undergone DUS testing since 2008. Out of these, 47 candidate varieties have come from public sector breeders and 60 are from private sector breeders, and six are farmers’ varieties. Out of total candidate varieties tested 73 are under the category of new varieties and 34 are under the category of extant/varieties of common knowledge (VCK) (Table 2, Fig.1a). Among the candidate varieties tested for DUS under new category (65%), private sector entries are more (47%) compared to public sector (18%). Whereas, in case of VCK (27%), public sector has contributed more varieties (23%) compared to private sector (4%). Under the extant category (3%), again private sector had more entries (2%) than public sector (1%). Further, parental lines constituted more than half of the candidate varieties tested and rest were either open pollinated varieties or hybrids or farmers’ varieties (Fig.1b).
Table 2. Candidate varieties undergone DUS testing since 2008

<table>
<thead>
<tr>
<th>Year</th>
<th>New</th>
<th>Ext/VCK</th>
<th>FV</th>
<th>Total</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008 (Kh)</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
<td>All Pvt.</td>
</tr>
<tr>
<td>2008 (Rabi)</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>Public</td>
</tr>
<tr>
<td>2009 (Kh)</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>5 Publ. + 1 Pvt.</td>
</tr>
<tr>
<td>2010 (Kh)</td>
<td>8</td>
<td>2</td>
<td>0</td>
<td>10</td>
<td>6 Publ. + 4 Pvt.</td>
</tr>
<tr>
<td>2011 (Kh)</td>
<td>14</td>
<td>0</td>
<td>0</td>
<td>14</td>
<td>All Pvt.</td>
</tr>
<tr>
<td>2011 (Rabi)</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>5</td>
<td>3 Publ. + 2 Pvt.</td>
</tr>
<tr>
<td>2012 (Kh)</td>
<td>7</td>
<td>20</td>
<td>1</td>
<td>28</td>
<td>20 Publ. + 7 Pvt.</td>
</tr>
<tr>
<td>2012 (Rabi)</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>7</td>
<td>1 Publ. + 6 Pvt.</td>
</tr>
<tr>
<td>2013 (Kh)</td>
<td>9</td>
<td>6</td>
<td>0</td>
<td>15</td>
<td>4 Publ. + 11 Pvt.</td>
</tr>
<tr>
<td>2013 (Rabi)</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>1 Publ. + 3 Pvt.</td>
</tr>
<tr>
<td>2014 (Kh)</td>
<td>6</td>
<td>0</td>
<td>4</td>
<td>10</td>
<td>4 Publ. + 2 Pvt.</td>
</tr>
<tr>
<td>2014 (Rabi)</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>4</td>
<td>2 Publ. + 1 Pvt.</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>73</strong></td>
<td><strong>34</strong></td>
<td><strong>6</strong></td>
<td><strong>113</strong></td>
<td><strong>47 Publ. + 60 Pvt.</strong></td>
</tr>
</tbody>
</table>

Ext: Extant; VCK: Variety of Common Knowledge; FV: Farmers’ Variety

![Graph](image1.png)

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

Frequency of reference varieties used

For comparing the 113 candidate varieties tested for DUS traits since 2008, a total of 62 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 14 candidate varieties, while restorers CS 3541 and RS 29 have been claimed for 12 candidate varieties. The short duration hybrid CSH 14 was used as reference for 11 candidate varieties while another hybrid CSH 9 was used as reference for nine candidate varieties. Among the open pollinated varieties CSV 15 and M 35-1 have been claimed as reference varieties maximum number of times. Out of 62 reference varieties, 21 were used in case of single candidate variety only.

Stability of reference varieties over seasons

Season-wise analysis of reference varieties planted since 2008 showed that out of the 62 reference varieties used for comparing candidate varieties, one reference variety was planted for nine seasons, five were planted for eight seasons, one was planted for seven seasons, five each were planted for six, five and four seasons, 11 for three seasons, 21 for two seasons and eight for a single season (Fig. 3). Data sheet formats (Fig. 4) for assessing the stability of expression of different morpho-agronomic descriptors in each reference variety over the seasons are being prepared and analyzed using the season-wise DUS testing data (Hariprasanna et al., 2015).
Figure 2. Frequency of reference varieties used in DUS testing

Figure 3. Reference varieties planted over the seasons (2008-2014)
Most commonly claimed distinct traits

The claimed distinct characteristics by the applicants in the 113 candidate varieties 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 density followed by panicle shape, total height of the plant, glume colour and caryopsis colour after threshing (Table 3). Among these, three traits were used for grouping of the varieties (DUS #22, DUS #15 and DUS #26) also. The deviation from the claims (by the applicant) was mostly observed in case of panicle density and shape, plant height and time of panicle emergence. The characteristics that were claimed less in general were colour of vitreous albumen in grain, length of branches in panicle and anthocyanin colouration of stigma (Table 3). 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. Therefore, when the breeders plan to develop new varieties it would be better for the breeders to look for distinctiveness in characteristics that are claimed least so far so that the chances of qualifying the DUS test are higher.

Table 3. More common (> 40%) and less common (< 10%) claimed distinct traits

<table>
<thead>
<tr>
<th>DUS #</th>
<th>Characteristics</th>
<th>Claimed (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. (*)</td>
<td>Panicle: Density at maturity (ear head compactness)</td>
<td>56</td>
</tr>
<tr>
<td>22. (*) (+)</td>
<td>Panicle: Shape</td>
<td>54</td>
</tr>
<tr>
<td>15. (*)</td>
<td>Plant: Total height</td>
<td>46</td>
</tr>
<tr>
<td>14. (*) (+)</td>
<td>Glume: Colour</td>
<td>45</td>
</tr>
<tr>
<td>26. (*)</td>
<td>Caryopsis: Colour after threshing</td>
<td>42</td>
</tr>
</tbody>
</table>

Status of applications filed and registration certificates granted

Both public and private sector plant breeders have taken a proactive stand in filing applications for registration of sorghum varieties since the establishment of PPV&FRA. Till date 234 applications have been filed and sorghum stands 4th in terms of total number of applications received by PPV&FRA under cereals and millets (Table 4). Among the applications, 107 are from public sector and 91 are from private sector, and 36 are farmers’ varieties. So far, 105 sorghum varieties have been registered and certificate of registration have been issued (PPV&FRA, 2015). Out of 105, 67 are public sector bred varieties and 37 are private sorghum varieties (Table 5).
Table 4. Status of applications received by PPV&FRA (till April, 2015)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Public</th>
<th>Private</th>
<th>Farmers’ var.</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maize</td>
<td>120</td>
<td>300</td>
<td>126</td>
<td>546</td>
</tr>
<tr>
<td>Pearl millet</td>
<td>61</td>
<td>209</td>
<td>7</td>
<td>277</td>
</tr>
<tr>
<td>Rice</td>
<td>258</td>
<td>297</td>
<td>3672</td>
<td>4227</td>
</tr>
<tr>
<td>Sorghum</td>
<td>107</td>
<td>91</td>
<td>36</td>
<td>234</td>
</tr>
<tr>
<td>Wheat</td>
<td>127</td>
<td>20</td>
<td>50</td>
<td>197</td>
</tr>
<tr>
<td>Total (63 crops)</td>
<td>1393</td>
<td>2812</td>
<td>4805</td>
<td>9010</td>
</tr>
</tbody>
</table>

