# Report on the AICSIP Coordinating team
# Contents

# 1. Sorghum production: 2007- 08 estimates

***Compiled by Chari Appaji and B Dayakar Rao***
*Source: DMD, Jaipur (GOI)*

Sorghum is cultivated during the kharif season in 19 states and union territories of the country The normal area under kharif sorghum is about 4.o million ha. The major sorghum growing states in the country where the area is over 0.1 m ha are: Maharashtra. Karnataka, Tamil Nadu, Andhra Pradesh, and Uttar Pradesh.

**Table 1: Production of Jowar (Kharif and Rabi) in India (2000-2001 to 2007-2008)**

Note : * : Advance Estimates, As on 19.07.2007.
# : 1st Advance Estimates As on 19.09.2007.
Source : Ministry of Agriculture, Govt. of India.

(Million Tonnes)

| Year | Kharif | Rabi | Total |
|---|---|---|---|
| 2000-01 | 4.56 | 2.97 | 7.53 |
| 2001-02 | 4.23 | 3.33 | 7.56 |
| 2002-03 | 4.22 | 2.79 | 7.01 |
| 2003-04 | 4.84 | 1.84 | 6.68 |
| 2004-05 | 4.04 | 3.20 | 7.24 |
| 2005-06 (Final Estimates) | 4.07 | 3.56 | 7.63 |
| 2006-07 (Targets) | 4.28 | 3.33 | 7.61 |
| 2006-07 * | 3.68 | 3.72 | 7.40 |
| 2007-08(Targets) | 4.20 | 3.80 | 8.00 |
| 2007-08# | 3.60 | - | - |

The total area sown during the kharif season 2007 is 3.58 m ha, which is about 6 % less then the area sown during the year 2006. Sorghum area has shown an increasing trend in the states of Karnataka 6%), Uttar Pradesh (42%), and Gujarat (18 %), Haryana (10%) over 2006-07. Decrease in area observed in the states of Maharashtra (13%), Madhya Pradesh (10%), Rajasthan (13%) Tamil Nadu (8%) and Andhra Pradesh (4%). The main crops replacing sorghum are Bt. cotton, and soybean

**Table 2: Area, production and yield of sorghum 2007-08 (as on 30 January 2008)**

| Year | Kharif | Rabi | Total |
|---|---|---|---|
| Area in m.ha | 3.58 | 3.32 | 6.90 |
| Production in m.tonnes | 3.60 | NA | NA |
| Yield (kg/ha) | 1006 | NA | NA |
| NA:Not available | | | |

The estimated production in the country is likely to be at least 3.65 m tonnes during the kharif season of 2007.Of these Maharashtra s likely to contribute about 1.6 m tonnes, followed by

Madhya Pradesh (0.6) and Karnataka (0.5) tonnes. The states like Rajasthan (0.4) , Uttar Pradesh (0.22), Tamil Nadu (0.17 , Andhra Pradesh (0.23) are expected to contribute the rest.

**Table 2.1: Status of sorghum cultivation in the country - Kharif season 2007**

** Estimates only*

| S.No | State | Area x 0.1 m ha) | Production (tonnes)* | Yield – 100 kg/ha* |
|---|---|---|---|---|
| 1 | Andhra Pradesh | 2.33 | 2.3 | 9.87 |
| 2 | Bihar | 0.05 | 0.04 | 8.00 |
| 3 | Chhattisgarh | 0.07 | 0.05 | 7.14 |
| 4 | Gujarat | 0.90 | 0.85 | 9.44 |
| 5 | Haryana | 1.00 | 0.45 | 4.50 |
| 6 | J & K | 0.03 | 0.02 | 8.00 |
| 7 | Jharkhand | 0.01 | 0.001 | 1.00 |
| 8 | Karnataka | 3.20 | 5.03 | 15.72 |
| 9 | Madhya Pradesh | 5.00 | 6.14 | 12.28 |
| 10 | Maharashtra | 13.30 | 16.80 | 12.60 |
| 11 | Nagaland | 0.02 | 0.10 | 4.90 |
| 12 | Orissa | 0.11 | 0.06 | 5.45 |
| 13 | Rajasthan | 5.50 | 3.76 | 6.84 |
| 14 | Tamil Nadu | 2.00 | 1.73 | 8.65 |
| 15 | Uttar Pradesh | 3.25 | 2.23 | 6.86 |
| 16 | West Bengal | 0.01 | 0.01 | 11.00 |
| 17 | D & N Haveli | 0.01 | 0.004 | 8.00 |
| 18 | Delhi | 0.07 | 0.08 | 11.43 |
| 19 | Pauducherry | 0.001 | Neg. | 0.00 |
| **Total** | | **36.861** | **39.655** | **10.76** |

# Crop chemistry, toxicity, and nutrition

## 2. Starch and protein contents of kharif elite genotypes

***CV Ratnavathi, D Gopalakrishna, K Ganesamurthy, RB Ghorade, MY Kamatar and Vittal Sharma***

Sorghum is a nutritious cereal grain providing starch, protein, fiber and minerals to the consumers. The grain processing for roti though is difficult, other food products can be prepared by processing the grain by pearling, milling, flaking, extrusion and popping. The grain gets damaged during kharif season due to grain mold, thus receiving a low market price. Though the physical quality of grain deteriorates due to mold, the chemical quality does not always get affected. The starch and protein are the two major constituents affecting main uses of sorghum. Therefore, percent starch and protein in the advanced sorghum varieties and hybrids was studied. The grain samples from four locations viz. Coimbatore (Zone I), Akola, Dharwad (Zone II) and Udaipur (Zone III) were collected from kharif 2007 season for the study of grain quality.

**Coimbatore samples:** The data on starch and protein in 15 genotypes for this location of zone I is presented in Table 1. The variability for starch across locations and genotypes was very limited. The pooled average starch content was not significantly different between genotypes. The starch content varied from 63.10 (SPH 1596) to 66.20 % (CSH 23). Three genotypes SPV 1774 (66.00), SPV 1616 (65.6) and SPV 1742 (65.60) were superior to checks CSV 15, CSV 17 and SPV 462 for starch. CSH 23 (66.20) was the only check having high starch content. However, the protein content varied significantly among genotypes. The variation obtained for protein was from 8.28 (SPV 1774) to 9.52 (SPV 1733). Five genotypes SPH 1596, SPV 1733, SPV 1600, CSH 16 and CSH 18 recorded protein content above 9.0%.

**Akola & Dharwad samples** (Table 2): The pooled average starch content was not significant among the 17 genotypes tested. The starch content varied from 63.50 (CSH 16) to 65.50 % (SPV 1786). Three genotypes SPV 1786, SPV 1774 and SPV 1600 and three check varieties SPV 1616, CSH 18 and CSH 23 had starch content above 65%. The protein content varied significantly among genotypes. The variation obtained for protein was from 8.36 (SPV 1774) to 8.96% (CSH 23). Two genotypes SPV 1786 (8.51), SPV 1746, SPV 1742 (8.90) and SPV 1616 had protein content above 8.5%.

**Udaipur** (Table 3): A total of 19 genotypes including six checks samples from Udaipur were analyzed. The pooled average starch content was significant among genotypes. The starch content varied from 62.17 (SPH 1596) to 66.84 % (SPV 462). Six genotypes SPV 1774, SPV 1616, SPV 462, SPH 1342, SPV 1600, SPV 1746) had starch content above 65%. The protein content varied significantly among genotypes. The variation obtained for protein was from 8.28 (SPV 1775) to 9.69 (SPV 1600). Two genotypes (SPV 1775 and CSV 15) had low protein content i.e. below 8.5%.

**Conclusions:** The elite materials tested do not show much variation for starch percentage but they do differ for protein percentages.

**Table 1: Grain starch and protein percentage in 15 genotypes located at Coimbatore (AVHT-I, Zone-I)**

| | | Coimbatore | | Coimbatore | |
|---|---|---|---|---|---|
| S No. | Entry | Protein% | Rank | Starch % | Rank |
| 1 | SPV 1774 | 8.28 | 15 | 66.00 | 2 |
| 2 | SPV 1775 | 8.35 | 14 | 64.40 | 13 |
| 3 | SPH 1596 | 9.36 | 4 | 63.10 | 15 |
| 4 | SPV 1733 | 9.52 | 1 | 65.40 | 6 |
| 5 | CSH 16 | 9.39 | 3 | 64.60 | 12 |
| 6 | SPV 1616 | 8.78 | 10 | 65.60 | 4 |
| 7 | CSH 23 | 9.20 | 7 | 66.20 | 1 |
| 8 | SPV 462 | 8.51 | 13 | 64.90 | 9 |
| 9 | CSV 15 | 9.01 | 8 | 63.40 | 14 |
| 10 | CSV 17 | 9.21 | 6 | 65.40 | 8 |
| 11 | Local Ch | 8.53 | 12 | 65.40 | 7 |
| 12 | SPV 1600 | 9.23 | 5 | 64.60 | 11 |
| 13 | SPV 1746 | 8.70 | 11 | 64.80 | 10 |
| 14 | SPV 1742 | 8.92 | 9 | 65.60 | 5 |
| 15 | CSH 18 | 9.40 | 2 | 65.90 | 3 |
| | LOC. MEAN | 8.96 | | 65.00 | |
| | C.D. (5%) | 0.60 | | 2.00 | |
| | C.D. (1%) | 0.81 | | 2.70 | |
| | C.V. (%) | 4.02 | | 1.82 | |
| | F (Probability) | 0.00 | | 0.00 | |

**Table 2: Grain starch and protein percentage in 15 genotypes located at Akola and Dharwad (AVHT-II, Zone –II)**

| Sl. | | Akola | | Dharwad | | Average | | Akola | | Dharwad | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Entry | Protein % | Rank | Protein % | Rank | Protein % | Rank | Starch % | Rank | Starch % | Rank | Starch % | Rank |
| 1 | SPV 1786 | 8.33 | 11 | 8.68 | 10 | 8.51 | 11 | 66.70 | 1 | 64.30 | 12 | 65.50 | 1 |
| 2 | SPH 1567 | 8.14 | 14 | 8.72 | 8 | 8.43 | 13 | 65.70 | 4 | 64.10 | 13 | 64.90 | 9 |
| 3 | SPV 1774 | 8.14 | 15 | 8.57 | 11 | 8.36 | 15 | 66.20 | 2 | 64.70 | 6 | 65.50 | 2 |
| 4 | CSH 16 | 8.78 | 3 | 8.91 | 2 | 8.84 | 3 | 63.10 | 15 | 64.00 | 14 | 63.50 | 15 |
| 5 | SPV 1616 | 8.64 | 5 | 8.71 | 9 | 8.68 | 7 | 64.80 | 10 | 65.50 | 2 | 65.10 | 7 |
| 6 | CSH 23 | 8.90 | 2 | 9.02 | 1 | 8.96 | 1 | 65.60 | 5 | 64.60 | 7 | 65.10 | 8 |
| 7 | SPV 462 | 8.46 | 9 | 8.53 | 13 | 8.50 | 12 | 64.90 | 9 | 65.50 | 1 | 65.20 | 6 |
| 8 | CSV 15 | 8.53 | 7 | 8.56 | 12 | 8.55 | 9 | 63.40 | 14 | 64.60 | 9 | 64.00 | 13 |
| 9 | CSV 17 | 8.31 | 12 | 8.75 | 7 | 8.53 | 10 | 63.60 | 12 | 63.70 | 15 | 63.60 | 14 |
| 10 | Local ch | 8.26 | 13 | 8.51 | 14 | 8.38 | 14 | 65.10 | 8 | 64.40 | 11 | 64.70 | 10 |
| 11 | SPV 1600 | 8.64 | 6 | 8.91 | 2 | 8.77 | 4 | 65.80 | 3 | 65.10 | 5 | 65.50 | 3 |
| 12 | SPV 1746 | 8.40 | 10 | 8.84 | 4 | 8.62 | 8 | 63.60 | 13 | 64.60 | 8 | 64.10 | 11 |
| 13 | SPV 1742 | 8.50 | 8 | 8.87 | 3 | 8.68 | 6 | 65.40 | 7 | 65.20 | 4 | 65.30 | 5 |
| 14 | CSH 16 | 8.97 | 1 | 8.83 | 5 | 8.90 | 2 | 63.60 | 11 | 64.40 | 10 | 64.00 | 12 |
| 15 | CSH 18 | 8.71 | 4 | 8.76 | 6 | 8.74 | 5 | 65.50 | 6 | 65.20 | 3 | 65.40 | 4 |
| | LOC. MEAN | 8.51 | | 8.75 | | 8.63 | | 64.90 | | 64.70 | | 64.80 | |
| | C.D. (5%) | 0.47 | | 0.49 | | 0.30 | | 2.00 | | 1.30 | | 1.70 | |
| | C.D. (1%) | 0.63 | | 0.66 | | 0.42 | | 2.70 | | 1.80 | | 2.30 | |
| | C.V. (%) | 3.29 | | 3.36 | | 1.64 | | 1.84 | | 1.25 | | 1.21 | |
| | F (Probability) | 0.00 | | 0.00 | | 0.01 | | 0.00 | | 0.00 | | 0.18 | |

**Table 3: Grain starch and protein percentage in 15 genotypes located at Udaipur (AVHT-III - Zone – III)**

| | | Udaipur | | Udaipur | |
|---|---|---|---|---|---|
| S No | Entry | Protein % | Rank | Starch % | Rank |
| 1 | SPV 1774 | 8.80 | 15 | | 6 |
| 2 | SPV 1775 | 8.28 | 19 | 63.97 | 15 |
| 3 | SPV 1742 | 8.87 | 12 | 65.42 | 9 |
| 4 | SPV 1786 | 8.81 | 14 | 64.44 | 12 |
| 5 | CSH 16 | 9.16 | 8 | 64.00 | 14 |
| 6 | SPV 1733 | 9.00 | 10 | 64.67 | 11 |
| 7 | SPV 1730 | 9.52 | 2 | 65.90 | 7 |
| 8 | CSH 16 | 9.13 | 9 | 65.33 | 10 |
| 9 | SPV 1616 | 9.20 | 7 | 66.57 | 3 |
| 10 | SPH 1342 | 9.34 | 5 | 66.07 | 5 |
| 11 | SPV 462 | 8.60 | 16 | 66.84 | 1 |
| 12 | CSV 15 | 8.49 | 18 | 64.28 | 13 |
| 13 | CSV 17 | 9.22 | 6 | 63.65 | 17 |
| 14 | L Check | 8.55 | 17 | 63.76 | 16 |
| 15 | SPH 1587 | 8.91 | 11 | 63.38 | 18 |
| 16 | SPH 1596 | 9.39 | 4 | 62.17 | 19 |
| 17 | SPV 1600 | 9.69 | 1 | 66.31 | 4 |
| 18 | SPV 1746 | 8.84 | 13 | 66.83 | 2 |
| 19 | CSH 18 | 9.40 | 3 | 65.63 | 8 |
| | L. MEAN | 9.01 | | 65.01 | |
| | C.D. (5%) | 0.60 | | 2.18 | |
| | C.D. (1%) | 0.80 | | 2.93 | |
| | C.V. (%) | 4.00 | | 2.03 | |

**Table-4 Range of percent starch and Protein in different zones**

| S.No. | | Starch % | Protein % |
|---|---|---|---|
| 1 | Zone I | 63.10 - 66.20 | 8.28 - 9.52 |
| 2 | Zone II | 63.50 - 65.50 | 8.36 - 8.96 |
| 3 | Zone III | 62.17 - 66.84 | 8.28 - 9.69 |

## Table-5: Summary Results: Genotypic Differences in Grain Protein and Starch at 5 locations during Kharif 2008

| | | Zone I | | Zone II | | | Zone III | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Coimbatore | | Akola & Dharwad | | | Udaipur | | |
| Sl. No. | *Entry* | *Protein %* | *Starch %* | *Entry* | *Protein %* | *Starch %* | *Entry* | *Protein %* | *Starch %* |
| 1 | SPV 1774 | 8.28 | 66.00 | SPV 1786 | 8.51 | 65.50 | SPV 1774 | 8.80 | 66.03 |
| 2 | SPV 1775 | 8.35 | 64.40 | SPH 1567 | 8.43 | 64.90 | SPV 1775 | 8.28 | 63.97 |
| 3 | SPH 1596 | 9.36 | 63.10 | SPV 1774 | 8.36 | 65.50 | SPV 1742 | 8.87 | 65.42 |
| 4 | SPV 1733 | 9.52 | 65.40 | CSH 16 | 8.84 | 63.50 | SPV 1786 | 8.81 | 64.44 |
| 5 | CSH 16 | 9.39 | 64.60 | SPV 1616 | 8.68 | 65.10 | CSH 16 | 9.16 | 64.00 |
| 6 | SPV 1616 | 8.78 | 65.60 | CSH 23 | 8.96 | 65.10 | SPV 1733 | 9.00 | 64.67 |
| 7 | CSH 23 | 9.20 | 66.20 | SPV 462 | 8.50 | 65.20 | SPV 1730 | 9.52 | 65.90 |
| 8 | SPV 462 | 8.51 | 64.90 | CSV 15 | 8.55 | 64.00 | CSH 16 | 9.13 | 65.33 |
| 9 | CSV 15 | 9.01 | 63.40 | CSV 17 | 8.53 | 63.60 | SPV 1616 | 9.20 | 66.57 |
| 10 | CSV 17 | 9.21 | 65.40 | Local ch | 8.38 | 64.70 | SPH 1342 | 9.34 | 66.07 |
| 11 | Local Ch | 8.53 | 65.40 | SPV 1600 | 8.77 | 65.50 | SPV 462 | 8.60 | 66.84 |
| 12 | SPV 1600 | 9.23 | 64.60 | SPV 1746 | 8.62 | 64.10 | CSV 15 | 8.49 | 64.28 |
| 13 | SPV 1746 | 8.70 | 64.80 | SPV 1742 | 8.68 | 65.30 | CSV 17 | 9.22 | 63.65 |
| 14 | SPV 1742 | 8.92 | 65.60 | CSH 16 | 8.90 | 64.00 | Local Check | 8.55 | 63.76 |
| 15 | CSH 18 | 9.40 | 65.90 | CSH 18 | 8.74 | 65.40 | SPH 1587 | 8.91 | 63.38 |
| | | | | | | | SPH 1596 | 9.39 | 62.17 |
| | | | | | | | SPV 1600 | 9.69 | 66.31 |
| | | | | | | | SPV 1746 | 8.84 | 66.83 |
| | | | | | | | CSH 18 | 9.40 | 65.63 |
| | L. MEAN | 8.96 | 65.00 | | 8.63 | 64.80 | | 9.01 | 65.01 |
| | C.D. (5%) | 0.60 | 2.00 | | 0.30 | 1.70 | | 0.60 | 2.18 |
| | C.D. (1%) | 0.81 | 2.70 | | 0.42 | 2.30 | | 0.80 | 2.93 |
| | C.V. (%) | 4.02 | 1.82 | | 1.64 | 1.21 | | 4.00 | 2.03 |
| | F (Probability) | 0.00 | 0.00 | | 0.01 | 0.18 | | 0.00 | 0.00 |

# 3. Proximate analysis of sorghum grain at Akola

Two sets of materials were analyzed to identify superior one from the point of nutrition. Many of the materials tested scored well for the nutritional compositing.

### A) Nutritional qualities of grain from elite genotypes, kharif 2007

| Sl. No. | Nutritional qualities | Assessment |
|---|---|---|
| 1 | Protein % | Hybrid CSH 16 recorded highest (9.88%). Next SPV 462 (9.81%), CSV 15 (9.75%), CSV 17 (9.69%) and SPV 1742 (9.63%). |
| 2 | Fat % | SPV 1746 recorded highest fat content (2.95%). Next CSH 16 and SPV 1567 (2.84% each). Variety SPV 462 and CSV 17 with 2.83% ranked third followed by CSV 15 with 2.80%. |
| 3 | Starch % | SPV 1746 content highest starch (71.05%). 2nd rank - CSV 17 (70.94%), 3$^{d}$ rank – SPH 840 (70.22%) and 4$^{h}$ rank – SPH 1567 (70.11%). |
| 4 | Mineral matter | SPV 462 showed highest (2.38%). Next SPV 1746 (2.30%), CSV 15 (2.20%) and SPV 1600 (2.15%). |

**Conclusion:** In general, hybrid CSH 16 and SPH 1567 along with variety SPV 462, CSV 15, CSV 17 and SPV 1746 were observed to be maximum quality traits.

### B) Screening of kharif sorghum genotypes for nutritive values

| Sl. No. | Nutritional qualities | Assessment |
|---|---|---|
| 1 | Protein % | Spv 669 RECORDED (9.88%). Second place – AKSV 24 and AKSV 97 recorded (9.85%); AKSV 101 also recorded 9.79%, and AKSV 56.1 and AKSV 84 75%. |
| 2 | Fat % | AKSV 102 (2.90%). Second place – AKSV 24 with 2.85%; AKSV 56.1 and AKSV 88 recorded 2.85%, and PVK 801 had 2.82%. |
| 3 | Starch % | 3 Varieties showed >70% starch, AKSV 98 (70.91%) followed by AKSV 114 (70.55%), AKSV 96 (70.21%). Rest: AKSV 24 (69.93%) and AKSV 102 (69.86%). |
| 4 | Mineral matter | AKSV 84 showed highest (2.57%) followed by AKSV 88 (2.38%), SPV 669 (2.14%), AKSV 114 (2.09%) and CSV 15 (2.03%) |

**Conclusion:** In general, SPV 669, KSV 24, AKSV 97, AKSV 101, AKSV 102, AKSV 56.2, AKSV 84, AKSV 88, AKSV 98, AKSV 114, AKSV 96, CSV 15 and PVK 801 were promising genotypes for better nutritional quality.

# 4. Dough and *roti* quality of sorghum

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*1 Mahatma Phule Krishi Vidyapeeth, Rahuri, 2 NRCS, Hyderabad, 3 UAS, Dharwad*

Though sorghum grains are nutritious, the consumption of this cereal is decreasing due to the easy availability of, and easy methods of cooking of fine cereals. The other major reasons are: dying traditional food habits, requirement of special skill for preparing sorghum rotis, and non-availability of ready-made flour and suji from sorghum in the market. In India sorghum is traditionally consumed in the form of unleavened bread (*bhakri*). For many years, sorghum eating population particularly in rabi growing areas, the roti made from Maldandi (M35-1) is preferred for its taste and softness, over other genotypes. Analyses of dough, and roti quality of 15 kharif sorghum genotypes (including 7 checks and kharif hybrids and varieties) grown at Dharwad was done to compare genotypes.

**Dough quality:** Following seven different dough quality parameters were analyzed:

1. Percent water absorption capacity,
2. Soluble proteins
3. Crude protein (%)
4. Free aminoacids
5. Total soluble sugars
6. Starch%, and
7. Hectoliter weight of the grain

Seven advanced genotypes which include one hybrid and six varieties were compared with seven popular commercial cultivars used as checks (CSH16, CSH23, SPV462, Dharwad check, CSV 15, CSV17 & CSH18). The Dharwad check genotype showed excellent dough quality. The summary of the results is presented in **Table-1** (next page).

***Roti* quality** (kharif 07): A taste panel at Dharwad consisting of 10 members trained for tasting and scoring rotis was used for the assessment of roti quality. The evaluation was performed on a hedonic scale 1 to 9 ranging from Like Extremely (Excellent) 1 to Dislike Extremely (9). The results of the roti quality of kharif 07 genotypes were presented below. The roti quality was evaluated with following nine different rot quality parameters:

1. Colour and appearance
2. Flavour/aroma
3. Texture
4. Taste
5. Overall acceptability
6. Water required to make dough
7. Kneading quality
8. Spreading quality and
9. Storage quality at 4, 8 and 24 hrs duration.

The overall roti quality of the Dharwad check genotype was superior to test genotypes and remaining check genotypes. The summary of the results presented in **Table-2**

## Table-1 Summary results of dough quality

| S.No | Dough quality Parameters | Assessment of Genotypes |
|---|---|---|
| 1 | Water absorption capacity (%) | Range: 118.56 (SPH 1567) - 186.6 ( Dharwad check)<br>Superior genotypes : SPV 1616 (177.44), SPV 1746 (171.83), SPV 1742 (172.67)> all checks except Dharwad check |
| 2 | Soluble Proteins (%) | Range: 0.92 (CSV 15) – 1.31( SPV 1746)<br>Superior genotypes : SPV 1742 (1.26)< SPV 1746 (1.31)> Dharwad check (1.29) |
| 3 | Crude Protein (%) | Range: 7.75 (CSH 23) – 10.25( Dharwad check)<br>Superior genotypes : SPV 1616 (9.13), SPV 1600 (9.27), SPV 1746 (9.83), SPV 1742 (9.38)> 9.0 |
| 4 | Free amino acids (mg/100g) | Range: 50.29 (CSH 16) – 92.07 ( SPV 1616)<br>Superior genotypes : SPV 1616 (92.07)> Dharwad check (87.92)> SPV 1774 (86.86), SPV 1600 (86.29), SPV 1746 (87.50) > all other checks |
| 5 | Starch (%) | Range: 61.8 (SPV 462) – 70.62 ( CSH 18)<br>Superior genotypes : SPV 1742 (70.58) & SPV 1746 (70.49)> Dharwad check (69.75) |
| 6 | Total soluble sugars (%) | Range: 1.59 (CSH 16) – 2.19( Dharwad check)<br>Superior genotypes : SPV 1746 (2.12), SPV 1742 (2.11), SPV 1616 (2.09), SPV 1600 (2.01) > all other checks |
| 7 | Hecto Litre weight of the Grain (Kg/hl) | Range: 78.11 (CSH 23) – 81.70 ( Dharwad check)<br>Superior genotypes : SPV 1746 (81.62), SPV 1742 (81.38), SPV 1774 (81.03) > checks CSH 16 &CSH 18 |

## Table-2 Summary results of Roti quality

| S.No | Roti quality Parameters | Assessment of Genotypes |
|---|---|---|
| 1 | Water required for dough (ml/100g flour) | Range: 87.22 (SPV1786) - 128.89 ( SPV 1746)<br>Superior genotypes : Dharwad check (125.00)> SPV 1616 (120.56), SPV 1600 (108.33), SPV 1742 (104.44), CSH 16 (107.78) |
| 2 | Colour and appearance | Range: 1.67(Dharwad check ) – 5.03( CSV 17)<br>Superior genotypes : SPV 1616 (2.33), SPV 1600 (2.23), SPV 1746 (2.67), SPV 1742 (2.27) |
| 3 | Flavour/Aroma | Range: 2.00 (Dharwad check) – 4.63( CSV 17)<br>Superior genotypes : SPV 1616 (2.23), SPV 1600 (2.87), SPV 1746 (2.67), SPV 1742 (2.50) |
| 4 | Texture | Range: 2.03 (Dharwad check) – 4.77 ( CSV 17)<br>Superior genotypes : SPV 1616 (2.50), SPV 1600 (2.43), SPV 1746 (2.80), SPV 1742 (2.67) |
| 5 | Taste | Range: 2.17 (Dharwad check) – 4.67( CSH 17)<br>Superior genotypes : SPV 1616 (2.40) SPV 1600 ( 2.57), SPV 1746 (2.70), SPV 1742 (2.90) |
| 6 | Overall acceptability | Range: 1.67 (Dharwad check) – 4.67(CSH 23)<br>Superior genotypes : SPV 1616 (2.30), SPV 1742 (2.47), SPV 1600 (2.47), SPV 1746 (2.67) |
| 7 | Kneading quality of dough | Range: 1.00 (Dharwad check) – 2.22 ( SPV 1786)<br>Superior genotypes : SPV 1567(1.00), SPV 1616 (1.00), SPV 1600 (1.00) , SPV 1742 (1.00), CSH 16 (1.00), CSH 18 (1.00) |
| 8 | Spreading quality of roti | Range: 1.00 (Dharwad check and SPV 1600 ) – 2.22 ( SPV 1786)<br>Superior genotypes : CSH 16 (1.11), SPV 1746 (1.22), SPV 1616 (1.22), SPV 1746 (1.22) |
| 9 | Storage study of roti (4 hrs) & 8 hrs | Range: 4 hrs 1.64 (SPV 462) – 3.45 ( SPV 1786);<br>8 hrs 2.39 (SPV 462)- 4.14 (SPV 1786)<br>Superior genotypes : Dharwad check (1.65, 2.47), SPV 1742 (1.67, 2.47), CSH 16 (1.77, 2.45) , CSH 18 (1.66, 2.66), |
| 10 | Storage study of roti (24 hrs) | Range: 4.65 (Dharwad check) – 6.75 ( SPV 1774)<br>Superior genotypes : SPV 1567 (4.89) and SPV 1616 (4.94) |

# 5. Mycotoxins contamination in sorghum

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The major disease in sorghum grown during kharif is grain mould. When grains are caught under high humidity due to rains during grain filling, they are infected by several, largely saprophytic fungi such as *Fusarium* and *Aspergillus*, *Curvularia* and *Phoma*. During kharif, 2007, a total of 258 grain sorghum samples from four kharif growing locations (Coimbatore, Akola, Udaipur and Dharwad) were collected and analyzed for aflatoxins and fumonisins was undertaken through indirect competitive ELISA. Samples from AVHT sorghum grain from all zones, and those of dual purpose types in zone I and III were used. In 24% of the total samples (61 Nos.) aflatoxin $B_1$ contamination was above safety limit (10 µg/kg) and in 5.8 % of the total samples (15 Nos.) fumonisin $B_1$ contamination was above safety limit (200 µg/kg).

**Zone I:** The data on aflatoxin and fumonisin contamination in grain samples from location of zone I (Coimbatore) were presented in Table 1. Aflatoxin contamination was relatively more compared to fumonisin contamination. The percent contamination of aflatoxins and fumonisins was higher in high yielding kharif genotypes (AVHT) grain samples collected from Coimbatore as compared to dual purpose sorghum grain samples. The range of aflatoxins was 12.79 (SPV 1775) - 263.98 (SPH 1596) µg/kg and fumonisins was 36.3 (SPV 1774) to 1397.94 (SPV 1742) µg/kg. Thus all the AVHT grain sorghum samples (earlier to mature than dual purpose types) contain aflatoxin above safety limit (10 µg/kg). None of the genotypes are resistant for aflatoxin contamination. Either the grain may be severely infested with *Aspergillus* or it was improperly stored before sending for analysis. The genotypes SPV 1774, SPV 1775, SPH 1596, SPV 1733 and CSH 16 recorded fumonisin within the safe limit (200µg/kg). The dual purpose sorghum recorded aflatoxins and fumonisins at a very low level (Table-4)

**Zone II:** The data on aflatoxin and fumonisin contamination in grain samples from locations of zone II viz. Akola and Dharwad were presented in Table 2. Contamination was low in zone II. At Akola location the aflatoxin ranged from 8.26 (SPV 1774) to 139.11(Local check) µg/kg. Only one genotype SPV 1774 was resistant for aflatoxin contamination At Dharwad location the range of aflatoxin was 6.44 (CSH 23) to 97.68 (SPV 1746). Four genotypes SPV 1786, CSH 23, SPV 462 and Local check were resistant for aflatoxin contamination. At both Akola and Dharwad locations the fumonisins were recorded but all the samples contain fumonisin $B_1$ with in the safety limit (200µg/kg). The range of fumonisins at Akola was 5.20 (SPV 462) to 40.11 (CSV 17) µg/kg and at Dharwad location the range was 5.58 (Local check) to 97.68 (SPV 1746). None of the samples were toxic for fumonisins.

**Zone III:** The grain sorghum samples collected from location Udaipur recorded lowest aflatoxins as compared to all other locations. The range of AFB1 was 0.57 (SPV 462) to 15.16 (SPV 1730). Three genotypes SPV 1733, SPV 1730 and SPV 1616 recorded aflatoxins above safety limit (10µg/kg). Remaining genotypes were resistant for aflatoxin. All the genotypes recorded fumonisins with a range of 9.11 -62.38µg/kg. All the genotypes were resistant for fumonisin contamination. All the genotypes of dual-purpose sorghum from Udaipur location showed very low levels of aflatoxin and fumonisins. None of the genotypes recorded aflatoxins and fumonisins above their respective safety limits.

**Conclusion:** All the genotypes were positive for the presence of aflatoxins and fumonisins. Locations Coimbatore, Akola and Dharwad were more prone to aflatoxin contamination and at Coimbatore location fumonisin contamination was the highest. The toxin contamination was mostly attributed to the grain storage conditions. Post harvesting handling is very critical, especially with the kharif produce. However resistance from the genotype is also visible in this study.

