

वार्षिक प्रतिवेदन
Annual Report
2008-2009



ज्वार अनुसंधान निदेशालय
Directorate of Sorghum Research (DSR)
Rajendranagar, Hyderabad - 500 030
Andhra Pradesh, India



1 Executive summary

A. Genetic resources

New germplasm collection: Four basmati-like (scented) sorghum were unique among the collections from Bundelkhand region of Madhya Pradesh. A total of 32 accessions were collected from North Gujarat including important landraces such as Malwan, Gundri, Deshi, Solapuri, Kamaparva and Chachadia. Malwan is a popular dual-purpose landrace with great demand of seed from the farmers.

Characterization of germplasm for insect resistance: Germplasm accessions were screened and many new sources of resistance to stem borer and shoot bug were identified. The genotypes GGUB 13, CJV 25, GGUB 27, EJ 22, EC 15, ES 21, GGUB 61 and EP 37 were more tolerant to stem borer. The entries CJV 25, GGUB 27, EJ 22, EC 15, ES 21, EP 61, GGUB 50, E 63, GGUB 68, EG 21, GGUB 28, EP 31 and E 20 were found tolerant to stem borer as well as shoot bug.

Registration of genetic stocks with NBPGR:

Following nine genetic stocks were registered with the NBPGR during 2008–09:

MS 463B (INGR 08080), MS 486R (INGR 08081), EC 13 (IC 345715) (INGR 08082, SPV 1742 (INGR 09017), 126A&B (INGR 09018), 91A&B (INGR 09019), 356A&B (INGR 09020), 288A&B (INGR 09021) and 45A&B (INGR 09022).

B. Pre-breeding and genetic diversification

Interspecific hybrids of sorghum: Extensive efforts made to cross cultivated sorghum CS 3541 with *S. usumbarense*, *S. versicolor* and *S. hewisonii* resulted in success with some combinations. Interspecific crosses with *S. usumbarense*, *S. versicolor* and *S. hewisonii* with sorghum CS3541 resulted in success with

some combinations. F_1 of *S. bicolor* x *S. hewisonii* and F_2 of *S. bicolor* x *S. usumbarense* were tested positive for hybridity.

C. Cultivar identification for release and evaluation of elite materials

- SPH 1643, a hybrid based on newly developed parents, showed significantly higher grain and fodder yields over the checks CSH 23 and CSH 16 in AICSIP multi-location trials.
- SPH 1640 jointly developed with Parbhani Center (MAU) performed superiorly and is advanced to AVHT in AICSIP trial
- SPV 1746 was identified by Varietal Identification Committee for good quality grain and superior roti-making quality. It was on par for grain and stover yields with the check CSV 15.
- A new sweet sorghum variety, SPSSV6, superior to check SSV84 was identified for release at national level for all the sorghum growing regions.

D. Elite breeding stocks and hybrid parents developed

(i) Kharif grain sorghums

Characterization of genetic stocks and MS lines: Based on evaluation over three years, 25 genetic stocks and 19 MS lines were identified as superior for following traits: grain mould resistance, sweet stalk, stover quality and grain yield.

Development of new kharif sorghum parental lines

Good combiner MS line for starch content identified: Two lines – 05R GTC SPA10, and 05R GTC SPA 12 – showed high starch content; the latter was also a good combiner. Compared with 27B as check, 05R GTC SPA507, 05R GTC SPA585, and 05R GTC

SPA487 were superior combiners for grain yield.

Evaluation of random-mating restorer population steriles for grain mold: A total of 190 steriles from the random mating R population were evaluated for grain mold resistance in replicated field trial. After the second cycle, the mold tolerance of the population was improved and the population mean decreased from 4.0 to 3.8, on 1–9 scale (1=most resistant) at physiological maturity (PGS), and from 7.0 to 6.4 at harvest maturity (TGS). Around 11% of these lines were almost free from grain mold at physiological maturity (PGS<3.0). Of these, 15 lines scored fairly high for mold tolerance score (TGS=5.0) even at harvest maturity and were statistically at par with the resistant check, B 58586 (TGS= 5.0).

Identification of stable mold resistant lines: Twenty-five advanced generation breeding lines were evaluated along with 5 checks at high rainfall zones of Karnataka and Maharashtra viz., Shimoga, Hassan, Dharwad and Kolhapur. The mean mold score was highest at Dharwad, followed by Rajendranagar and Hassan. Out of 25 lines tested, 219 A X CB 29, 219 A X CB 33, 219 A X CB 32, BN 1309-R 07, BN 1314-R 07, BN 1316 R 07, BN 1320 R 07, BN 1324 R 07, and BN 1325 R 07 were found resistant with a mold score of <4 on a 1–9 scale across locations. The susceptible checks, Bulk Y and 296B recorded score from 8–9, while resistant checks recorded 2.0 to 2.5.