Table 5. Sorghum varieties registered in the Plant Varieties Registry (till April, 2015)

<table>
<thead>
<tr>
<th>Year</th>
<th>No. of varieties</th>
<th>Category</th>
<th>Public</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>12</td>
<td>Extant/VCK</td>
<td>ICAR (11)</td>
<td>JK Agri (1)</td>
</tr>
<tr>
<td>2010</td>
<td>1</td>
<td>- do -</td>
<td>ICAR (1)</td>
<td>-</td>
</tr>
<tr>
<td>2011</td>
<td>6</td>
<td>FV</td>
<td>Dr. PDKV (2)</td>
<td>MAHYCO (2), JK Agri (1), Devgen (1)</td>
</tr>
<tr>
<td>2012</td>
<td>15</td>
<td>FV</td>
<td>TNAU (5), GBPUA&amp;T (1), RVSKVV (1), MKV (2), MPUA&amp;T (1), MPKV (3)</td>
<td>MAHYCO (1), Devgen (1)</td>
</tr>
<tr>
<td>2013</td>
<td>10</td>
<td>FV</td>
<td>TNAU (1), ICAR (3), ANGRAU (1)</td>
<td>MAHYCO (2), JK Agri (2), Devgen (1)</td>
</tr>
<tr>
<td>2014</td>
<td>54</td>
<td>FV</td>
<td>TNAU (27), MPKV (3), MAU (1), RVSKVV (1), CCISHAU (1)</td>
<td>Kaveri (8), Devgen (5), Bayer (2), Nuziveedu (2), Hytech (1), JK Agri (1), Nirmal (1)</td>
</tr>
<tr>
<td>2015</td>
<td>7</td>
<td>FV</td>
<td>ICAR (2)</td>
<td>Devgen (2), Kaveri (2), Nirmal (1)</td>
</tr>
<tr>
<td>Total</td>
<td>105</td>
<td></td>
<td>38</td>
<td>66</td>
</tr>
</tbody>
</table>

New descriptors for sorghum

The PPV&FRA is planning to review the existing DUS test guidelines for sorghum for which DUS testing started in 2008 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 omitted while some other new descriptors can be added to the list of DUS test guidelines. Some of the new descriptors that can be considered are given in Table 6. 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. The sorghum researchers are hereby requested to provide suggestions on new descriptors that can be considered in case of sorghum for further strengthening the plant variety protection system in India.

Table 6. New descriptors proposed for sorghum DUS testing

<table>
<thead>
<tr>
<th>Category</th>
<th>Characters</th>
<th>States</th>
<th>Stage of observation</th>
<th>Type of assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain sorghum</td>
<td>Stem/leaf: Waxy bloom (epicuticular wax)</td>
<td>1-Absent; 3-Slightly bloomy; 5- Mostly bloomy</td>
<td>Flowering / End of flowering</td>
<td>VG</td>
</tr>
<tr>
<td>- do -</td>
<td>Foliage: intensity of green colour</td>
<td>1-Light; 3-Medium; 5-Dark</td>
<td>Flowering</td>
<td>VG</td>
</tr>
<tr>
<td>- do -</td>
<td>Plant : pigmentation</td>
<td>1-Yellow green; 5-Greyed purple</td>
<td>Physiological maturity</td>
<td>VG</td>
</tr>
<tr>
<td>Sweet sorghum</td>
<td>Stem: Field brix (%)</td>
<td>1-low (&lt;12); 3-Medium (12-15); 5- High (15-18); 7-Very high (&gt;18)</td>
<td>Physiological maturity</td>
<td>MS</td>
</tr>
<tr>
<td>- do -</td>
<td>Plant: Biomass (g/plant)</td>
<td>1-Low (&lt;250); 3-Medium (251-350); 5-High (351-450); 7-Very high (&gt;451)</td>
<td>Physiological maturity</td>
<td>MS</td>
</tr>
<tr>
<td>Forage Sorghum</td>
<td>Plant: Tillering ability</td>
<td>1-Absent; 3-Few (1-3); 5-Many (&gt;4)</td>
<td>Flowering</td>
<td>MS</td>
</tr>
<tr>
<td>- do -</td>
<td>Plant: Biomass (g/plant)</td>
<td>1-Low (&lt;150); 3-Medium (151-250); 5-High (251-350); 7-Very high (&gt;351)</td>
<td>Flowering</td>
<td>MS</td>
</tr>
</tbody>
</table>
Importance of DUS characterization in AICRP trials

In view of the establishment of PPV&FRA, it has become relevant to bring about changes in the varietal development programme, to get maximum advantage from the new regime. It is pertinent that the plant breeders and geneticists reorient and fine-tune their crop improvement programmes and activities to be in line with the provisions of PPV&FR Act. It will be always better to start DUS testing by the PPV&FRA and national level VCU evaluation under AICRP together, which will ensure that protection of new variety is not getting delayed. It is also possible that in case an experimental variety has extraordinary trait(s), such as male sterility, the developer may like to first get the variety protected and then submit for national level evaluation for VCU. While taking decisions to initiate DUS and national level VCU testing or even the number of years for research station and farmer-field trials, it should be kept in mind that the time gap between varietal development and commercialization should be as minimal as possible, and protection being for a fixed period of time, it may not be advisable to delay VCU testing and formal release (Dhillon et al., 2006).

After the completion of the advanced variety/hybrid trial (AVT/AHT) when the entry is proposed for identification for release in the varietal release committee (VIC) of AICRP, the breeder is required to provide the observations on DUS characteristics as per the PPV&FRA guidelines. It is mandatory for the breeder to provide the DUS characteristics data in the release proposal to be submitted to the Central Sub-Committee on Crop Standards, Notification and Release of Varieties. Hence, it is necessary for every breeder to be familiar with DUS characterization and record the data well in advance, preferably at least in the AVT-II stage to avoid delay in release of identified variety. The proposed revision in the test guidelines of varietal evaluation under AICRPs of the ICAR requires the testing system to generate information on DUS traits as well as on the agronomic superiority/advantage over the existing varieties. Accordingly, it must be ensured that data on varietal descriptors generated at AVT-II stage (as additional data) include all the characters specified under DUS testing and generated as per DUS norms. This would also help the breeder in making right claims with respect to distinctiveness for protection of plant variety with PPV&FRA. In the application distinct traits claimed should be unique or really distinct from the close reference variety so that the DUS test do not fail and protection is guaranteed.