**Table-1 Aflatoxin and Fumonisin Contamination in sorghum at Coimbatore (Zone I) Grain sorghum - AVHT Kharif 2007**

| S.No. | Entry | Aflatoxin $B_1$ (µg/kg) | Fumonisins $B_1$ (µg/kg) |
|---|---|---|---|
| 1 | SPV 1774 | 85.32 | 36.3 |
| 2 | SPV 1775 | 12.79 | 96.64 |
| 3 | SPH 1596 | 263.98 | 52.66 |
| 4 | SPV 1733 | 40.84 | 149.66 |
| 5 | CSH 16 | 103.89 | 191.34 |
| 6 | SPV 1616 | 45.6 | 364.49 |
| 7 | CSH 23 | 92.47 | 739.08 |
| 8 | SPV 462 | 55.48 | 294.13 |
| 9 | CSV 15 | 38.79 | 310.03 |
| 10 | CSV 17 | 32.55 | 260.18 |
| 11 | Local Check | 71.73 | 751.23 |
| 12 | SPV 1600 | 119.58 | 490.57 |
| 13 | SPV 1746 | 44.62 | 356.64 |
| 14 | SPV 1742 | 82.73 | 1397.94 |
| 15 | CSH 18 | 87.46 | 364.49 |
| | Mean | 78.52 | 390.36 |
| | S E | 15.32 | 90.91 |
| | S D | 59.34 | 352.08 |
| | C V% | 75.58 | 90.19 |
| | Range | 251.19 | 1361.64 |
| | Minimum | 12.79 | 36.30 |
| | Maximum | 263.98 | 1397.94 |
| | CD (5.0%) | 32.86 | 194.98 |

**Table-2 Aflatoxin and Fumonisin Contamination in sorghum at Akola & Dharwad (Zone II) Grain sorghum - AVHT Kharif 2007**

| | | Akola | | Dharwad | |
|---|---|---|---|---|---|
| S. No | Entry | Aflatoxin $B_1$ (µg/kg) | Fumonisin $B_1$ (µg/kg) | Aflatoxin $B_1$ (µg/kg) | Fumonisin $B_1$ (µg/kg) |
| 1 | SPV 1786 | 20.03 | 20.46 | 8.08 | 29.77 |
| 2 | SPH 1567 | 13.54 | 5.26 | 17.79 | 28.83 |
| 3 | SPV 1774 | 8.26 | 6.11 | 10.68 | 41.53 |
| 4 | CSH 16 | 22.25 | 15 | 21.2 | 19.09 |
| 5 | SPV 1616 | 15.73 | 22.81 | 11.03 | 18.67 |
| 6 | CSH 23 | 11.02 | 10.09 | 6.44 | 50.92 |
| 7 | SPV 462 | 101.67 | 5.2 | 8.7 | 18.48 |
| 8 | CSV 15 | 15.73 | 8.12 | 16.58 | 12.89 |
| 9 | CSV 17 | 91.61 | 40.11 | 14.65 | 35.45 |
| 10 | Local check | 139.11 | 13.97 | 7.4 | 5.58 |
| 11 | SPV 1600 | 27.18 | 39.35 | 12.9 | 15.14 |
| 12 | SPV 1746 | 55.63 | 29.24 | 12.49 | 97.68 |
| 13 | SPV 1742 | 38.25 | 20.34 | 16.79 | 27.91 |
| 14 | CSH 16 | 105.7 | 21.06 | 17.71 | 44.29 |
| 15 | CSH 18 | 34.42 | 26.1 | 13.61 | 12.48 |
| | Mean | 46.68 | 18.88 | 13.07 | 30.58 |
| | S E | 10.87 | 2.95 | 1.13 | 5.85 |
| | S D | 42.11 | 11.41 | 4.38 | 22.65 |
| | C V% | 90.21 | 60.42 | 33.55 | 74.07 |
| | Range | 130.85 | 34.91 | 14.76 | 92.1 |
| | Minimum | 8.26 | 5.20 | 6.44 | 5.58 |
| | Maximum | 139.11 | 40.11 | 21.2 | 97.68 |
| | CD (5.0%) | 23.32 | 6.32 | 2.428 | 12.54 |

**Table-3 Aflatoxin and Fumonisin Contamination in sorghum at Udaipur (Zone III)**
**Grain sorghum - AVHT Kharif 2007**

| | | Udaipur (Zone III) | |
|---|---|---|---|
| S. No | Entry | Aflatoxin $B_1$ µg/kg) | Fumonisin $B_1$(µg/kg) |
| 1 | SPV 1774 | 5.92 | 16.99 |
| 2 | SPV 1775 | 3.49 | 15.09 |
| 3 | SPV 1742 | 4.48 | 9.30 |
| 4 | SPV 1786 | 3.04 | 9.30 |
| 5 | CSH 16 | 5.33 | 21.23 |
| 6 | SPV 1733 | 12.02 | 9.11 |
| 7 | SPV 1730 | 15.16 | 16.87 |
| 8 | CSH 16 | 8.99 | 38.40 |
| 9 | SPV 1616 | 10.48 | 26.41 |
| 10 | SPH 1342 | 9.1 | 46.79 |
| 11 | SPV 462 | 0.57 | 11.86 |
| 12 | CSV 15 | 3.94 | 11.55 |
| 13 | CSV 17 | 5.82 | 42.42 |
| 14 | Local check | 5.89 | 62.38 |
| 15 | SPH 1587 | 3.99 | 31.02 |
| 16 | SPH 1596 | 6.29 | 37.72 |
| 17 | SPV 1600 | 5.27 | 20.06 |
| 18 | SPV 1746 | 6.42 | 58.45 |
| 19 | CSH 18 | 7.14 | 12.63 |
| | Mean | 6.49 | 26.19 |
| | S E | 0.79 | 3.89 |
| | S D | 3.43 | 16.94 |
| | C V% | 52.86 | 64.69 |
| | Range | 14.59 | 53.27 |
| | Minimum | 0.57 | 9.11 |
| | Maximum | 15.16 | 62.38 |
| | CD(5.0%) | 1.65 | 8.17 |

**Table-4 Aflatoxin and Fumonisin Contamination in Dual Purpose Sorghum at Coimbatore (Zone I) & Udaipur (Zone III) - AVHT Kharif 2007**

| | | Coimbatore (Zone I) | | Udaipur (Zone III) | |
|---|---|---|---|---|---|
| S. No | Entry | Aflatoxin $B_1$(µg/kg) | Fumonisin $B_1$ (µg/kg) | Aflatoxin $B_1$(µg/kg) | Fumonisin $B_1$ (µg/kg) |
| 1 | SPV 1778 | 2.48 | 6.43 | 0.26 | 0.35 |
| 2 | SPH 1467 | 1.48 | 11.59 | 2.02 | 2.64 |
| 3 | SPV 1781 | 1.43 | 8.85 | 2.24 | 2.43 |
| 4 | SPV 1754 | 1.8 | 14.22 | 2.1 | 1.28 |
| 5 | SPV 1753 | 1.99 | 11 | 1.08 | 1.02 |
| 6 | SPV 1616 | 2.38 | 1.95 | 1.87 | 0.83 |
| 7 | SPV 1750 | 1.89 | 22.06 | 1.11 | 14.65 |
| 8 | SPV 1779 | 2.02 | 4.18 | 0.51 | 2.06 |
| 9 | CSV 15 | 1.26 | 16.62 | 3.9 | 0.88 |
| 10 | SPV 1782 | 0.88 | 17.43 | 1.82 | 0.48 |
| 11 | CSH 18 | 2.44 | 13.71 | 1 | 3.01 |
| | Mean | 1.82 | 11.64 | 1.63 | 2.69 |
| | S E | 0.16 | 1.82 | 0.30 | 1.23 |
| | S D | 0.52 | 6.02 | 1.00 | 4.07 |
| | C V% | 28.36 | 51.74 | 61.70 | 151.02 |
| | Range | 1.60 | 20.11 | 3.64 | 14.30 |
| | Minimum | 0.88 | 1.95 | 0.26 | 0.35 |
| | Maximum | 2.48 | 22.06 | 3.9 | 14.65 |
| | CD(5.0%) | 0.35 | 4.05 | 0.67 | 2.73 |

# 6. Analysis of stover quality in grain and dual purpose sorghum

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The sorghum stover is an important crop residue in dryland agriculture that has greater economic significance in the farming system. Besides the quantum of the stover produced, the quality of stover determines the potential of the genotype in contributing to the efficiency of any animal husbandry system. Therefore, the quality of stover in terms of its digestibility, fibre, protein and ash content were analyzed for all the genotypes in the advanced trials of grain and dual purpose sorghum during kharif 2007. These findings are reported hereunder.

**AVHT grain sorghum: kharif 2007**

**Zone 1:** Similar to the previous year, none of the entries exceeded the checks for stover quality traits tested (Table 1). Among the hybrids, CSH 18 topped for digestibility (ivomd of 52.1%) and CSH 23 was superior for crude protein content (5.49%). The hybrid SPH 1596 was on par with CSH 18 for digestibility (ivomd of 48.7%). In terms of higher ash content, NDF and ADF, CSH 16 was superior. The entry SPH 1596 was on par with the check CSH 16 for ash content (11.96%) and ADF (44.8%). Among the varieties, SPV 1600 recorded the highest digestibility of 52.1% which was on par with that of SPV 1616 and SPV 1774. Greater protein content was in the stover of CSV 17 (5.3%), followed by SPV 1774 (5.13%) and SPV 1733 (5.02%) which were all on par. CSV 17 also topped for ash content while SPV 1746 had similar NDF and ADF content as that of CSV 17, CSV 15 and SPV 1733. In general, varieties had marginally higher digestibility and protein content compared to hybrids though they were statistically on par.

**Zone 2:** The checks were superior for most of the stover quality traits in this zone as well (Table 2). While SPH 1596 had performed well for stover quality traits in zone one, SPH 1567 was superior and or on par with the superior hybrids for all the traits measured. CSH 18, CSH 16 and CSH 23 were either at the top or were on par with the top in all cases.
The variety SPV 1600 continued to group at the top for digestibility as in zone 1 while SPV 1742 was on par with the top for rest of the traits. SPV 1774 with 56.5% ivomd exhibited highest digestibility, which also had good ADF and NDF content. SPV 1786 recorded the highest stover protein content in this zone.

**Zone 3:** The check hybrids and varieties occupied the top slots for all the stover quality traits, but the new varietal entries grouped ahead of checks for digestibility (Table 3). SPH 1587 was a potential hybrid that was on par with the top checks/hybrids for all the quality traits whereas SPH 1596 was good for all traits except protein content.
SPV 1742, SPV 1730 and SPV 1746 had superior stover quality characteristics among varieties whereas SPV 1774 topped for digestibility (ivomd of 56.5%) followed by SPV 1600.

**AVHT dual purpose sorghum: kharif 2007:** The stover digestibility of entries SPV 1782 (ivomd 53.2%), SPV 1753 (52.8%), SPV 1750 (52.4%), SPV 1779 (51.8%) and SPV 1754 (51.7%) were higher than the rest, though were on par with the check CSV 15 (50.6%) (Table 4). The check CSV 15 yielded highest ash (10.58%) and protein (5.71%) content. The hybrid entry SPH 1467 had the highest ADF (43.1%) followed by SPV 1778 (42.5%). SPH 1467 also had high ash content (10.42%), NDF (67.6%) and protein content (5.05%), on par with CSV 15. However, its digestibility was the lowest of all, at 49.7%. The entries SPV 1778 and SPV 1781 also recorded lower digestibility and protein content. Notable was SPV 1782 for the highest digestibility (53.2%) coupled with lowest protein content (4.43%).

**Table 1 Stover quality of grain sorghum genotypes in Advanced Varietal & Hybrid Trial- Zone 1 (Kharif 2007)**

| Sl. No. | Entry | Ash% | | | | | | NDF% | | | | | | ADF% | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Palem | R | Coimbatore | R | Average | R | Palem | R | Coimbatore | R | Average | R | Palem | R | Coimbatore | R | Average | R |
| 1 | SPV 1774 | 8.50 | 12 | 11.88 | 10 | 10.19 | 11 | 65.5 | 11 | 68.2 | 8 | 66.9 | 12 | 41.2 | 14 | 43.2 | 11 | 42.2 | 13 |
| 2 | SPV 1775 | 8.47 | 14 | 11.46 | 13 | 9.97 | 12 | 64.7 | 14 | 67.4 | 14 | 66.0 | 14 | 41.2 | 13 | 43.0 | 14 | 42.1 | 14 |
| 3 | SPH 1596 | 10.79 | 5 | 13.14 | 3 | 11.96 | 2 | 67.1 | 6 | 68.8 | 7 | 67.9 | 6 | 45.0 | 5 | 44.7 | 2 | 44.8 | 4 |
| 4 | SPV 1733 | 9.37 | 9 | 13.25 | 2 | 11.31 | 7 | 66.1 | 8 | 67.8 | 12 | 66.9 | 10 | 42.3 | 9 | 43.7 | 6 | 43.0 | 10 |
| 5 | CSH 16 | 12.71 | 1 | 13.35 | 1 | 13.03 | 1 | 67.6 | 5 | 71.0 | 1 | 69.3 | 1 | 46.1 | 2 | 47.4 | 1 | 46.8 | 1 |
| 6 | SPV 1616 | 8.92 | 10 | 12.12 | 8 | 10.52 | 10 | 65.7 | 10 | 68.2 | 9 | 66.9 | 11 | 41.5 | 12 | 43.1 | 12 | 42.3 | 12 |
| 7 | CSH 23 | 11.36 | 3 | 12.25 | 6 | 11.81 | 4 | 69.2 | 2 | 68.9 | 4 | 69.1 | 2 | 46.0 | 3 | 44.0 | 5 | 45.0 | 2 |
| 8 | SPV 462 | 9.55 | 8 | 12.15 | 7 | 10.85 | 9 | 69.6 | 1 | 67.8 | 13 | 68.7 | 3 | 46.1 | 1 | 43.5 | 9 | 44.8 | 3 |
| 9 | CSV 15 | 10.30 | 7 | 11.87 | 11 | 11.09 | 8 | 64.9 | 13 | 67.8 | 11 | 66.3 | 13 | 41.6 | 11 | 43.6 | 8 | 42.6 | 11 |
| 10 | CSV 17 | 11.71 | 2 | 12.04 | 9 | 11.87 | 3 | 68.2 | 3 | 68.8 | 6 | 68.5 | 4 | 45.7 | 4 | 43.0 | 13 | 44.4 | 5 |
| 11 | Local Check | 10.44 | 6 | 12.96 | 4 | 11.70 | 6 | 66.1 | 7 | 68.0 | 10 | 67.1 | 8 | 43.3 | 7 | 44.2 | 4 | 43.8 | 7 |
| 12 | SPV 1600 | 8.77 | 11 | 10.91 | 15 | 9.84 | 14 | 63.6 | 15 | 67.3 | 15 | 65.5 | 15 | 40.1 | 15 | 42.1 | 15 | 41.1 | 15 |
| 13 | SPV 1746 | 7.67 | 15 | 11.79 | 12 | 9.73 | 15 | 65.8 | 9 | 69.7 | 2 | 67.7 | 7 | 42.0 | 10 | 44.6 | 3 | 43.3 | 8 |
| 14 | SPV 1742 | 11.17 | 4 | 12.30 | 5 | 11.73 | 5 | 65.0 | 12 | 68.9 | 5 | 67.0 | 9 | 44.4 | 6 | 43.5 | 10 | 43.9 | 6 |
| 15 | CSH 18 | 8.48 | 13 | 11.23 | 14 | 9.86 | 13 | 67.6 | 4 | 69.2 | 3 | 68.4 | 5 | 42.4 | 8 | 43.6 | 7 | 43.0 | 9 |
| LOC. MEAN | | 9.88 | | 12.18 | | 11.03 | | 66.4 | | 68.5 | | 67.5 | | 43.3 | | 43.8 | | 43.5 | |
| C.D. (5%) | | 1.54 | | 1.56 | | 1.77 | | 3.6 | | 2.5 | | 2.4 | | 3.9 | | 2.3 | | 2.7 | |
| C.D. (1%) | | 2.08 | | 2.10 | | 2.46 | | 4.9 | | 3.3 | | 3.4 | | 5.2 | | 3.1 | | 3.8 | |
| C.V. (%) | | 9.34 | | 7.65 | | 7.50 | | 3.25 | | 2.16 | | 1.67 | | 5.34 | | 3.15 | | 2.92 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.03 | | 0.00 | | 0.00 | | 0.10 | | 0.00 | | 0.00 | | 0.04 | |

NDF- Neuter detergent fibre; ADF- Acid detergent fibre; R-Rank

**Table 1 Continued...)**

| Sl. No. | Entry | ivomd% | | | | | | CP% | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Palem | | Coimbatore | | Average | | Palem | | Coimbatore | | Average | |
| | | | R | | R | | R | | R | | R | | R |
| 1 | SPV 1774 | 52.9 | 1 | 49.0 | 9 | 51.0 | 3 | 4.25 | 6 | 6.02 | 2 | 5.13 | 4 |
| 2 | SPV 1775 | 52.1 | 5 | 48.9 | 10 | 50.5 | 5 | 3.78 | 12 | 5.92 | 4 | 4.85 | 10 |
| 3 | SPH 1596 | 49.3 | 10 | 48.1 | 12 | 48.7 | 11 | 4.19 | 8 | 4.96 | 12 | 4.58 | 12 |
| 4 | SPV 1733 | 51.2 | 6 | 49.4 | 5 | 50.3 | 6 | 4.22 | 7 | 5.82 | 5 | 5.02 | 5 |
| 5 | CSH 16 | 48.5 | 14 | 44.4 | 15 | 46.4 | 15 | 5.24 | 1 | 4.70 | 14 | 4.97 | 6 |
| 6 | SPV 1616 | 52.5 | 3 | 50.7 | 3 | 51.6 | 2 | 4.13 | 10 | 5.64 | 7 | 4.89 | 9 |
| 7 | CSH 23 | 49.0 | 12 | 47.9 | 13 | 48.4 | 13 | 4.65 | 3 | 6.33 | 1 | 5.49 | 1 |
| 8 | SPV 462 | 48.7 | 13 | 50.7 | 2 | 49.7 | 9 | 3.68 | 13 | 5.35 | 11 | 4.51 | 13 |
| 9 | CSV 15 | 52.2 | 4 | 49.2 | 7 | 50.7 | 4 | 4.02 | 11 | 5.78 | 6 | 4.90 | 7 |
| 10 | CSV 17 | 48.1 | 15 | 49.1 | 8 | 48.6 | 12 | 4.59 | 4 | 6.01 | 3 | 5.30 | 2 |
| 11 | Local Check | 51.0 | 7 | 49.3 | 6 | 50.1 | 8 | 4.88 | 2 | 5.41 | 9 | 5.14 | 3 |
| 12 | SPV 1600 | 52.6 | 2 | 51.6 | 1 | 52.1 | 1 | 3.24 | 14 | 5.36 | 10 | 4.30 | 14 |
| 13 | SPV 1746 | 50.3 | 9 | 48.5 | 11 | 49.4 | 10 | 3.01 | 15 | 4.94 | 13 | 3.98 | 15 |
| 14 | SPV 1742 | 49.2 | 11 | 47.4 | 14 | 48.3 | 14 | 4.18 | 9 | 5.59 | 8 | 4.89 | 8 |
| 15 | CSH 18 | 50.4 | 8 | 50.0 | 4 | 50.2 | 7 | 4.54 | 5 | 4.69 | 15 | 4.62 | 11 |
| LOC. MEAN | | 50.5 | | 48.9 | | 49.7 | | 4.17 | | 5.50 | | 4.84 | |
| C.D. (5%) | | 3.6 | | 3.1 | | 2.5 | | 1.45 | | 1.11 | | 1.16 | |
| C.D. (1%) | | 4.8 | | 4.2 | | 3.5 | | 1.95 | | 1.50 | | 1.61 | |
| C.V. (%) | | 4.21 | | 3.80 | | 2.33 | | 20.71 | | 12.08 | | 11.17 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.02 | | 0.00 | | 0.00 | | 0.47 | |

ivomd- *in vitro* organic matter digestibility(%) ; CP - Crude protein content (%) R-Rank

## Table 2 Stover quality of sorghum genotypes in Advanced Varietal & Hybrid Trial -Zone 2 (Kharif 2007)

| Sl. No. | Entry | Ash% | | | | | | | | NDF% | | | | | | | | ADF% | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PARBHANI | | AKOLA | | DHARWAD | | Average | | PARBHANI | | AKOLA | | DHARWAD | | Average | | PARBHANI | | AKOLA | | DHARWAD | | Average | |
| | | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R |
| 1 | SPV 1786 | 11.36 | 2 | 9.13 | 13 | 10.53 | 8 | 10.34 | 8 | 66.0 | 11 | 72.2 | 9 | 66.2 | 13 | 68.1 | 13 | 42.0 | 9 | 46.0 | 14 | 42.6 | 14 | 43.5 | 14 |
| 2 | SPH 1567 | 10.88 | 3 | 10.32 | 7 | 12.89 | 1 | 11.36 | 2 | 65.9 | 13 | 74.4 | 3 | 71.0 | 2 | 70.4 | 5 | 42.0 | 10 | 49.2 | 3 | 49.4 | 1 | 46.8 | 1 |
| 3 | SPV 1774 | 9.05 | 13 | 8.98 | 14 | 8.95 | 15 | 9.00 | 14 | 66.5 | 9 | 73.1 | 6 | 69.1 | 8 | 69.6 | 10 | 43.1 | 6 | 47.2 | 11 | 45.8 | 8 | 45.4 | 9 |
| 4 | CSH 16 | 10.64 | 4 | 11.03 | 1 | 12.30 | 2 | 11.32 | 3 | 69.1 | 3 | 72.1 | 10 | 70.5 | 3 | 70.5 | 4 | 43.7 | 4 | 47.8 | 7 | 47.9 | 2 | 46.5 | 4 |
| 5 | SPV 1616 | 9.06 | 12 | 10.42 | 4 | 12.22 | 3 | 10.57 | 5 | 65.2 | 14 | 71.6 | 14 | 67.7 | 12 | 68.2 | 12 | 40.7 | 13 | 47.5 | 9 | 46.3 | 7 | 44.8 | 12 |
| 6 | CSH 23 | 9.36 | 11 | 10.61 | 3 | 10.23 | 10 | 10.07 | 10 | 67.0 | 7 | 72.7 | 8 | 69.8 | 5 | 69.8 | 8 | 41.8 | 11 | 47.6 | 8 | 45.5 | 11 | 45.0 | 11 |
| 7 | SPV 462 | 9.84 | 7 | 10.31 | 8 | 11.84 | 6 | 10.66 | 4 | 68.6 | 4 | 71.9 | 11 | 69.1 | 7 | 69.9 | 7 | 44.7 | 2 | 47.2 | 10 | 46.4 | 6 | 46.1 | 5 |
| 8 | CSV 15 | 9.61 | 8 | 9.22 | 12 | 12.15 | 4 | 10.32 | 9 | 63.9 | 15 | 71.7 | 12 | 66.0 | 15 | 67.2 | 15 | 40.0 | 15 | 46.6 | 13 | 44.3 | 13 | 43.6 | 13 |
| 9 | CSV 17 | 10.58 | 5 | 10.34 | 6 | 10.49 | 9 | 10.47 | 7 | 68.4 | 5 | 70.9 | 15 | 68.0 | 11 | 69.1 | 11 | 44.2 | 3 | 46.9 | 12 | 44.8 | 12 | 45.3 | 10 |
| 10 | Local check | 9.51 | 10 | 10.20 | 9 | 10.03 | 11 | 9.91 | 11 | 71.2 | 1 | 72.9 | 7 | 68.9 | 10 | 71.0 | 2 | 46.0 | 1 | 47.9 | 6 | 45.7 | 9 | 46.5 | 3 |
| 11 | SPV 1600 | 8.75 | 14 | 10.06 | 10 | 9.81 | 13 | 9.54 | 13 | 66.0 | 12 | 71.7 | 13 | 66.1 | 14 | 67.9 | 14 | 40.1 | 14 | 45.8 | 15 | 42.5 | 15 | 42.8 | 15 |
| 12 | SPV 1746 | 8.09 | 15 | 8.86 | 15 | 9.45 | 14 | 8.80 | 15 | 66.5 | 8 | 75.8 | 2 | 70.4 | 4 | 70.9 | 3 | 40.8 | 12 | 49.6 | 1 | 46.9 | 4 | 45.8 | 7 |
| 13 | SPV 1742 | 10.35 | 6 | 10.39 | 5 | 10.79 | 7 | 10.51 | 6 | 67.1 | 6 | 73.9 | 4 | 68.9 | 9 | 70.0 | 6 | 42.8 | 7 | 48.9 | 4 | 45.6 | 10 | 45.7 | 8 |
| 14 | CSH 16 | 11.66 | 1 | 10.94 | 2 | 11.88 | 5 | 11.49 | 1 | 66.0 | 10 | 73.8 | 5 | 69.5 | 6 | 69.8 | 9 | 42.8 | 8 | 48.6 | 5 | 46.8 | 5 | 46.1 | 6 |
| 15 | CSH 18 | 9.56 | 9 | 9.52 | 11 | 9.91 | 12 | 9.66 | 12 | 70.2 | 2 | 76.5 | 1 | 71.7 | 1 | 72.8 | 1 | 43.4 | 5 | 49.4 | 2 | 47.1 | 3 | 46.6 | 2 |
| LOC. MEAN | | 9.89 | | 10.02 | | 10.90 | | 10.27 | | 67.2 | | 73.0 | | 68.9 | | 69.7 | | 42.5 | | 47.7 | | 45.8 | | 45.4 | |
| C.D. (5%) | | 2.21 | | 1.86 | | 1.45 | | 1.21 | | 3.1 | | 3.8 | | 3.2 | | 2.2 | | 2.2 | | 3.2 | | 3.4 | | 2.1 | |
| C.D. (1%) | | 2.98 | | 2.51 | | 1.95 | | 1.63 | | 4.2 | | 5.1 | | 4.4 | | 2.9 | | 3.0 | | 4.3 | | 4.6 | | 2.9 | |
| C.V. (%) | | 13.35 | | 11.09 | | 7.95 | | 7.04 | | 2.74 | | 3.08 | | 2.82 | | 1.87 | | 3.08 | | 4.04 | | 4.45 | | 2.79 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.01 | |

NDF- Neuter detergent fibre; ADF- Acid detergent fibre; R-Rank

**Table 2 Continued…)**

| Sl. No. | Entry | ivomd | | | | | | | | CP | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PARBHANI | | AKOLA | | DHARWAD | | Average | | PARBHANI | | AKOLA | | DHARWAD | | Average | |
| | | | R | | R | | R | | R | | R | | R | | R | | R |
| 1 | SPV 1786 | 52.7 | 6 | 51.2 | 2 | 51.0 | 2 | 51.6 | 3 | 5.15 | 1 | 2.33 | 10 | 5.40 | 3 | 4.29 | 1 |
| 2 | SPH 1567 | 52.1 | 8 | 49.2 | 13 | 46.6 | 15 | 49.3 | 12 | 4.63 | 5 | 2.46 | 8 | 4.75 | 7 | 3.95 | 8 |
| 3 | SPV 1774 | 51.7 | 10 | 50.6 | 4 | 48.4 | 10 | 50.2 | 6 | 3.26 | 14 | 2.13 | 13 | 2.92 | 15 | 2.77 | 15 |
| 4 | CSH 16 | 52.1 | 9 | 49.9 | 8 | 47.5 | 13 | 49.8 | 11 | 3.83 | 9 | 3.50 | 1 | 5.09 | 4 | 4.14 | 5 |
| 5 | SPV 1616 | 54.6 | 1 | 50.9 | 3 | 49.9 | 4 | 51.8 | 2 | 3.47 | 13 | 2.55 | 7 | 4.45 | 9 | 3.49 | 11 |
| 6 | CSH 23 | 53.7 | 4 | 49.7 | 9 | 48.8 | 8 | 50.8 | 5 | 3.83 | 8 | 3.13 | 3 | 4.93 | 5 | 3.96 | 7 |
| 7 | SPV 462 | 50.8 | 13 | 49.6 | 10 | 49.7 | 5 | 50.0 | 8 | 3.64 | 11 | 2.43 | 9 | 4.17 | 11 | 3.41 | 12 |
| 8 | CSV 15 | 54.2 | 2 | 50.4 | 6 | 50.2 | 3 | 51.6 | 4 | 3.93 | 6 | 2.70 | 5 | 6.02 | 1 | 4.22 | 3 |
| 9 | CSV 17 | 51.3 | 12 | 50.0 | 7 | 48.2 | 11 | 49.9 | 10 | 3.70 | 10 | 3.02 | 4 | 5.91 | 2 | 4.21 | 4 |
| 10 | Local check | 47.8 | 15 | 50.5 | 5 | 48.4 | 9 | 48.9 | 14 | 3.07 | 15 | 2.23 | 12 | 4.17 | 12 | 3.15 | 13 |
| 11 | SPV 1600 | 54.2 | 3 | 51.3 | 1 | 52.3 | 1 | 52.6 | 1 | 3.64 | 12 | 2.70 | 6 | 4.19 | 10 | 3.51 | 10 |
| 12 | SPV 1746 | 52.7 | 5 | 47.3 | 15 | 47.2 | 14 | 49.1 | 13 | 3.92 | 7 | 1.79 | 15 | 3.34 | 14 | 3.02 | 14 |
| 13 | SPV 1742 | 51.7 | 11 | 49.4 | 11 | 48.9 | 7 | 50.0 | 9 | 4.80 | 4 | 2.27 | 11 | 4.84 | 6 | 3.97 | 6 |
| 14 | CSH 16 | 52.2 | 7 | 49.4 | 12 | 49.1 | 6 | 50.2 | 7 | 4.81 | 3 | 3.36 | 2 | 4.62 | 8 | 4.26 | 2 |
| 15 | CSH 18 | 50.3 | 14 | 48.5 | 14 | 47.7 | 12 | 48.9 | 15 | 4.84 | 2 | 2.00 | 14 | 3.83 | 13 | 3.56 | 9 |
| LOC. MEAN | | 52.1 | | 49.9 | | 48.9 | | 50.3 | | 4.03 | | 2.57 | | 4.58 | | 3.73 | |
| C.D. (5%) | | 2.9 | | 3.3 | | 2.8 | | 1.9 | | 1.60 | | 1.08 | | 1.70 | | 0.97 | |
| C.D. (1%) | | 4.0 | | 4.4 | | 3.8 | | 2.5 | | 2.16 | | 1.46 | | 2.30 | | 1.31 | |
| C.V. (%) | | 3.38 | | 3.92 | | 3.45 | | 2.24 | | 23.75 | | 25.10 | | 22.26 | | 15.59 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.00 | | 0.01 | | 0.00 | | 0.00 | | 0.00 | | 0.04 | |

ivomd - *in vitro* organic matter digestibility(%) ; CP - Crude protein content (%) R-Rank

## Table 3 Stover quality of sorghum genotypes in Advanced Varietal & Hybrid Trial - Zone 3 (Kharif 2007)

| Sl. No. | Entry | Ash% | | NDF% | | ADF% | | IVDMD | | CP | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | UDAIPUR | | UDAIPUR | | UDAIPUR | | UDAIPUR | | UDAIPUR | |
| | | | R | | R | | R | | R | | R |
| 1 | SPV 1774 | 7.83 | 17 | 63.6 | 19 | 37.0 | 18 | 56.5 | 1 | 4.76 | 15 |
| 2 | SPV 1775 | 8.52 | 14 | 66.3 | 12 | 39.3 | 11 | 52.7 | 13 | 5.21 | 8 |
| 3 | SPV 1742 | 9.73 | 4 | 67.4 | 6 | 40.1 | 6 | 53.8 | 11 | 5.28 | 7 |
| 4 | SPV 1786 | 8.85 | 11 | 66.8 | 9 | 39.9 | 7 | 52.2 | 16 | 4.74 | 16 |
| 5 | CSH 16 | 9.73 | 3 | 67.4 | 5 | 39.8 | 8 | 53.7 | 12 | 5.91 | 2 |
| 6 | SPV 1733 | 8.78 | 13 | 65.7 | 15 | 38.3 | 16 | 55.0 | 3 | 4.98 | 11 |
| 7 | SPV 1730 | 8.91 | 9 | 66.6 | 11 | 39.0 | 12 | 54.6 | 6 | 5.20 | 9 |
| 8 | CSH 16 | 10.36 | 1 | 70.1 | 1 | 41.6 | 2 | 52.3 | 15 | 5.73 | 3 |
| 9 | SPV 1616 | 8.79 | 12 | 65.6 | 16 | 38.1 | 17 | 54.0 | 9 | 5.45 | 5 |
| 10 | SPH 1342 | 10.36 | 1 | 69.1 | 3 | 41.6 | 3 | 51.3 | 18 | 5.51 | 4 |
| 11 | SPV 462 | 7.38 | 18 | 68.2 | 4 | 40.5 | 5 | 51.9 | 17 | 3.46 | 19 |
| 12 | CSV 15 | 8.41 | 15 | 66.3 | 13 | 39.0 | 14 | 54.3 | 8 | 4.90 | 12 |
| 13 | CSV 17 | 9.80 | 2 | 66.9 | 8 | 39.3 | 10 | 54.5 | 7 | 5.39 | 6 |
| 14 | Local Check | 9.55 | 6 | 70.0 | 2 | 43.2 | 1 | 50.1 | 19 | 4.37 | 18 |
| 15 | SPH 1587 | 9.08 | 8 | 65.9 | 14 | 39.4 | 9 | 53.9 | 10 | 5.11 | 10 |
| 16 | SPH 1596 | 9.56 | 5 | 66.7 | 10 | 40.8 | 4 | 52.5 | 14 | 4.80 | 14 |
| 17 | SPV 1600 | 7.95 | 16 | 63.6 | 18 | 36.6 | 19 | 55.6 | 2 | 4.88 | 13 |
| 18 | SPV 1746 | 8.88 | 10 | 65.1 | 17 | 38.4 | 15 | 54.7 | 5 | 4.72 | 17 |
| 19 | CSH 18 | 9.53 | 7 | 67.3 | 7 | 39.0 | 13 | 54.8 | 4 | 6.02 | 1 |
| LOC. MEAN | | 9.05 | | 66.8 | | 39.5 | | 53.6 | | 5.08 | |
| C.D. (5%) | | 1.94 | | 5.7 | | 4.7 | | 4.5 | | 1.79 | |
| C.D. (1%) | | 2.60 | | 7.6 | | 6.3 | | 6.0 | | 2.40 | |
| C.V. (%) | | 12.92 | | 5.11 | | 7.19 | | 5.04 | | 21.33 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.00 | | 0.00 | | 0.00 | |