(ii) Rabi sorghums

Developing varieties with improved rabi adaptation traits: Out of 98 improved breeding lines evaluated separately on shallow, medium, and deep soils, 33 were promising, and were superior to checks Mauli, M35–1, and CSV–18. Twelve lines were significantly superior to Mauli on shallow soil, and gave 4.9 to 53.6% more grain yield than the check variety Mauli; 21 lines on deep soil, over CSV–18 for grain and fodder yields. On deep soil, 17 lines showed 6.9 to 42.6%

superiority for grain yield over CSV–18.

Developing new rabi parental lines with diversity to broaden the genetic base: A total of 33 indigenous and 11 exotic CMS lines were characterized for 23 traits. Promising 10 CRS lines, 94 A/B lines, 43R lines were multiplied along with 59 elite stocks. Conversion programme continued for 65 BC₅, 34 BC₄, 31 BC₃ (indigenous and exotic) 27 BC₂, 100 BC₁ progenies and for 64 new lines. Out of these, 21 BC₅, 9 BC₄, 4 BC₃, 10 BC₂ and 62 BC₁ were selected. B line improvement initiated for diversifying genetic base led to the selection of 23 B lines out of 32 tested. Selected B lines (SLB–9, 10, 11, 12, 19, 25, 29, 36, 39, 45, 46, 48, 49, 60, 69, 72 and 83) gave 7.8 to 49.1% more grain yield than the check 104B.

R line improvement for diversifying genetic base led to selection of 14 R lines out of 19 lines tested. Twenty B x B, and 18 R x R crosses were made to induce rabi adaptability, better grain size and quality characters. Selected R lines (SLR–29, 38, 39, 47, 57, 66, 69, 71 and 72) gave 4.2 to 31.8% more grain yield than the check RS–585. All the 76 experimental hybrids tested were fully fertile. Selected hybrids (104A x SLR–30, 104A x SLR–31, 104A x SLV–30, 104A x SLR–57, 104A x SLV–67 and 104A x SLR–70, recorded 10.6 to 44.3% more grain yield than CSH–15R.

(iii) Multi-cut forages

Multi-cut forages: B line development programme for the enhancement of fodder yield and quality was initiated using 40 grain type, and 37 sweet-stalk sorghum B lines. Forage x forage, and sweet sorghum x forage crosses were made to improve the forage restorers. The materials in F₂ and F₃ stages are promising. Work was initiated to incorporate shoot fly resistance into parental lines of forage sorghum utilizing two shoot fly resistant sources, IS 18551 and IS 2122. Trait-specific improvement of forage sorghum for important traits such as fodder



quality, yield, resistances to leaf diseases, stem borer and shoot fly has begun collaboratively with various AICSIP centres.

Evaluation of multi-cut forage hybrids: The hybrid NMFH 931, followed by NMFH 958 and NMFH 948 were superior to rest of the entries in terms of green forage yield from two cuttings. All the hybrids were superior to the checks in terms of green forage yield. One hybrid NMFH 936 recorded high forage yield in the second cut as well.

(iv) Single-cut forages

Single-cut forages: In zone II (southern parts of India), the single-cut forage genotype, NFS-2 performed well in advanced varietal trial under AICSIP with 41.2 tonnes/ha green fodder yield against 35.7 tonnes/ha of the check, HC 308. Also, efforts are being made to transfer shoot fly resistance to HC 308.

Promising dual-purpose lines for yield and stover quality: NRCS F6-4, NRCS F6-9 and NRCS F6-10 significantly out-yielded the checks in terms of fodder yield. NRCS F6-12 was on par to the check for grain yield and was significantly superior for fodder yield. Amongst the brown-midrib types, the entry NRCS F6-14 was on par to the check for grain and fodder yields while NRCS F6-18 was promising for fodder yields alone. The stover quality analysis done during rabi 2007-08 revealed the superiority of the brown midrib genotype NRCS F6-15 in terms of digestibility (57%) against check CSV 15 (54%).

(v) Sweet sorghum

Evaluation of sweet sorghum B lines for sugar yield traits: The B lines NSSB 20, NSSB 25 and NSSB 1008 were superior for brix yield (> 18.5%). Further, B lines NSSB 7, NSSB 11 and NSSB 1001 recorded highest fresh stalk yield (> 500 g/ plant).