Generation of information on the DUS traits will also help in registering the genotype with NBPGR in case the entry does not qualify for release/identification but possesses important traits for biotic or abiotic stress tolerance. As the application for registration has to mention unique feature(s) as criteria for registration along with complete description of the germplasm material using standard descriptors, prior knowledge on the distinguishing characteristics of the material would help the breeder in placing appropriate claims, which merit consideration for registration.

Under the changed regime of PVP, breeders may reorient their perspective. So far the objective was breeding for productivity and not for distinctiveness. A productive variety may not possess distinctiveness and vice-versa. In the former case the new variety fails to get PVP while in latter it does qualify for PVP, but what would be the commercial value of such a variety is a point to ponder upon. Hence, a structured tailoring of reproductive capacity and morpho-agronomic traits is what the future breeder is expected to do.

Suggested References

Sorghum food technology research report 2014-15

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

Research highlights
1. Among the new sorghum genotypes grown at Dharwad center (Kharif Season-2014), from AVT; SPV 2250, CSV 27, from AHT; SPH 1748, SPH 1724 and from demonstration trials DSV 6, CSH 16 and SHD 36 genotypes were found promising for nutritional quality only.
2. From Rabi 2014-15 Rahuri centers' sorghum samples, among the new sorghum genotypes for the flour, dough, roti and nutritional quality parameters the new sorghum genotypes from AVHT, AVHT-1004, AVHT-1007, AVHT-1014 and AVHT-1005 and from IVHT, IVHT-2010, IVHT-2004, IVHT-2003, IVHT-2005, IVHT-2024 and IVHT-2015 were found promising for roti as well as nutritional quality.
3. From Rabi 2014-15 Dharwad centers' sorghum samples, among the new sorghum genotypes for the flour, dough, roti and nutritional quality parameters the new sorghum genotypes from AVHT, AVHT-1014, AVHT-1006, AVHT-1007, AVHT-1011 and AVHT-1004 were found promising for roti as well as nutritional quality.
4. The new genotype RSSGV 46 developed for hurda purpose showed potential benefits over the RSSGV 3 in term of yield as well as nutritional quality.
5. The new genotype RPASV - 3 for papad purpose should be considered for commercial use and make it available to the farmers by releasing it as soon as possible.

A. Results: Kharif - 2014, sorghum genotypes (AVT and AHT) 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 was done on the dough, roti and nutritional quality of 8 AVT, 9 AHT and 6 demonstration trials of Kharif-2014 sorghum genotypes grown at Dharwad to identify superior genotypes.

a) Flour and Dough quality: Following 11 different flour and dough quality parameters were measured:

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hectoliter weight (kg/hl)</td>
<td>1. Hectoliter weight (kg/hl)</td>
</tr>
<tr>
<td>Water absorption (%)</td>
<td>2. Water absorption (%)</td>
</tr>
<tr>
<td>Spreading quality (Scale 1-3)</td>
<td>3. Kneading quality (Scale 1-3)</td>
</tr>
<tr>
<td>Soluble protein (%)</td>
<td>4. Spreading quality (Scale 1-3)</td>
</tr>
<tr>
<td>Starch (%)</td>
<td>5. Water required for dough (%)</td>
</tr>
<tr>
<td>Phenolics (%)</td>
<td>6. Crude protein (%)</td>
</tr>
<tr>
<td>Total soluble sugars (%)</td>
<td>7. Soluble protein (%)</td>
</tr>
<tr>
<td>Free amino acids (mg/100g)</td>
<td>8. Total soluble sugars (%)</td>
</tr>
<tr>
<td></td>
<td>9. Free amino acids (mg/100g)</td>
</tr>
<tr>
<td></td>
<td>10. Starch (%)</td>
</tr>
<tr>
<td></td>
<td>11. Phenolics (%)</td>
</tr>
</tbody>
</table>

Results on flour, dough and roti quality of 20 advanced genotypes, compared with DSV-6 are presented in Tables 1 to 6.

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 71.32 to 77.63 kg/hl for AVT, 72.39 to 77.70 kg/hl for AHT, and 71.75 to 77.91 for demonstration trials respectively. The DSV-6 genotype gave higher hectoliter weight than rest of the genotypes studied in AVT, AHT and demonstration trials.

Water absorption capacity: The water absorption capacity is positively correlated to the roti quality. The higher the water absorption capacity superior was the quality of the roti. The water absorption capacity of flour ranged from 100 to 110% in AVT, AHT and demonstration trials genotypes.

Crude protein: The crude protein content ranged from 8.52% (SPV 2242) to 10.07% (DSV 6) in the advanced varietal genotypes studied with their checks. In AHT protein content ranged from 7.82% (SPH 1724) to 9.80 (CSH 25 which is higher than the check studied (CSH 14). The protein content ranged from 8.75 to 10.70% in demonstration trials (Table 5).

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 1.04% [SPV 2250] to 1.40% [CSV 20] in AVT trials. In AHT soluble protein ranged from 1.06 (CSH 25) to 1.35% (SPH 1737). The soluble protein content of demonstration trials ranged from 1.03 (SHD 6) to 1.27% (CSH 16). All the genotypes were significantly different in their soluble content.
Total soluble sugars: In AVT trials the total soluble sugars ranged from 1.07% (CSV 23) to 1.64% (SPV 2250). In AHT total sugar content ranged from 1.18% (SPH 1724) to 1.83% (SPH 1736). In demonstration trials total soluble sugars ranged from 1.17% (CSH 14) to 1.67% (CSH 16). All the genotypes studied were significantly different. The higher sugar percentage in sorghum flour representing good amylolyptic activity while preparation of roti. It also responsible for good taste of the roti.

Starch: The starch content of the advanced varietal genotypes ranged from 50.14% (CSV 27) to 55.58% (DSV 6). In AHT starch ranged from 52.04% (CSH 25) to 56.99% (SPH 1748). In demonstration trials starch content ranged from 53.73% (DSV 6) to 58.61% (CSH 30). Higher starch content gives good colour and amylolyptic activity during roti preparation.

Free amino acids: The free amino acids in the studied genotypes of AVT trials ranged from 73.36 mg/100g flour (SPV 2165) to 81.76 mg/100g flour (DSV 6). In AHT trials free amino acids ranged from 66.30 mg/100g flour (CSH 14) to 75.23 mg/100g flour (SPH 1748). The advanced sorghum genotypes were significantly different in the free amino acid content.

Phenolics: The phenolics content in the studied genotypes of AVT trials ranged from 1.65% (DSV 6) to 2.87% (CSV 23). In AHT trials phenolics content ranged from 1.38% (CSH 30) to 2.44% (CSH 23). The demonstration trials content phenolics from 1.52% to 2.92%.

b) Roti quality: All grain samples of AVT, AHT and demonstration trials of kharif season grown at Dharwad center were highly mould infected, black in colour and not found suitable for the roti quality. Roties were prepared and evaluated but due to very low organoleptic score (range between 5 to 6 only) interpretation is not done.