NDF- Neuter detergent fibre; ADF- Acid detergent fibre; ivomd- *in vitro* organic matter digestibility(%) ; CP- Crude protein content (%) R-Rank

**Table 4 Stover Quality of sorghum genotypes in Dual Purpose Advanced Varietal & Hybrid Trial (Kharif 2007)**

| Sl. No. | Entry | Ash% | | | | | | | | NDF% | | | | | | | | ADF% | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PALEM | | COIMBATORE | | UDAIPUR | | Average | | PALEM | | COIMBATORE | | UDAIPUR | | Average | | PALEM | | COIMBATORE | | UDAIPUR | | Average | |
| | | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R | | R |
| 1 | SPV 1778 | 11.17 | 1 | 11.87 | 5 | 8.10 | 7 | 10.38 | 3 | 66.7 | 1 | 68.5 | 7 | 64.5 | 7 | 66.5 | 4 | 45.2 | 1 | 44.2 | 5 | 38.1 | 5 | 42.5 | 2 |
| 2 | SPH 1467 | 9.91 | 5 | 11.80 | 7 | 9.53 | 1 | 10.42 | 2 | 65.3 | 5 | 68.5 | 8 | 69.1 | 2 | 67.6 | 2 | 43.2 | 3 | 44.0 | 7 | 42.1 | 1 | 43.1 | 1 |
| 3 | SPV 1781 | 10.35 | 3 | 12.00 | 4 | 7.16 | 11 | 9.84 | 7 | 64.4 | 8 | 68.4 | 9 | 64.7 | 4 | 65.8 | 6 | 42.6 | 4 | 43.6 | 9 | 38.2 | 4 | 41.5 | 6 |
| 4 | SPV 1754 | 9.99 | 4 | 12.38 | 3 | 8.20 | 6 | 10.19 | 4 | 64.4 | 9 | 69.4 | 3 | 61.4 | 10 | 65.0 | 10 | 41.8 | 8 | 45.1 | 1 | 35.7 | 10 | 40.8 | 8 |
| 5 | SPV 1753 | 9.38 | 8 | 13.07 | 1 | 7.33 | 10 | 9.92 | 6 | 64.9 | 7 | 67.5 | 10 | 61.5 | 9 | 64.6 | 11 | 41.7 | 10 | 43.7 | 8 | 35.9 | 9 | 40.4 | 11 |
| 6 | SPV 1616 | 9.49 | 7 | 11.80 | 7 | 8.59 | 5 | 9.96 | 5 | 64.2 | 10 | 69.1 | 5 | 65.7 | 3 | 66.3 | 5 | 42.0 | 5 | 44.1 | 6 | 38.6 | 3 | 41.6 | 5 |
| 7 | SPV 1750 | 9.24 | 9 | 11.54 | 8 | 7.97 | 8 | 9.58 | 11 | 65.8 | 4 | 67.1 | 11 | 64.6 | 6 | 65.8 | 7 | 42.0 | 6 | 42.6 | 11 | 38.0 | 6 | 40.8 | 7 |
| 8 | SPV 1779 | 8.95 | 10 | 11.09 | 10 | 8.75 | 4 | 9.59 | 10 | 64.9 | 6 | 69.7 | 1 | 60.9 | 11 | 65.2 | 9 | 41.8 | 7 | 45.0 | 2 | 35.5 | 11 | 40.8 | 9 |
| 9 | CSV 15 | 9.79 | 6 | 12.74 | 2 | 9.22 | 2 | 10.58 | 1 | 66.4 | 2 | 69.0 | 6 | 64.6 | 5 | 66.7 | 3 | 43.7 | 2 | 44.9 | 3 | 37.7 | 7 | 42.1 | 4 |
| 10 | SPV 1782 | 10.94 | 2 | 11.12 | 9 | 7.38 | 9 | 9.81 | 8 | 62.8 | 11 | 69.5 | 2 | 64.0 | 8 | 65.4 | 8 | 41.7 | 9 | 43.3 | 10 | 36.4 | 8 | 40.5 | 10 |
| 11 | CSH 18 | 8.09 | 11 | 11.83 | 6 | 9.13 | 3 | 9.68 | 9 | 66.2 | 3 | 69.3 | 4 | 69.6 | 1 | 68.4 | 1 | 41.7 | 11 | 44.3 | 4 | 40.9 | 2 | 42.3 | 3 |
| LOC. MEAN | | 9.75 | | 11.93 | | 8.30 | | 10.00 | | 65.1 | | 68.7 | | 64.6 | | 66.1 | | 42.5 | | 44.1 | | 37.9 | | 41.5 | |
| C.D. (5%) | | 1.73 | | 1.49 | | 1.24 | | 1.45 | | 4.6 | | 3.4 | | 3.8 | | 3.0 | | 3.7 | | 2.9 | | 3.7 | | 2.4 | |
| C.D. (1%) | | 2.36 | | 2.03 | | 1.70 | | 1.97 | | 6.3 | | 4.6 | | 5.2 | | 4.1 | | 5.1 | | 3.9 | | 5.1 | | 3.2 | |
| C.V. (%) | | 10.42 | | 7.33 | | 8.80 | | 8.49 | | 4.16 | | 2.89 | | 3.48 | | 2.67 | | 5.17 | | 3.81 | | 5.79 | | 3.33 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.00 | | 0.87 | | 0.00 | | 0.00 | | 0.00 | | 0.34 | | 0.00 | | 0.00 | | 0.00 | | 0.30 | |

NDF- Neuter detergent fibre; ADF- Acid detergent fibre; R-Rank

**Table 4 Continued…)**

| Sl. No. | Entry | ivomd | | | | | | | | CP | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | PALEM | | COIMBATORE | | UDAIPUR | | Average | | PALEM | | COIMBATORE | | UDAIPUR | | Average | |
| | | | R | | R | | R | | R | | R | | R | | R | | R |
| 1 | SPV 1778 | 48.0 | 11 | 48.3 | 8 | 53.8 | 7 | 50.0 | 10 | 4.41 | 5 | 5.21 | 8 | 5.10 | 7 | 4.91 | 7 |
| 2 | SPH 1467 | 51.0 | 9 | 48.8 | 5 | 49.3 | 11 | 49.7 | 11 | 4.27 | 6 | 5.68 | 5 | 5.19 | 6 | 5.05 | 3 |
| 3 | SPV 1781 | 51.3 | 8 | 49.6 | 3 | 52.9 | 8 | 51.3 | 7 | 4.15 | 7 | 5.76 | 3 | 4.14 | 11 | 4.68 | 10 |
| 4 | SPV 1754 | 52.9 | 3 | 46.5 | 11 | 55.7 | 4 | 51.7 | 5 | 4.46 | 4 | 5.74 | 4 | 5.74 | 2 | 5.32 | 2 |
| 5 | SPV 1753 | 53.7 | 1 | 48.8 | 6 | 56.0 | 3 | 52.8 | 2 | 4.49 | 3 | 6.11 | 1 | 4.52 | 10 | 5.04 | 4 |
| 6 | SPV 1616 | 52.8 | 4 | 49.3 | 4 | 52.8 | 9 | 51.6 | 6 | 3.89 | 8 | 5.50 | 6 | 5.02 | 8 | 4.80 | 8 |
| 7 | SPV 1750 | 51.7 | 7 | 51.0 | 1 | 54.5 | 6 | 52.4 | 3 | 4.57 | 2 | 5.09 | 9 | 5.29 | 5 | 4.99 | 5 |
| 8 | SPV 1779 | 52.2 | 5 | 47.0 | 10 | 56.2 | 2 | 51.8 | 4 | 3.53 | 11 | 5.00 | 10 | 5.60 | 4 | 4.71 | 9 |
| 9 | CSV 15 | 49.8 | 10 | 48.3 | 7 | 54.5 | 5 | 50.9 | 8 | 4.73 | 1 | 6.08 | 2 | 6.34 | 1 | 5.71 | 1 |
| 10 | SPV 1782 | 53.1 | 2 | 50.2 | 2 | 56.2 | 1 | 53.2 | 1 | 3.70 | 9 | 4.97 | 11 | 4.62 | 9 | 4.43 | 11 |
| 11 | CSH 18 | 52.1 | 6 | 48.1 | 9 | 51.3 | 10 | 50.5 | 9 | 3.66 | 10 | 5.41 | 7 | 5.68 | 3 | 4.92 | 6 |
| LOC. MEAN | | 51.7 | | 48.7 | | 53.9 | | 51.4 | | 4.17 | | 5.50 | | 5.20 | | 4.96 | |
| C.D. (5%) | | 3.5 | | 3.6 | | 4.2 | | 2.8 | | 1.08 | | 1.31 | | 1.42 | | 0.74 | |
| C.D. (1%) | | 4.8 | | 5.0 | | 5.8 | | 3.9 | | 1.48 | | 1.79 | | 1.93 | | 1.01 | |
| C.V. (%) | | 4.03 | | 4.38 | | 4.62 | | 3.24 | | 15.28 | | 13.98 | | 16.00 | | 8.81 | |
| F (Probability) | | 0.00 | | 0.00 | | 0.00 | | 0.28 | | 0.00 | | 0.00 | | 0.00 | | 0.12 | |

ivomd - *in vitro* organic matter digestibility(%) ; CP - Crude protein content (%) R-Rank

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# 7. Market prices criteria for advancing sorghum genotypes in AICSIP trials

*B Dayakar Rao, P Prakash, OV Ramana, K Rajesh Chaithanya, and N Seetharama*

**Summary**
Many technical parameters have to be considered for identification of cultivars for commercialization in a region. Among these, market price is an important parameter as it reflects the quality of the grain as perceived by traders and consumers. So, the market price data is collected from AVHT zones and analyzed for price behavior. The varieties quoted highest mean price, significant difference existed between hybrid and varieties in all the zones, and the variation in prices across the entries is not highly significant. The prices fetched by the entries are much higher than the government announced MSP of Rs 600/q. The gap between hybrids and varieties has narrowed unlike in the past. This feature is prompting that the currently tested hybrids are qualitatively not very far behind standard varietal checks during a normal year.

## 1.0 Introduction

The selection process for identification of hybrid or variety and its suitability to a region or country as a whole is rigorous, which involves many technical parameters. The need for promoting the advanced materials to release a stage of hybrid/variety based on market price is worth-considering, as market price reflects the quality of the grain as perceived by traders and consumers.

Normally sorghum grain with bright luster, bold size and plump shape (not flat and not with beak) fetches higher price. Further, varieties fetch higher prices than hybrids. In this report, only prices of kharif grain are reported. Rabi grain is yet to be received, therefore it will be reported later (*www.nrcsorghum.res.in*). The current year analysis is characterized by the zone-wise analysis as done in the previous year.

## 2.0 Objectives

1. To ascertain the relative market values of sorghum cultivars received from various test centres under AICSIP.
2. To understand the correlation of market prices with grain parameters such as size, grain yield and grain mold infection level.

## 3.0 Methodology

The data was collected during Jan.-Feb. 2008. 11 entries each were received from two AICSIP locations *viz.*, Coimbatore and Udaipur in dual purpose zone. Form Coimbatore location, 15 entries were received from AVHT Zone I. Form Akola and Dharwad locations, 15 entries each were received from AVHT Zone II. From Udaipur location 19 entries were received from AVHT Zone III. The sample market prices were collected from 5 urban regulated markets: Solapur, Pune, Nagpur, Gulbarga, and Indore. Four sub-markets (traders) were used from each of above mentioned markets whose prices were averaged. The mean, SD, CV, SE, minimum, maximum and the range were calculated for each AVHT samples from various locations. SPSS package was used for working out correlations.

## 4.0 Results

### 4.1.0 Variation in prices of the entries across the samples from AICSIP centres and across varieties and hybrids.

### 4.1.1 The effect of location from where the samples originated:

**Zone I:** AVHT samples are obtained from lone Coimbatore centre whose market prices were assessed from five markets. The mean highest price is Rs 903/q fetched from Gulbarga market. (Table 2)

**Zone II:** AVHT samples from Akola had relatively higher prices (mean = Rs 785/q) compared with Dharwad centre; the range was also high (Rs 159/q) and CV of 5.75 (Table 3)

**Zone III:** The mean price of various entries from Udaipur centre were obtained from five markets averaged Rs. 825/q, with a range Rs 116 and lowest CV 3.87% in case of Udaipur centre (Table 4).

#### 4.1.2.1 Varieties Vs Hybrids:

**Zone I:**

1. The sample values from all the locations were pooled and analyzed for price behavior. It was found that SPV 1616 (CSV 20) ranked first whose grain yield ranking is 9 in Zone-I was quoted highest price among varieties, and followed by entries SPV 1774 and SPV 1733 too fetched a mean price very close to above price.
2. Highest mean price for hybrids was obtained for SPH 1596 (grain yield rank in trials = 2), however its overall AVHT grain price ranking is 14 as this is a combined hybrid/varietal trial.

**Zone II:**

1. Pooled analysis: Varietal entry SPV 1774 which ranked number one in grain price of Rs.774/q had fetched 12 rank in grain yield, while among hybrid entries, SPH 1567 fetched highest mean price of Rs.691/q
2. In these combined AVHT trials, a large price difference between hybrids and varieties is observed in this zone.

**Zone III:**

1. Pooled analysis: Analysis for price behavior across the entries revealed that SPV 1730 ranking 1 with Rs 883/q (grain yield ranking is 17) fetched highest. mean price. While, among hybrids lone entry SPH 1587 with mean price of Rs 826/q ranked 11 among combined AVHT whose grain yield rank is second.
2. In this combined AVHT trials, first four entries with highest mean prices are varieties.

### 4.1.3 Dual purpose AVHT cultivars:

1. Among samples from two locations, AVHT sample from Udaipur fetched highest mean of Rs 869/q, with a range of Rs 95 and CV of 3.19 % (Table 1).
2. Pooled analysis: All the samples from both the locations examined for price behavior, across the varietal entries, revealed that SPV 1753 fetched highest grain price of 831/q whose grain yield rank is number five. SPV 1779 and SPV 1778 follow with Rs 818 /q and Rs 809/q.
3. Lone hybrid entry SPH 1467 fared better than varietal checks in market price of Rs. 838/q which has secured number one rank. Establishing the fact that it is the most promising hybrid entry which has proven on both the criteria.

### 4.2.0 Correlation

Correlation between market price and other variables such as seed size (1000 grain weight.), grain yield and grain mold score (threshed grade) are worked out. In fact market price in isolation may not solely reflect the superiority of the entries tested.

1. There is a negative correlation between market price and yield in zone III.
2. Correlation between market price and seed weight is positive but non- significant.
3. Market price is again negatively correlated with mold score and is significant in the case of AVHT Zone I (r = -0.777) threshed grain score used. The "p" value indicates highly significant values (Table 6).

## 5.0.0 Conclusions

1. Among the AVT entries SPV 1730, SPV 1616 (CSV 20) and SPV 1774 have established as superior entries across the markets in Zone I, II and III respectively and the overall mean too vouches for the same (Table 5). The price commended for these three is much higher (17-46%) than the government announced Minimum Support Price (MSP) of Rs 600/q (Maldandi). Obviously, all the entries have fetched higher than MSP. However, grain yield ranks are not fully in same line with that of grain price rankings.
2. Unlike the AVT entries, there is no agreement on superiority of any single AHT entry over the other. No AHT entry with highest mean market price in a particular market has repeated its performance in other zone. In all, the variation in prices across the entries was not highly significant.
3. Lone hybrid entry SPH 1467 fared better than varietal checks in market price of Rs. 838/q among the Dual purpose entries, it has secured number one rank. And established its superiority assuring that it is the most promising hybrid entry on account of proven performance on both the important criteria
4. Except SPH 1567 and 1587 entries other hybrid entries have fetched lower market prices. This feature is prompting that the currently bred hybrids are qualitatively not very far from the new varieties bred. This will encourage breeders. Also nutritional and food quality traits are to be considered.
5. Negative and significant correlation existed between market price and threshed grain mold score agrees the popular belief molded grain reduces the profitability of growing such entries.

**Table 1: Mean values of market prices (Rs/q) for the dual purpose genotypes from different AICSIP locations: AVHT, 2007-08**

| Sl. No. | Entry | AICSIP locations | | Average | Ranking |
|---|---|---|---|---|---|
| | | Coimbatore | Udaipur | | |
| 1 | SPH 1467 | 826 | 851 | 838 | 1 |
| 2 | SPV 1753 | 792 | 869 | 831 | 2 |
| 3 | CSH 18 | 824 | 834 | 829 | 3 |
| 4 | SPV 1779 | 804 | 833 | 818 | 4 |
| 5 | SPV 1778 | 794 | 824 | 809 | 5 |
| 6 | SPV 1782 | 800 | 817 | 808 | 6 |
| 7 | CSV 20 | 807 | 809 | 808 | 7 |
| 8 | SPV 1754 | 805 | 805 | 805 | 8 |
| 9 | SPV 1750 | 801 | 799 | 800 | 9 |
| 10 | SPV 1781 | 739 | 838 | 788 | 10 |
| 11 | CSV 15 | 790 | 774 | 782 | 11 |
| | Mean | 798.21 | 822.84 | 810.53 | |
| | SE | 6.91 | 7.91 | 5.25 | |
| | SD | 22.93 | 26.24 | 17.42 | |
| | Range | 87.30 | 95.00 | 55.90 | |
| | Minimum | 738.50 | 774.25 | 782.25 | |
| | Maximum | 825.80 | 869.25 | 838.15 | |
| | CD (5%) | 15.40 | 17.63 | 11.71 | |
| | CV(%) | 2.87 | 3.19 | 2.15 | |
| | F (prob) | 0.00 | 0.00 | 0.00 | |

*Source: - Market price survey of AICSIP samples 2007-08, AICSIP, NRCS, Hyderabad*
**Figures in parentheses indicate number of APMC's markets (sub-market) in each regulated market*

**Table 2: Mean values of market prices (Rs/q) for the sorghum genotypes from different AICSIP locations for Zone I: AVHT, 2007-08**

| S. No. | Entry | Prices in various markets (Rs/q) | | | | | Mean Price (Rs/q) | Ranking |
|---|---|---|---|---|---|---|---|---|
| | | Gulbarga | Solapur | Pune | Indore | Nagpur | | |
| 1 | CSV 20 | 1067 | 744 | 925 | 790 | 863 | 878 | 1 |
| 2 | SPV 1774 | 1033 | 813 | 900 | 736 | 763 | 849 | 2 |
| 3 | SPV 1733 | 1033 | 719 | 931 | 753 | 788 | 845 | 3 |
| 4 | SPV 1775 | 967 | 774 | 901 | 739 | 788 | 834 | 4 |
| 5 | SPV 1746 | 967 | 699 | 905 | 756 | 813 | 828 | 5 |
| 6 | CSH 18 | 933 | 719 | 932 | 738 | 788 | 822 | 6 |
| 7 | Local Check | 950 | 706 | 890 | 731 | 763 | 808 | 7 |
| 8 | SPV 1742 | 917 | 713 | 898 | 719 | 775 | 804 | 8 |
| 9 | CSH 16 | 867 | 758 | 853 | 700 | 750 | 785 | 9 |
| 10 | CSV 15 | 925 | 678 | 874 | 719 | 731 | 785 | 10 |
| 11 | SPV 462 | 775 | 707 | 861 | 705 | 731 | 756 | 11 |
| 12 | CSH 23 | 783 | 713 | 819 | 719 | 725 | 752 | 12 |
| 13 | SPV 1600 | 800 | 689 | 806 | 710 | 731 | 747 | 13 |
| 14 | SPH 1596 | 783 | 658 | 808 | 716 | 731 | 739 | 14 |
| 15 | CSV 17 | 750 | 689 | 801 | 706 | 744 | 738 | 15 |
| | Mean | 903.33 | 718.37 | 873.53 | 729.08 | 765.42 | 797.95 | |
| | SE | 26.99 | 10.24 | 12.02 | 6.18 | 9.81 | 11.52 | |
| | SD | 104.55 | 39.66 | 46.54 | 23.93 | 38.01 | 44.61 | |
| | Range | 316.67 | 155.25 | 130.25 | 90.00 | 137.50 | 139.58 | |
| | Minimum | 750.00 | 657.50 | 801.25 | 700.00 | 725.00 | 738.00 | |
| | Maximum | 1066.67 | 812.75 | 931.50 | 790.00 | 862.50 | 877.58 | |
| | CD (5%) | 57.90 | 21.96 | 25.77 | 13.25 | 21.05 | 24.70 | |
| | CV(%) | 11.57 | 5.52 | 5.33 | 3.28 | 4.97 | 5.59 | |
| | F(prob) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |

*Source: - Market price survey of AICSIP samples 2007-08, AICSIP, NRCS, Hyderabad*

**Table 3: Mean values of market prices (Rs/q) for the sorghum genotypes from different AICSIP locations for Zone II: AVHT, 2007-08**

| S. No. | Entry | AICSIP locations | | Average | Ranking |
|---|---|---|---|---|---|
| | | *Akola* | *Dharwad* | | |
| 1 | SPV 1774 | 861 | 687 | 774 | 1 |
| 2 | CSH 18 | 796 | 702 | 749 | 2 |
| 3 | SPV 1746 | 838 | 651 | 744 | 3 |
| 4 | CSV 15 | 805 | 659 | 732 | 4 |
| 5 | CSH 16 | 766 | 673 | 720 | 5 |
| 6 | SPV 462 | 795 | 635 | 715 | 6 |
| 7 | SPV 1600 | 780 | 648 | 714 | 7 |
| 8 | SPV 1742 | 786 | 625 | 705 | 8 |
| 9 | CSV 20 | 837 | 571 | 704 | 9 |
| 10 | SPH 1567 | 785 | 598 | 691 | 10 |
| 11 | CSH 23 | 702 | 677 | 689 | 11 |
| 12 | SPV 1786 | 823 | 555 | 689 | 12 |
| 13 | Local check | 740 | 636 | 688 | 13 |
| 14 | CSH 16 | 762 | 601 | 681 | 14 |
| 15 | CSV 17 | 712 | 547 | 629 | 15 |
| | Mean | 785.73 | 630.89 | 708.31 | |
| | SE | 11.66 | 12.40 | 8.87 | |
| | SD | 45.14 | 48.01 | 34.37 | |
| | Range | 159.30 | 155.75 | 145.03 | |
| | Minimum | 701.75 | 546.50 | 629.13 | |
| | Maximum | 861.05 | 702.25 | 774.15 | |
| | CD(5%) | 25.00 | 26.58 | 19.03 | |
| | CV(%) | 5.75 | 7.61 | 4.85 | |
| | F(prob) | 0.00 | 0.00 | 0.00 | |

*Source: - Market price survey of AICSIP samples 2007-08, AICSIP, NRCS, Hyderabad*

**Table 4: Mean values of market prices (Rs/q) for the sorghum genotypes from Udaipur AICSIP location for Zone III: AVHT, 2007-08**

| S. No. | Entry | Prices in various markets (Rs/q) | | | | | Mean Price (Rs/q) | Ranking |
|---|---|---|---|---|---|---|---|---|
| | | *Gulbarga* | *Solapur* | *Pune* | *Indore* | *Nagpur* | | |
| 1 | SPV 1730 | 988 | 844 | 900 | 789 | 894 | 883 | 1 |
| 2 | SPV 1733 | 1000 | 788 | 944 | 784 | 850 | 873 | 2 |
| 3 | SPV 1746 | 975 | 792 | 885 | 759 | 863 | 855 | 3 |
| 4 | CSV 20 | 938 | 756 | 904 | 759 | 869 | 845 | 4 |
| 5 | CSV 15 | 950 | 781 | 873 | 750 | 863 | 843 | 5 |
| 6 | CSH 18 | 950 | 734 | 881 | 788 | 838 | 838 | 6 |
| 7 | CSH 16 | 906 | 786 | 913 | 753 | 831 | 838 | 7 |
| 8 | SPV 1786 | 925 | 770 | 888 | 776 | 825 | 837 | 8 |
| 9 | CSH 16 | 888 | 769 | 908 | 763 | 856 | 837 | 9 |
| 10 | SPV 1775 | 925 | 775 | 875 | 754 | 838 | 833 | 10 |
| 11 | SPH 1587 | 863 | 781 | 883 | 771 | 831 | 826 | 11 |
| 12 | SPV 1774 | 938 | 743 | 860 | 766 | 806 | 823 | 12 |
| 13 | SPV 1742 | 888 | 755 | 880 | 764 | 825 | 822 | 13 |
| 14 | SPV 462 | 875 | 763 | 888 | 741 | 831 | 820 | 14 |
| 15 | SPV 1600 | 875 | 744 | 829 | 756 | 844 | 810 | 15 |
| 16 | SPH 1596 | 813 | 759 | 819 | 735 | 781 | 781 | 16 |
| 17 | Local Check | 838 | 711 | 819 | 748 | 769 | 777 | 17 |
| 18 | SPH 1342 | 863 | 736 | 789 | 729 | 756 | 775 | 18 |
| 19 | CSV 17 | 825 | 706 | 804 | 731 | 769 | 767 | 19 |
| | Mean | 906.25 | 762.78 | 870.38 | 758.66 | 828.34 | 825.28 | |
| | SE | 12.47 | 7.21 | 9.36 | 4.10 | 8.55 | 7.33 | |
| | SD | 54.37 | 31.42 | 40.81 | 17.85 | 37.26 | 31.95 | |
| | Range | 187.50 | 137.50 | 155.00 | 60.00 | 137.50 | 115.75 | |
| | Minimum | 812.50 | 706.25 | 788.75 | 728.75 | 756.25 | 767.00 | |
| | Maximum | 1000.00 | 843.75 | 943.75 | 788.75 | 893.75 | 882.75 | |
| | CD(5%) | 26.20 | 15.14 | 19.67 | 8.61 | 17.96 | 15.40 | |
| | CV(%) | 6.00 | 4.12 | 4.69 | 2.35 | 4.50 | 3.87 | |
| | F(prob) | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | |

*Source: - Market price survey of AICSIP samples 2007-08, AICSIP, NRCS, Hyderabad*

**Table 5: Best performing AVT entries in different AICSIP locations based on market prices**

| S. No. | Location | Entry fetch highest | Price (Rs/q) |
|---|---|---|---|
| **AVHT** | | | |
| *Zone I* | Coimbatore (lone) | SPV1616 | 878 |
| | | SPH 1596 (Lone) | 739 |
| *Zone II* | Akola | SPV 1774 | 838 |
| | | SPH 1567 | 861 |
| *Zone III* | Udaipur (lone) | SPV 1730 | 883 |
| | | SPH 1587 (< Check) | 826 |
| | **Overall** | SPV 1730 | 883 |
| | | SPH 1567 | 861 |
| **Dual purpose** | Udaipur | SPV 1753 | 831 |
| | | SPH 1467 | 838 |

*Source: Analysis based on Market survey data, AICSIP / NRCS, Hyderabad 2007-08*

**Table 6: Correlation between market prices and other parameters of AICSIP entries for 2007-08**

| Zones | Correlation between | Correlation (r ) value | Status of significance | P value |
|---|---|---|---|---|
| **Zone I , AVHT** | Price and yield | -0.009 | NS | - |
| | Price and seed wt (100 gr.wt) | 0.063 | NS | - |
| | Price and mold score (threshed) | -0.777 | HS | -0.001 |
| **Zone II, AVHT** | Price and yield | -0.103 | NS | - |
| | Price and seed wt (100 gr.wt) | 0.036 | NS | - |
| | Price and mold score (threshed) | -0.468 | NS | - |
| **Zone III, AVHT** | Price and yield | -0.466 | S | -0.044 |
| | Price and seed wt (100 gr.wt) | -0.058 | NS | - |
| | Price and mold score (threshed) | -0.391 | NS | - |
| **Dual purpose, AVHT** | Price and yield | 0.562 | NS | - |
| | Price and seed wt (100 gr.wt) | -0.043 | NS | - |
| | Price and mold score (threshed) | -0.079 | NS | - |

*r-correlation coefficient; p-probability level (%); NS-Not significant; S –Significant and HS-Highly significant.*

*Source: Analysis based on Market survey data, AICSIP / NRCS, Hyderabad 2007-08*

# 8. Special projects at NRCS and their progress during 2007-08

*Compiled by Venkatesh Bhat and KBRS Visarada*

**(Please note: NAIP Project on *"Creation for Demand for Millet Foods through PCS Value-chain"* covered in next article in detail)**

## A. Sweet Sorghum

| **1. Value chain model for bio-ethanol production from sweet sorghum in rainfed areas through collective action and partnership (NAIP project led by ICRISAT)** | |
|---|---|
| **Funding source** | NAIP |
| **Budget** | 108.9 Lakhs |
| **PI** | Dr. SS Rao |
| **Associates** | Dr Umakanth, Dr Dayakar, Dr. Shyam Prasad |
| **Duration** | 4.5 years (2007-2012) |

**Objectives**

1. Assess economic and environmental viability, enabling policies and institutions for promoting cultivation of sweet sorghum for bio-ethanol production and its impact on environment, rural incomes, livelihoods and social capital development.
2. Develop and establish pilot-scale Public Private People Partnership (PPPPs) value chain bio-ethanol enterprise models through "Seed-to-Tank" approach encompassing sweet sorghum production, processing, value addition, marketing and protecting environment.
3. Farmers' participatory multilocation testing of the improved biomass (stalks and grain) and juice yielding sweet sorghum cultivars under on-farm situations and development of production and seed systems in the targeted area.
4. Fine-tuning of package of practices for increased harvest window, mechanization and development of protocols for by-product utilization.
5. Capacity building and skill development of all the stakeholders including rural communities in the enhanced sweet sorghum production and value chain for bio-ethanol production.