Sweet sorghum physiology: When stalks are stored under ambient room conditions, the juice brix and total soluble sugars (TSS) deteriorate; they can be retained in stalks up to only 2 days without any significant losses

in sugar quality. However, SPSSV 30 was an exception; its stalks can be stored for 7 days under moderate temperatures.

To ensure continuous supply of stalks to the factory, serial planting is desired. In staggered planting experiments, stalk yield and computed ethanol yields did not differ significantly from the crops planted between first and third week of June. July and August planting decreased the stalk yields by > 100% over June planting. CSH 22SS gave highest mean ethanol yields (820 L/ha) followed by SSV 74 (549 L/ha) across the planting dates.

E. New initiatives to quicken diversification of breeding stocks and to improve quality and resistance levels

Diversification of breeding stocks: With a major initiative on parental line development and diversification, nearly 800 crosses of kharif sorghum and 600 crosses of rabi sorghum were produced involving promising B and R lines, released varieties and parents of released hybrids. The $F_{1.2}$ seeds were distributed to 12 AICSIP centres and other cooperators. During rabi 2008-09, seeds of F_3 generation received from 11 centres were advanced at Hyderabad, Warangal and Coimbatore during the off-season. A total of 2242 new selections were made and the seeds were distributed back to the concerned AICSIP centre for further advancement, and for location- and trait-specific selections during the kharif 2009 season. A total of 534 new F_2 generations of crosses were distributed across 15 AICSIP centres for advancement and further selections at their end. A part of the selections was shared with Plant Protection groups for screening in their respective nurseries against different biotic stress factors.

F. Transgenics

Sorghum Bt transgenic plants with resistance to stem borer: Sorghum transgenics with lepidopteron-specific synthetic cry1B gene is



Purpose	Cross/Population (No. of RILs)	Progress during 2008–09
Shoot fly resistance and	296B x IS18551 (350)	Major QTL for leaf glossiness, Oviposition, Deadhearts
for	27B x IS2122 (434)	trichome density identified and tagged with SSRs Multi-location, multi-season phenotyping completed
Grain mold tolerance	296B x B58586 (215)	2 years Multi-location phenotyping completed for 1 year
Drought	M35-1 x B35 (500)	tolerance, roti quality Skeletal linkage map prepared; staygreen QTL validated

promising in all generations till T₄. PCR, Southern analysis and RT-PCR analysis of transgenic plants at various generations confirmed the presence of cry1B and bar genes. The transgenic sorghum plants produced Cry1B protein at concentrations ranging from 1–2 µg/g of fresh leaf weight, and showed very high levels of resistance against stem borer, when tested with 10 larvae released in the whorl of each plant at 40 days after sowing.

Suppression of HCN formation in forage sorghum using antisense technology: T₁ generation plants of 37 T₀ events were analyzed for HCN content at 45 days after sowing, in a containment glasshouse, where they were irrigated regularly. The plants tested positive for transgene in PCR and the HCN contents varied from 5.1 to 149.8 ppm as against 211.5 ppm HCN in non-transformed control plants.

G. Marker-assisted breeding

Progress in identification of DNA marker-based quantitative trait loci (QTL) are summarized below.

Molecular tagging of restoration gene(s): Two F₂ mapping populations (A₁122 x M1 and A₁KS57 x M3) differing for restoration gene on A₁ cytoplasm, and one F₂ population (A₂N184 x M1) segregating for A₂ fertility restoration were used for this study. SSR

markers Drenhsbm95 and Xcup05 were used to genotype the F₂ plants, and single marker analysis was done to associate marker allele with fertility restoration. It was found that the SSR marker Drenhsbm95 and Xcup05 are linked with Rf₁ gene on A₁. The Rf₁ was mapped on linkage groups on SBI-04. The comparative mapping showed that sorghum Rf₁ locus is syntenic to Rf₂ gene on rice chromosome OS-02, and Rf₂ gene on maize chromosome ZM-04.

Multi year evaluation of RILs (296B x IS58586) for grain mold resistance: This mapping population comprising of 212 recombinant inbred lines (RILs) of 296B x B58586 was characterized for grain mold reactions, and data from 3 seasons were pooled and analyzed. Thirty-three RILs were resistant at physiological maturity (PM) {(filled grain score (FGS) ≤3.0 on 1–9 scale; where 1 = most desired)}. Further, 20 RIL were moderately resistant at harvest maturity (HM; FGS ≤5.0). The RIL nos. 25, 85, 92, 93, 95, 97, 98, 124, 158, 161, 169, 170, and 209 were highly resistant to grain mold {(panicle grain mold score (PGS) 2.2 to 3.2 at PM, and 3.7 to 5.3 at HM on 1–9 scale)}. The checks used were: resistant, B 58586 (PGS at PM–2.1, and at HM – 4.7) and susceptible, 296 B (6.6, and 8.3).