Conclusions: During Kharif-2014 (Dharwad center) 23 sorghum genotypes from AVT, AHT and demonstration were evaluated for nutritional quality using above quality parameters. On the basis of these characters among the new sorghum genotypes from AVT; SPV 2250, CSV 27, from AHT; SPH 1748, SPH 1724 and from demonstration trials DSV 6, CSH 16 and SHD 36 genotypes were found promising (Table 1 to 6) for nutritional quality only.

B. Rabi 2014-15 (AVHT) sorghum genotypes from Rahuri center for dough roti and nutritional quality evaluation
During Rabi -2014-15, sorghum genotypes 14 from AVHT, and 25 genotypes from IVHT were evaluated for flour, dough, roti and nutritional quality using following quality parameters.

1. Hectoliter weight (kg/hl)
2. Water absorption (%)
3. Kneading quality (Scale 1-3)
4. Spreading quality (Scale 1-3)
5. Water required for dough (%)
6. Crude protein (%)
7. Soluble protein (%) 
8. Total soluble sugars (%)
9. Free amino acids (mg/100g)
10. Starch (%)

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. Considering the flour, dough, roti and nutritional quality parameters among the new sorghum genotypes from AVHT, AVHT-1004, AVHT-1007, AVHT-1014 and AVHT-1005 and from IVHT, IVHT-2010, IVHT-2004, IVHT-2003, IVHT-2005, IVHT-2024 and IVHT-2015 were found promising for roti as well as nutritional quality (Table 7 & 10).

C. Rabi 2014-15 (AVHT) sorghum genotypes from Dharwad center for dough, roti and nutritional quality evaluation
During Rabi - 2014-15, AVHT-14 sorghum genotypes were evaluated for flour, dough, roti and nutritional quality using following quality parameters.

1. Hectoliter weight (kg/hl)
2. Water absorption (%)
3. Kneading quality (Scale 1-3)
4. Spreading quality (Scale 1-3)
5. Water required for dough (%)
6. Crude protein (%)
7. Soluble protein (%) 
8. Total soluble sugars (%)
9. Free amino acids (mg/100g)
10. Starch (%)

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 judges by the semi-trained judges and nutritional quality based on some of the important nutrient present in sorghum grain. Considering the flour, dough, roti and nutritional quality parameters among the new sorghum genotypes from AVHT, AVHT-1014, AVHT-1006, AVHT-1007, AVHT-1011 and AVHT-1014 and AVHT-1004 were found promising for roti as well as nutritional quality (Table 11 & 12).
Table 1. Nutritional constituents responsible for roti quality prepared from different genotypes of Kharif (AVT) cultivars of sorghum (Dharwad Center 2014).

<table>
<thead>
<tr>
<th>Genotype/Entry code</th>
<th>Colour of the grain</th>
<th>Appearance/Shape of the grain</th>
<th>Hectoliter weight (Kg/hl)</th>
<th>Water absorption (ml/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
<th>Total sugars (%)</th>
<th>Starch (%)</th>
<th>Free amino acids (mg/100g)</th>
<th>Phenolics (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSV 23</td>
<td>DB</td>
<td>RO</td>
<td>71.32</td>
<td>100</td>
<td>8.83</td>
<td>1.17</td>
<td>1.07</td>
<td>54.19</td>
<td>76.13</td>
<td>2.87</td>
</tr>
<tr>
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Range - - 71.32-77.63 100-110 8.52-10.07 1.04-1.40 1.07-1.64 50.14-55.58 75.36-81.76 1.65-2.87

Mean - - 75.19 103 9.15 1.23 1.38 53.02 78.01 2.13

S.E. + - - 1.70 4 0.48 0.13 0.19 1.59 2.21 0.36

C.D. at 5 % - - 5.11 13 1.44 0.41 0.57 4.78 6.63 1.10


Table 2. Organoleptic quality of roti prepared from different genotypes of Kharif (AVT) cultivars of sorghum (Dharwad Center, 2014).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Water required for dough (ml)</th>
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<th>Spreading quality</th>
<th>Colour &amp; appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall acceptability</th>
<th>Rank by DMRT</th>
<th>Loss in weight during storage (%)</th>
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<td>4.67-5.62</td>
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<td>0.20</td>
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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.
Table 3. Nutritional constituents responsible for roti quality prepared from different genotypes of Kharif (AHT) cultivars of sorghum (Dharwad Center 2014).

<table>
<thead>
<tr>
<th>Genotype/Entry code</th>
<th>Colour of the grain</th>
<th>Appearance/Shape of the grain</th>
<th>Hectoliter weight (Kg/hl)</th>
<th>Water absorption (ml/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
<th>Total sugars (%)</th>
<th>Starch (%)</th>
<th>Free amino acids (mg/100g)</th>
<th>Phenolics (%)</th>
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Range: - - 72.39-77.70 100-110 7.82-9.80 1.06-1.35 1.18-1.83 52.04-56.99 66.30-75.23 1.38-2.44
Mean: - - 75.25 103 9.07 1.21 1.38 53.68 72.20 1.86
S.E. + - - 1.53 4 0.58 0.10 0.18 1.52 2.56 0.39
C.D. at 5 % - - 4.61 13 1.75 0.32 0.54 4.59 7.68 1.20

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 genotypes of Kharif (AHT) cultivars of sorghum (Dharwad Center, 2014).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Water required for dough (ml)</th>
<th>Kneading quality</th>
<th>Spreading quality</th>
<th>Organoleptic quality parameters</th>
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<th>Loss in weight during storage (%)</th>
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<tbody>
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<td>Colour &amp; appearance</td>
<td>Flavour</td>
<td>Texture</td>
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<td>-</td>
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<td>1.39</td>
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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.
Table 5. Nutritional constituents responsible for roti quality prepared from different Kharif cultivars of sorghum (Dharwad Center 2014).

<table>
<thead>
<tr>
<th>Genotype/Entry code</th>
<th>Colour of the grain</th>
<th>Appearance/Shape of the grain</th>
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<th>Water absorption (ml/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
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Table 6. Organoleptic quality of roti prepared from different genotypes of Kharif cultivars of sorghum (Dharwad Center, 2014).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Water required for dough (ml)</th>
<th>Kneading quality</th>
<th>Spreading quality</th>
<th>Colour &amp; appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall acceptability</th>
<th>Rank by DMRT</th>
<th>Loss in weight during storage (%)</th>
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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.
Table 7. Nutritional constituents responsible for roti quality prepared from different Rabi (AVHT) cultivars of sorghum (Rahuri Center 2014-15).