**Progress so far**

1. The project is has just begun in January 2008
2. All partners met at ICRISAT on 17-18 ,January 2008 and finalized the work program for the year 2008
3. Recruitment of RAs and SRFs completed
4. Experiments of on-farm seed production in progress
5. 200 abstracts on sweet sorghum collected

| 2. Development of an Appropriate Technology for Efficient conversion of Sweet sorghum Bagasse to Ethanol Phase I: Optimization of hemicellulose fractionation and hydrolysate fermentation (DBT Project led by TERI) | |
|---|---|
| **Funding source** | DBT |
| **Budget** | 14.12 Lakhs |
| **PI** | Dr. SS RAO |
| **Associates**<br>**Collaborators** | Dr CV Ratnavathi<br>TERI and Praj Industries |
| **Duration** | 3 years (2007-2010) |
| **Objectives** | |
| 1. Understand and characterize sweet sorghum bagasse feedstock for maximum ethanol production<br>2. Optimization of process parameters for conversion of hemicellulose derived pentose sugars to ethanol by isolated microorganism(s) | |
| **Progress so far** | |
| • The project is has just begun in December 2007<br>• Work planning meeting was finalized in October 2007, New Delhi<br>• Recruitment of JRF completed<br>• Bagasse of 20 sweet sorghum genotypes prepared for compositional analysis<br>• Relevant literature search on the project collected | |

## B. Marker-assisted selection

| 3. Mapping QTLs associated with traits determining tolerance to rabi root and stalk rots, and terminal drought | |
|---|---|
| **Funding source** | **AP-Cess, ICAR** |
| **Budget** | Rs. 8.15 lakhs |
| **PI** | Dr. R Madhusudhana |
| **Associates** | Dr. IK Das, Dr. Prabhakar |
| **Duration** | 3 years (2005-2008) |
| **Objectives** | |
| 1. To develop a linkage map of sorghum using available RILs, and develop additional populations based on parental screening for appropriate traits.<br>2. To identify QTLs associated with root and stalk rots and terminal drought tolerance in sorghum. | |
| **Progress so far** | |
| 1. Designed and synthesized 110 new PCR-based primer pairs for use in genetic mapping<br>2. Linkage map constructed with 137 SSR and 3 morphological markers<br>3. New F6 mapping population for charcoal rot tolerance [CSV216R(S) x B35 (R)] with 400 RILs developed<br>4. Mapping population with 517 $F_5$ RILs of M35 x B35 has been advanced to $F_7$.<br>5. QTLs identified for shoot fly tolerance traits | |

| 4. Mapping QTLs associated with traits determining terminal drought tolerance in |
|---|

| rabi sorghum | |
|---|---|
| **Funding source** | **DBT** |
| **Budget** | Rs.41.51 lakhs |
| **PI** | Dr. N Seetharama |
| **Associates** | Dr. R Madhusudhana, Dr. Prabhakar, Dr. IK Das and Dr. HS Talwar |
| **Duration** | 3 years (2005-2008) |

**Objectives**

1. To develop a new mapping population (M35-1 x B35- ~500 $F_6$ RILs) for staygreen trait using B35 as the donor
2. To develop genetic linkage map for the recombinant inbred population (M35-1 x B35) using SSR markers, and map the QTLs for component traits of terminal drought tolerance under stressed and non-stresses environments.
3. MAS for terminal drought tolerance in elite sorghum genotypes

**Progress so far**

- DNA extraction : Genomic DNA of 400 $F_7$ RILs extracted
- Parental polymorphism : Out of 380 SSRs tested, 180 SSRs (48%) were found to be polymorphic between the parents (M35-1 and B35)
- Genotyping with 190 RILs : A total of 73 SSRs were used to genotype 190 $F_7$ RIL progeny, and linkage map constructed with 55 SSR markers (19 on SBI-01, 13 on SBI-02, 9 on SBI-03, 4 on SBI-04, 0 on SBI-05, 0 on SBI-06, 3 on SBI-07, 2 on SBI-08, 2 on SBI-09 and 3 on SBI-10).
- QTL identification: Identified staygreen QTLs StgA, Stg1, Stg3 and A2 in the present population M35-1 x B35 which were reported earlier involving B35 and E36-1 staygreen donors. Also identified QTLs for plant height, green fodder yield, panicle branches, no. of nodes per panicle and stover ash content.

| **5. Development of lines tolerant to salinity and identification of associated molecular markers in Oats (DBT project led by IGFRI)** | |
|---|---|
| **Funding source** | DBT |
| **Budget** | Rs. 15.8 lakhs (for NRCS) |
| **PI** | Dr. HS Talwar |
| **Collaborators** | Drs. AK Roy (IGFRI, Jhansi), RN Arora and AS Nandwal (HAU, Hisar) |
| **Duration** | 3 years (2007-2010) |
| **Objectives** | |

1. To characterize the parents and progenies for level of tolerance in forage oats
2. To study the genetical and physiological mechanism associated with tolerance
3. To identify putative markers (EST- SSR and RAPD) associated with salinity tolerance in different lines/ progenies of *Avena sativa* as well as gene expression profiling study

**Progress so far**

- A set of parental lines are being screened under salinity conditions at 3 centres.

| **6. Identification of QTLs for the genetic improvement of stover quality and resistance** |
|---|

| to foliar diseases in dual purpose sorghum | |
|---|---|
| **Funding source** | **DBT** |
| **Budget** | Rs. 41.6 lakhs (for NRCS) |
| **PI** | Dr. B Venkatesh Bhat |
| **Associates** | Drs. R Madhusudhana and AV Umakanth |
| **Collaborators** | Drs. GP Shukla and Sultan Singh of IGFRI, Jhansi; K Mathur of MPUAT, Udaipur |
| **Duration** | 3 years (2007-2010) |

**Objectives**

1. To develop mapping population for stover quality (*in vitro* digestibility, protein content and stem sugar content) and resistance to foliar diseases (leaf blight and anthracnose) in dual purpose sorghum.
2. To saturate the probable linkage group regions using candidate-gene approach for traits of interest
3. To identify quantitative trait loci linked to stover quality and resistance to foliar diseases

**Progress so far**

- A set of parental lines identified for developing the mapping population
- Parental lines raised for making crosses

## C. Transgenics

| 7. Development of Stem Borer and shoot fly Resistant Transgenic Sorghum | |
|---|---|
| **Funding source** | **ICAR Network - transgenics** |
| **Budget** | Rs 84.00/- lakhs |
| **PI** | Dr KBRS Visarada |
| **Associates** | Dr PG Padmaja, Mr D Balakrishna |
| **Duration** | Oct 2005- Mar 2012 |

**Objectives**

- Production of 200 more transgenic plants with different *Bt* genes
- Assessment of gene integration and copy number through Southern analysis
- Qualitative and quantitative expression of the Bt gene in $T_2$, and $T_3$ progeny plants by Western blotting and ELISA
- Bioassays/ Phenotyping under containment conditions (Lab/ Glasshouse)
- Dosage response curves for stemborer and shoot fly
- Advancing the promising plants to $T_2$ and $T_3$ generations by keeping a close track with molecular data.
- Strip trials and MLRT for transgenic event evaluation
- Biosafety assessment tests for *cry1Aa* and *cry1B* (to be done outside)
- Backcrossing and testing heterotic combinations to develop a promising and viable transgenic product
- Transgene pyramiding

**Progress so far**

- A total of 48 transgenic plants were produced so far. (CS3541 with *cry1Aa* - 6 plants, 296B with *cry1Aa* - 3 plants, 296B with *cry1B* – 5 plants, C43 with *cry1B* -26 plants, 27B with *cry1B* -8 plants)
- 20 more transgenic plants in 296B with Bt *cry1Aa* and *Cry1Ac* are in pipeline.
- PCR analysis confirmed 6 plants in CS3541 (*cry1Aa*) and 3 plants in 296B (*cry1Aa)* and 1 plant in 27B

(*cry1B*).

- $T_1$ generation plants ( 41 plants)) from 1 event (117) in the genotype 296B and 5 events (106, 107, 109, 110 &111) in CS3541 are grown and evaluated by PCR. 17 plants were positive. Southern for gene integration and copy number in progress

| **8. Development of transgenic sorghum for improved salinity tolerance** | |
|---|---|
| **Funding source** | **DBT** |
| **Budget** | Rs. 20.07 lakhs |
| **PI** | D. Balakrishna |
| **Associates** | N. Seetharama |
| **Duration** | 3 years (29.03.2005 to 31.3.2008) |

**Objectives**

1. Genetic transformation of sorghum with the gene for salinity (*PcSrp*) employing through particle bombardment / *Agrobacterium* mediated transformation methods
2. Molecular analysis of transgenics and their evaluation for salinity tolerance

**Progress so far**

- Selection and plant regeneration: A total of 74 NaCl resistant putative transgenic plants were regenerated from bombarded shoot apices of sorghum genotype M35-1 with *PcSrp* gene for salinity tolerance.
- PCR analysis of sorghum transgenic plants: Thirty two $T_0$ plants were found to be positive out of fifty two plants tested for amplification of 836 bp fragment of the *PcSrp* gene
- Southern analysis of sorghum putative transgenic plants: A total of plants exhibited a hybridization band of 1.2 Kb, indicated the stable integration of the *PcSrp* gene in sorghum genome.
- Analysis of T1 transgenic plants for salinity tolerance: The seeds obtained from 15 $T_0$ transformants were subjected to NaCl stress at 200 mM at the germination stage. Seven events showed germination percentage to fit to 3:1 ration. Whereas, the non-transformed control seed failed to germinate in 200 mM NaCl
- *Agrobacterium* mediated transformation: A total of 1000 infected shoot tips of 296B and CS3541 sorghum genotypes were in regeneration medium with phosphinothricin.

| **9. Enhancing tolerance of sorghum to abiotic stress through Agrobacterium - mediated transformation (APNL project led by CRIDA)** | |
|---|---|
| **Funding source** | **Andhra Pradesh – Netherlands Biotechnology programme** I |
| **Budget** | Rs. 2.25 lakhs / year for the NRCS |
| **PI** | Dr. SV Rao |
| **Collaborator** | Dr. (Mrs) M Maheswari, CRIDA, Hyderabad |
| **Duration** | October 2001 to November, 2007 (Requested for extension) |

**Objectives**

1. Producing transgenics using the *mtlD* gene construct in sorghum using Agro infection method.
2. Testing the transgenics by PCR and other molecular methods. Segregation analysis

**Progress so far**

1. In experiments on molecular evaluation of plants with *mtlD* gene, when DNA for all 26 plants were isolated and analyzed by PCR nine plants were conformed.
2. In the salt ( NaCl) tolerance tests T1 plants of 21 events were evaluated and for each event 15-20

seeds were used. 300 plants were identified to be positive / resistant in events which are PCR positive.
3. In the hygromycin tolerance tests Plants from 15 events were evaluated 40 Plants were tested positive.
4. Protocols for non -radioactive southern (M/s amersham's alkaphos CDP star) was standardized using plasmid construct pCAMBIA 1305.1. In T2 generation of event numbers 6 and 12 , three plants have shown southern positive.
5. In the events using SPV 462 explants, of six events, three have tested PCR positive.

| **10. Evolving transgenic sorghum for resistance to stem borer with suitable Bt gene constructs** | |
|---|---|
| **Funding source** | **APNL Biotechnology program** |
| **Budget** | Rs 34.88/- lakhs |
| **PI** | Dr KBRS Visarada |
| **Associates** | Dr PG Padmaja |
| **Duration** | Feb 2004 – Aug 2007 |

**Objectives**

1. Production of *Bt* transgenic plants in sorghum using elite parental lines/varieties of India.
2. Introduction of Bt genes *Cry1Aa* and *Cry1B* to impart resistance against stemborer
3. Molecular evaluation and confirmation of Bt protein expression in leaf tissues.
4. Insect bioassays

**Progress so far**

1. A total of 15 transgenic plants were generated in the 2 parental lines, CS3541 and 296B of Sorghum.
2. Among them 14 events carry *Bt cry1B* gene while one event has *Bt cry1Aa* gene.
3. All the events were confirmed for gene integration. Four events were identified for Single copy integration.
4. Expression of Bt protein in fresh leaves was confirmed in all the events by Western blotting.
5. Levels of Bt protein were estimated through ELISA at 25-30d and 40-50 d of plant growth stage. They ranged from 35 -500 ng/1g fresh leaf tissue.
6. Detailed phenotyping of insect bioassays was done in terms of leaf damage, larval survival and number of plants without deadheart formation.
7. Twelve events were promising in terms of insect bioassays and *Bt* protein expression.
8. Applied for seeking permission from RCGM to conduct Strip trials.

| **11. Development of low-HCN accumulating sorghum using anti -sense approach** | |
|---|---|
| **Funding source** | **DBT** |
| **Budget** | Rs. 17.66 lakhs |
| **PI** | Dr. B Venkatesh Bhat |
| **Duration** | 3 years (2005-2008) |

**Objectives**

1. To develop anti-sense construct for the cytochrome P450 CYP79A1 gene involved in the cyanogenic dhurrin pathway of sorghum.
2. To develop transgenic forage sorghum with the antisense constructs

| Progress so far |
|---|
| 1. The gene CYP79A1 was isolated by RT-PCR (cDNA) approach and further cloned into plant transformation vector pJS108 plasmid in anti-sense orientation.<br>2. Genetic transformation of sorghum using the anti-sense construct and regeneration of transgenics done<br>3. 65 transgenics regenerated and 27 of them confirmed by PCR and 10 by Southern<br>4. Substantially Lower HCN levels in $T_0$ plants (17 ppm to 178 ppm) compared to (control 192±2.2 ppm) |

## D. Food safety

| 12. Prevention and management of mycotoxins in commercially important agricultural commodities | |
|---|---|
| **Funding source** | ICAR |
| **Budget** | Rs.35.45 lakhs |
| **PI** | Dr. C.V. Ratnavathi (for Sorghum) |
| **Associates** | Dr. Y.D. Narayana, UAS, Dharwad<br>Dr. I.K.Das, NRCS, Hyderabad |
| **Duration** | 3 years (January, 2005 -January, 2008) |
| **Objectives** | |
| 1. To determine mycotoxin levels in samples in different stages of production and marketing<br>2. To prevent preharvest mycotoxin contamination through management options that include screening of genotypes with good tolerance and post harvest management techniques.<br>3. To develop a repository of isolates of fungus (*Fusarium* and *Aspergillus*)<br>4. To characterize mechanism of resistance to prevent mycotoxin contamination in sorghum. | |
| **Progress so far** | |
| • Incidence of *Fusarium* is more in grain mold affected sorghum and it is a preharvest infection<br>• *Aspergillus* occurrence is during storage and it is a post harvest infection<br>• Fumonisin contamination is more compared to aflatoxin and ochratoxin A<br>• Most of the sorghum samples are safer for consumption in terms of mycotoxicity and a very few samples are severely contaminated<br>• Samples collected from feed unit are free from toxin where as samples from brewery are toxic<br>• Post harvest management techniques like pearling of molded grain removed mycotoxins completely.<br>• Among the *Aspergillus* and *Fusarium* strains isolated from sorghum both nontoxic and highly toxic strains were present<br>• No correlation was found between grain mold score and mycotoxin contamination<br>• Significant variation for mechanism of infection was observed in toxic isolates of *Aspergillus*<br>• *Bacillus* and *pseudomonas* strains were found to be having inhibitory effect against fumonisin production and contamination<br>• No fumonisin was detected in bio-agent (Rhizobacter) treated grains as compared to 8.0 ppb fumonisin detected on untreated grains | |

## E. Basic and strategic research

| 13. Induction of apomixis insorghum by down-regulation of somatic –embryogenesis-receptor-kinase (SERK) gene in the ovules | |
|---|---|
| **Funding source** | **National Fund for Basic and Strategic Research in Agriculture (NFBSRA)** |

| | |
|---|---|
| **Budget** | Rs. 87.67 lakhs (for NRCS) |
| **PI** | Dr. B Venkatesh Bhat |
| **Collaborators** | Drs. Imran Siddiqi of CCMB, Hyderabad; Vishnu Bhat of DU, Delhi |
| **Duration** | 5 years (2007-2012) |

**Objectives**

1. Isolation and characterization of S*ERK* gene in sorghum
2. Isolation of ovule specific promoter from sorghum or other species and the analysis of its expression in sorghum
3. Development of transgenic sorghum plants with reduced expression of SERK gene in ovules using RNA interference
4. Analysis of elements of apomixis induced and seed development in the SERK -down regulated transgenic plants

**Progress so far**

- SERK genes in sorghum cloned
- Ovule specific promoter isolated in Arabidopsis

## F. GoI supported activities
### (Extension, Implementation of IPR and seed production)

| **14. Frontline demonstration** | |
|---|---|
| **Funding source** | **MOA** |
| **Budget** | 36.00 Lakhs |
| **PI** | Dr. Chari Appaji |
| **Associates** | - |
| **Duration** | Continuous since 1996 |

**Objectives**

- To demonstrate the production potentials of the recently recommended crops varieties and package of practices to the farmers and also the extension agencies for the rapid transfer of technology, production and productivity.
- Analyzing the production constraints
- Assessing the performance of the technologies under the socio-economic conditions of the farmers.

**Progress so far**

1. During kharif 400 ha FLD involving 527 farmers
2. For the first time , IGFRI Jhansi, involved in the programme.
3. Organized farmers day/ Krishi diwas in UP, Rajasthan. AP, MP, Parbhani, Coimbatore, Dharwad, Ranchi for exposing farmers, extension officials etc, to new cultivars (CSV 20- SPV 1616) being demonstrated.
4. Preference to dual purpose cultivars in Jharkhand and J&K and early maturing cultivars given by farmers of Bundelkhand region
5. Organized 600 ha FLD during rabi season, involving about 856 farmers.

| **15. Preparation of plant variety protection and DUS testing through ICAR – SAU system** | |
|---|---|
| **Funding source** | **DAC, MOA, Govt. of India.** |
| **Budget** | 41.5 lakhs |
| **PI** | Dr. S Audilakshmi (2003-04 to 2004-05)<br>Dr. N Kannababu (2005-06 to 2006-07) |
| **Associates** | Dr. VA Tonapi |
| **Duration** | 2003-04 to 2006-07 (4 years) |

**Objectives**

1. Developing national test guidelines for 2003-04 only.
2. Equipping of designated centres for DUS testing and documentation
3. Digitization / database of extant notified varieties.

**Progress so far**

- Revised the guidelines for DUS testing on sorghum: The revised 'DUS test guidelines for sorghum' (with 33 characteristics) were published by NRCS during November 2006. Again, the latest guidelines (with 33 characteristics) submitted to PPV&FRA were further corrected by the 'Task Force (1 / 2005)' and published by the Authority during February 2007.
- DUS characterization at NRCS, Hyderabad (as per the latest DUS test guidelines published by PPV& FRA): During Kharif 2006, the observations were recorded with 66 Kharif entries for 33 characteristics and were grouped under different states of characteristics. During Rabi 2006-07, the observations were recorded with 23 Rabi entries for 33 characteristics and were grouped under different states of characteristics. During Kharif 2007, the observations were recorded with 77 Kharif entries for 33 characteristics and were grouped under different states of characteristics. During Rabi 2007-08, the observations are being recorded for 33 characteristics.
- Coordination of DUS trials at Rahuri, Hisar & Pantnagar centres: Coordinated and monitored the DUS trials during Kharif & Rabi seasons GBPUA&T, Pantnagar, CCS HAU, Hisar and MPKV, Rahuri centres.
- Training programmes on 'Sorghum DUS Testing': Two training program on sorghum DUS testing were organized during 2005 & 2006 with an objective to make the sorghum researchers aware of IPR and DUS testing protocols and to train them on recording of DUS observations, and to demonstrate the example varieties for the trait and sub-traits.
- Seed multiplication of DUS example varieties (30 nos.) Seed multiplication block of 30 example varieties as per the DUS test guidelines were sown at NRCS during I week of November 2007.

| **16. Mega seed project** | |
|---|---|
| **Funding source** | **ICAR** |
| **Budget** | 3.5 lakhs (revolving fund) |
| **PI** | Dr. Vilas A Tonapi |
| **Duration** | ongoing |
| **Objectives** | |
| To produce nucleus, breeder, foundation and certified seeds of new and popular kharif and rabi hybrids and varieties for their spread across sorghum growing states in India to increase the seed replacement ratio | |
| **Progress** | |
| • During 2007-08, 50 tons of seed was produced and sold. Similar target is also fixed for 2007-08.<br>• During 2006-07, Rs. 8.5 lakhs income was generated | |

| **17. National Seed Project (crops)** | |
|---|---|
| **Funding source** | **ICAR** |
| **Budget** | 2.7 lakhs (Recurring contingencies only) |
| **PI** | Dr. N Kannababu (2002-03 to 2006-07) |
| **Associates** | Dr. VA Tonapi |
| **Duration** | 2002-03 to 2006-07(5 years) |
| **Objectives** | Nucleus and Breeder seed production of sorghum |
| **Progress so far** | |

- Breeder seed production: During X plan, the 'seed systems' were developed at NRCS for smooth functioning of production, purity testing, storage and distribution of breeder seed. There was surplus production of allocated breeder seed lines at NRCS during X plan (2002-03 to 2006-07).
- The BSP programme as per BSP-I targets was organized at different field isolations and activities as per calendar were performed. The genetic purity of the breeder seed produced at NRCS was confirmed by conducting grow-out tests every year.
- NRCS has single window system for breeder seed production / distribution. NRCS supplies the breeder seed to the indenting public seed corporations, private companies and seed producers as per the uniform prices fixed by ICAR/NRCS.
- Efforts were made to utilize the profits for developmental works related to breeder seed production.
- Nucleus seed production: Published the guidelines for 'nucleus seed production in sorghum' and streamlined the activities for functioning of nucleus seed production of sorghum varieties and parental lines in national program and also at NRCS.
- Seed Days: The seed days were organized for the participants from public & private seed industry, seed growers, farmers including women, officers (Agriculture & Extension), students and scientists of various disciplines including media.
- Coordination of BSP program at AICSIP centres

# 9. NAIP- supported special project by NRCS-lead consortium

| | | |
|---|---|---|
| Title of Proposal | : | **Creation of demand for millet foods through PCS value-chain** |
| Component Code | : | **II** |
| Name of the Consortium Leader: | | **Dr N Seetharama, Director, NRCS, Hyderabad** |
| Name of CPI | : | **Dr B Dayakar Rao** |
| Institution | : | **National Research Centre for Sorghum (NRCS)** |
| Mailing Address | : | **Senior Economist, NRCS, Rajendranagar, Hyderabad, 500 030 (AP)**<br>Telephone No: **040-24015349**<br>Fax No. **040-24016378**<br>Email: **dayakar@nrcsorghum.res.in** |
| Consortium Partners | : | **1.** Dr. MP Rajendra Prasad, **National Institute of Nutrition (NIN), Hyderabad.**<br>2. K Nirmal Reddy **ITC Limited, International (Business) Division, Secunderabad.**<br>**3.** Dr Kamini Devi, **Acharya N.G. Ranga Agricultural University, (ANGRAU), Hyderabad.** |
| Associate Partners | : | **Public institutions:**<br>1. Panchayat Raj of Govt. of AP (APARD)<br>2. CFTRI, Hyderabad<br>3. CIPHET, Ludhiana<br>4. CIAE, Bhopal<br>**Private partners:**<br>1. Snaffy Foods, Hyderabad<br>2. Sunera Foods, Kolkatta<br>3. Rahul malts, Jaipur<br>4. Agarkar Research Institute, Pune<br>5. NCDEX, Mumbai; & other need based members for specific task and period.<br>**NGOs:**<br>1. RDS (NGO), Mahabubnagar<br>**Financial institutes:**<br>1. State Banks |
| Date of Start | : | **20 December 2007** |
| Duration | : | **4.5 years** |
| **Fund Requirement** | **:** | **5.80 Crores** |

**Background:** In India, millets {small-grained cereals like sorghum (jowar), pearl millet (bajra) and finger millet (ragi)} are grown on about 20 million ha with annual production of 18 million tonnes. Millets contribute ~ 10% to the country's food grain basket supporting specially ~12 million people who belong to either rural poor, or urban vulnerable groups. Millets are adapted to low or no purchased inputs and to harsh environments of the semi-arid tropics (SAT), and therefore forms the backbone of dryland agriculture.

In the wake of disincentives resulting from PDS for fine cereals at very low cost to consumers, and other practices, it has become necessary for reorientation of R&D efforts on millets to generate demand through value-addition of processed foods, feed and industrial products. To augment such efforts, *"production to consumption system"* (PCS) models for specific products and markets are needed. The present proposal focuses on such an effort focusing on selected millet foods led by NRCS (ICAR) as a lead consortium.

**Objectives:** The five objectives framed to be accomplished are:

1. To enable market-driven millets production for specific end-uses, procurement and primary processing for continuous supply-chain management.
2. Fine-tuning of the technologies for development of millet food products and upscaling.
3. Testing for nutritional evaluation and safety of selected millet foods.
4. Assessing consumer acceptability, price and market strategies, and social and policy imperatives.
5. Developing entrepreneurship and appropriate strategies to promote and popularize millets for commercialization through value-addition and branding as health foods.

**Brief project description of consortium partners and their roles:** The proposed project "Creation of demand for millet foods through PCS value-chain" will be undertaken by National Research Centre for Sorghum, Hyderabad (lead centre) and three partners, NIN and ANGRAU (government institutions) and ITC (private sector). Panchayat Raj Institutions (role: training of trainers), CFTRI, Hyderabad (role: processing technologies), PDP, Hyderabad, NIANP, Bangalore, NCDEX (marketing), RDS- an NGOs (mid-day meals), SHG's, entrepreneurs such as Sunera foods, Kolkata (role: gluten-free) and Snaffy foods, Hyderabad (multi-grain *rotis*), small-scale processors will be involved as associate partners/stakeholders in this project.

**Roles of partners:** A comprehensive methodology is worked out to achieve all above mentioned objectives. The lead centre NRCS, apart from planning, coordinating and monitoring of all activities of the project, will undertake research on identification of suitable genotypes, R&D on enhancing shelf-life of grain as well as processed products, antioxidants, development and fine-tuning of sorghum food products. It will help in coalition-building and establishing linkages among the various stakeholders and institutions for enabling PCS value-chain on millet foods. NRCS will work on development, marketing and popularization of multi-grain products. Further, our partner, ITC will facilitate on-farm production of sorghum offering buyback assurance. Along with NRCS they will also undertake integrated extension services and the procurement and aggregation of farm produce. They will also conduct extensive market survey (through marketing consultants) for assessing the market potential and consumer acceptability of the on-shelf processed millet food products. NIN (will evaluate the nutrient composition of millet foods based on metabolic and organoleptic studies. They will also assess the effect of dietary intake of millet foods on obese, diabetic and other social group consumers. ANGRAU, Hyderabad will concentrate on the development of food products of pearl millet and their popularization and marketing. They will also handle the primary processing aspects of sorghum grain with the help of their associate, AICRP on post-harvest unit, Hyderabad.

Most of the model framework for revival of millet economy-based on promotion as health and convenient food will be carried out using sorghum so that the same can be extended to other millets later. Limited demonstration of pearl millet will also be dealt with, but emphasis will be on multi-grain, value-added convenient and commercially viable foods.

The total budgetary outlay for this venture is Rs 5.80 Crores excluding salary component of temporary employees in all institutes. Thus the model developed under NAIP will stimulate similar endeavors at other stations, especially where AICSIP centres are located, and to promote pro-poor dryland farmers interests, while simultaneously benefiting society at large exposing the varied benefits of millets.

**Project location and jurisdiction:** Actual farm production for specific end-products will be undertaken in contiguous area between districts of Adilabad and Nizamabad (AP) for kharif sorghum and Parbhani and Solapur (Maharashtra) for rabi sorghum. Adilabad is highest kharif growing district

in AP while Solapur has highest rabi area in the country. The contiguous region between two districts is chosen as the ITC *e-choupal* network and infrastructure is already available for testing a model where sorghum production is assured market buy-back and end product specific production.

**Table 1. Development and fine-tuning of proposed processed products**

| S No. | Product | Sorghum | Pearl millet |
|---|---|---|---|
| 1 | Rawa | v | X |
| 2 | Flakes | v | X |
| 3 | Extruded products | v | X |
| 4 | Flour | X | v |
| 5 | Multi-grain* | v | v |
| 6 | Gluten-free | v | X |
| 7 | Malt | v | X |

**Millets, wheat, soy bean etc.,*

## List of innovations

1. Deviation from commodity-based, on-farm production to market-driven end-product specific farm production and market assurance to the millet farmers through buy-back facilitation.
2. Ready-to-eat and convenient foods to overcome cumbersome and time-consuming food preparation of millets and branding them as health foods for value-addition through nutritional evaluation and certification, and implementation of HACCP.
3. Products for niche markets (existing) and non-conventional millet consuming areas (to be created).
4. Training to all the stakeholders through Panchayat Raj institutes such as APARD in AP as planned, and linking with other government schemes for Rural Development.
5. Innovative approaches for popularization such as establishment of millet dhaba, brand-ambassador, and millet tableaux for Republic day or Independence Day parade, and at important public places and functions.
6. New commercialization strategies such as floating proposed SPV with Sunera foods, Kolkatta for gluten-free and multi-grain up-marketing products, linking up with Snaffy foods, Hyderabad, for retail marketing of rotis with the help of large-scale roti making machine to be fabricated at NRCS.
7. Coalition building with other research and private groups working on millets elsewhere in the world through visits and conducting global conference on millets and newsletter.

## List of important deliverables and expected outcomes:

- Increased availability and use of technologies developed between consortium partners.
- Increased interaction between private and public sector for agriculture innovative proposes.
- One pilot model for value-chain on millet foods developed
- 500-1000 farmers brought under market assured model of on farm production with buy back and public private partnership (PPP) model for holistic farm extension services enabled.
- Value realization to all the stakeholders through enabling value-chain in terms of income enhancement, nutritional enhancement and employment generation.
- Higher millets consumption levels either through direct food or value-added nutritious processed foods.
- New entrepreneurs for rural industries empowered in commercial millet foods production.
- Continuous supply-chain management model for millet foods enabled.
- Branding of millets based on nutritional certification for normal, obese and diabetic groups.
- Stakeholders' empowerment through increased incomes & employment generation through post harvest activity clusters.
- 1000 people at different levels (farmers, development agents, industry) for helping millets food products development.

# Biotechnology

## 10. Marker-assisted improvement of sorghum - Progress of work at NRCS and collaborating institutions

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*NRCS, AICSIP and UAS (B)*

Sorghum is considered as an excellent model crop to study genetic, biochemical and physiological mechanisms due its higher and wider adaptation to harsh environments, tolerance of stress conditions, its rich genetic diversity and its small genome size (~750 Mb). Despite its late start compared to other cereals, the sorghum genomic research has made very significant advancements in the recent past. Sorghum will be the second cereal after rice whose complete genome sequence will be published soon (http://www.phytozome.net).

Sorghum research under AICSIP umbrella has resulted in the development and release of many high yielding cultivars in the country. However, most of them are highly susceptible to biotic (Insects: shoot fly, stem borer, aphids, head bugs; Diseases: grain mold, foliar diseases, charcoal rot, ergot) and abiotic stresses (susceptibility to terminal drought, and cold). There are several factors associated with each of the resistance mechanisms to these biotic and abiotic stresses. Each factor is inherited polygenically involving many resistance mechanisms with different genetic control interacting with various environmental factors. Thus, breeding to improve resistance against these stresses in sorghum is very complex. Conventional breeding approaches are successful to a limited extent only; the process of crop improvement can be hastened only with the combination of conventional and novel molecular breeding methods, for which development and application of tools of molecular biology are very imminent for this dry land crop.

Sorghum is rich in diverse germplasm. Against all the stresses, suitable genetic resistance sources are available to ameliorate the problems, provided new molecular technologies are applied on a large scale. Use of molecular marker techniques, helps us in combining different mechanisms of resistance to increase the level of resistance in the high-yielding progenies. Molecular markers increase the selection efficiency and improve the chances of obtaining lines with increased level of resistance.

The status of work being done at various AICSIP centers with respect to population development, QTL mapping, marker-assisted selection etc., is summarized below.

**I. Mapping populations, QTL identification:** At NRCS, the application of molecular tools to improve sorghum has started in the recent past. It started with the objective of developing various mapping populations to identify the gene/s (QTLs) associated with the component traits of resistance mechanisms. The work on identifying QTLs to shoot fly, foliar diseases, drought also progressed with various mapping populations and the results of the experiments are summarized below.

**Developed and maintained following mapping populations**

| S. No | Trait | Cross used | RILs | Stage |
|---|---|---|---|---|
| 1 | Shoot fly | 296B x IS18551 | 350 | $F_{10}$ |
| 2 | Shoot fly | 27B x IS2122 | 434 | $F_7$ |
| 3 | Grain mold | 296B x B58586 | 223 | $F_7$ |
| 4 | Rabi traits, drought | M35-1 x B35 | 500 | $F_8$ |
| 5 | Rabi traits, drought, charcoal rot | CSV216R x B35 | 400 | $F_7$ |
| 6 | Staygreen, striga, charcoal rot | N13 x E36-1 | 221 | $F_8$ |
| 7 | Staygreen, striga, charcoal rot | IS9830 x E36-1 | 223 | $F_8$ |
| 8 | Stem borer | SSV84 x IS2205 | 250 | $F_3$ |
| 9 | Foliar diseases | IS10284 x IS26866 | 250 | $F_3$ |
| 10 | Ergot | CS3541 x IS8525 | 250 | $F_3$ |
| 11 | Stover quality | SPV1616 x PC5 | 250 | F3 |
| 12 | Stalk sugar | BJ248 x 27B | 250 | F3 |

a. Genetic linkage maps of shoot fly mapping population (296B x IS18551: with 142 SSRs) and drought population (M35-1 x B35 with 55 SSRs) have been constructed.

b. Mapped QTLs for component traits of shoot fly tolerance (leaf glossiness, seedling vigour, ovipositional non-preference, deadhearts, trichome density). The genomic regions on sorghum LG SBI-10 between flanking markers Xcup16-Trit found to be significantly associated with ovipositional non-preference, deadhearts and trichome density, and on LG SBI-05 between Xtxp65-Xtxp30 for glossiness. These QTL regions are the targets for marker-assisted introgression to improve the shoot fly tolerance in elite sorghum genotypes.

c. Putative map position of fertility restoration gene (*Rf1*) identified on to LG SBI-04 near to SSR marker Sdre95 at 6 cM using 296B x IS18551 RIL based hybrids. This needs to be confirmed in a $F_2$ population using BSA approach for its routine use in categorizing sorghum breeding lines into B and R lines.

d. Map position of genes for morphological traits viz., plant color, glume cover, midrib type identified on to the sorghum LG SBI-06.

e. Identified genomic region on SBI-06 between flanking markers Xtxp17- Plcor to harbor major genes significantly contributing to resistance for foliar diseases caused by different fungal diseases (leaf blight, target leaf spot, zonate leaf spot).

f. The genotype, IS18551 male parent of shoot fly mapping population (296B x IS18551) was found to be significantly different for its seedling traits (shoot length and seedling vigour index). Mapping QTL for these traits using the RIL population identified 5 QTLs for shoot length, and 2 for vigour index. One shoot length QTL between Xtxp92–Xtxp295 overlaps with QTL for plant height at maturity. This region has been reported to carry the dw3 gene for plant height in sorghum.

g. One consistent QTL for seed weight was identified between Xtxp343-Srrd100-2 with 4.40 LOD value explaining 12% of the phenotypic variation.

h. Use of bioinformatics tools at NRCS has lead to the development of different marker systems (EST-SSRs specific to drought and staygreen, genomic SSRs, retrotransposon RAPDs, cytoplasm markers) for their employment in gene tagging / QTL identification and marker-assisted breeding programmes.

| | Type of marker | Number |
|---|---|---|
| A | Drought related | Sdre 1-100 |
| B | Unigene based | Sues 1-50 |
| C | Staygreen based | Stg 1-50 |
| D | Plant height | Dw3 1-5 |
| E | Flowering and maturity | 1-7 |
| F | Brown midrib | Bmr 1-2 |
| G | Plant color | SM1-6 |
| H | Retro RAPD | Srrd 1-100 |
| I | CMS | SCMS1-40 |
| | Total | 360 |

i. Developed better SSR markers specific to stay green QTLs and validated their map positions.

j. Genetic diversity analysis through molecular markers using 48 rabi sorghum genotypes collected from various sorghum research stations indicated that most of the rabi sorghum genotypes are genetically related to M35-1, and much needed diversity for exploitation of heterosis for higher grain yields through hybrid is not available. However, few of the genotypes (PMS 20B, SB401B, R2191, B35) are genetically more diverse from rest of the rabi genotypes, and need to be exploited in hybrid development.

k. Identified QTLs for some of the agronomic traits (time to maturity, plant height, panicle weight and length, seed mass)

l. The QTLs reported for various traits in sorghum by different sorghum workers are summarized in Table 1.