H. Plant protection

(i) Insect resistance management



Shoot fly and stem borer management: As a part of integrated insect management approach, Thiamethoxam 70 WS was found effective as seed treatment for controlling sorghum shoot fly during both rabi and kharif seasons.

(ii) Disease management

Control of charcoal rot: Application of bleaching powder (80kg/ha) reduced charcoal rot by 22%, and boric acid (30kg/ha), and cotton cake (1000kg/ha) by 10% at Solapur. Application of cotton cake increased fodder yield by 36% and boric acid and bleaching powder, by 15%; however they did not influence grain yield. Seed application of the rhizobacteria strain Rb124 significantly reduced field-incidence of charcoal rot and lodging.

Efficacy of elite bacterial strains for seedling growth stimulation: Bacterial strains under co-inoculation, in general, produced better germination of seed than co-cultivation. Significant increase in seed germination percentage (83 to 90%) was recorded when seeds were co-inoculated with multiple strains - Rb29+Rb205, Rb124+Rb205, R b 1 0 + R b 2 9 + R b 1 2 4 and Rb10+Rb29+Rb205 - as compared to the control (68%). The combination Rb10+Rb29+Rb124 increased germination (22%) under both the inoculation methods.

Grain mold and foliar disease management: In grain mold programme potential resistant donors for grain molds resistance were identified and mold rating scale changed from 1-5 to 1-9 to increase the precision. Parental line CRP58 has been found to possess resistance against rust and downy mildew diseases.

Identification of colored grain sources with Fusarium mold resistance: Susceptibility to Fusarium infection among accessions with coloured grains is less (13%) when compared with white grain (32%). Results showed that Fusarium grain-infection ranged from 8 to 47% among 25 color-grain genotypes, and 8

to 80% among white-grain types. The lines IS 25100, IS 25070, IS 25104 and IS 8525 were resistant to infection and colonization by Fusarium.

I. Crop management

Organic farming practices for rabi sorghum: A field experiment comprising eight organic farming practices comprising FYM @ 6 tonnes/ha, Vermicompost @ 2 tonnes/ha, glyricidia @ 5 tonnes/ha, green manuring of sunhemp, legume-rabi sorghum sequential cropping, 100% RDF (60:30:30 kg NPK/ha), 75% RDF + 3 tonnes/ha FYM + Azospirillum + phosphate solubilising bacteria (PSB) and farmers practice (10 kg N + 3 tonnes/ha FYM) was conducted during rabi 2007-08 under dryland conditions. The grain yield of sorghum cv. CSV 18R under different treatments was quite low (353-493 kg/ha). The highest biological yield was recorded with INM of 75% RDF + 3 tonnes/ha FYM + Azospirillum + PSB (4455 kg/ha) followed by glyricidia (3600 kg/ha) and farmers practice (3566 kg/ha).

Relative performance of sorghum cultivars in rice-fallows under zero tillage: Sorghum in rice-fallows in coastal Andhra Pradesh, especially in Guntur and adjoining districts is gaining popularity among the farmers. Sorghum is preferred over maize in areas with limited water for irrigation. The crop is sown manually under zero tillage immediately after harvest of rice in December to utilize the residual soil moisture. Of the 13 sorghum cultivars evaluated in rice-fallows at farmers fields, Sudama 333 (8.44 tonnes/ha), CSH 16 (7.80 tonnes/ha), MJ 4334 (7.37 tonnes/ha) and MRS 4094 (7.14 tonnes/ha) registered high grain yields. The local check 'Laxmi' yielded much less (5.89 tonnes/ha).

J. Crop utilization and food safety

Sorghum utilization: Out of 300 genotypes analyzed for physical characters of grain, 53 were suitable for semolina production. Three traditional food type cultivars CSV 18, CSV 216 R and C-43 were identified as suitable for

popping.

Food safety: A total of 228 grain samples from four locations (Dharwad, Akola, Coimbatore and Udaipur) were collected and evaluated for aflatoxins and fumonisins. Aflatoxin contamination was relatively less compared to fumonisin contamination. The range of aflatoxins was 0.00 (in SPH 1604, SPH 1606) to 13.30 µg/kg (SPV 462) and fumonisins 0.00 (SPH 1606) to 736.94 µg/kg (CSH 23). Fumonisin contamination was low in three locations Dharwad, Akola, and Coimbatore. Maximum toxin was recorded at Udaipur (736.94 µg/kg), and 2 samples from Udaipur had aflatoxin above safety limit (10 µg/kg).