<table>
<thead>
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<th>Genotype</th>
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<th>Appearance/Shape of the grain</th>
<th>Hectoliter weight (Kg/hl)</th>
<th>Water absorption (ml/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
<th>Total sugars (%)</th>
<th>Starch (%)</th>
<th>Free amino acids (mg/100g)</th>
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<td>2.07</td>
<td>61.82</td>
<td>77.06</td>
<td>2.26</td>
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</table>

Range: 74.07-77.01, 8.16-10.49, 1.28-1.94, 1.57-2.07, 50.62-63.92, 70.97-81.22
Mean: 75.55, 9.35, 1.68, 1.82, 58.01, 77.18
S.E. + 8.05, 0.76, 0.25, 0.60, 0.08, 0.14
C.D. at 5% 2.51, 0.35, 0.09, 0.23, 0.06, 0.07

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 8. Organoleptic quality of roti prepared from different hybrid/varieties of Rabi (AVHT) cultivars of sorghum (Rahuri Center, 2014-15).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Water required for dough (ml)</th>
<th>Kneading quality</th>
<th>Spreading quality</th>
<th>Organoleptic quality parameters</th>
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<th>Loss in weight during storage (%)</th>
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<td>2.95 4.78 10.33</td>
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<td>2.13-2.98 4.10-4.81 10.25-12.85</td>
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</table>

S.E. + 1.10, 1.02, 1.22, 1.33, 1.13, 0.29, 0.25, 0.70
C.D. at 5% 0.30, 0.28, 0.30, 0.30, 0.30, 0.30, 0.30, 0.30

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.

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Table 9. Nutritional constituents responsible for roti quality prepared from different Rabi (IVHT) cultivars of sorghum (Rahuri Center 2014-15).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Colour of the grain</th>
<th>Appearance/Shape of the grain</th>
<th>Hectoliter weight (Kg/Hl)</th>
<th>Water absorption (mL/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
<th>Total sugars (%)</th>
<th>Starch (%)</th>
<th>Free amino acids (mg/100g)</th>
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Range: 72.60-77.84, Mean: 75.51, S.E. + C.D. at 5 %: 3.49, 14.70, 2.19, 0.72, 0.48, 20.22, 12.93, 0.88

### Table 10. Organoleptic quality of roti prepared from different hybrid/varieties of Rabi (VMT) cultivars of sorghum (Rahuri Center, 2014-15).

<table>
<thead>
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<th>Genotype</th>
<th>Water required for dough (ml)</th>
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<th>Spreading quality</th>
<th>Organoleptic quality parameters</th>
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<td>-</td>
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</table>

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.
### Table 11. Nutritional constituents responsible for roti quality prepared from different Rabi (AVHT) cultivars of sorghum (Dharwad 2014-15)

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Colour of the grain</th>
<th>Appearance/Shape of the grain</th>
<th>Hectoliter weight (Kg/Hl)</th>
<th>Water absorption (ml/100g)</th>
<th>Crude Protein (%)</th>
<th>Soluble proteins (%)</th>
<th>Total sugars (%)</th>
<th>Starch (%)</th>
<th>Free amino acids (mg/100g)</th>
<th>Phenolics (%)</th>
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<td>1.71</td>
<td>62.94</td>
<td>74.73</td>
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<td>100</td>
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<td>1.43</td>
<td>1.58</td>
<td>56.34</td>
<td>79.98</td>
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<td>105</td>
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<td>1.20</td>
<td>1.84</td>
<td>56.04</td>
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Range: 74.44-100.14
Mean: 78.45
Standard deviation: 1.37
Coefficient of variation: 4.78

### Table 12. Organoleptic quality of roti prepared from different hybrid/varieties of Rabi (AVHT) cultivars of sorghum (Dharwad Center, 2014-15)

<table>
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<th>Genotype</th>
<th>Water required for dough (ml)</th>
<th>Kneading quality</th>
<th>Spreading quality</th>
<th>Colour &amp; appearance</th>
<th>Flavour</th>
<th>Texture</th>
<th>Taste</th>
<th>Overall acceptability</th>
<th>Rank by DMR &amp;</th>
<th>Loss in weight during storage (%)</th>
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<td>-</td>
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<td>5.6-9.9</td>
<td>6.0-9.0</td>
<td>5.85-8.06</td>
<td>-</td>
<td>2.16-2.92</td>
<td>4.13-4.87</td>
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<td>0.92</td>
<td>0.94</td>
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<td>C.D. at 5%</td>
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<td>-</td>
<td>-</td>
<td>3.16</td>
<td>2.70</td>
<td>3.09</td>
<td>2.81</td>
<td>2.81</td>
<td>-</td>
<td>0.80</td>
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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.
D. Varietal identification for product specific:

**Title of the Project:** Standardization of protocol and selection of suitable variety for niche products like sorghum papad.

**Technical Staff:** Dr. U. D. Chavan, Dr. S. R. Gadakh

**Experimental details:** Process standardized and selection of genotype for the preparation of sorghum papad.

**Results:** For selection and standardization of suitable variety for sorghum papads, some genotypes were grown at Sorghum Improvement project, Mahatma Phule Krishi Vidyapeeth, Rahuri and used for papad quality testing. From various sorghum genotypes RPASV-3 was found suitable for good quality papads when they were compared with other sorghum genotype as well as with finger millet and black gram. All results are presented in Tables 17 to 20. Therefore, the new genotype RPASV-3 for papad purpose should be considered for commercial use and make it available to the farmers by releasing it as soon as possible.

### Table 13. Nutritional and mineral composition of sorghum genotypes.

<table>
<thead>
<tr>
<th>Name of genotype</th>
<th>Protein, %</th>
<th>Total sugars, %</th>
<th>Fat, %</th>
<th>Fiber, %</th>
<th>Ash, %</th>
<th>Ca, mg/100g</th>
<th>Zn, mg/100g</th>
<th>Fe, mg/100g</th>
<th>Anthocyanins (mg/100g)</th>
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</thead>
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<tr>
<td>RPASV-3</td>
<td>11.27</td>
<td>1.12</td>
<td>1.63</td>
<td>3.61</td>
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<td>3.67</td>
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</table>

*All observations are mean of three replications. ND = Not detected.

### Table 14. Comparison of sorghum papad with black gram & nachani / finger millet papads for general consumer acceptance*.

<table>
<thead>
<tr>
<th>Name of papad</th>
<th>Colour &amp; appearance</th>
<th>Texture</th>
<th>Flavour</th>
<th>Taste</th>
<th>Overall acceptability</th>
<th>Ranking</th>
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<tr>
<td>Black gram papad</td>
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<td>7.6</td>
<td>7.8</td>
<td>7.80</td>
<td>3</td>
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</tbody>
</table>

*All observations are mean of 10 replications. Organoleptic evaluation is on 9 point hedonic scale.