**II. Marker-assisted improvement of elite sorghum parents:**

**Bijapur and Parbhani:** Using already available information in sorghum for QTLs for staygreen and shoot fly tolerance, marker-assisted introgression programme has been initiated to transfer both staygreen and shoot fly QTLs into rabi restorers (R354 and CSV216R) at RRS, Bijapur, and seed parents (116B, 104B, 107B, SPV 492, 20B, KR192 ) at MAU, Parbhani. Presently, at Bijapur, selected $BC_3F_1$ generation breeding material is being advanced to $BC_4F_1/BC_1F_4$ for restorer R354, while at MAU, Parbhani, 23$BC_2F_4$s and 34 $BC_2F_4$s of recurrent parents 20B and KR192 are available which were evaluated for shoot fly resistance at three locations (NRCS-Hyderabad, UAS-Dharwad, MAU-Parbhani) during late Kharif 2007 and three locations (NRCS-Hyderabad, RRS-Bijapur and MAU-Parbhani) in *rabi* 2007-08. Across locations, the MAS progenies of 20B *viz.*, MAS 1062-3 (QTL for trichome, *tr*), MAS 1076-1(three QTLs on *dhov+tr+gl*), and MAS 1261-3 (QTL *tr*) recorded lower infestation and were at par with resistant check IS18551 at 5%.

**NRCS:** Under this programme, improvement of popular Kharif seed parent 296B for shoot fly tolerance, and rabi cultivar M35-1 for staygreen trait were targeted through marker-assisted backcrossing using donor IS18551 (for shoot fly) and B35 (for staygreen). A total of 6 $BC_2F_1$s of ((296B x IS18551) x 296B) and 23 $BC_2F_1$s (((M35-1 x B35) x M35-1) x M35-1) were developed using 296B and M35-1 as recurrent parent. The material will be advanced to $BC_3F_1$s and $BC_2F_2$s and foreground and background selection will be done to identify the backcross progenies similar to the recurrent parents with introgressed genomic segment from the donor parents.

**III. Mapping QTLs for Charcoal rot tolerance:** At UAS, Dharwad, the work on mapping QTLs for charcoal rot resistance identified 2 QTLs for lodging percent, one each on linkage group D (Xtxp343-Xtxp12) & I (xtx1274-iabt29); 2 QTLs for length of infection on linkage group B (iabt-275-iabt214) and linkage group A (AC13-iabt234), and one QTL for number of nodes crossed by the rot on LG B (Xtxp279-iabt82).

**IV. QTLs for root morphology:** Joint efforts have been made by NRCS and UAS, Bangalore to identify QTLs associated with root morphology in sorghum. Initially during 2006, 129 sorghum accessions supplied by NRCS, Hyderabad were characterized for root morphological parameters at UAS, Bangalore using special phenotyping facility. From this study, , the genotypes BRJ356, RS29, Pusegaon, CSV15, RSSV-9, Khadaki, Maindargi have been found to be very promising based on the scoring of all the genotypes for various agronomic and root morphology traits. At present, 517 $F_7$RILs of the cross M35-1 x B35 supplied by NRCS have been characterized for their root morphology at UAS, Bangalore.

**V. QTLs for stover quality and foliar diseases:** To identify the QTL for the genetic improvement of stover quality and resistance to foliar diseases in dual-purpose sorghum, a DBT sponsored project has been initiated jointly between NRCS, MPUAT, Udaipur and IGFRI, Jhansi.

**VI. Drought screening:** Characterization of sorghum germplasm for drought tolerance is being done at TNAU, Coimbatore involving 1000 native germplasm. During the rabi season of 2007-08, a subset of selected 400 germplasm lines have been evaluated for their drought tolerance at CRS, Solapur.

**VII. Fingerprinting of sorghum varieties:** At NBPGR, New Delhi, DNA fingerprinting of 126 sorghum varieties has been done. This set contains 40 sorghum extant varieties and 86 other varieties. DNA profiling of these varieties has been completed using different marker systems viz., STMS/SSRs (65 genotypes), AFLPs (24 genotypes) and RAPDs (37 genotypes).

**VIII. Genotyping facility at ICRISAT:** Molecular markers increase the selection efficiency by predicting the plants phenotype. Effective and efficient plant breeding requires high-throughput allele identification at a cheaper rate for their routine use in marker-assisted breeding programmes. In this regard, NRCS is using the genotyping facility available at the Center of Excellence in Genomics (CEG) at ICRISAT which has been established with the financial support of the DBT. At present, a panel of 30 genotypes representing released cultivars, parental lines, potential genotypes are being DNA fingerprinted with 500 SSRs. It has also been envisaged to utilize this genotyping facility for various mapping populations. We are in the process of genotyping two large mapping populations developed to identify QTLs for drought and shoot fly tolerance.

**IX. MAS Training:** Under the aegis of ICAR, a training programme on marker-assisted selection for crop improvement has been planned for scientists from various ICAR institutes at the Center of Excellence in Genomics, ICRISAT, Hyderabad. This training will provide hands-on opportunity to gain expertise in the use of molecular markers for their use in diversity analysis, linkage map construction, gene/QTL mapping and marker-assisted breeding. The course will also focus on the essentials of experimental design and data analysis components of molecular markers for their effective and efficient employment in breeding programmes.

**X. Sequenom platform:** Sequenom's MassARRAY® technology is one of the most robust methodologies available for DNA analysis. MassARRAY technology is recognized as an accurate method used for a number of other applications, including allele frequency analysis, quantitative gene expression, and SNP discovery and methylation studies. At NRCS, it is being contemplated to propose a joint public-private project to utilize the MassARRAY® techniques for various genomic applications for sorghum improvement.

**Table 1: Summary of Quantitative Trait Loci Studies in sorghum**

| Trait | No. of QTL | Phenotypic variation explained (%) | Effects of individual QTLs (Range, in %) | Number of linkage groups | Reference |
|---|---|---|---|---|---|
| Plant Height | 6 | 71.0 | | 5 | Lin *et al* (1995) |
| | 1 | 54.8 | | 1 | Lin *et al* (1995) |
| | 4 | 63.4 | 9.2-28.7 | 4; orthologous to maize | Pereira and Lee (1995) |
| | 2 | 67.3 | | | Rami *et al.* (1998) |
| | 2 | 29.6-35.0 | 11.8-17.8 | 2 | Klein *et al.* (2001b) |
| | 5 | 52.0-65.8 | 7.6-40.1 | 4 | Hart *et al.* (2001) |
| Tallest Basal tiller height | 2 | 29.9-30.5 | 10.2-19.7 | 2 | Hart *et al.* (2001) |
| Tiller Number | 4 | 23.7 | | | Paterson *et al.* (1995) |
| | 3 | 57.0-70.8 | 23.0-39.0 | 2 | Hart *et al.* (2001) |
| Tillers with heads | 4 | 48.9-86.3 | 9.7-48.7 | 3 | Hart *et al.* (2001) |
| Photoperiod | 8-10 | - | 13.6-18.0 | 3 | Chantereau *et al.* (2001) |
| Flowering | 3 | 85.7 | | | Lin *et al* (1995) |
| | 2 | 8.5-10.94 | 5-10 | 2 | Kebede *et al.* (2001) |
| Maturity | 2 | 57.0 | 17-40 | 2 | Crasta *et al.* (1999) |
| | 3 | 8.2-33.1 | 8.2-22.0 | | Hart *et al.* (2001) |
| Pre-flowering stress tolerance | 6 | 14.0-43.0 | | | Tuinstra *et al.* (1996) |
| | 4 | 25.7 | 11.9-22.2 | 3 | Kebede *et al.*(2001) |
| Stay Green (Post-flowering stress tolerance) | 6 | | 2 Major | 6 | Tuinstra *et al.* (1997) |
| | 7 | 63.0 | 3 major QTL- 42.0 4 minor QTL- 25.0 | 6 | Crasta *et al.*(1999) |
| | 2-3 | - | 10.3-15.3 | 3 | Tao *et al.* (2000) |
| | 4 | 30-46 | | 3 | Xu *et al.* (2000) |
| | 4 | 30-54 | 9.1-29.2 | 3; Confirm Xu *et al.* (2000) | Subudhi *et al.* (2000) |
| | 9 | 15.5-26.1 | 10.2-15.5 | 7; 3 QTL confirm earlier studies | Kebede *et al.*(2001) |
| | 5-8 | 31-42 | 5-26 | 8; 3 QTL consistent across genotypes & years | Haussmann *et al.* (2003) |
| Chlorophyll content | 3 | | 21-32 | 2; all coincide with 3 of 4 stay-green QTL | Xu *et al.* (2000) |
| Leaf angle | 3 | 35.8-64.5 | 7.4-45.3 | 3 | Hart *et al.* (2001) |
| Lodging tolerance | 3 | 17.8 | 14.6-19.1 | 3 | Kebede *et al.*(2001) |
| Striga resistance | 2-8 | 27-94 | 20-76 | 8 | Haussmann *et al.* (2003) |
| Molds during seed ger. (%) | 3 | 33.8 | | | Rami *et al.* (1998) |
| Molds after harvest | 1 | 28.3 | | | Rami *et al.* (1998) |

| Trait | No. of QTL | Phenotypic variation explained (%) | Effects of individual QTLs (Range, in %) | Number of linkage groups | Reference |
|---|---|---|---|---|---|
| Grain mold | 2 | 20.5 -37 | 10.0-23.6 | 2 | Klein *et al.* (2001b) |
| Anthracnose | 1 | 55.5 | 55.5 | 1 | Klein *et al.* (2001b) |
| Zonal leaf spot | 1 | 32.1 | 32.1 | 1 | Klein *et al.* (2001b) |
| Bacterial leaf stripe | 1 | 32.8 | 32.8 | 1 | Klein *et al.* (2001b) |
| Oval leaf spot | 1 | | | 1 | Klein *et al.* (2001b) |
| Rust resistance | 4 | | 6.8-42.6 | 4 | Tao *et al.* (1998) |
| Shootfly resistance | 8 | | 34-46.5 | 4 | Sajjanar (2002) |
| Midge resistance -antixenosis | 2 | 27.0 | 12.0-15.0 | 2 | Tao *et al.* (2003) |
| Midge resistance -antibiosis | 1 | 34.5 | 34.5 | 1 | Tao *et al.* (2003) |
| Green bug resistance & tolerance | 9 | 53-79 | 5.6-38.4 | 7 | Agrama *et al.* (2002) |
| Pre-harvest sprouting resistance | 2 | 83 | 53 | 2 | Lijavetzsky *et al.* (2000) |
| Panicle length | 6 | 70.0 | 9-25 | | Pereira *et al.*(1995) |
| | 4 | 54.1 | | | Rami *et al.* (1998) |
| | 3 | 20.6-31.6 | 8.6-20.6 | 3 | Hart *et al.* (2001) |
| Panicle compactness | 3 | 40.3 | | | Rami *et al.* (1998) |
| Panicle width | 7 | 47.9-85.9 | 9.5-32.9 | 5 | Hart *et al.* (2001) |
| Seed branch length | 5 | 69.0 | 8-37 | | Pereira *et al.*(1995) |
| Length of sterile portion of seed branch | 2 | 34.0 | 17 each | | Pereira *et al.*(1995) |
| Peduncle length | 2 | 32-44 | 10.9-32.7 | 2 | Klein *et al.* (2001b) |
| Peduncle diameter | 6 | 43.0 | 7-10 | | Pereira *et al.*(1995) |
| Awn length | 1 | 6.7 | 6.7 | 1 | Hart *et al.* (2001) |
| Number of seed branches/panicle | 3 | 30.0 | 9-14 | | Pereira *et al.*(1995) |
| Number of kernels/panicle | 1 | 12.3 | | 1 | Rami *et al.* (1998) |
| Kernel weight/panicle | 1 | 31.3 | | 1 | Rami *et al.* (1998) |
| Seed size | 9 | 51.7 | 5.3-11.9 | 8 | Paterson *et al.* (1995) |
| Seed number | 4 | 19.1 | 4.2-6.8 | 4 | Paterson *et al.* (1995) |
| 100-seed weight | 3 | 28.0 | 9-16 | | Pereira *et al.* (1995) |
| 1000-kernel weight | 1 | 35.2 | | 1 | Rami *et al.* (1998) |
| Threshing percentage | 1 | 15.3 | | 1 | Rami *et al.* (1998) |
| Dehulling yield (%) | 3 | 43.0 | | | Rami *et al.* (1998) |
| Kernel flouriness | 2 | 57.1 | | | Rami *et al.* (1998) |
| Kernel friability | 1 | 13.7 | | 1 | Rami *et al.* (1998) |
| Kernel hardness | 4 | 44.8 | | | Rami *et al.* (1998) |
| Amylose content (%) | 2 | 38.9 | | | Rami *et al.* (1998) |
| Protein content(%) | 2 | 26.0 | | | Rami *et al.* (1998) |
| Lipid content (%) | 1 | 14.7 | | 1 | Rami *et al.* (1998) |
| Germination rate | 2 | 43.0 | | | Rami *et al.* (1998) |
| Rhizomatousness | 3 | 21.8 | | | Paterson *et al.* (1995) |
| Ratooning ability | 6 | 29.9 | | | Paterson *et al.* (1995) |
| Grain mill hardness | 2 | 29.7 | 14.4-15.3 | 2 | Klein *et al.* (2001b) |
| Ergot infection | 5 | 46.94 | 5.50-11.41 | 5 | Parh *et al.* (2004) |
| Ergot-pollen quantity | 5 | 50.43 | 7.1-14.20 | 5 | Parh *et al.* (2004) |
| Ergot-pollen viability | 3 | 23.60 | 6.46-9.51 | 3 | Parh *et al.* (2004) |
| Glume cover | 3/2 | 35.9/24.2 | | 3 | Feltus *et al.* (2006) |
| Glume persistence | 2 | 34.4 | | 2 | Feltus *et al.* (2006) |
| Grain weight | 1/0 | 14.3 | | 1 | Feltus *et al.* (2006) |
| Head exsertion | 1 | 12.9 | | 1 | Feltus *et al.* (2006) |
| Head weight | 1/0 | 13.9 | | 1 | Feltus *et al.* (2006) |
| Height uniformity | 3/1 | 62.4/25.9 | | 4 | Feltus *et al.* (2006) |
| Kernel weight | 3 | 35.2 | | 8 | Feltus *et al.* (2006) |
| Leaf curve | 4/2 | 36.6/16.8 | | 4 | Feltus *et al.* (2006) |
| Leaf length | 3/2 | 26.3/17.8 | | 5 | Feltus *et al.* (2006) |
| Leaf pitch | 2/0 | 20.7 | | 2 | Feltus *et al.* (2006) |
| Leaf scorch | 1/0 | 8.5 | | 1 | Feltus *et al.* (2006) |
| Leaf senescence | 3/3 | 58.4/56.2 | | 4 | Feltus *et al.* (2006) |
| Leaf width | 2/2 | 29.0/18.8 | | 6 | Feltus *et al.* (2006) |
| Tiller height | 4 | 20.4 | | 3 | Feltus *et al.* (2006) |
| Cold tolerance (early season) | 2 | 21.0 | 9.4-11.5 | 2 | Knoll *et al.* (2007) |

# 11. Transgenic sorghum

***B Venkatesh Bhat, D Balakrishna, KBRS Visarada, PG Padmaja and N Seetharama***

*National Research Centre for Sorghum, Rajendranagar, Hyderabad*

Plant breeding allows the introduction of genes at existing loci, while the advances in plant genetic transformation enable the introduction of selective gene sequences at new loci. A new set of agronomically useful traits are thus introduced into crop gene pool to further develop transgenic crop varieties and products. After developing the transgenic plants, these putative transformants are confirmed for integration of the gene and number of copies through Southern blotting, while the qualitative and quantitative expression of the transgene are verified through Western blotting and ELISA.

Sorghum is considered recalcitrant for tissue culture and thereby for genetic transformation among cereals. Advances in transgenic technology of sorghum are low as compared to other cereals such as rice, maize and barley. Key factors that can be attributed are lack of model genotypes, low regeneration, rapid decline in regeneration after sub-culturing and low survival during hardening. Nevertheless, transgenic research in sorghum has picked up momentum worldwide in the past decade. Many organizations - both the public and private - are addressing the genetic transformation of sorghum for crop improvement sorghum in India because of the crop demand for multipurpose utilization nation wide.

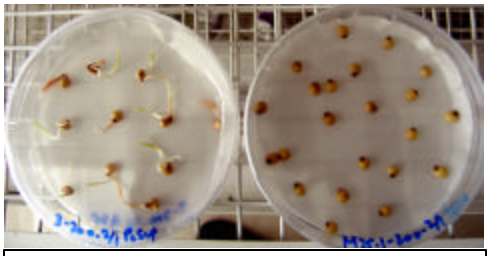
Particle bombardment and *Agrobacterium*-mediated method of gene introduction are successful in sorghum, however, with a low efficiency (0.1-5.0 %) compared to other cereals (>20%). A number of groups are working for crop improvement through transgenic technology at national (Table 1) as well as international level (Table 2). Sorghum is grown under low input conditions and development of host plant resistance is only the viable option to realize sustainable yields under low inputs. Introduction of traits through genetic transformation can help to build up resistance to various biotic and abiotic stresses and value addition (Tables 1 and 2). Transgenic technology thus can be extended as an important tool for addition of new genes from biological gene pool to sorghum gene pool and for supplementation of crop improvement programs.

**Table 1: Status of genetic transformation at NRCS**

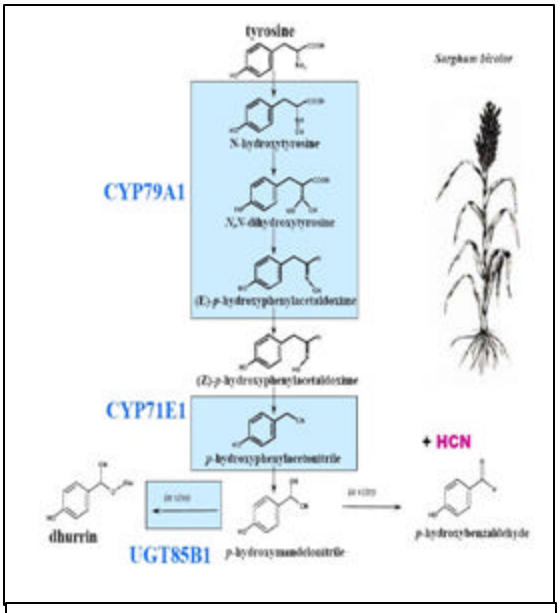
| S No | Purpose | Transgene used | Source of transgene | Progress to date | Scientists |
|---|---|---|---|---|---|
| 1 | Resistance to stemborer | *Bt Cry1Aa* and *Cry1B* | CIRAD-Monique Royer, France | 5 promising lines ready for limited field trials | NRCS- Balakrishna, Padmaja, Visarada |
| 2 | Tolerance to drought | *mtld* | University of Delhi-Partha Sarathy, Delhi | Confirmed transgenic plants available in advanced generations | CRIDA (Lead Centre)-Maheshwari and NRCS-SV Rao |
| 3 | Tolerance to salinity | *PcSrp* | Dashavantha Reddy - Osmania University, Hyderabad | Confirmed transgenic plants available in early generations | NRCS- Balakrishna |
| 4 | Low HCN content in forage sorghum | *Cyp79A1* | NRCS-Bhat, Sorghum genes modified for antisense expression | Putative transgenic plants produced with less HCN production. | NRCS-V Bhat |
| 5 | Fixing heterozygosity in sorghum hybrids | *SERK* | NRCS-Bhat, Sorghum SERK genes with modification | Sorghum native SERK gene sequences cloned | NRCS (Lead Centre)-V. Bhat, CCMB, Hyderabad-I. Siddiqi and University of Delhi-Vishnu Bhat |

Note: Besides at above, there is an attempt at UAS, Dharwad to develop transposon-tagged lines


**Bt transgenic sorghum resistant to stem borer**



**pcSrp transgenic progeny seeds (Left) tolerant to sodium chloride compared to non-transformed control (right)**




**Dhurrin biosynthesi s in sorghum**

**HCN levels (dry weight basis) in *Cyp79A1* antisense (To) transgenics**

| Plant type | Range (ppm) | Mean (ppm) |
|---|---|---|
| Transgenics (n=27 events) | 17.25 - 178.66 | 104.06 |
| Control (CSV 15, 6 reps) | 180.5-209.33 | 192.08 ±2.15 |

## Table 2: Genetic transformation of agronomically important traits reported in sorghum

| Transgenic trait | Transgenes | Method | Organization | References |
|---|---|---|---|---|
| Resistance to stem borer | *Bt cry1Ac* | Bombardmen t | ICRISAT, India | Girijashankar et al (2005) |
| Resistance to stalk root | *Rice chitinase* | *Agrobacterium* and Bombardment | Kansas Univ, USA | Zhu et al (1998), Krishnaveni et al (2001) |
| Enrichment of lysine content (Nutritional improvement) | *dhdps-r1* | Bombardment | Vrije Univ, Belgium | Tadesse et al (2003) |
| Drought resistance | *HVA1* | Bombardment | Michigan Univ, USA | Devi et al (2004) |

# Basic research

## 12. Basic and strategic research in sorghum physiology

***H.S. Talwar, Plant Physiologist, NRCS Hyderabad***

### *A. Drought tolerance*

Drought, particularly at end off season, is one of the major production constraints responsible for destabilizing the rabi sorghum productivity. The crop is cultivated predominantly on residual soil moisture in postrainy season and invariably subjected to moisture stress during flowering and grain filling stage (terminal drought). Superior genetic resources and judicial use and efficient management of water are required to reduce the risk of losses in productivity.

*Progress made so far*

(i) Sorghum phenology and growth stages characterized on the standard scale of "0" to "9".

(ii) Delayed senescence or staygreen is identified as a useful trait for plant adaptation to terminal drought stress. Lines with stay green expression have been identified.

(iii) Other secondary traits which are associated with terminal drought tolerance in rabi sorghum include low SLA (high SLW), higher stomatal conductance, SPAD chlorophyll meter values, total chlorophyll, SLN, CSI, RWC, and deep roots after anthesis

(iv) Quantitative trait loci (QTL) and the corresponding markers for staygreen have been defined.

(v) SPAD values can be used as a better physiological criterion of staygreen than current visual rating method.

(vi) All rabi adapted tall types depleted greater moisture than staygreen dwarf and semi-tall indicative of deep-rooted ness of the former than later.

(vii) An early maturing drought tolerant rabi sorghum variety RSLG 262 (Maulee) have been identified for shallow to medium vertisols of central India (Maharastra and Karnataka) which gave 20% high yields than standard check M 35-1.

(viii) Advanced breeding lines and germplasm have been evaluated for terminal drought tolerance and improved sources for TD have been identified (SLR 17, SLR 30).

*Future Strategy*

(i) Continuation of evaluation of advanced breeding lines, landraces and germplasm and staygreen mapping populations for terminal drought tolerance to identify better sources for terminal drought tolerance.

(ii) Identifications of short to medium duration high yielding genotypes that can escape terminal drought with minimum loss in yield potential.

(iii) Defining physiological mechanisms and ideotypes with target traits to enhance crop water productivity and/or drought tolerance in rabi sorghum.

(iv) Identifying the variability for water Use Efficiency (WUE) under terminal drought conditions.

(v) Characterizing genotypes for rate and duration of grain growth during GS 3 stage

(vi) Unraveling the association between root traits and drought tolerance.

### *B. Assess the impacts of Climate change on sorghum productivity.*

This is our new imitative under "ICAR network project on climate change" proposed under XI plan. Based on the recommendations during the recent national workshop on climate change, a project proposal entitled "Assess the impacts of climate change on sorghum productivity" has been submitted with following two objectives:

(i) Assessing and quantify the impact of likely change in climate on growth and productivity of rabi, dual purpose and sweet sorghum.

(ii) Based on impact identify the management options (genotype, planting dates etc.) to mitigate and adapt to the likely change in climate scenario.

Following action plan is proposed to achieve these objectives.

(i) *Preliminary assessment of impacts on rabi, dual purpose and sweet sorghum* through synthesis from literature and expert consultation and compiling phenology and agronomic data from AICSIP centers
(iii) *Impact assessment on growth and productivity of rabi, dual purpose & sweet sorghum by* simulation using databases on soil, weather and management and quantifying the effects of likely climatic change (particularly with rise in temperature) on plant growth, pollen viability and spikelet sterility, partitioning and productivity by conducting field experiments on selected rabi, dual purpose and sweat sorghum genotypes.
(iv) *Adaptation- identified and quantified* by conducting field experiments across locations (AICSIP centers) and planting dates and validate the crop growth model

***C. Salinity tolerance***

Sorghum, being a moderately salt tolerant, is a potential contestant crop for salt affected area in semiarid areas of India. Moreover, building up of salinity problems in its tradition area of Maharashtra and Gujarat has created a threat to sorghum productivity. Vast areas of coastal rice fallows and parts of Gujarat and Rajasthan, which remain un-cropped due to transient salinity during the post rainy season are partly the potential areas for fodder cultivation. The growing needs of feed and fodder, besides food in India have to be met with both, enhanced production and expanding cultivation into other non-traditional areas. Therefore, improving salinity tolerance of sorghum is vital. Last year NRCS has initiated research in this area. In our preliminary field evaluations for salinity tolerance, genetic variability was noticed among the germplasm and breeding material. To further enhance our efforts we (in collaboration with selective AICSIP centers) propose a following project on salinity tolerance

*Title*: **Selections for salinity tolerance in sorghum**

*Objectives:*

(i) Identify the sources of salinity tolerance in sorghum from the reference collection of germplasm accessions
(ii) Identify the mechanism of salt tolerance using selected entries of sorghum

*Collaborative Centers*: Hisar and Deesa AICSIP centers *Duration 2008*-2012

*Activity Plan*

*Screening the reference collection of sorghum germplasm for salinity tolerance:* Selective sorghum germplasm accessions and new breeding material would be screened in field condition at NRCS , Hisar and Deesa AICSIP center. A subset of these entries would be evaluated on Alfisols irrigated with an equivalent of 200 mM NaCl solution irrigated once to field capacity in pots during rabi seasons. A small set of accessions will be evaluated in a salinity screening facility with uniformly salinized micro plots at NRCS, Rajendranagar.

*Identification of mechanisms of salinity tolerance in sorghum*: Pot experiments will be carried out at NRCS and Hisar to quantify the plant growth (root and shoot), water relation and ionic concentration of ions in root, stem, leaves in relation to various concentration of NaCl. Effect of salinity on gas exchange and photosynthesis will be quantified.

# 13. Agriculturally important microorganisms for sorghum production

***IK Das, NRCS***

**(A) Bio-suppression of root and stalk rot**

Natural microbial processes in sorghum production system highly influence the productivity of this crop. Isolation, characterization, identification, use and conservation of agriculturally beneficial microflora of this low-input, rainfed production system is of enormous importance for disease and nutrient management, maintaining natural soil processes, soil health, and purity of the system for organic agriculture. Charcoal rot of sorghum is an importance disease for which high level of genetic resistance is not available, and use of microbial strains for direct protection is required.

***Progress made so far***

i. Generated information on diversity of bacteria in sorghum rhizosphere and their usefulness in rainfed agriculture.
ii. Developed *Pseudomonas* strain Rb124 which significantly reduced field-incidence of charcoal root and stalk rot (charcoal rot) and lodging, indicating that soil inundation with beneficial strains can further improve disease suppressive ability of this rainfed production system.
iii. The bacterial strains Rb8-1, Rb124 and Rb213-1, with antagonistic effects on the charcoal rot pathogen, and plant growth stimulating effects on sorghum seedlings will serve as useful source for further study in the important field of organic agriculture.
iv. Illustrated mechanisms of disease suppression and plant growth promotion by sorghum rhizobacteria.
v. Identified heat-tolerant *Bacillus* strains Rb8-1 for stimulation of seedling growth and improvement of crop establishment in rabi sorghum.
vi. Demonstrated usefulness of inundative use of beneficial strains in rainfed sorghum for improved plant growth and disease suppression.

**(B) *Thichoderma* to promote industrial uses of sweet sorghum**

This a new initiative proposed under ICAR Network project on "Agricultural and Industrial Uses of *Thichoderma* strains". A concept note has been sent to NBAIM for this project for consideration with the following objectives:

i. Identification of Thichoderma strains for efficient bioconversion of sweet sorghum biomass/ bagasse to easily fermentable sugar for ethanol production.
ii. Development of Thichoderma mediated simple cost effective method of saccharification of sorghum-stalk cellulose and hemicellulose.
iii. Identification and development of yeast strains for sweet stalked sorghum juice fermentation.
iv. Use of microbial strains for reducing mycotoxins contamination in sorghum stalk.

**(C) Future Strategies**

i. Development of microbial consortia for improved plant nutrition and root disease suppression.
ii. Development of practicable management practices of charcoal rot by utilizing effective bio-agents with integration of other biological means.
iii. Evaluation of microbial inoculants for broad spectrum activity against other diseases and crops grown in the agro-ecosystem.
iv. Study the effect of soil amendment for the management of rabi sorghum diseases.

**(D) Linkages**

i. National Bureau of Agriculturally important microorganisms (NBAIM), Mau
ii. International Crops Research Institute for Semi-arid Tropics (ICRISAT), Patancheru.

# 14. Proposals under XI plan – Special projects

Over the years, there has been declining trend in developing and sharing germplasm, especially the improved germplasm among AICSIP centers. It will be almost impressible to each center to execute independently, and greater mutually supportive and transparent efforts and intense communication are needed. This can be achieved under special compact network projects. Although these values and practices are embedded in the AICPs, it has become necessary to have specially dedicated smaller teams to make a dent under the current competing and demanding circumstances. Therefore, we plan to meet above challenges to by creating smaller sub-projects within AICSIP to specially address complex problems in a time-bound manner. These efforts will be far beyond traditional empirical tests and analysis. Obviously, such efforts need more resources, better identification of team-members and grater managerial acumen to promote common and shared interest. This is especially true if we want to compete with the private sector effectively, and to ensure supply of seeds at lower cost to the farmers. Therefore, following four network projects are proposed under XI plan.

**Title of the project**

### A. Network project to enhance resistance to biotic stresses, and to enhance product quality(food, fodder and industrial products) in sorghum

**Background:** Although much has been of done to improve the resistance to common insect pests and diseases, much more is to be done for those traits which are controlled by multiple genes with low level of heritability such as resistance to grain molds, and product quality and digestibility parameters. This is especially true for local and niche products that differ markedly from place to place. Promotion of sorghum as an industrial crop will attract more inputs for its cultivation, but yield and quality expectations will also be higher. So far the improvements for such traits are based on a set of local (narrow) genetic base only, but now we need to get more carefully selected diverse germplasm incorporated into our genetic stocks. This calls for carefully managed nurseries even in hot spots, and support form laboratory or glasshouse-based strategic research services. In all, eight dedicated compact teams, each lead by a competent and experienced scientist will be assigned the job of developing genetically-enhanced source materials for others to us under AICSIP umbrella. Over years, many new and novel germplasm lines have been identified and confirmed by AICSIP, but they were never put to use fully or properly because of special efforts and facilities needed to make them work (meaning competing with existing cultivars or parental lines). The teams under this network will put up special effort to incorporate polygenic traits from these into breeding stocks and evaluate them. Promising lines will be registered by the teams before sharing or licensing.

This network sub-project will also help to develop new skills, and lay the foundation for effective basic and strategic research capability at the AICSIP centers.