Effect of Eugenol on aflatoxin production: Eugenol at concentrations of 100 and 150 µl containing 107 and 160.5 mg respectively were effective and showed no aflatoxin because of inhibition of Lipid peroxidation property. The genotypes C-43 and LPJ showed less aflatoxin compared to M 35-1. Eugenol was effective at 150 µl (160.5 mg) concentration on the two different highly toxic *Aspergillus* strains, when cultured in YES medium.

K. Basic investigations

Seed longevity and viability potential of lines, testers and their cross-combinations

Initial seed vigour (seeds not subjected to accelerated ageing): Among the 6 lines tested, 2219A showed highly significant and positive gca effects for seed germination, seedling vigour index and field emergence of fresh seed. Among the 9 testers, Indore 12 and AKR150 showed positive gca effects for seed germination, seedling vigour index and field emergence. Six crosses recorded highly significant and positive sca effects for all the three traits.

Seed viability potential (accelerated ageing seeds): Among the 6 lines tested, 2219A showed highly significant and positive gca effects for seed germination, seedling vigour index, and field emergence of accelerated

aged seeds followed by 14A with positive gca effects for these traits. Among the 9 testers, RS29, Cs3541 and Indore 12 showed significant and positive gca effects for seed germination, seedling vigour index and field emergence respectively of accelerated aged seeds.

Histo-chemistry and cyto-anatomy of sugarcane-sorghum hybrids and sweet sorghum lines: Sweet sorghum varieties Urja, SSV 74 followed by SSV 84 have highest starch-less parenchyma filled with syrup. They also have less collenchyma yielding less bagasse. Sorghum x sugarcane hybrids had more collenchyma than either of parents. Hybrids of grain sorghum had more starch deposition in the nodes. Sorghum x sugarcane hybrids showed hybrid vigour in expression of bundle sheath collenchymas. This information will be used in selecting sorghum with different end-uses such as bioethanol and paper.

L. Research services

DUS characterization: On request from PPV & FRA, a total of 9 candidate varieties were characterized during kharif 2008. During rabi, one candidate variety (CSV17) was characterized. At DSR, a total of 92 new entries consisting of hybrids, varieties and parental lines (consisting of 12 AB pairs, 10 R lines, 50 varieties and 20 hybrids) were characterized for 33 DUS traits during kharif season.

HRD: The human resource development programme for skill improvement of scientists, technical personnel and administrative staff has been done on a regular basis. Three special trainings courses on specific areas were organized for technical people. Scientists underwent trainings in cutting-edge technologies and the administrative staff members were deputed for trainings in the relevant areas. In addition, two training courses were organized for outside clientele.

M. Commercialization and



entrepreneurship development

Orientation of farmers for intensive kharif sorghum cultivation and feed-back on future prospects: One tonne seed each of CSH 23 and CSH 16 were distributed to 500 farmers in 20 e-Choupals in Indravely hub of Adilabad district in collaboration with ITC Ltd., Hyderabad. Orientation on package of practices was imparted to 500 kharif sorghum farmers in Adilabad district. About 200 ha of sorghum cultivation is altogether brought under market assured buy-back procurement (e-Choupal system of ITC) model. A major proportion of sorghum is utilized for home consumption of farmers, and a mere 20% was available as marketing surplus. Since, this model created a guaranteed market, and farmers were under

the guidance of knowledgeable scientists, farmers were enthused to use essential inputs and were more agreeable to greater commercialization of sorghum.

Commercialization: The new varieties and hybrids namely CSH23 (grain sorghum), CSH22SS (sweet sorghum), CSH20MF and CSH24MF (multi-cut forage sorghum hybrids) were licensed on non-exclusive basis to seed enterprises. The novel technologies based on sweet sorghum for electricity generation and biofuel production was licensed for commercialization as per ICAR guidelines on IP protection and commercialization. Commercialization of the multigrain flour (where jowar is main component) which is suitable for automatic roti making machine and jowar flakes is



A book on “Seed system innovations in semi arid tropics of Andhra Pradesh” being released by Shri. Sharad Pawar, Hon’ble Union Minister of Agriculture, Dr. PK Mishra, Secretary, Department of Agriculture, is seen on left; Dr. Mangala Rai, DG, ICAR on right on May 26, 2008

Shri. Sharad Pawar, Hon’ble Union Minister of Agriculture and state agricultural minister visiting sorghum stall on May 26, 2008