### Table 15. Physical characteristics of sorghum papad as compared with finger millet and black gram papads (2014-2015).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>No of papads /kg</th>
<th>Colour of papads</th>
<th>Thickness of papad, mm</th>
<th>Diameter of papad (cm)</th>
<th>Weight of papad (g)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Before frying</td>
<td>After frying</td>
<td>Expansion, %</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Before frying</td>
<td>After frying</td>
<td>Before frying</td>
</tr>
<tr>
<td>RPASV – 3</td>
<td>65</td>
<td>Red brown</td>
<td>0.059</td>
<td>16.5</td>
<td>22.2</td>
</tr>
<tr>
<td>M 35 – 1</td>
<td>65</td>
<td>Faint yellowish</td>
<td>0.057</td>
<td>15.8</td>
<td>20.1</td>
</tr>
<tr>
<td>Finger millet</td>
<td>Market sample</td>
<td>White faint brown</td>
<td>0.056</td>
<td>11.2</td>
<td>22.3</td>
</tr>
<tr>
<td>Black gram</td>
<td>Market sample</td>
<td>Yellowish</td>
<td>0.57</td>
<td>13.6</td>
<td>15.1</td>
</tr>
</tbody>
</table>

*All observations are mean of three replications.

### Table 16. Keeping quality / shelf life of sorghum papad stored in plastic bag and card board box at room temperature (2014-2015).

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Plastic box</th>
<th>Card board box</th>
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<td></td>
<td>Storage period in months</td>
<td>Storage period in months</td>
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<tr>
<td>RPASV 46</td>
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<td>Very good</td>
</tr>
<tr>
<td>M 35 - 1</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>Finger millet, Market sample</td>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>Black gram, Market sample</td>
<td>Very good</td>
<td>Very good</td>
</tr>
</tbody>
</table>

*All samples were tested for the physical appearance and organoleptic properties.
Research Publications and extension activities during 2014-2015:

Books

Research Papers

Poster Presentation Award-2013.
Compositional grain quality of sorghum varieties & hybrids evaluated under advanced trial

CV Ratnavathi, G. Jayaramulu, U Lavanya and JV Patil
ICAR-Indian Institute of Millets Research, Hyderabad - 500030

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, fat and protein are the three major constituents of grain affecting the quality in sorghum. Starch, fat and protein were determined in the randomly collected replicated grain samples from the entries evaluated during kharif 2013 at two locations viz., Akola, and Udaipur. The results of advanced hybrid trial are presented in Table 1 and advanced varietal trial is presented in Table 2.

Advanced Hybrid Trial (Table-1A):
The data on percent starch, fat and protein in 4 test hybrids along with 4 check hybrids and one local check genotype from Akola, and Udaipur locations is presented in Table 1. The data on percent starch, fat and protein in 9 genotypes which include 4 test entries from the above two locations is presented in Table 1. Four grain sorghum hybrids were compared for all three grain quality parameters with five checks including one local check.

Fat: The mean fat content varied from 2.70% (SPH 1724) to 3.00% (SPH 1748). There is no difference between the locations for fat content. At location Akola, the range of fat was 2.60% (SPH 1736) to 3.00% (SPH 1748). In Location Udaipur the fat content ranged from 2.70% (SPH 1724) to 2.93% (SPH 1748). In both locations there is no significant difference for fat content. Very minor difference exists among the four test entries and SPH 1748 has showed higher fat content (Table-1).

Protein: The mean protein content varied from 8.62% (CSH 25) to 9.75% (SPH 1737). At location Akola, the range of protein was 6.50% (SPH 1737) to 8.10 (CSH 25). In Location Udaipur the protein content ranged from 10.43(SPH 1724) to 11.40 (CSH 25). In Udaipur most of the samples showed more protein as compared to the other location. Among the four test entries SPH 1748 and SPH 1736 are having protein content above 9.00%, on par with some checks, but not superior to check genotypes. Remaining two entries recorded low protein content (Table-1).

Starch: The mean starch content of the three locations varied from 64.78 (Local check) to 69.37 % (CSH 30).The starch content significantly varied across locations. The starch content in Akola ranges from 65.10 (CSH 25) to 71.53% (CSH 30) and in Udaipur the range was 64.10% (Local check) to 69.33(SPH 1724 & SPH 1737). Out of Four test hybrids two test hybrids (SPH 1724, and SPH 1737) are superior to 4 check genotypes except check CSH 30 with mean starch content (Table-1)

Advanced Varietal Trial (Table-2): The data on percent starch, fat and protein in 3 test hybrids along with 4 check varieties and one local check genotype from Akola, and Udaipur locations is presented in Table 2. The data on percent starch fat and protein in 8 genotypes from the above two locations is presented in Table 2. Three grain sorghums were compared for all three grain quality parameters with five checks including one local check.

Fat: The mean fat content varied from 2.83% (CSV 17) to 2.98% (CSV 23). There is no difference between the locations for fat content. At location Akola, the range of fat was 2.83% (SPV 2242) to 3.00% (CSV 23). In Location Udaipur the fat content ranged from 2.80% (CSV 17) to 2.97% (CSV 23). In both locations there is no significant difference for fat content. Very minor difference exists among the three test entries and SPV 2250 has showed higher fat content (Table-2).
**Protein:** The mean protein content varied from 8.42% (SPV 2165) to 9.03% (CSH 23). At location Akola, all samples showed very low protein and it ranged from 6.57% (CSV 20) to 7.80 (SPV 2250). In Location Udaipur the protein content ranged from 10.23 (SPV 2165) to 11.03 (CSV 17). One test entry SPV 2250 showed protein content above 9.03 and on par with check genotypes.

**Starch:** The mean starch content of the four locations varied from 65.53% (SPV 2165) to 70.72 % (CSV 27). The starch content in Akola ranges from 64.73% (SPV 2165) to 69.10% (CSV 27) and in Udaipur the range was 66.33 % (SPV 2165) to 72.33(CSV 27). The two test varieties (SPV 2242 & SPV 2250) are superior to local check with mean starch content higher than the local check (66.42) and on par with other check genotypes.

**Major observations:**
- Protein content in the samples from Akola is low.
- Starch % in all the grain samples is good.
- Test hybrids SPH 1748 and SPH 1736 are good for protein and SPH 1724 & SPH 1737 are good for starch content.
- Test variety SPV 2250 is good for protein and varieties SPV 2242and SPV 2250 are good for starch content.
- Samples from Coimbatore were not received.