**Objectives:**

1. Enhanced germplasm utilization to improve grain and stover yield, including forage quality
2. Accelerated breeding for shootfly, stem borer, grain mold and resistance
3. Development and utilization of sweet sorghum cultivars for bio-ethanol, and diversified co-products
4. Improving grain, food and *roti* quality
5. Management of major soil and seed borne diseases
6. Improving performance of sorghum under adaphic stresses

**Plan of work:**

| S No | Title of the sub-Project | Collaborating centers | Activities |
|---|---|---|---|
| 1 | Utilization of new germplasm and advanced breeding stocks for development of dual-purpose sorghum with consistent Stover yields and improved quality | PDSR, Udaipur, Coimbatore, Indore, Pantnagar, Kovilpatti and ILRI, located at Patancheru | Advance material from all centers pooled to make crosses at PDSR.<br>The hybrid programme will be at PDSR & Indore centers.<br>The segregating F2 population will be shared with Surat, Kovilpatti, Dharwad & Palem.<br>Materials will be produced with a range of maturities, to suit different regions / soils and cropping systems<br>Special attention will be given to brown mid rib / high stover digestability |
| 2 | Enhancing shoot fly and stem borer resistance lives in grain and forage sorghum | PDSR, Akola, Parbhani, Udaipur, Hisar and Kanpur | 1. Generation of material will be taken care of by PDSR, Parbhani, Udaipur, Indore, and Surat.<br>2. Udaipur, Indore, Surat Hisar and Kanpur will concentrate on stem borer screening during Kharif and Parbhani, Rahuri, Bijapur, and Solapur on shootfly screening during Rabi.<br>3. During Kharif both shoot fly and stem borer screening will be handled at Indore, PDSR, Surat & Coimbatore centers. Rabi screening will be at Rahuri, Bijapur & Solapur Centers. |
| 3 | Breeding for grain mold resistance | PDSR, Parbhani, Akola, Dharwad & Bidar | 1. Colored grain sources can be used for increasing tolerance, especially for industrial uses. Coloured and slightly molded grains will be tested for animal digestibility and health. In addition to AICSIP centres testing will take place at high rainfall sites in Karnataka and Maharashtra (Hassan, Mudgod, Kolhapur).<br>2. Surat and Akola will screen the material<br>3. Parbhani centre will be involved in parental line development & making crosses. The lines developed so far are moderate but not resistant types atthis moment. |
| 4 | Improving grain, food and roti quality of elite lines | Dharwad, ANGRAU, PDSR (Homescience), Akola, Indore | 1. Dharwad & Home Science Dept., Hyd were identified.<br>2. Rahuri centre and PDSR will work on keeping quality of atta and roti. |
| 5 | Management of major soil and seed borne diseases/Cold tolerance | Bijapur, Dharwad, Mahabaleshwar, Rahuri, PDSR | 1. Eco-friendly management of soil-borne and seed borne diseases in high-yielding sorghum".<br>2. Bijapur and Dharwad centers need to conserve the sick plot for the field experiment.<br>3. Work on sorghum ergot will be initiated at Dharwad, Rahuri and PDSR<br>4. Work on cold tolerance will be carried out at Mahabaleshwar, Rahuri and PDSR |
| 6 | Use of new and novel germplasm for development of improved cultivars of forage sorghum lines with better seed set, and stress tolerance | PDSR, Akola, Surat, Rahuri, Deesa, Udaipur, Ludhiana, Hisar, Pantnagar & IGFRI | 1. New sorghum germplasm and Sudan grass lines will be screened and identified as source materials.<br>2. Deesa centre will take up seed production.<br>3. For testing fodder quality parameters the materials should be sent to PDSR; a small set may also be checked at IGFRI.<br>4. Surat centre will work on single as well as multi-cut varieties.<br>5. Udaipur & Pantnagar will work on development and screening of resistance.<br>6. Coimbatore preferred for screening of advanced material.<br>7. Hisar centre will screen for borer resistance |
| 7 | Selections for salinity tolerance in sorghum | Deesa, PDSR, Hisar, Udaipur | Udaipur centre will be included and will be responsible to wll collect and analyze soil sample for identification of salinity tracts in the centre in the project. Final tests will be in specially prepared salt pits at PDSR. |
| 8 | Organic rabi sorghum production and marketing | Dharwad, PDSR (Solapur) | Tw o centers (Dharwad and Solapur) are identified. Bidar (Vet. Univ.) could be ideal centre for seed multiplication for organic cultures. Nishe markets are to be developed. |

| S No | Title of the sub-Project | Collaborating centers | Activities |
|---|---|---|---|
| 9 | Utilization of kharif grain for snack foods | Parbhani, Dharwad, NARI, PDSR | Work should also be initiated on production and testing of pop, hurda, syrup and need based funds will be provided. |

**Duration :** 2007 - 2012
**Total proposed budget:** Rs. 280.00 Lakhs

| S. No. | Item | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | Total |
|---|---|---|---|---|---|---|---|
| 1 | Contractual services | 0.00 | 20.00 | 20.00 | 20.00 | 20.00 | 80.00 |
| 2 | Contingencies | 0.00 | 21.00 | 21.00 | 21.00 | 21.00 | 84.00 |
| 3 | Travel for field surveys and advising farmers consultancy and monitoring | 0.00 | 7.00 | 7.00 | 7.00 | 7.00 | 28.00 |
| 4 | Lab supplies, and for equipment or facilities, maintenance contracts, field supplies literature dissemination, field demos, exhibitions, etc. | 0.00 | 22.00 | 22.00 | 22.00 | 22.00 | 88.00 |
| | **Total** | **0.00** | **70.00** | **70.00** | **70.00** | **70.00** | **280.00** |

**Anticipated output**

1. Enhanced usage of recently well characterized germplasm to generate advanced materials to be shared across centres to evolve advanced lines for various traits.
2. Improved high yielding grain, dual purpose and forage genetic stocks with local and wide adaptation
3. Improved new sources of resistance to shootfly, stem borer, grain mold with superior agronomic background
4. Improved sorghum lines with various local specialized uses, and for micro-entrepreneurs (nische foods)

## Title of the network project

### B. Network project on accelerated development and testing of parental lines for making better hybrids that can maintain the competitive edge of the public system

**Background:** Often, it has been justifiably felt that hybrid yields are pleateauing (although the fact is it is only slowing down). About 80% of the kharif hybrids in the country are produced with a single female parent (296B) bred at PDSR. However, the need for zone-specific hybrids calls for development of diversified set of male and female parents. This activity has been slow because of the complexity of the problem, and the fear of small teams not to be able to compete. This also leaves many resources untapped such as new sources of resistance and quality. It also excludes many new market opportunities for specific end-products which are not yet exploited.

There is ample opportunity for India to be the hub of global seed production provided we diversify, test and exploit variety of sources available to us. The increasing cost of labor and priorities have resulted in declining efforts in this regard. Further, all female lines developed so far are only for grain sorghum that too only for yield (with little resistance); we need many more types to make hybrids of forage, sweet stalk, colored feed grain. For many traits with low heritability, we need to improve both the parents (such as to produce shoot fly tolerant hybrids). This calls for grater efforts and resources. Therefore PDSR will lead two teams – one for production of a range of B lines with specific end-use and adaptation in mind, and the other for R lines. Crosses will be made at central locations by PDSR. Screening and selection will be at SAU centers under a set of prioritized environments/managed nurseries. The selections from all centers will be poled each year, and tested gain. This way we should be able to come up with a number of parental lines well characterized, and registered for use by others. Registered lines can be used to make new hybrids either within AICSIP or by private sector licensees.

The new development of automation of DNA marker-based selections, and a variety of laboratory or green-house tests at PDSR will add efficiency and value to above protocol. During XI plan our capability for handling large number of samples for such tests will be strengthened at PDSR building on good foundation already built with the funds allocated during X plan.

**Objectives:**

1. To generate diversified parental materials (B & R lines) to the stake holders on a fixed time frame
2. To screen and identify superior parental lines combining yield and specific resistance or quality traits
3. To establish identity of these lines (for IPR protection) and share (public system) or license (to private parties) so that better and more productive hybrids are made available at the quickest time.

**Duration** : 2007 - 2012
**Proposed budget** : Rs. 120.00 Lakhs

| S. No. | Item | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | Total |
|---|---|---|---|---|---|---|---|
| 1 | Recurring contingencies / contractual services | 0.00 | 20.00 | 22.00 | 24.00 | 24.00 | 90.00 |
| 2 | TA / travel charges | 0.00 | 2.00 | 2.00 | 2.00 | 2.00 | 8.00 |
| 3 | Non-recurring contingencies (Lab supplies, and for equipment or facilities, maintenance contracts, field supplies literature dissemination, field demos, exhibitions, etc.) | 0.00 | 8.00 | 6.00 | 4.00 | 4.00 | 22.00 |
| | **Total** | **0.00** | **30.00** | **30.00** | **30.00** | **30.00** | **120.00** |

**Anticipated output:**

1. Diversified high yielding parental lines for making hybrids of grain, forage and specific alternate uses
2. Enhanced resistance and quality of new generation of parental lines
3. Better performing hybrids with enhanced performance across agro-eco systems

## Title of the network project

### C. Breeding for nutritionally improved sorghum for better health in India with special reference to bio-fortification and health benefits

**Background:** Sorghum is the staple food grain for a large segment of the human populations in the states of Maharashtra, Karnataka, Andhra Pradesh and Madhya Pradesh. Its grain has a nutritional profile better than that of rice, the chief staple food of majority of the Indian human population especially for protein, minerals, fiber, calcium, phosphorous, iron, ß-carotene and other essential amino acids like thiamine, riboflavin, folic acid. However, a diet based exclusively on sorghum is not adequate to meet the nutritional growth and maintenance requirements of the population, and needs to be supplemented with essential amino acids and micronutrients in their diets. In this context, it is important to identify sorghum germplam lines and develop high yielding sorghum varieties having micronutrients specially Iron (Fe) and Zinc (Zn), essential amino acids (lysine) and ßcarotene (and other carotenoids) concentrations higher than the existing cultivars, and to study interaction between genotype and environment (GxE) and the inheritance pattern of these nutritionally important ingredients in sorghum. The proposed project seeks to develop more nutritious sorghum genotypes that contains increased levels of essential amino acids especially lysine, increased levels of Vitamins A and E, and more bioavailable iron and zinc in a period of five years. Food fortification can benefit from nutritional point of view. Therefore, multi-grain products will also be looked into.

**Objectives:**

1. To determine the extent of genetic variability available in a genetically varied group of sorghum genotypes for essential amino acid (lysine), microelements Fe, Zn and ß-carotene (and other carotenoids)
2. To study the inheritance of lysine, Fe, Zn and ß-carotene levels
3. To assess their stability levels under different growing environments (e.g. Iow and high fertility conditions)
4. To develop high yielding genotypes with higher levels of these micronutrients for improved human health
5. To test food products from multi-grain atta, and by other fortification measures

**Activities and output**

| Activity | Outputs | Partners | Centers |
|---|---|---|---|
| Purification and evaluation of sorghum lines | 1. Pure seed of germplasm lines (1000) collected<br>2. Identification of lines with higher nutrients with high grain yield | Breeder, Biochemist | PDSR, Rahuri, Bijapur, Parbhani Akola |
| Conducting multi - location trials (METs) | 3. Argonomically superior lines identified<br>4. G x E interaction studied | Breeder, Biochemist, Agronomist | PDSR, Rahuri, Bijapur, Parbhani Akola |
| Inheritance studies | 5. $F_1$s for Diallel analysis made with high and low genotypes (8 x8)<br>6. $F_1$s evaluated and gene action effects estimated<br>7. Backcross material developed | Breeder, Biochemist, Agronomist | PDSR, Bijapur, Parbhani NRCS, Rahuri, Bijapur, Parbhani, Akola |
| Selection, seed increase | 8. Seed of micronutrient rich high yielding lines increased<br>9. Final report submitted | Breeder | PDSR, Bijapur, Parbhani |
| Bio-fortification and health benefits | 10. Testing of foods from elite lines for nutritional and health benefit<br>11. To test best multi -grain and products for bio-fortification | Biochemist, Nutritionist | PDSR, ARI (Pune), NIN and Home Science Colleges at Madurai & Dharwad |

**Duration** : 2007 - 2012
**Proposed budget** : Rs. 120.00 Lakhs

| S. No. | Item | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | Total |
|---|---|---|---|---|---|---|---|
| 1 | Recurring contingencies / contractual services | 0.00 | 20.00 | 22.00 | 24.00 | 24.00 | 90.00 |
| 2 | TA / travel charges | 0.00 | 2.00 | 2.00 | 2.00 | 2.00 | 8.00 |
| 3 | Non-recurring contingencies (Lab supplies, and for equipment or facilities, maintenance contracts, field supplies literature dissemination, field demos, exhibitions, etc.) | 0.00 | 8.00 | 6.00 | 4.00 | 4.00 | 22.00 |
| | **Total** | **0.00** | **30.00** | **30.00** | **30.00** | **30.00** | **120.00** |

## Title of the network project

### D. Gene pyramiding for resistances through population breeding and molecular markers

**Background:** Sorghum is generally considered to be a self - pollinating crop with less than 10% crosses pollination. Sorghum breeders have been successful in exploiting the variability in the crop by direct selection among landrace cultivars and by the use of conventional methods of pedigree and back-cross breeding in the development of superior genotypes. In the recent years there has been a

growing feeling that the conventional breeding programmes of the self-pollinated crops suffer from narrow genetic base and limited genetic recombination. There has been increased interest in expanding the genetic variability available to the breeder for which population improvement provides an answer. Population improvement involves the generation of broad-based gene pools and their improvement through recurrent selection. Favorable genes should be concentrated through recurrent selection, resulting in increased mean of the population and superior performance of the best families. Population improvement provides ample opportunities for recombination after each cycle of selection. The repeated cycling of selection and recombination is particularly important for improvement of polygenic traits and for simultaneous improvement of several traits. Thus population breeding helps us in pyramiding genes for the traits of our interest. Using molecular marker techniques along with population breeding increases selection efficiency and helps us in combining different mechanisms of resistance to increase the level of resistance. The populations are useful to the sorghum breeder as a continuous source of new entries for the breeding nursery. They further serve as source for the extraction of inbred lines excelling in multiple desirable traits. Population improvement can also be employed in hybrid breeding programmes since genetically improved populations are good parental material for breeding inbred parents of the hybrids. Population improvement allows more recombination and accumulation of a large number of favourable alleles than is possible with the same number of plants handled via pedigree methods. In comparison with traditional methods of breeding where pyramiding of characters is done by adding each new character after reaching satisfactory levels of other characters, population improvement techniques permit simultaneous selection of traits more rapidly and effectively than by conventional breeding.

While population improvement in sorghum is certainly advantageous in providing the useful genetic variability and in pyramiding the genes of interest especially for the complex traits like resistance to shoot fly, grain moulds and grain quality attributes, maintenance of populations each in an isolation and evaluation of the derivatives using molecular markers requires a lot of resources. To meet with the expenses, a project is being proposed on "Gene pyramiding for resistances through population breeding and molecular markers". The proposed research work will help in pyramiding different genes responsible for different mechanisms of resistance through marker assisted breeding, thus increasing the efficiency of breeding for shoot fly and grain mould resistance. The National Research Center for Sorghum (NRCS) has good facilities, skilled staff and a network of partners in India through its AICSIP (All India Coordinated Sorghum Improvement Project) programme. At National Research Centre for Sorghum (NRCS), the population improvement programme was started for the improvement of the trait grain mould resistance. Two populations for grain mould resistance, one for the male-sterile line improvement and another for improvement of restorer are being handled at NRCS. The DNA markers are already available at the centre for shoot fly resistance. More markers will be developed for shoot fly and grain moulds and stringent QTL will be identified for the traits. The advantage here is that the AICSIP provides a mechanism for multilocation evaluation of the selections from populations. The proposed project aims to develop sorghum genotypes with increased levels of resistance to shoot fly and grain mould. Adoption of latest DNA marker technologies such as (DaRT) that can handle large number of samples at low cost makes it viable to apply MAS to RM population breeding projects also.

**Objectives:**

1. To increase the diversity in the base populations for the target traits, viz., shoot fly and grain moulds (and all other traits for which DNA markers are available or being developed)
2. To develop sorghum genotypes with improved levels of resistance to shoot fly and grain moulds using random mating populations and molecular marker technology
3. To derive lines and test for presence of alleles for various resistance traits (by testing in field and by use of DNA markers)

## Activities and output

| Activity | Outputs | Partners | Centers |
|---|---|---|---|
| Random mating of the populations | 1. Random mated populations in isolation | Breeders | PDSR, Udaipur Rahuri, Bijapur |
| Recurrent selections | 2. Selections from the base population<br>3. Selections evaluated for the target trait using molecular markers and the trait per se | Breeder, Entomologist/ Pathologist | PDSR, Udaipur Rahuri, Bijapur |
| Random mating of the selected lines | 4. Random mating of selected lines allowing pyramiding of genes<br>5. Selections from population | Breeder, Entomologist/ Pathologist | PDSR, Udaipur Rahuri, Bijapur |
| Testing of selections made | 6. Selections evaluated for the target trait using markers<br>7. Selected lines brought to uniformity | Breeder, Entomologist/ Pathologist | PDSR, Udaipur Rahuri, Bijapur |
| Multilocation testing of selections made | 8. Multilocation testing of the selections made<br>9. Final report submitted | Breeder, Entomologist/ Pathologist | PDSR, Udaipur Rahuri, Bijapur |

**Duration** : 2007 - 2012
**Proposed budget** : Rs. 120.00 Lakhs

| S. No. | Item | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | Total |
|---|---|---|---|---|---|---|---|
| **1** | Recurring contingencies / contractual services | 0.00 | 20.00 | 22.00 | 24.00 | 24.00 | 90.00 |
| **2** | TA / travel charges | 0.00 | 2.00 | 2.00 | 2.00 | 2.00 | 8.00 |
| **3** | Non-recurring contingencies (Lab supplies, and for equipment or facilities, maintenance contracts, field supplies literature dissemination, field demos, exhibitions, etc.) | 0.00 | 8.00 | 6.00 | 4.00 | 4.00 | 22.00 |
| | **Total** | **0.00** | **30.00** | **30.00** | **30.00** | **30.00** | **120.00** |

## Total budget component (plan) of network projects – year-wise

| S. No. | Network project | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | Total |
|---|---|---|---|---|---|---|---|
| 1 | A. Network project to enhance resistance to biotic stresses, and to enhance product quality(food, fodder and industrial products) in sorghum | 0.00 | 70.00 | 70.00 | 70.00 | 70.00 | 280.00 |
| 2 | B. Network project on accelerated development and testing of parental lines for making better hybrids that can maintain the competitive edge of the public system | 0.00 | 30.00 | 30.00 | 30.00 | 30.00 | 120.00 |
| 3 | C. Breeding for nutritionally improved sorghum for better health in India with special reference to bio-fortification and health benefits | 0.00 | 30.00 | 30.00 | 30.00 | 30.00 | 120.00 |
| 4 | D. Gene pyramiding for resistances through population breeding and molecular markers | 0.00 | 30.00 | 30.00 | 30.00 | 30.00 | 120.00 |
| | **Total** | **0.00** | **160.00** | **160.00** | **160.00** | **160.00** | **640.00** |

# 15. Comparison of performance of sorghum cultivars sold in the market with those released from public programs

***Chari Appaji, NRCS***

A total of 51 hybrids both produced and sold by public and private sector were tested in 5 major sorghum growing regions in the country.

At Palem center, the average grain yield obtained was 11q/ha which was low while the highest average grain yield of the hybrid was 60q/ha in Indore. At both Coimbatore and Dharwad the mean grain yield obtainable was 41q/ha.

The cultivars based on their grain yield were categorized based on grain yield levels: low, medium, and high grain yielders.

Majority of the hybrids fell in the category of medium grain yielders at all the locations, the number of hybrids that fell into this category ranged between 30 and 41. The national checks CSH 16 and CSH 18 also fell in this group in majority of locations.

On an average the time of flowering of hybrids ranged from 57 to 75 days in different locations.

The average fodder yields ranged between 58 to 153 q/ha across the locations; the variation for fodder yield was higher than that for grain.

May seed-lots were not pure, accounting up to 25% roughs in al the replication.

At least there were several duplicates.

Many were very similar to public sector hybrids.

**Table1: Center wise performance of hybrids sold to farmers. (n=51)**

| Category | Palem | Udaipur | Indore | Dharwad | Coimbatore |
|---|---|---|---|---|---|
| **Grain yield Mean (Range)** | **11 (4.2-19)** | **41 (24-57)** | **60 (21-84)** | **41 (28-51)** | **35 (23-47)** |
| Grain yield Low (< Mean – 1.0 SD) | 8 (CSH 14 (16 %) | 10 (CSH 14) (20%) | 9 (CSH 14, CSH 16) (18%) | 5 (10%) | 4 (CSH 14) (8%) |
| Grain yield Medium (Bet. Mean – 1.0 SD and Mean + 1.0SD) | 37 (CSH 16, CSH 18) (73 %) | 32 (CSH 16 and CSH 18) (63%) | 30 (59%) | 37 (CSH 14, CSH 16 and CSH 18 (73%) | 41 (80%) |
| Grain yield High (> Mean + 1.0SD) | 6 (12%) | 9 (18%) | 12 (CSH 18) (24%) | 9 (18%) | 6 (CSH 16, CSH 18) (12%) |
| Fodder yield: Mean(Range) | 153 (120-192) | 109 (90-133) | 109 (90-133) | 58 (31-88) | 171 (107-244) |
| Days to flower :Mean (Range) | 58 (55-65) | 66 (60-72) | 59 (56-66) | 57 (52-71) | 75 (66-79) |

# 16. Publications of AICSIP and NRCS scientists

**AICSIP Publications**

During the year 2007-08, a total of 25 publications in different categories were published. The details of category wise publications are given in the table below.

| S.no | Publication Category | No. Published |
|---|---|---|
| 1 | Journal papers | |
| | *International* | 1 |
| | *National* | 13 |
| 2 | Book chapter | 1 |
| 3 | Conference Poster | 1 |
| 4 | Technical Articles | 7 |
| 5 | Pamphlet | 1 |
| 6 | Booklet | 1 |
| | **Total** | **25** |

**Journal Papers**

***International***

Patil, S.P., Manjare, M.R., Kamdi, S.R., Dethe, A.M. and Ingale, M.N. 2007. Stability analysis in sorghum (*Sorghum bicolor* L. Moench). *International Journal of Plant Sciences* **2** (2): 70-75 **(IF: 8.4)**.

***National***

Balikai, R.A. 2007. Management of shoot fly (*Atherigina soccata* Rondani) through seed treatment in rabi sorghum. *Indian Journal of Entomology* **69** (2): 178-180 **(IF: 4.0)**.

Ghorade, R.B. and Dipali, V. Ghive. 2007. Heterosis studies in sorghum. *Asian Journal of Bioscience* **2** (1): 200.

Hundekar, A.R., Balikai, R.A., Biradar, B.D. and Sajjanar, G.M. 2007. Shootbug, *Peregrinus maidis* (Ashmead), a vector of sorghum stripe disease: Trend in Karnataka during post rainy season on sorghum. *Int. J. Agricult. Stat. Sci.* **3** (2) :481-483.

Jirali, D.I., Biradar, B.D., Rao, S.S. 2007. Performance of rabi sorghum genotypes under receding soil moisture conditions in different soil types. *Karnataka Journal of Agricultural Sciences* **20** (3):603-604 **(IF: 1.0).**

Jirali, D.I., Biradar, B.D., Rao, S.S. 2007. Evaluation of rabi sorghum germplasm (*Sorghum bicolor* L. Moench). *Karnataka Journal of Agricultural Sciences* **20** (3):600-602 **(IF: 1.0).**

Kadam, D.E., Kulkarni, V.M., Katule, B.K. and Patil, S.V. 2007. Combining ability studies in rabi sorghum (*Sorghum bicolor* (L.) Moench) under rainfed condition. *Advances in Plant Sciences* **20**(1):39-41.

Kandalkar, H.G. and Men, U.B. 2007. Reaction of some sorghum elite lines and some nursery lines against shoot fly and stemborer. *PKV Research Journal* **31** (2): 309-312.

Kandalkar, H.G., Men, U.B. and Kahate, P. A. 2007. Development of some advanced sorghum cultivars and genotypes for resistance to shoot pests. *PKV Research Journal* **31** (2): 315-316.

Kulkarni, V.M., Kadam, D.E., Patil, S.V. and Chaudhary, S.B. 2007. Heterosis studies in rabi sorghum (*Sorghum bicolor* (L.) Moench) under rainfed condition. *Advances in Plant Sciences* **20**(1):89-91.

Patil, U.V., Ghorade, R.B., Bagade, A.B. and Mane, P.N. 2008. *Annals of Plant Physiology*. Accepted.

Raju Anaji and Balikai, R.A. 2007. Screening of rabi sorghum genotypes against shoot bug, *Perigrinus maidis* (Ashmead). *International Journal of Agricultural Sciences* **3** (2) :144-146.

Raju Anaji and Balikai, R.A. 2007. Crop loss estimation due to *Peregrinus maidis* and its economic injury level in rabi sorghum. *Annals of Plant Protection Sciences* **15**(2): 474-475. **(IF: 2.0).**

Shekharappa and Bhuti, S.G. 2007. Integrated management of sorghum shoot fly, *Atherigona soccata* Rondani. *Karnataka Journal of Agricultural Sciences* **20**(3): 535-536 **(IF: 1.0).**

## Book Chapters

Raju Anaji and Balikai, R.A. 2007. Management of sorghum shoot bug, *Peregrinus maidis* (Ashmead) through seed dressers. In: Biotechnology and Insect Pest Management (Eds. S. Ignacimuthu and Jayaraj, S.) Elite Publishing House Pvt. Ltd. New Delhi: 231-234.

## Papers presented in Seminars / Symposia / Conference

### *Conference Posters*

Balikai, R.A., Raju Anaji, Biradar, B.D., Sajjanar, G.M. and Hundekar, A.R. 2007. Loss estimation due to shoot bug, Peregrinus maidis (ashmead) in rabi sorghum under field conditions. 10th International Plant Virus Epidemiology Symposium, 15-19 October, 2007, ICRISAT, India.S-02, PP-2-42.

## Pamphlet

Sachhan, S.P. 2007. *Jowar ki unnath kheti.*Chandrasekhar Azad University ofAgriculture and Technology, Crop Research Centre, Mauranipur, Jhansi, Uttarpradesh, India. (***In Hindi)***

## Booklet

Dwivedi, R.N., Chari Appaji, Maharaj Singh, Sharma, R.K. Meena, B.S. and Upadhaya, J.P. 2007. *Jowar avem makka ki unnath kheti.*Published by Director, Indian Grassland and Fodder Research Centre (IGFRI), Jhansi, Uttar Pradesh, India. (***In Hindi)***

## Technical articles

AICSIP team, Surat. 2007. New fodder sorghum single-cut variety SRF 286 identified. *Jowar Samachar* **3** (1): 1.

Biradar, B.D. 2007. Sorghum in Indian Postal stamps. *Jowar Samachar* **3** (1): 5.

Elangovan, M. and Ghorade, R.B. 2007. Sorghum germplasm collection from Melghat regions of Maharashtra. *Jowar Samachar* **3** (1): 4.

Ghorade, R.B., Dethe, A.M. and Kahate, P.A. 2007. AKSSV-22, A new high yielding sweet sorghum variety for Vidarbha region. *Jowar Samachar* **3** (2):3.

Nagabhushana, V., Prakash, N., Mallikarjunappa, S., Ramachandra, B. and Biradar, U.S. 2007. Nutritional evaluation of Jowar under intensive sheep production. *Jowar Samachar* **3** (2):7.

Shrotria, P.K. 2007. Pant Chari 6 – New multicut forage sorghum variety for Uttarakhand. *Jowar Samachar* **3** (1): 3-4.

Usha Saxena, Sheela Verma, Upadhyay, S.N. and Kataria, V.P. 2007. Jawahar Jowar 1022 – An early maturing dual purpose variety for Madhya Pradesh. *Jowar Samachar* **3** (2): 6-7.

## NRCS Publications

A total of 79 publications in different categories were published.16 Journal papers were published, out of which 6 are in international journals (IF 4.0 to 7.7) and 10 in national journals (IF 2.0 to 4.0). The details of category wise publications are given in the table below.

| S. No | Publication Category | No. Published |
|---|---|---|
| 1 | Journal papers | |
| | *International* | 6 |
| | *National* | 10 |
| 2 | Books edited | 3 |
| 3 | Book chapters | 1 |
| 4 | Conference papers | |
| | *Papers* | 7 |
| | *Abstracts* | 6 |
| | *Posters* | 4 |
| 5 | Technical Articles | 7 |
| 6 | Popular Articles | 3 |
| 7 | Teaching Reviews | 2 |
| 8 | Reports | 5 |
| 9 | Extension posters | 12 |
| 10 | Miscellaneous | 13 |
| | **Total** | **79** |

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

*VR Bhagwat and G Shyam Prasad*

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

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

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

## National sorghum insect pest resistance screening trials and nurseries

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

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

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

**When and how to sow**

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

## Methodology for observations

***Sorghum shoot fly (Atherigona soccata)***

- Record the total number of plants per plot, and the plants with eggs, and the total number of eggs at 14 or 21 days after seedling emergence (DAE).
- Count the number of plants with deadheart symptoms at 21 or 28 DAE. Distinguish the plants with shoot fly and stem borer deadhearts.
- Plants with stem borer deadhearts have leaf feeding symptoms, and more than one leaf becomes dry, while in case of shoot fly, normally one leaf dries up.
- Additional data may be recorded at maturity on number of tillers and the tillers with productive panicles.
- Also record data on days to 50% flowering, plant height, and grain yield per plot at maturity.

***Stem borer (Chilo partellus)***

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

***Sugarcane aphid (Melanaphis sacchari)***

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

- The test material can also be maintained under infested and un-infested conditions for comparison or protected and non-protected conditions.

***Shoot bug (Peregrinus maidis)***

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

***Sorghum midge (Stenodiplosis sorghicola)***

- Sorghum midge larvae feed on developing grain resulting in production of chaffy spikelets. Hot-spots, sowing date, split sowings, infester row technique, selective use of insecticides to control other insects, and grouping the material according to maturity and height increase the efficiency of screening for resistance to sorghum midge.
- Caging sorghum midge females with sorghum panicles at flowering permits screening for resistance under uniform insect pressure.
- Releasing 40 midges into each cage for 2 consecutive days is very effective to screen for resistance to sorghum midge.
- Remove the cages 15 days after infestation and evaluate the midge damage.
- Record sorghum midge damage in 250 spikelets at 15 days after flowering or at maturity. Collect five primary branches each from top, middle, and bottom portions of each panicle. Bulk the spikelets from all the panicles, split into secondary branches. Record the number of chaffy spikelets in a sample of 250 spikelets.
- At the milk stage, squeeze the chaffy spikelets with forceps, and record the numbers of spikelets producing red ooze.
- Evaluate midge damage on a 1 to 9 scale (1 = <10, 2 = 11 – 20, 3 = 21 – 30, 4 = 31 – 40, 5 = 41 – 50, 6 = 51 - 60, 7 = 61 – 70, 8 = 71 – 80, and 9 = >81% midge damaged spikelets). Record grain yield at maturity.

***Head bug (Calocoris angustatus)***

- Ear head bugs, Calocoris and Eurystylus are serious pests of sorghum in Asia and Africa. The nymphs and adults suck the sap from the developing grain, which results in tanning and shriveling of the grain. Adjust sowing dates such that flowering of the test material coincides with maximum head bug density.
- Group the test material according to maturity and height, and include resistant and susceptible checks of appropriate maturity. Sow the test material in two sets at an interval of 10 - 15 days to reduce the chances of escape. Plant four rows after every 16 - 20 rows of the test material.

- Collect head bugs from other fields and spread in the infester rows at panicle emergence. For no-choice head-cage screening, infest each panicle with 10 head bug pairs at the 50% flowering stage.
- Data can be recorded on head bug numbers at 20 days after flowering or infestation.
- At maturity, evaluate head bug damage visually on a 1- 9 scale (1 = grains fully developed, and a few grains with feeding punctures, 2 = grain fully developed and with feeding punctures, 3 = grains showing slight tanning or browning, 4 = most grains with feeding punctures and a few showing slight shriveling, 5 = grains showing 25% shriveling and browning, 6 = grains showing more than 50% shriveling and tanned, 7 = most of the grain highly shriveled and highly tanned, 8 = grain highly shriveled and slightly visible outside the glumes, and 9 = Most of the grains highly shriveled and almost invisible outside the glumes).
- Harvest all panicles from the middle row(s) of each plot or genotype at maturity and record grain yield in each plot or panicle.