### Table 1: Grain quality of grain sorghum hybrids in Advanced Hybrid Trial - Kharif 2014

<table>
<thead>
<tr>
<th>Entry</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
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<tbody>
<tr>
<td>SPH 1724</td>
<td>2.77</td>
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<td>6.10</td>
<td>7.83</td>
<td>67.90</td>
<td>69.33</td>
<td>1.62</td>
</tr>
<tr>
<td>2</td>
<td>SPH 1736</td>
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<td>2.87</td>
<td>2.92</td>
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<td>6.97</td>
<td>66.13</td>
<td>64.97</td>
<td>75.55</td>
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<td>2.84</td>
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<td>66.13</td>
<td>64.97</td>
<td>75.55</td>
</tr>
<tr>
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<td>2.97</td>
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<td>7.83</td>
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<td>65.77</td>
<td>75.67</td>
</tr>
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<td>2.77</td>
<td>2.88</td>
<td>7.97</td>
<td>7.83</td>
<td>67.90</td>
<td>65.37</td>
<td>66.53</td>
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<td>CSV 23</td>
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<td>2.80</td>
<td>2.86</td>
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<td>7.83</td>
<td>65.20</td>
<td>67.10</td>
<td>66.51</td>
</tr>
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<td>CSV 25</td>
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<td>2.87</td>
<td>2.84</td>
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<td>7.83</td>
<td>65.10</td>
<td>68.52</td>
<td>66.82</td>
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<td>8</td>
<td>CSV 30</td>
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<td>2.80</td>
<td>2.88</td>
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<td>10.63</td>
<td>69.53</td>
<td>67.60</td>
<td>69.37</td>
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<tr>
<td>9</td>
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<td>2.90</td>
<td>2.85</td>
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<td>10.73</td>
<td>65.47</td>
<td>64.10</td>
<td>67.78</td>
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</table>

### Table 2: Grain quality of grain sorghum hybrids in Advanced Varietal Trial - Kharif 2014

<table>
<thead>
<tr>
<th>Entry</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
<th>AKOLA R</th>
<th>AKOLA UDAIPUR R</th>
<th>Average</th>
</tr>
</thead>
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</tr>
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<td>SPV 2242</td>
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<td>SPV 2250</td>
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<td>2.92</td>
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<td>65.33</td>
<td>67.60</td>
<td>66.47</td>
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<td>CSV 27</td>
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<td>2.83</td>
<td>2.86</td>
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<td>65.73</td>
<td>67.60</td>
<td>66.47</td>
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<td>2.83</td>
<td>2.86</td>
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<td>65.80</td>
<td>66.30</td>
<td>65.72</td>
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<td>2.83</td>
<td>2.85</td>
<td>7.13</td>
<td>10.73</td>
<td>65.80</td>
<td>66.30</td>
<td>65.72</td>
</tr>
</tbody>
</table>

Report of the AICSIP Coordinating Team-agm15.doc  Page 63 of 75
Analysis of stover quality in grain and dual purpose sorghum

B Venkatesh Bhat, A Vishala Devender, Michael Blummel* & JV Patil

Indian Institute of Millets Research, Rajendranagar, Hyderabad
* International Livestock Research Institute, Patancheru, Telangana

Stover is an important byproduct of crop production and a crucial component of farmers’ decision to cultivate sorghum. Sorghum stover is a main source of fodder in semi-arid tropical India. The stover of sorghum is highly nutritious and beneficial to the feeding cattle in the dryland farming system. Therefore, the quality of stover is a very important trait in cultivar selection. While protein content and digestibility (measured as in vitro organic matter digestibility, IVOMD) are the important traits for stover quality, the fibre content (ADF and NDF) play a crucial role in providing roughage as well as in determining digestibility along with lignin quantity and structural composition. Ash content gives an idea of the minerals that are made available through stover. High quality stover, in addition to high protein content and high digestibility, will have a higher energy concentration (lower ADF) and will be consumed in greater quantities (due to lower NDF), than the low quality stover. Lower lignin content in stover helps increasing its digestibility. This report summarizes the quality of stover in terms of its digestibility, fibre, protein and ash content for all the genotypes in the advanced varietal (AVT) and hybrid (AHT) trials of grain and dual purpose sorghum during kharif 2014.

The stover samples from three locations were analysed for stover quality, i.e., from Coimbatore and Udaipur in zone 1; from Akola in zone 2. Under AVT, 3 test varieties of grain/dual purpose sorghum were characterized for stover quality traits and compared with 4 national checks and a local check. There were 4 grain/dual purpose hybrids in the AHT along with 4 national checks and a local check.

AVT grain and dual purpose sorghum (kharif 2014)
The analysis of data revealed highly significant differences among entries at each location, though the pooled data did not show significant differences for many of the traits (Table 1). This indicated the interaction of genotype with the environment. Significantly higher digestibility (46.25%) as well as metabolizable energy (6.66 mj/kg) along with least NDF (60.6%; NDF is proportional to animal intake, consists of structural components of the plant, specifically cell wall) were seen in the samples of entry variety SPV 2250. Except for these, no test entry performed better than checks for other traits, including protein and ash content. However, it is noteworthy that SPV 2242 had lowest lignin content (5.15%) among test entries. Among check varieties, CSV 23 had significant high protein, digestibility, significantly lower lignin and ADF (highly indigestible plant material). Highest protein content was recorded by CSV 17 and the lowest NDF was recorded by check CSV 23.

AHT grain and dual purpose sorghum (kharif 2014)
The analysis of data from hybrids as well revealed highly significant differences among entries at each location, though the pooled data did not show significant differences for any of the traits (Table 2). None of the entries showed significant superiority over the checks except SPH 1736 and SPH 1737 for protein content, metabolizable energy and digestibility. Test hybrids SPH 1736 possessed highest protein content (7.34%), metabolizable energy (6.49 mj/kg) and IVOMD (45.48%) in the trial followed by check CSH 25. It also had the lowest lignin content (5.44%) and least ADF (42.7%) showed by any test hybrid. The test entry SPH 1737 recorded second highest protein content (6.52%) and ADF (43.83%) among test entries. Test entry SPH 1724 recorded the highest NDF content. Amongst the checks, CSH 25 possessed significantly more protein content and digestibility coupled with lower ADF content. CSH 30 had high digestibility and metabolizable energy, perhaps resulting from lower ADF and lowest lignin content.
### Table 1: Stover quality of grain/dual purpose sorghum genotypes in Advanced Varietal Trial (Kharif 2014)

<table>
<thead>
<tr>
<th>Entry</th>
<th>COIMBA TORE</th>
<th>AKOLA</th>
<th>UDAIPUR</th>
<th>Average</th>
<th>COIMBATORE</th>
<th>AKOLA</th>
<th>UDAIPUR</th>
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<tbody>
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<td>C.D. (%)</td>
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</table>

Protein data from Akola location not considered for conclusions due to High C.V.(i.e > 25%) of 28%
### Table 2: Stover quality of grain/dual purpose sorghum genotypes in Advanced Hybrid Trial (Kharif 2014)

<table>
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<th>Sl. No.</th>
<th>Entry</th>
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<th>UDAIPUR</th>
<th>Average</th>
<th>COIMBARE</th>
<th>AKOLA</th>
<th>UDAIPUR</th>
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</tr>
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<td>R</td>
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<td>R</td>
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<tr>
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</tbody>
</table>

Protein data from Akola location not considered for conclusions due to high C.V. (i.e. > 25%) of 42.8%
Appendices

Appendix I: AICRP on Sorghum 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

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

(2 pages)

To
The Project Coordinator
All India Coordinated Research Project on Sorghum
Indian Institute of Millets 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: _____________________________ |

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.