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

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

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

## Validation of IPM modules for shoot pests

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

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

*Treatments*

1) Sole commercial cultivar (without any treatment)
2) Sole crop with seed treatment (Thiomethoxam 70 WS (@ 3 g/kg of seed)
3) Intercropping with legumes without any treatment (as per agronomic cropping system recommendations)
4) Intercropping with legumes (as per agronomic cropping system recommendations) + seed treatment with Thiomethoxam 70 WS (@ 3 g/kg of seed)

5) Sole crop with seed treatment (Thiomethoxam 70 WS @ 3 g/kg of seed) > spray of NSKE spray @ 5% at 45 DAE
6) Sole crop with seed treatment (Thiomethoxam 70 WS @ 3 g/kg of seed) > spray of endosulfan 0.07% at 45 DAE
7) Farmers practice (check).

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

## Important suggestions and responsibility

***I. Pest Survey***

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

***II. Technical***

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

***III. Receipt of Seeds and data***

1) Please send the seed of PR lines (300 g each) before 23rd May, 2007 for Kharif and before 15th August, 2007 for Rabi to NRCS for further distributions.

2) Very little information on cost-benefit ratio along with additional net returns has been furnished for all the trials on chemicals, biological, and IPM practices. Therefore, furnish all necessary information. Please mention net plot size (sq m) harvested for calculating grain yield kg/ha.

3) Three years data on IPM recommendations may be compiled and published. Similarly, three years data on effectiveness of new chemical will also be required to publish.
4) All the Entomologists are requested to send the data booklets of one copy to the PI (Entomology), AICSIP, NRCS, Hyderabad, by furnishing the replicated data. Please strictly adhere to the sequence of entries furnished in the list along with the trial seed supplied. The data should be sent in two batches: 1) early part of the growth, 2) at harvest. Please adhere to the submission of all data booklets filled latest by Nov 30, 2008 for Kharif and Feb 15 for Rabi season trials. In addition, detailed analyzed report of each centre should be submitted by Dec 15, and March 1, respectively for kharif and Rabi season trials, respectively. The data should be clearly written (not with a pencil) or typed clearly and legibly. It would be encouraged to send the data in MS Excel file in a CD as well as a hard copy of complete original data. You must retain all original notebooks.
5) Maintain the seed material of resistant sources identified/developed at their respective centers with their known pedigrees.
6) The details on pedigree, crosses, etc., must be supplied to the testing centers, so that trials will be considered for screening under AVT, IVT, AHT, IHT, SPN and PLT.
7) Two rows of 4 m length with 2/3 replications are to be sown in evaluation trials for two times, whereas the minimum plot size in IPM trials, 20 sq m in Kharif and Rabi should be maintained.

***IV. Publications***

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

***V. Administration***

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

**Please send the results to:**

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

## Parameter for insect resistance (to be considered during data recording)

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

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

## 'Hot spot' or endemic locations for major insect pests in sorghum

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

## Resistant, susceptible, and local/qualified checks for grain sorghum trials

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

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

## Scoring (scale: 1-9) for biotic stress 1= Most desirable, 9=Least desirable

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

## Format for recording pest survey data from farmer's field-year

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

# Frontline demonstration - Kharif 2007-08

***Dr. Chari Appaji***
*Sr. Scientist, NRC for Sorghum, Hyderabad*

*With contributions from:*

| S. No | Name of collaborating scientists | Organization |
|---|---|---|
| 1 | 1.Dr. Anjaneyalu<br>2. Dr. Pooranchand | AICSIP, RARS, Palem , Dist. Mahaboobnagar |
| 2 | 1.Dr. Changole<br>2.Dr. Misal, MB | AICSIP, Parbhani, Maharashtra |
| 3 | 1.Dr. RP Thakur<br>2.Dr. Upadhaya | AICSIP, Indore, M.P. |
| 4 | 1.Dr. Pushpender Singh<br>2. Dr. Vittal Sharma | AICSIP, Udaipur, Rajasthan |
| 5 | 1. Dr. YK Singh<br>2. Dr. Sachan | AICSIP, Mauranipur, Dist. Jhansi |
| 6. | 1.Dr. RS Dwiwadi<br>2. Dr. KA Singh | IGFRI, Jhansi |
| 7 | 1. Dr. Anand Singh<br>2. Dr. Rakesh Nanda | KVK, Jammu, Sher-E Kashmir University of Agriculture and technology, Jammu |
| 8 | 1. Dr. Yogesh K Singh<br>2. Dr. BN Singh | Birsa Agril. University, Ranchi, Jharkhand |
| 9 | 1. Dr. SS Angadi<br>2. Dr. MY Kamtar | AICSIP, UAS, Dharwad, Karnataka |
| 10 | 1. Dr. Poonuswamy<br>2. Dr. Ganesh Murthy | AICSIP, TNAU, Coimbatore, T.N |
| 11 | 1. Dr. JP Deshmukh<br>2. Dr. RB Gorade | AICSIP, Akola, Maharashtra |
| 12 | Dr. BS Jadhav | AICSIP, Surat, Gujarat |
| 13 | Dr. R Mahala | ACSIP, Deesa, Gujarat |
| 14 | Dr. Shirothia | AICSIP, Pantnagar |
| 15 | Dr. MS Prasad | I/C KVK, CRIDA, Hyderabad |


The frontline demonstration programme during kharif season of the year 2007-08 covered an area of 312 ha out of the allotted 400 ha in all the major sorghum-growing states of the country. The reason for shortfall was delayed receipt of approval for conduct of the programme from the Ministry of agriculture, Government of India, New Delhi. The programme involved 479 farmers in the 9 sorghum growing states of country. The demonstrations were of two types.

**a. Whole package demonstrations:** The demonstrations with recently identified varieties such as CSV 20 (SPV 1616), DSV 6, GJ 42, Bundhala, Parbhani Sainath and pre-released cultivars SPV 1686, SPV 1685, SPV 1664, PJ 1430, SU 1080, SPV 1714, form the whole package demonstrations. The new varieties with complete package of practices were demonstrated under the realistic farm situation to the farmers.

**b. Component demonstrations :** The demonstrations with the released cultivars which are more then two years old but are less then 7 years after their release. Nationally released cultivar CSV 17, CSH 18 and state released cultivars such as PVK 801 and PVK 809 (Maharashtra); JJ 1041 and JJ 1022 (MP), Co(s) 28 (T.N), PSV 1, PC 5 and PC 6 form these demonstration. The complete recommended package of practices which include quality seed, fertilizer, insecticide, etc were demonstrated under this component.

**Table 1: Progress of Kharif FLD 2007**

| State | Centre | Allotted (ha) | Achieved (ha) | Percent success (%) |
|---|---|---|---|---|
| A.P | Palem | 10 | 7.2 | 72 |
| | KVK CRIDA | 25 | 0 | 0 |
| Maharashtra | Parbhani | 40 | 28.4 | 71 |
| | Akola | 40 | 23 | 57.5 |
| Karnataka | Dharwad | 30 | 23 | 77 |
| Gujarat | Surat | 20 | 21 | 105 |
| | Deesa | 10 | 10 | 100 |
| M.P | Indore | 30 | 34 | 112 |
| U.P | Mauranipur | 30 | 22.4 | 75 |
| | IGFRI | 15 | 15 | 100 |
| Rajasthan | Udaipur | 40 | 51 | 128 |
| Uttarakhand | Panthnagar | 40 | 39 | 97.5 |
| Jharkhand | BAU, Ranchi | 20 | 10 | 50 |
| J&K | KVK, Jammu | 20 | 8 | 40 |
| Tamil Nadu | Coimbatore | 30 | 30 | 100 |
| **Total** | | **400** | **322** | **80.43** |

**1. Grain yields** (Tables 3 to 7): The introduction of new sorghum cultivars in the farmer's field will have an increase in grain yield by about 53 per cent. The adoption of the existing sorghum cultivars will lead to an increase by 35.4 per cent over existing practices. On an all-India basis, the improved cultivars showed an increase in the grain yields by about 44.3 per cent over farmers practice.

**Table 2: Technology wise performance of improved cultivars under FLDs**. (q/ha)

| Technology | Grain Yield (IP) | Grain Yield (FP) | % Increase of grain yield over FP |
|---|---|---|---|
| Whole package technology | 22.7 | 14.6 | 35.4 |
| Component technology | 20.7 | 9.6 | 53.8 |
| All India average all demonstrations | 21.6 | 12.2 | 44.3 |

*(IP: Improved practice; FP: Farmers practice)*

**2. Profitability** (Tables 8-9): The average cost of cultivation following the improved varietal technology is Rs 6515/ha, while that of farmers practice is Rs 5500/ha. The gross income that the farmer gets following the improved varietal technology is Rs. 16990, while that with farmers practice is Rs. 11294. The net returns obtainable following the improved cultivation practices is Rs 10427/ha as compared to the net returns obtainable following the farmers practice which is Rs 5742/ha. So the additional benefit by adopting the recommended technology is Rs 4685. The Incremental Cost Benefit Ratio is 1.81. This indicates that on every one rupee invested by the farmer, the possible returns that farmer would accrue is Rs 1.81 following the recommended practices for cultivation of improved sorghum varieties. The gross returns the farmer can expect following recommended practices for hybrid cultivation for grain and fodder production would be Rs 21680 as compared to the farmers practice where the net returns are Rs 14474/ha. The ICBR is 1.64 for hybrid grain sorghum cultivation

**3. Yield gap analysis:** On all India basis the yield gap between the FLD farmers yields and average estimated yield for 2007-08 kharif season is about 50 %

a. **State-wise yield gap:** The state wise gap between the FLD farmers yields and average estimated yields for 2007-08 kharif season indicated that in the extent of gap was between 66 to 69 per cent in Uttar Pradesh and Rajasthan. The gap percent ranged between 42 per cent in Maharashtra;45 per cent

in Madhya Pradesh. In Andhra Pradesh the gap percent is about 50 per cent, while in Tamil Nadu it is about 39 per cent. This gap can effectively reduced by the replacement of seed of the local cultivars with that of the improved cultivar

b. **District wise yield gap:** The district wise yield gap between the average FLD yields and average district yields indicated that the least gap was observed in the Gwalior district, where the FLD average yield and the district average yield did not show any gap followed by Indore district which has a yield gap of about 8 per cent. In the other districts of Madhya Pradesh the yield gap ranged between 33 per cent in Shajapur to 76 per cent in Ujjain districts. In A P, the yield gap of about 53 percent is observed in Mahaboobnagar district. In Tamil Nadu, the yield gap between the FLD yields and district average in Coimbatore district is about 73 per cent. In Rajasthan, the Ajmir district had a yield gap of 83 percent between the FLD yields and district average. In Uttar Pradesh the yield gap of about 58 per cent between the FLD and district average is observed, while in Jammu and Kashmir, a gap of 53 per cent is observed.

**Exploitable yield reservoir in kharif sorghum:** The data from the front-line demonstrations reveal that with the exploitation of the currently available sorghum production technologies, farmers could realize additional yield up to 50 percent over the prevailing farmer's practices under wide range of agro ecological and crop growing situations. The total production of sorghum during the kharif season during the period of 2007-08 is estimated to be 0.396 m. tonnes. The performance of the improved technologies has clearly shown that the yield could be increased by 50 per cent. Thus there exists an exploitable yield reservoir of at least 0.199 m. tonnes over the existing national production which can be added to the current sorghum production in the country from the existing area and available improved production technologies being completely adopted by the farmers. Thus the total sorghum production during the kharif season would have been 0.595 m. tonnes.

**Table 2: Exploitable yield reservoir in sorghum**

| Mean realizable yield with improved technology (kg/ha) * | National average (kg/ha) # | Realizable yield gap | | Present national production (m. tonnes) # | Expected production (m. tonnes) $ | |
|---|---|---|---|---|---|---|
| | | Absolute kg/ha | Percent (&) | | Additional Col.3*Col4/100 | Total Col.5+Col.6 |
| 2168 | 1076 | 1092 | 50.4 | 0.396 | 0.199 | 0.595 |

** Data from FLD (2007-08); # National average during 2007-08; & Percentage to national average yield (col. 3/col. 2x100); $ Expected production if realizable yield gap is bridged through complete adoption of improved technology*

In spite of decrease in area under cultivation of sorghum at all India levels by about 6% during the kharif season, productivity levels of sorghum grain are maintained at about 0.4 m tonnes; which is about the same as last year. This is mainly due to the efforts being made by the state governments to take up seed replacement programme with the nationally and state release improved cultivars (National conference on agriculture for kharif campaign 2008, - Feb 27-28, New Delhi.). These cultivars which have been demonstrated under FLD programme over the years have impressed the policy makers to take up such decisions for the benefit of the farming community. The frontline demonstrations are only on a pilot scale on the farmer's fields. These results only indicate the possibility of increasing the yields of sorghum there by increase the income to the farmer with the introduction of the improved cultivars on a large scale. The performance of the improved technologies has clearly shown that the yield could be increased by 50 per cent. Thus there exists an exploitable yield reservoir of at least 0.199 m. tonnes over the existing national production which can be added to the current sorghum production in the country from the existing area and available improved production technologies being completely adopted by the farmers.

The dual purpose variety CSV 20, should be recommended for cultivation on large scale as it has demonstrated its high grain yielding capabilities in the states of A.P., U.P, Jharkhand, Rajasthan, M.P and Maharashtra to enhance the livelihood of farmers. Similarly, CSV 17 which is also recommended for drought prone areas of Rajasthan (Ajmer and Pali districts, Bundelkhand region of U.P, should be taken up for adoption on large scale. The state departments of agriculture should ensure timely transfer of technology and availability of inputs for following the recommended package of practices by the farmers.

The yield gap analysis indicated the gap between possible yields obtained by the farmers and any increase in the yields can be achieved through seed replacement with improved cultivars. The lesser the yield gap higher is the chance for acceptability of the technology by the farmers.

**Table 3: Whole package demonstrations performance of SPV 1616 Vs Local under real farm situation**

| State | Area (ha) | No. of demo | Grain yield (q/ha) | Grain yield (q/ha) | % increase Grain Yield over FP | Fodder yield (q/ha) | Fodder yield (q/ha) | % increase Fodder yield over FP |
|---|---|---|---|---|---|---|---|---|
| | | | IP | FP | | IP | FP | |
| A.P | 4.8 | 12 | 23 | 16 | 30 | 86 | 74 | 14 |
| Maharashtra | 13.2 | 33 | 11 | 7 | 32 | 48 | 32 | 33 |
| M.P. | 0.6 | 2 | 23 | 18 | 23 | 89 | 64 | 28 |
| Rajasthan | 6.1 | 21 | 26 | 7 | 74 | 109 | 89 | 18 |
| U.P | 20 | 20 | 20 | 14 | 31 | 103 | 117 | -13 |
| J&K | 8 | 8 | 13 | 6 | 56 | 83 | 104 | -25 |
| Jharkhand* | 5 | 5 | 3 | 2 | 24 | 124 | 115 | 7 |
| Total/Average | **57.7** | **101** | **17** | **10** | **39** | **92** | **85** | **9** |

*IP: Improved practice, FP farmer's practice. * Low grain yields due to sever bird damage.*

**Table 4: Whole package demonstrations with other state/pre-release cultivars Vs Local under real farm situation**

| State | Area (ha) | No. of demo | IP | Grain yield (q/ha) | | % increase Grain Yield over FP | Fodder yield (q/ha) | | % increase Fodder yield over FP |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *IP* | *FP* | | *IP* | *FP* | |
| Maharashtra | 0.8 | 2 | P. Sainath | 22 | 8 | 66 | 50 | 33 | 34 |
| Rajasthan | 4 | 10 | SPV 1664 | 26 | 7 | 74 | 113 | 97 | 14 |
| | 0.2 | 1 | SPV 1714 | 30 | 8 | 73 | 118 | 118 | 0 |
| | 1.8 | 7 | SPV 1685 | 24 | 7 | 71 | 113 | 79 | 30 |
| | 7 | 16 | SPV 1686 | 24 | 7 | 71 | 108 | 83 | 23 |
| | 0.9 | 4 | PC 9 | 19 | 7 | 62 | 122 | 71 | 42 |
| U.P | 3 | 3 | Bundhela | 20 | 15 | 27 | 90 | 105 | -17 |
| | 5 | 5 | 9205 | 23 | 16 | 33 | 107 | 110 | -3 |
| | **22.7** | **48** | | | | | | | |

*IP: Improved practice, FP farmer's practice*

**Table 5: Component demonstrations - Performance of national release hybrid CSH 16 Vs Local under real farm situation**

| State | Area (ha) | No. of demo | Grain yield (q/ha) | | % increase Grain Yield over FP | Fodder yield (q/ha) | | % increase Fodder yield over FP |
|---|---|---|---|---|---|---|---|---|
| | | | IP | FP | | IP | FP | |
| Mah | 0.8 | 2 | 17 | 7 | 59 | 44 | 36 | 17 |
| M.P. | 2 | 5 | 32 | 27 | 17 | 105 | 80 | 24 |
| Total/Average | **2.8** | **7** | **25** | **17** | **32** | **74** | **58** | **22** |

**Table 6: Component demonstrations: Performance of national and state release varieties Vs Local under real farm situation**

| State | Area (ha) | No. of demo | IP | Grain yield (q/ha) | | % increase Grain Yield over FP | Fodder yield (q/ha) | | % increase Fodder yield over FP |
|---|---|---|---|---|---|---|---|---|---|
| | | | | *IP* | *FP* | | *IP* | *FP* | |
| A.P | 0.4 | 1 | PSV 1 | 25 | 18 | 28 | 70 | 60 | 14 |
| Maharashtra | 8.4 | 20 | PVK 809 | 11 | 7 | 36 | 52 | 32 | 38 |
| Maharashtra | 3.2 | 8 | PVK-801 | 10 | 7 | 27 | 38 | 30 | 21 |
| Rajasthan | 7 | 14 | CSV 15 | 26 | 6 | 76 | 58 | 44 | 25 |
| Rajasthan | 17 | 26 | CSV 17 | 14 | 7 | 53 | 46 | 41 | 11 |
| Rajasthan | 4.4 | 11 | PJ 1430 | 21 | 7 | 70 | 76 | 63 | 17 |
| Rajasthan | 1 | 2 | SU 1080 | 28 | 7 | 73 | 128 | 98 | 24 |
| M.P. | 3 | 7 | JJ 1022 | 20 | 16 | 19 | 72 | 58 | 20 |
| M.P. | 27.8 | 68 | JJ 1041 | 22 | 16 | 28 | 76 | 56 | 27 |
| T.N | 30 | 30 | COS28 | 14 | 7 | 50 | 37 | 41 | -13 |
| Total/Average | **102** | **187** | | **19** | **10** | **46** | **65** | **52** | **18** |

*IP: Improved practice, FP farmer's practice*

**Table 7: Component demonstrations - Performance of national release hybrid CSH 18 Vs Local under real farm situation**

| State | Area (ha) | No. of demo | Grain yield (q/ha) | | % increase Grain Yield over FP | Fodder yield (q/ha) | | % increase Fodder yield over FP |
|---|---|---|---|---|---|---|---|---|
| | | | *IP* | *FP* | | *IP* | *FP* | |
| A.P | 5 | 5 | 25 | 18 | 28 | 70 | 60 | 14 |
| Maharashtra | 2 | 5 | 17 | 7 | 56 | 46 | 32 | 30 |
| M.P. | 0.3 | 1 | 31 | 25 | 21 | 109 | 86 | 21 |
| Rajasthan | 1.5 | 5 | 28 | 8 | 72 | 104 | 78 | 24 |
| U.P | 8 | 8 | 20 | 15 | 28 | 101 | 121 | -20 |
| Jharkhand* | 5 | 5 | 2 | 2 | 1 | 101 | 112 | -11 |
| Total/Average | **21.8** | **29** | **21** | **12** | **40** | **88** | **82** | **8** |

*IP: Improved practice, FP farmer's practice. * Low grain yields due to sever bird damage.*

**Table 8: Comparison between average cost of cultivation of varietal technndogy and farmers practice under real farm situation. (Rs)**

| State | Gross incomeIP | Gross returns FP | Cost of cultivation IP | Cost of cultivation FP | Net returns IP | Net returns FP | ICBR |
|---|---|---|---|---|---|---|---|
| A.P | 17851 | 13573 | 11947 | 11531 | 5904 | 2043 | 2.89 |
| Mah | 9723 | 6802 | 7556 | 5873 | 2185 | 929 | 2.33 |
| M.P. | 25519 | 19257 | 4950 | 3838 | 20569 | 15419 | 1.33 |
| Rajasthan | 27319 | 15648 | 6190 | 6190 | 20819 | 9148 | 2.23 |
| U.P | 13058 | 9025 | 5050 | 3450 | 8008 | 5575 | 1.44 |
| J&K | 8472 | 3457 | 3397 | 2116 | 5075 | 1341 | 3.79 |
| **Average** | **16990** | **11294** | **6515** | **5500** | **10427** | **5742** | **1.81** |

**Table 9: Comparison between average cost of cultivation of hybrids and farmers practice under real farm situation (Rs)**

| State | Gross income IP | Gross returns FP | Cost of cultivation IP | Cost of cultivation FP | Net returns IP | Net returns FP | ICBR |
|---|---|---|---|---|---|---|---|
| A.P | 19450 | 14100 | 11750 | 10350 | 7700 | 3750 | 2.05 |
| Mah | 13823 | 6806 | 9272 | 6024 | 4551 | 782 | 5.82 |
| M.P. | 34565 | 27318 | 3400 | 1900 | 31165 | 25418 | 1.23 |
| Rajasthan | 27338 | 14630 | 6500 | 6500 | 20838 | 8130 | 2.56 |
| U.P | 13222 | 9515 | 5050 | 3450 | 8172 | 6065 | 1.35 |
| **Average** | **21680** | **14474** | **7194** | **5645** | **14485** | **8829** | **1.64** |

**Table 10: Comparison between average FLD yields and state average yields (q/ha)**

| State | FLD yields | State average yields* | Gap percent |
|---|---|---|---|
| A.P. | 19.9 | 9.9 | 50.6 |
| T.N | 14.1 | 8.6 | 38.6 |
| Maharashtra | 22.0 | 12.6 | 42.7 |
| M.P | 22.4 | 12.3 | 45.1 |
| Rajasthan | 22.0 | 6.8 | 69.1 |
| U.P | 20.4 | 6.8 | 66.4 |
| J&K | 12.9 | 8.0 | 38.1 |
| **All India** | **21.7** | **10.7** | **50.4** |

**Source: DMD Jaipur*

**Table 11: Comparison between average FLD yields and district average yields (q/ha)**

| State | District | FLD Yields | District av. yields* | Gap percent |
|---|---|---|---|---|
| A.P | Mahaboobnagar | 19.9 | 9.3 | 53.4 |
| T.N | Coimbatore | 14.1 | 3.7 | 73.7 |
| Maharashtra | Parbhani | 22.0 | 5.6 | 74.5 |
| M.P | Betul | 23.6 | 6.5 | 72.5 |
| | Chatterpur | 25.2 | 8.5 | 66.3 |
| | Dewas | 17.3 | 9.5 | 45.1 |
| | Dhar | 20.6 | 6.3 | 69.4 |
| | Gwalior | 28.0 | 28.0 | 0.0 |
| | Indore | 13.2 | 12.2 | 7.7 |
| | Shajapur | 20.5 | 13.7 | 33.3 |
| | Ujjain | 30.2 | 7.2 | 76.2 |
| | Jhabjua | 16.3 | 7.8 | 52.3 |
| | Datia | 19.3 | 6.4 | 66.8 |
| Rajasthan | Ajmir | 17.9 | 2.5 | 86.0 |
| | Chittorgarh | 25.3 | 6.4 | 74.7 |
| | Durgapur | 19.5 | 4.6 | 76.4 |
| | Pali | 11.9 | 4.2 | 64.7 |
| | Udaipur | 24.1 | 6.6 | 72.5 |
| | Rajsamand | 21.0 | 8.0 | 61.9 |
| U.P | Jhansi | 20.4 | 9.0 | 55.9 |
| J&K | Jammu | 12.9 | 6.0 | 53.6 |

** Source: SDDS-DES, Ministry of Agriculture, Govt. of India.*

# Summaries of disciplinary research

## 1. Genetic resources (M Elangovan and VA Tonapi)

The National Research Centre for Sorghum (NRCS) is one of the National Active Germplasm Sites (NAGS) with the responsibility to collect, conserve, evaluate, document, and distribute the sorghum germplasm to the bonafied user within the country. During the reporting period for the year 2007 – 08, the following progress has been made.

- 1188 accessions of sorghum germplasm received from various national and international centers for utilization.
- 276 accessions were multiplied and submitted to the National Genebank, NBPGR, New Delhi for long-term storage
- 59 accessions are being multiplied for utilization, mandatory submission to the National Genebank, and for sending out as trials.
- 1253 accessions were distributed to the sorghum researchers of the country; 330 accessions were supplied for trials
- 540 acc. of breeding materials exchanged to NRCS and AICSIP scientists

We have gathered all availbe 220 old SPV lines and have evaluated them. SPV-1290 was betters than the check (IS 38551) and SPV-1267, SPV 692, and SPV 824 were on bar with the checks for tolerant to shoot fly. 17 entries recorded moderate level of resistance to grain molds as against susceptible check recording 8 on 1-9 scale.

Further, so far we have submitted 47 applications for registration with PVP&FR Authority. More submissions are underway including new cultivars.

## 2. Forage sorghum – single, and multi-cut (C Aruna and BV Bhat)

During 2007-08, a total of 15 experiments were carried out across 17 locations all over India (North zone, and South zone)

***Single-cut***

In advanced trial, the genotype, PC 1003 ranked first both for green (408.5 q/ha) fodder and dry fodder (157.1 q/ha) yields. For green fodder yield SRF 305 ranked second (406.7 q/ha), whereas for dry fodder yield it ranked third (150.0 q/ha) at all India level. For fodder quality parameters, the genotype PC 1003 was found to be superior compared to all test entries (it ranked first in protein content and IVDMD values). The genotype, SRF 305 performed well over three years (2005-07). In the initial trial, the genotype SU 1175 ranked first for green (431.1 q/ha) as well as dry (176.6 q/ha) fodder yields, and green and dry fodder yields per day. Highest protein percentage was noticed in CSV 15 (8.17%) followed by UTFS 51 (8.13%). For IVDMD and TSS, UTFS 51 was ranking first.

***Multi-cut***

The hybrid UTMCH 1302 ranked first for green fodder yield (794.7 q/ha). For dry fodder yield, the check CSH 20MF was the highest yielder followed by UTMCH 1302 and UTMCH 1304. The average protein yield was highest in the genotype, UTMCH 1302 (15.5 q/ha). The average IVDMD percentage of two cuts was highest in UTMCH 1304 (49.9%), followed by UTMCH 1302 (45.4%). Among the varieties, UTMC 534 (46.43%) was the best. UTMCH 1302 was the best hybrid both for yield and quality. It performed well over four years (2004-07). Among varieties, UTMC 534 was good for quality. In the initial trial, the hybrid, UTMCH 1305 out yielded the

check, CSH 20MF for both green (711.1 q/ha) and dry (182.8 q/ha) fodder yields. UTMCH 1305 and ARFSH 559 were found to be better genotypes as far as quality parameters are concerned.

**Agronomy and quality**

***Single-cut***

Comparison of yields across three nitrogen rates (80, 100 and 120 kg N/ha) indicated that the application rates of 100 kg/ha (dry fodder yield 152 q $ha^{-1}$) and 120 kg/ha (171 q $ha^{-1}$) were significantly higher than 80 kg N $ha^{-1}$ (128 q $ha^{-1}$). There was no significant interaction between cultivar and fertilizer input across all the observations. The trial on effect of INM showed that the highest green and dry fodder yields of 621 & 167 q $ha^{-1}$ respectively were attained with application of 100% RDF and 25 kg Zinc Sulphate, and the protein percentage is higher (6.35%) when the recommended dose of fertliser is partly replaced by vermicompost. The intercropping of Sorghum and pillipesara (*Phaseolus trilobus*) in 1:1 ratio was found to be most profitable with a cost-benefit ratio of 2.36.

***Multi-cut***

Comparison of yields across four nitrogen rates (0 to 150 kg with 50kg increments) indicated that that there was no significant interaction between cultivar and fertilizer input across all the observations. The green and dry fodder yields increased significantly with the increasing levels of nitrogen from 0-150 kg/ha. Total protein and DDM yield increased considerably from 3.86 to 10.16 q/ha and 23.72 to 52.5 q/ha with an increase in nitrogen levels from 0 to 150 q/ha.

## 3. Dual-purpose sorghum trials (AVHT & IVT) (Umakanth)

**AVHT:** Eleven entries including 8 test varieties, 1 varietal check, 1 test and check hybrids were tested across 15 locations.

- In Zone I, SPV 1779 and SPV 1754 were the promising entries for stover yield, biomass and plant height .
- In Zone II, SPV 1782 and SPV 1779 were the superior entries for biomass and leaf width while SPH 1467 was promising for grain yield and biomass.
- In Zone III, SPV 1781 and SPV 1754 were better for both grain and fodder yields.
- At All India level, SPV 1779, SPV 1781, SPV 1754 and SPV 1782 were promising entries. The hybrid SPH 1467 performed better than the check for grain yield in all the zones and at all India level and for fodder yield in Zone II.
- With respect to shoot fly resistance, the entries SPV 1754 and SPV 1779 were found superior compared to other entries while for stem borer resistance, SPV 1750, SPV 1616, SPV 1779, SPV 1778, SPV 1754 and SPH 1467 were promising.
- All the test entries were highly susceptible to grain molds and none were found to have any resistance to grain molds. SPV 1779 recorded lowest downy mildew incidence.

*Conclusions:* SPV 1779, SPV 1781, SPV 1754 and SPV 1782 were promising entries.

**IVT:** Eight entries including check were tested across 14 locations.

- In all the 3 zones and at All India level, SPV 1822 and SPV 1823 performed consistently for grain and fodder yields and biomass.
- SPV 1616, SPV 1823 and SPV 1824 were found superior for stem borer resistance.
- All the test entries were highly susceptible to grain molds and none were found to have any resistance to grain molds.
- SPV 1822 was observed to have multiple resistances to Anthracnose, zonate leaf spot and downy mildew.
- SPV 1823 and SPV 1824 were also resistant to Anthracnose.

*Conclusions:* SPV 1822 and SPV 1823 were the promising entries.

## 4. Breeding for Kharif grain sorghum (S Audilakshmi)

Much progress as been achieved in resistance breeding for tolerance to biotic and abiotic stresses in the collaborative research undertaken with SAUs..

**Grain moulds (GM):** 15 RILs showed resistance on par with B 58586 (Field grain mold score =4.0) over the years and locations. Best performing lines breeding stocks (F5s) included >6 progenies which were better than the check (FGS ,2.0).

**Shoot fly (SF):** On average (over 2years, 3 locations), the best performing lines for SF tolerance are: SFRIL-128 and SFRIL- 206 with 41% deadhearts (DH), SFRIL-374 and SFRIL-404 with 42% and SFRIL-342 with 46% DH against the check of IS 2122 (40% DH).

**Drought:** Eighty $F_4$s from crosses between elite and drought resistance sources were evaluated at Udaipur, Kovilpatti and Coimbatore during kharif 2007. Entries SPV 772 x S 35-21, SPV 772 x S 35-29, and SPV 772 x S 35-38 were showing superior performance during drought conditions in flowering and maturity phase.

Similarly , significant achievements in sorghum breeding are reported from most at AICSIP centers:

- **Akola:** Six new MS lines developed, being used for developing hybrids.
- **Indore:** 16 local germplasm lines evaluated. GGUB 31 (170 g/plant) and GGUB 52 (123 g/plant) were highest grain yielders.
- **Parbhani:** Evaluated 90 MS and 70 R lines, superior lines were further crossed.
- **Coimbatore:** Superior dual purpose varieties and hybrids identified.
- **Udaipur:** Selections made for early, dual purpose types with shoot fly and foliar diseases resistance from $F_3$-$F_5$.
- **Dharwad:** Selections made from elite x locals for good grain quality and yield.

*Similarly, many achievements ar reported from the strategic research at NRCS, both by classical and DNA marker-assisted approach.* During 2007-08, we published 14 articles in international and national journals.

**Multi-location yield trials**

***Advanced Varietal and Hybrid Trial***

- *Zone I:* SPH 1596 yielded 4357 kg/ha against 3801 kg/ha of the check, CSH 18. None of the varieties were superior to the check, SPV 462.
- *Zone II:* SPH 1567 recorded 5260 kg/ha of grain yield against 4961 kg/ha of CSH 16 (check). Among the varieties, SPV 1786 recorded 7% higher grain yield compared to CSV 15, the check.
- *Zone III:* SPH 1596 and SPH 1587 recorded 3451 and 3248 kg/ha of grain yield as against 3001 kg/ha of CSH 18.

***Initial Varietal Trial***

- *Zone:I* SPV 1860 yielded 6483 kg/ha of grain against 6393 kg/ha of SPV 462 (check).
- *Zone II:* Two varieties, SPV 1816 and SPV 1808 showed 12% and 6 % superiority over the check, CSV 15.