<table>
<thead>
<tr>
<th>S. No</th>
<th>Name of the entry (station code)</th>
<th>Name of the trial and the Zone for which it is an entry§</th>
<th>Detailed Pedigree of hybrid variety**</th>
<th>DUS characteristics</th>
<th>Breeding method &amp; stage (F7 etc.)</th>
<th>Quantity of seed submitted(Kg)</th>
<th>Seed germination (%) at the time of submission of entry</th>
<th>Testing fees total (Rs.)</th>
<th>DD No. and date; Name of bank on which DD is drawn#</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Please note that entries should not be treated with any chemicals. Treated seeds are summarily rejected.</td>
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</table>
| 3.    | Your entries may not be accepted if: 
| a.   | Quantity is less than specified; |
| b.   | Germination after receiving is less than 85%; |
| c.   | Seed is a mixture, or treated with chemicals; |
| d.   | Not received before deadline. |
| 4.    | Please do not ask for extension of date for submission of seeds (date on which it reaches DSR only will be considered). |

IVT - Initial Varietal Trial; AVT - Advanced Varietal Trial; IHT - Initial Hybrid Trial; AHT - Advanced Hybrid Trial

(Signature & date)                                                                 (Seal / Stamp)
### Appendix III: Information on parental lines / entries submitted

(AICRP on Sorghum centre scientists to note: Without parental lines no hybrid will be accepted as entry in trials)

(minimum quantity to be submitted: 100g)

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

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<tr>
<td>2</td>
<td>Provide clear photographs of:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>A. Field view of crop</td>
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<td></td>
<td>B. Plant close-up</td>
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<td></td>
<td>C. Ear-head/Panicle (close-up)</td>
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<td>D. Grain (close-up)</td>
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<td>3</td>
<td>Summary of Proposal</td>
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<td>Summary yield data of coordinated varietal trials</td>
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<td>Reaction to insect pests</td>
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<td>Data on other important characters</td>
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<td>Copy of allotment of IC numbers from NBPGR*</td>
<td>Annexure V</td>
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<tr>
<td>15</td>
<td>Copy of recommendation of workshop*</td>
<td>Annexure VI</td>
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<td>Package of practice</td>
<td>Annexure VII</td>
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* This proforma can be used for VIC also, except for the marked ones.

Visit our website for complete format: [www.sorghum.res.in](http://www.sorghum.res.in)
Appendix V: Bench marking of varieties of important agricultural and horticultural crops

Indian Council of Agricultural Research
Kirishi Bhawan, New Delhi-110001
(Crop Science Division)

Subject: Bench marking of varieties of important agricultural and horticultural crops.

A meeting of all ADGs and Scientists, Crop Science Division, ICAR was held on 7.2.2015 under the chairmanship of DDG (CS) to discuss the bench marking of the varieties for identification/release in view of recommendations of the meeting on bench marking of varieties held on February 05, 2015 at DWBR, Karnal under the chairmanship of Secretary DARE and DG, ICAR and new guidelines for identification/release of varieties. After in-depth discussion, following recommendations were made for their proper implementation with immediate effect.

1) The potential yield along with nutrition value, disease & pest reactions, physio-chemical parameters, etc. of zone wise varieties notified during the last five years for different situations/systems should be prepared by respective Project coordinator/Director for fixing the benchmark. A copy of the same may also be submitted to respective ADG within 15 days.

2) The best check of the zone must be included across the varietal trials of different situations along with specific check. The disease and pest reaction of varieties/entries should be recorded from the first year of testing, IVT stage.

3) Director/Project Director shall not be part of Variety Identification Committee (VIC). The Project Coordinator/Principal Investigator (Plant Breeding) will convene the meeting. In the absence of DDG (CS), the senior most ADG will chair the meeting.

4) A certificate from Director/Director of Research is essential regarding availability of sufficient basic seed of candidate variety for planting at least 10 ha area, while submitting the variety identification proposal.

5) Complete package of practices along with seed production protocol of candidate variety should be annexed with VIC proposal.
6) The proforma under new guidelines should strictly be adopted while submitting variety identification/notification proposal.

**Table:** Average yield, disease & pest reactions and physico-chemical quality parameters of varieties (different zones & systems) released during the last five years for calculating the minimum benchmark of candidate varieties

<table>
<thead>
<tr>
<th>S.N.</th>
<th>Crop/variety/zone/trial</th>
<th>Yield Kg/ha</th>
<th>Quality parameters</th>
<th>Disease reaction</th>
<th>Pest reaction</th>
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</thead>
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<tr>
<td>1</td>
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<td>1 2 3 1 2</td>
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<tr>
<td>n</td>
<td>Average</td>
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</table>

Note: Separate average of zone/trial may be given.

(B.B.SINGH)
ADG (O&P)
Appendix VI: Criterion for best AICRP on Sorghum centre prize

To encourage healthy competition among AICRP on Sorghum centers (including voluntary centers) IIMR has decided to constitute a biannual Best AICRP on Sorghum Center Prize.

Eligibility criterion
Regular AICRP on Sorghum centers or voluntary centers approved from AICRP on Sorghum Coordinating cell (any change of location made at the center level will not be considered). A center receiving the prize will not be considered for next two years.

Selection criterion

| Monitoring team report: Mainly will cover the quality of experimentation (including sticking to sowing plan, field data recording, plant protection measures, cleanliness of the field etc.) (5 marks), maintenance of data booklet (5 marks), involvement of all the AICRP on Sorghum staffs in the programme (5 marks) | 15 marks |
| Data quality: Number of trials conducted (5 marks), whether data booklets have been filled and submitted in right format (5 mark), CV of various experiments and utility of the data (10 marks), consistency of the quality of the data over last three years (5 marks) | 25 marks |
| Compliance to the deadlines and response to Coordinating cell’s requests: Compliance of the centers to various deadlines (5 marks), Promptness in response (5 marks) | 10 marks |
| Quality & quantity of seeds of the entries/checks contributed by the centers: Whether seeds of the checks/entries supplied in right quantity and quality | 5 marks |
| Financial compliance: Fund utilization and submission of AUC | 5 marks |
| Publications: Publications as a team, AICRP on Sorghum, IIMR, quality of journal (AICRP on Sorghum-IIMR team publication 7 marks, AICRP on Sorghum publication 3, quality of journal 5 | 15 marks |
| Product releases: Number of variety / hybrid / technology releases | 10 marks |
| Seed productions: Variety/hybrid production (tons) | 15 marks |

Deciding authority
Project Coordinator with input from all PIs and Nodal Officers

Prize
A certificate and a trophy