***Initial Hybrid Trial***

- *Zone I:* Nine hybrids were significantly superior to CSH 18, the check, for grain yield. SPH 1616 (6293 kg/ha) and SPH 1606 (6279 kg/ha) ranked 1st and 2nd for grain yield, where as the check, CSH 18 yielded 4941 kg/ha of grain.
- *Zone II:* The hybrids, SPH nos 1610, 1611, 1616, and 1615 recorded numerical superiority over the check, CSH16 for grain yield. SPH 1610 gave maximum grain yield of 7153 kg/ha against 6639 kg/ha of CSH 16.
- *Zone III:3* hybrids, SPH nos 1611, 1606, and 1610 were superior to the check, CSH 18 by 17, 6 and 5%.

## 5. Sweet sorghum (SS Rao and AV Umakanth)

**Trial 1K. Evaluation of initial and advanced sweet sorghum varieties and hybrids trial (IASSVHT) entries:**
This trial was conducted at 13 locations to evaluate sixteen initial and advanced trial hybrids and varieties stalk yield, biomass, sugar content and bioethanol yields along with three checks (SSV 84, CSV 19SS & CSH 22 SS) in kharif 2007. Entries SPSSH 27(JK Agric), SPSSV 11 (Advanta hybrid) and SPSSH 24 (ICRISSAT) in hybrids and SPSSV 15 (RSSV104-Rahuri), SPSSV 20 (ICSV 93046-ICRISAT) and SPSSV 27(RSSV138-Rahuri) in varieties were superior for juice yield, sugar yields and bioethanol yields than checks.

**Table 2K: Evaluation of sweet sorghum germplasm for high biomass and stalk characteristics:**
Forty-eight promising sweet sorghum germplasm selected from among 150 germplasm lines from 2005-5006 were evaluated along with two checks i.e. SSV 84 and CSV 19 SS at Parbhani, Rahuri and Hyderabad in augmented design for stalk yield, brix content and biomass. Twenty two entries namely EC538169, IS5352, IS5353, IS 5356, IS5360, IS5362, IS6936, IS7073, IS7080, IS7541, IS7543, IS7546, IS7549, IS11152, IS11496, IS12135, IS17813, IS17814, IS17825, SSV74, EG25, and KARS 95 had shown superior performance than check CSV19 SS in terms of fresh stalk yield, & quality and could be used as potential donors for the sweet sorghum improvement aimed at high stalk yield, sugar content and high biomass production.

**Trial 3K. Influence of stage of harvesting on changes in quality, stalk yield and biomass in sweet sorghum:**
Bioethanol yields increased from flowering until hard-dough stage. Both sugar yields and bioethanol yields increased by 11 % when sweet sorghum crop harvested at hard-dough stage than at physiological maturity. CSH22 SS recorded highest bioethanol yield at hard-dough stage. Mean fresh and dry bagasse yields recorded at maturity across treatments and cultivars was 20.6 t/ha and 4.9 t/ha, respectively. While, mean fresh bagasse % stalk and dry bagasse (fibre) % stalk recorded was 61.4% and 14.6% across the cultivars and treatments. Mean moisture % stalk and moisture % bagasse recorded was 73.5% and 76.4% across the cultivars and treatments. Significantly higher moisture % stalk and moisture % bagasse were recorded at flowering followed by a decline until physiological maturity. Stalk harvesting at hard-dough stage is ideal as it contains less moisture than at soft-dough stage or flowering.

***Resistance to biotic stresses:*** *Shoot fly:* SPSSV 4 alone recorded least deadhearts formation and significantly not different from SPSSV nos. 20, 27, & 28; and SPSSH 25.

***Spotted stem borer***: The entries SPSSV nos 4, 15, 20, 27, & 28; and SPSSH nos 19 & 25 showed low deadheart formation and on par with CSV 19SS & CSH 22SS, including the resistant check, IS 2205. The entry, SPSSV 4 alone showed multiple resistance not only to shoot fly and but also deadhearts, leaf injury, and peduncle damage symptoms due to spotted stem borer and significantly not different from the commercial check, CSV 19SS. In addition, SPSSV nos 15 & 20, and SPSSH 19 recorded resistance to all the damage parameters of spotted stem borer.

***Diseases:*** Among the test entries, SPSSV 30 showed high degree of resistance to grain mold and downy mildew. The rust reaction recorded significantly low in SPSSV nos 15, 20, 27 & 29; and SPSSH numbers 24 & 27. The entries SPSSV 29 and SPSSH 24 & 27 had multiple disease resistance to downy mildew, rust, and zonate leaf spot. Whereas the commercial check, CSH 22SS showed multiple resistance to downy mildew and zonate leaf spot.

***Basic genetic studies in sweet sorghum:*** Frequency distribution of $F_2$ showed that brix is governed by polygenic genes and cane and juice yield by olygogenic genes. The mean performance showed that $F_1$ mean for brix tended towards $P_2$ indicating that high brix is dominant. The $F_1$ means for cane yield and juice yield were greater than those of both the parents, indicating that these traits are governed by over dominant genes. Generation mean analysis showed that additive and dominance gene actions were important for all the traits, and negative dominance x dominance gene interaction was predominant indicating presence of epistatic interaction.

## 6. Agronomy (MS Raut with AICSIP centers)

The results from various trails are summarized in the following table:

| S. No | Trial | Experiments | Test genotype | Check genotype | Location | Promising entries / treatments |
|---|---|---|---|---|---|---|
| **A.** | **Mandatory Trial** | | | | | |
| 1. | 1(K)A | Evaluation of promising genotypes for their yield potential under rainfed condition in Zone - I | SPV-1733 | SPV-1616, SPV-462, CSV-17 and Yellow Jona | Palem, Coimbatore | 120 Kg N + 60 Kg $P_2O_5$ / ha gave 28% higher grain yield than 100% RDF; CSV 17 produced highest grain yield |
| 2. | 1(K)B | Evaluation of promising genotypes for their yield potential under rainfed conditions in Zone-II | SPH-1567, SPV-1746 | SPV-1616, CSV-17. CSV-15 | Akola, Indore, Surat, Dharwad, Parbhani | 120 Kg N + 60 Kg $P_2O_5$ / ha was found optimum; SPH 1567 and SPV 1746 were superior to SPV 1616 & CSV 17 |
| 3. | 1(K)C | Evaluation of promising genotypes for their potential under rainfed condition Zone-III | SPV-1730, SPV-1733 | SPV-1616, SPV-462, CSV-17 | Deesa, Udaipur, Pantnagar, Mauranipur | 80 Kg N + 40 Kg $P_2O_5$ / ha was found optimum; SPV 1730 and SPV 1733 were superior to CSV 17 but on par with SPV 462 |
| 4 | 1(K)D | Evaluation of promising genotypes for their yield potential under rainfed condition late kharif early rabi zone | SPH-1577 | SPV-1616, SPV-462, CSV-17 | Kovilpatti | 120 Kg N + 60 Kg $P_2O_5$ / ha revealed maximum grain yield; SPH 1577 was superior to CSV 17 |
| 5 | 1(K)E | Evaluation of promising genotypes (Dual purpose) for their yield potential under rainfed conditions | SPV-1750, SPV-1753, SPV-1754, CSV-15, SPH-1467 | -- | Palem, Udaipur, Pantnagar, Coimbatore | 80 Kg N + 40 Kg $P_2O_5$ / ha was found optimum; SPH 1467 produced highest grain yield |
| **B.** | **Location specific trials** | | | | | |
| 6. | 1.1(A) | Maximization of sweet sorghum cane yield | SSV-84, CSV-19SS/ CSH-22SS | -- | Akola, Coimbatore Pantnagar, Solapur | Sweet sorghum genotypes CSH 22SS, SSV 84, CSV 19SS sown at row spacing 45 cm x 15 cm fertilized with 120 kg N / ha was promising |
| 7. | 1.1(B) | Evaluation of sweet sorghum genotypes for their yield potential at different fertility levels | SPSSV-11, SPSSV-15, SPSSV-20 | SSV-84, CSV-19SS, CSH-22SS | Akola, Coimbatore , Indore, Pantnagar, Solapur | Sweet sorghum genotypes SPSSV 20 was high yielding. Response to 120 kg N / ha + 60 Kg $P_2O_5$ / ha was significant |
| 8. | 1.2 | Integrated nutrient and moisture conservation in kharif sorghum | CSH-14 | -- | Parbhani, Akola, Dharwad, Udaipur | Opening furrow at 21 DAS along with 80 Kg N + 40 Kg $P_2O_5$ / ha was found optimum |
| 9. | 1.3 | Studies on nutrient uptake grain and stover qualities of different sorghum genotypes | SPV-1616, CSV-15, CSH-16, SSV-84, HC-308 and SSG-59-3 | | Coimbatore, Parbhani, Dharwad, Indore, Udaipur, Deesa, Solapur Pantnagar | CSH 16 revealed highest DDM at crude protein yields |
| 10. | 2.1 | Nutrient recycling in sorghum based double cropping system | | | Indore, Surat | Sorghum in Sorghum (K)-chickpea sequence responded significantly up to 80 Kg N + 40 Kg $P_2O_5$ / ha |
| 11. | 3.1 | Effect soil moisture conservation practices on yield of sorghum | | | Indore | Moisture conservation through earthing up at 25 DAS and application of glycidia were promising |
| 12. | 3.2 | Response of forage sorghum genotypes to different fertility level | UTFS- 43, HC-308, S - 540 and S 541 | -- | Dharwad | Forage sorghum genotype UTFS 43 was highest yielding; Response to 30 Kg N / ha was significant |

## 7. Pest survey and surveillance- Kharif 2007 (VR Bhagwat)

Low infestation (< 15%) of shoot fly was observed. Stem borer infestation (20-25%) was moderate. Midge incidence was low (< 5%) in Coimbatore district of Tamil Nadu. Moisture stress was experienced in some parts in late sown crop. In Mahboobnagar (AP) district of AP, moderate to heavy attack of shoot fly (50% deadhearts) was recorded.

Stem borer incidence was negligible in Karnataka. Army worm incidence was more (-15%) noticed in the different farmers fields. In Maharashtra, shoot fly incidence was moderate (40%) but severe in late sown crop. In Tapangiri village of Parbhani 38% shoot fly deadhearts recorded where CSH 9 was intercropped with pigeon pea.

In Madhya Pradesh, moderate incidence of stem borer (15-25%). The late sown crop in Shajapur and Jhabua districts suffered moderate damage due to shoot fly (40-50%). In Surat district of Gujarat, moderate to higher level of shoot fly incidence in local cultivar (57 % DH) was recorded. The stem borer infestation was moderate (> 38% DH). Moderate incidence of shoot fly (30-50 %) and low incidence of stem borer (<15%) was recorded in the farmer's field in Deesa district.

In Rajasthan, 10-20 % shoot fly deadhearts were recorded. Low incidence of stem borer was recorded (<10% DH). There was low incidence of shoot bug (3-7% damaged plants) and moderate damage by head bugs to panicles (5- 7 on scale of 1-9).

## 8. Entomology (VR Bhagwat & G Shyam Prasad)

**Shoot fly Nursery (SFN) :**The entries, SUENT 12, SUENT 13, SUENT 14, SUENT 15, NRCSFR07-4 and NRCSFR07-5 has identified as resistant source for shoot fly.

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

**Development of new sources of resistance for genetic diversity:** 167 single plants were selected for shoot fly resistant from nine progenies. Similarly, 154 single plants from 8 progenies were selected for stem borer resistant.

**Evaluation of trials and nursery for grain sorghum:** None of the varieties or hybrid withstood attack of shoot fly, when compared to resistant check IS 2312 at 5% level. The entries CSH 23, SPV 462, CSV 17, CSH 16, SPV 1616, SPV 1746, local check, SPV 1730, CSV 15, SPV 1821, SPV 1821, CSH 16, SPH 1617, SPH 1606 showed relatively low deadhearts due to stem borer (< 9-12 %).

**Evaluation of trials and nursery for dual purpose sorghum**: Local check, SPV 1779, SPV 1754, SPV 1616, CSV 15, SPV 1822, and SPV 1825 showed < 40% deadhearts due to shoot fly. The entries SPV 1750, SPV 1616, SPV 1779, SPV 1823 and local check recorded below 10% deadhearts for stem borer.

**Evaluation of trials and nursery for sweet sorghum :** SPSSV 4 and CSV 19SS showed soot fly deadhearts < 36% and comparable with resistant check IS 2205 and the entries SPSSV 20, SPSSV 27 have recorded lower stem borer deadhearts (< 11%) and on par with resistant check ICSV 714.

**Validation of IPM modules for shoot pests**: Seed treatment and Intercropping: When treated sorghum with Thiamethoxam 70 WS @t 3 g/kg seed was intercropped either with redgram (Dharwad), soybean (Parbhani) or greengram (Udaipur) found to be effective in reducing shoot fly and stem borer damage and identified as profitable model of IPM in terms of monitory gain.

## 9. Disease scenario - Kharif 2007 (TG Nageshwara Rao and AICSIP colleagues)

Grain mold of sorghum has been found to be most damaging disease of sorghum in rainy crop. Periodic visits to farmer's fields revealed severe to moderate incidence of grain mold in states of AP, MS, TN and Karnataka. The disease was comparatively less in Marathwada region as compared to in Vidharbha of Maharashtra and that could be attributed to scanty rains in grain filing stage and also observed that varieties were less susceptible than Hybrids. Foliar diseases like zonate leaf spot & anthacnose were moderate in July but in August it took severe forms due rains and. severe incidence of anthracnose and zonate leaf spots was recorded on SPV 1616, CSH-18 in Rajasthan. In Pantnagar region Anthracnose and zonate leaf spot were found often severe with total. precipitation of1144.0 mm spread over 33 rainy days. The severity of these diseases was observed high on varieties PC-6, CSV-15, SPV 1616 and local cultivars. The incidence of downy mildew was 7.6% in Karnataka whereas it was 63% Coimbatore district of TN.

## 10. Pathology (TG Nageshwar Rao)

**Disease scenario**: Incidence of grain mold was moderate to severe in AP, Maharashtra, Tamil Nadu and Karnataka states. Foliar diseases viz., Zonate leaf spot, and Anthracnose were severe in UP, Rajasthan. Grain mold resistance was observed in two entries (SPV 1774 and SPV 1775), 4 entries in IHT and 10 entries in SGMRSN trials.

Downy mildew resistance was found in all entries except in SPH 1613 in the nurseries screened. 21 IS lines and 35 DM resistance. Breeding nursery had high levels of resistance. Target Leaf Spot: Moderate level of resistance was observed in 19 entries in all the trials tested. Rust resistance was found in 5 entries (SPH 1577, SPV 1814, SPV 1815, ASSV 15 and 24. Multiple disease resistance was found in 9 entries in all the trials tested. In pest and disease resistant nursery, one entry (NRCFRO6-1) was resistant to shoot fly and foliar disease. Sorghum anthracnose pathogen *Colletotrichum graminicola* survived in seeds up 15 months. Seed bio priming with *Trichoderma harzianum* TH 43 and TH 39 were effective in the management of sorghum anthracnose. The isolates of Downy mildew pathogen of sorghum and maize (*Peronosclerospora sorghi)* could be distinguished in to three groups based on RAPD analysis.

# Activities during 2007 - 08

## April - 07

**Annual Sorghum Group meeting at Udaipur**

The 37th annual sorghum group meeting of All-India Coordinated Sorghum Improvement Project (AICSIP) was conducted at the Maharana Pratap University of Agricultural& Technology, Udaipur during 5 -7 April, 2007.Dr SL Mehta, the Vice Chancellor of the University inaugurated the meeting. He emphasized on alternate use of sorghum with value-addition. A total of 210 participants from NRCS, IARI, IGFRI, CRIDA, ICRISAT, private seed industry, and non-governmental organizations apart from those from AICSIP centres enthusiastically participated. Dr SN Shukla, ADG (FFC), ICAR advised on marketability of sorghum products. Director of NRCS and PC of AICSIP appraised the audience on the progress of AICSIP and stressed the need for dedicated efforts with qualitative research. Dr RT Patil, Director, CIPHET emphasized the need for collaboration on commercially-viable projects on post-harvest technologies. Progress in various disciplines was presented by the concerned leaders of each team. Centre-wise progress reports were thoroughly discussed. Dr ND Jambhale, ADG (Seeds), spoke on needs of seeds and quality for the farmers during plenary session. Dr Vithal Sharma, Sorghum Breeder, MPAUT, Udaipur coordinated the meeting. Dr. VR Bhagwat served as the nodal officer from NRCS.

## May - 07

**Research on Apomixes in Sorghum reviewed at NRCS**

The one-day brainstorming meeting on apomixis research sponsored by NFBSRA (ICAR) was held at NRCS, Hyderabad on 20 May, 2007 under the chairmanship of Prof. RP Sharma, University of Hyderabad. Other distinguished experts were: Prof. KR Shivanna (Member;Ex-Head, Dept. of Botany, University of Delhi;) Dr. NP Sarma, (Member; Ex-Head, Biotechnology, DRR), Prof. V. Dashawanth Reddy, (Member; Director of CPMB, Osmania University) and Dr. A Bandyopadhyay, National Coordinator (NAIP), ICAR, New Delhi. Dr. B. Venkatesh Bhat presented the outline of the NFBSRA project on inducing apomixis in sorghum and the work plan for NRCS for the year 2007-08. Dr. Vishnu Bhat, Dept. of Botany, Delhi University explained the part of work he has planned as the Co-PI . Dr. Imran Siddiqi of CCMB is the third partner of the project. The Director, NRCS and Scientists Drs. SV Rao, KBRS Visarada, R. Madhusudhana, AV Umakanth and D. Balakrishna participated in the deliberations.

**Meeting of Institute Business Development Cell (IBDC)**

The first meeting of Institute Business Development Cell (IBDC) was held at NRCS on 7 May, 2007 under the chairmanship of Dr. N Seetharama. Other members are: S Audilakshmi, CV Ratnavathi, SS Rao, KJ Mathai (AO), and B Dayakar Rao, (Member secretary). The agenda Items based on the notes like consultancy on preparation of techno-economic feasibility of sweet sorghum for biofuel production from a firm owning business in India and Africa, and long-term revenue generation strategies were discussed.

## June – 07

**Review meeting of DBT- network project**

The review meeting of the DBT-sponsored network project on applications of biotechnology in millets, coordinated by NRCS, was held at the University of Agricultural Sciences, Bangalore on 15 June, 2007. Dr. PG Chengappa, Vice-chancellor of UAS, Bangalore inaugurated the meet. Dr. TK Prabhakara Setty, Director of Research, and various heads of the constituent colleges of the University also spoke on the occasion. The project monitoring team was represented by Dr. KK Narayanan, MD, Metahelix Life sciences, Bangalore and Dr. CT Hash, Principal Scientist, ICRISAT, Patancheru besides the DBT adviser Dr. RR Sinha. Twelve subprojects of the network including three from NRCS were reviewed. Dr. N. Seetharama, Director, NRCS is the coordinator of the network. The committee lauded the programme in the most of the subprojects, and advised on means of overcoming shortfall.

**Dr SN Shukla visits NRCS**

A meeting with Dr. SN Shukla, ADG (F&FC), ICAR New Delhi was held on 7 June 2007.The scientists along with Director discussed on various issues relating to financial and technical requirements at NRCS for the year 2007-08. Issues relating to strengthening of CRS Solapur, Effective utility of OSN Warangal Centre, and creation of centralized DNA finger-printing facility that can be used by the entire ICAR sister institutes at Hyderabad were discussed. Achievements under mega seed project and plans for the year 2007-08 were reviewed. Dr. Shukla appreciated the NRCS's efforts to commercialize the technologies and also advised on licensing aspects of national hybrids and varieties. Dr. Shukla was also shown the new facilities and civil construction works. The whole group is felt that a proposal for upgrading millet work under ICAR's umbrella into an institute.

**Group Meeting on ICAR-ICRISAT Partnership Project**

Group meeting to discuss on ICAR-ICRISAT Partnership Project entitled "Bio-intensive approaches for disease and nutrient management in sorghum" was held at ICRISAT, Hyderabad on 5 June, 2007. Dr. IK Das met with Drs. RP Thakur, OP Rupela and Rajan Sharma, and other scientists from ICRISAT and briefly discussed the results of last year's experiments. They further discussed and finalized the experimental details for the year 2007-08, which will begin with inspection of experimental site at Solapur by a joint ICRISAT-NRCS team.

**Half-day health seminar on *"Medicine-free life"***

Dr Prakash Kolhe, lecturer from "National Education" Secunderabad, delivered a seminar on 14 June 2007 on "Medicine free life". He highlighted that the practice of naturopathy such as, *Pranayama*, *Yoga*, and physical calisthenics is nothing but the harnessing one's own inner power, which helps to keep fit without any physical and psychological problems to realize peaceful means of achieving personal and organizational goals. These therapies in fact heal diseases like diabetics; blood pressure, cardiac disorder; gastric problem without any side effects to enable the individual to work peacefully and double the output. Dr. Kohle has also briefed about the use of magneto-therapy. This seminar stimulated the staff to think about making changes in their lifestyle to lead a healthy life.

**Experience sharing seminar on FLD**

An experience sharing seminar on frontline demonstrations on sorghum was delivered by Dr. Chari Appaji, on 8th June 2007 at NRCS, Hyderabad. Dr. DM Hegde, Director, Directorate of oilseeds, Hyderabad and scientists involved in the technology transfer and extension from sister ICAR institutes; (DOR, DRR and CRIDA) also participated in the seminar. Dr. Chari informed that the productivity of sorghum has been maintained at the levels of 1997-98 in spite of decrease in the area under cultivation under sorghum during the period of implementation of FLD. This he attributed to the introduction and adoption of improved sorghum cultivars developed. The other scientists are also shared their experiences relevant to their crops. A publication plan was developed to make best use of available data and to communicate to end-users.

## July - 07

**Sorghum stall at ICAR Foundation day**

NRCS set up a sorghum stall in the exhibition entitled "*Agro-food & value-added products*" organized by the ICAR on the eve of its foundation day at New Delhi from 16-17 July 2007. More than 500 dignitaries including the Hon'ble Union Agricultural Minister Sh. Sharad Pawar, Dr. Mangala Rai, DG ICAR, Dr. SP Tiwari, DDG (CS), Dr. SN Shukla, ADG (FFC )participated. Directors of many ICAR institutes, and scientists and agriculture officers from various SAUs visited the sorghum stall. The visitors showed keen interest in the new cultivars and newly developed technologies, especially on the innovative products developed from sorghum grain and stalk. The stall was organized by NRCS along with Rural Development Society, an NGO, Wanaparthi, and Sunira Food Products, Kolkata. The importance of sorghum as health and nutritious food was explained to the visitors and relevant literature was distributed. Dr. C Shashidhar Reddy and Mr. D Gopala Krishna represented NRCS.

**Two-day stakeholders' workshop on NAIP project**

The concept note on project entitled "*Food, nutritional security and income enhancement through diversification and value-addition of millets*" submitted to the National Agricultural Innovation Project (NAIP) for funding has been considered for further development and review by the competent authority. A two-day stakeholders' workshop was held at NRCS, Hyderabad during July 2-3, 2007 to refine the project proposal. Dr. JP Mittal, National Coordinator (Component II), NAIP facilitated the workshop, which was also graced by the National Director Dr. Mrithyunjaya. About 40 participants, (including experts nominated by NAIP, NGOs, Industry personnel, etc) across the country participated in this workshop.

**Workshop on *"Theory and practice of plant variety protection in India"***

A learning workshop on *"Theory and practice of plant variety protection in India"* was organized at NRCS from 24-27 July, 2007, to create awareness on IPR issues, Biodiversity and PVP Acts, for the benefit of seed industry and scientists from centres of All India Coordinated Research Project on Sorghum. This event also stimulates interaction between public and private sectors. The training was attended by 32 delegates representing the cross-section of the major private and public sector seed companies, and agricultural universities. The delegates studied the process of filling the PVP forms and discussed intricacies involved. Dr. KS Varaprasad, Officer in-charge, NBPGR-RS, Hyderabad, inaugurated this programme and released the training manual entitled "*Theory and practice of Plant Variety Protection in India*". The training programme encompassed four major themes : changing context of IPR, legalities in patents, trademarks and PVP, ICAR's policy for commercialization of technologies. Intricacies in filling PPV forms, and Indian and international patent litigations were also discussed. Dr. S Maurya, ADG (IPR), ICAR in his valedictory address, stressed upon the significance of Indian legislations. This training programme was coordinated by Drs. Vilas A Tonapi and M Elangovan.

**NRCS receives Best Annual Report Award**

The ***"Best Annual Report Award"*** for the year 2005-06 was bagged by the National Research Centre for Sorghum. Dr. Mangala Rai, presented the shield and certificate to the Director, NRCS on 16 July 2007 during the Directors' conference held at NASC auditorium, New Delhi.

**Consultative group meeting with officer-in- charges of AICSIP**

The consultative group meeting with officers in-charge of AICSIP centers was held on 23 July 2007 at NRCS. The group discussed on the priorities for sorghum improvement under AICSIP during XI-plan period. Dr N Seetharama, Director NRCS and PC, AICSIP elaborated on issues and sought feedback from the centers. In the context of stiff competition from many private sector hybrids, AICSIP should reorient itself to deliver through quality research and team work. During the afternoon session, under the chairmanship of Dr Vittal Sharma the group reviewed sub-projects to be taken during XI plan period. A total of 15 sub-projects covering all sorghum growing areas in the country were reviewed and discussed for further improvement. The meeting was coordinated by Drs VR Bhagwat, VA Tonapi, C Aruna, M Elangovan and Chari Appaji.

**Executive-body meeting of Society for Millets Research**

The IV executive body meeting of "*Society for Millets Research*" was held on 03 July 2007. Dr. NGP Rao,(President), IS Khairwal, PC- AICRP on Pearl Millets (Vice-President) Drs. KT Krishne Gowda, PC – AICRP on Small Millets (Joint Secretary), , Y Yogeshwar Rao (All executive members), Dr. N Seetharama, (General Secretary), Dr. A Sitaram, (Editor, *Journal of Millets Research*), and Vilas A Tonapi, (Treasurer) also participated in this meeting. Enhancing membership of the society, launching of the journal, liaison with the industry better utilization of sorghum were identified as priorities.

## August - 07

**Research Advisory Committee meeting**

The eighth Research Advisory Committee (RAC) met under the Chairmanship of Padmashri IV Subba Rao, Former Vice-Chancellor, ANGRAU, Hyderabad at NRCS on 25 August 2007. Other distinguished members present were: Drs. BN Narkhede (Retd. Sorghum Breeder, MPKV, Rahuri), RV Bhat (Ex-

Director, NIN, Hyderabad), N Seetharama, Director, NRCS and C Aruna, Member-Secretary. Unfortunately, other members had to cancel their journey in the last minute. During the meeting cumulative response to the recommendations of last three RAC meetings was presented. All scientists participated in the deliberations. The Director presented an overview of the progress made at NRCS during 2006-07, and projected plan on sorghum for short-term, as well as for the XI Plan period. These proposals which were fully endorsed by relevant documents were submitted to the committee. The Chairman appreciated the overall efforts being put in planning the research projects at NRCS.

**Seminar on prospects for use of a New DNA marker analysis system (MASS ARRAY system)**

Dr. Darryl Irwin, Leader, Sequenom Asia Pacific team and Product Specialist, Sequenom, Brisbane, Australia delivered a talk on "*The application of Sequenom Mass ARRAY system in SNP based genotyping, gene expression and epigenomics*" at NRCS on 23 August 2007. The Sequenom Indian office (New Delhi) team consisting of Drs. Puneet Chandna and AVSR Krishna Mohan were also present. Utility of the system for crop improvement research in ICAR institutes was discussed based on the already developed applications else where. Besides NRCS, colleagues from the sister ICAR institutes also participated in the discussion. It was concluded that while the cost of genotyping using this system may be cheaper than the cost of microsatellite marker genotyping, the much needed sequence information is vital to the success of using SNPs. With rice and sorghum genome sequence already in public domain, the importance of having a system in place for ICAR scientists of Hyderabad was emphasized by all the scientists. The seminar was a part of the efforts of NRCS for outsourcing and collaborating with potential partners for genomic research, initially, for high throughput genotyping. Local coordination was done by Sh. D Balakrishna. The director will consult CCMB and other existing customers before deciding on requesting ICAR for such an investment.

**Institute Management Committee meeting**

The 16th Institute Management Committee (IMC) meeting was held at NRCS on 4 August 2007. The members of IMC present were: Dr. N Seetharama (Chairman) Dr. P. Raghava Reddy, Dir. of Research, ANGRAU, Sh. D Rushendranath, Addl. Director of Agriculture, Hyderabad, Sh. VS Subramanian, FAO, NAARM, Hyderabad, Sh. Govind Pawar (Non-official member), Dr. KS Varaprasad, O/Ic, NBPGR, Hyderabad, Dr. MS Raut, O/Ic, CRS, Solapur, Dr. SV Rao, NRCS, Rajendranagar, Hyderabad (all members) Sh. KJ Mathai, Administrative Officer, NRCS, (Member-Secretary), Sh. NVRN Murty, AFAO, NRCS (Special Invitee). The Chairman apprised the committee about the progress made, infrastructure developed and the core areas for focused attention for future research. He further briefed the highlights of the QRT report and the recommendations along with the response of the Centre. The later was accepted by the committee. Other highlights of agenda items discussed were: proposal to allow PDP (ICAR) to install poultry sheds on NRCS land for joint research on feeds, and a proposal for a ICAR's showcase at the Rajendranagar junction where NRCS has some land.

**Inter-institutional Seminar**

Inter-institutional seminar on "Progress in genetic transformation in sorghum" was held at NRCS on 18 August 2007. Dr. SV Rao, principle scientist spoke on *roti* quality while Sh. D Balakrishna, Scientist (SS) delivered a lecture on Bt technology to induce borer resistance. This seminar was attended by the scientists of sister institutes working on similar theme, who also made many suggestions on future plans.

**Stakeholders dialogue on "*Biofuels in Energy Security*" in India.**

NRC Sorghum highlighted the importance of sweet sorghum as biofuel crop in the dry land semi-arid tropics during the meeting entitled "The role of biofuel in energy security of India", organized by the TERI, New Delhi on August 27, 2007. More than 20 experts include policy makers, scientists, engineers, representing government R & D departments such DBT, DST, PMO, MNCs, private and public institutions participated in the discussions. Dr SS Rao, Sr. Scientist represented NRC Sorghum. Many speakers emphasized the promotion of sweet sorghum as bioenergy crop for bioethanol production in drylands where growing sugarcane is problematic because of its high water demand.

## September - 07

### Seed industry and researchers meet

NRC for Sorghum organized a *"Sorghum Field day and interactive meet"* between seed industry and researchers on 29 September 2007. Twenty eight representatives from National Seeds Corporation (NSC), AP Seeds Corporation, ICRISAT and private seed companies participated in this event besides 25 scientists of NRCS. The participants were taken to the field and shown the trials of sweet sorghum, early grain hybrids, dual-purpose and forage types. Participants also visited the trials to compare most popular marketed cultivars in India under different brands, and the trial for characterizing cultivars before registration (DUS test). During the interactive session, the discussion involved review of new policies on registration, provisions for licensing cultivars bred with public funds, and issues related to marketing of sorghum seeds. Discussions centered on fulfilling requirement of sorghum cultivars with specific traits for different markets and promoting alternate uses and value-addition for food, feed, sweet stalk, and fodder type sorghums. Deliberations were also held on provisions for contract research and services, consultancy and training, formation of consortia based on specific product, region and service. The issues related to new regulatory systems under TRIPS and PVP regime, exchange of germplasm and licensing of advanced product lines, and mechanisms for implementing them were also discussed to pave way for arriving at best possible public-private sector partnership to commercialize ICAR technologies. This programme was coordinated by Drs Vilas A Tonapi, M Elangovan, VR Bhagwat and S Audilakshmi.

### Rabi group meeting at CRS Solapur

The Fifth Annual Rabi sorghum research planning meeting was held on 1September, 2007 at the Centre on Rabi Sorghum (NRCS), Solapur. The meeting was organized to review and discuss rabi sorghum research activities at various AICSIP centres and NRCS in all the disciplines and formulate technical programme for rabi 2007-08.The participants included rabi sorghum workers from Rahuri, Parbhani, Bijapur, Dharwad, Surat and NRCS (Hyderabad & Solapur). Scientists from all disciplines briefly described the research achievements and presented the experiments planned for rabi 2006-07 with details. The meeting thoroughly discussed the following aspects: NRCS core projects and AICSIP interface: (collaborative research support programme) CRSP; new initiatives for diversification in rabi breeding materials, MAS, plant health management strategies, commercialization, food quality, marketing technologies other than seed; breeder seed production and seed village concept. Besides these, design of plant protection trials using biocontrol methods and production of organic sorghum were also discussed. Emphasis was given to the development of parental lines and sharing of responsibilities, accessing the germplasm material, evaluating genotypes for roti making, and testing at multi-locations, registration of plant materials with NBPGR, and sharing of IPR among centers based on contributions.

## October - 07

### DDG visits NRCS

Dr. PL Gautam, Deputy Director General (Crop Sciences), ICAR, visited NRCS on the afternoon of 27 October 2007. He addressed the NRCS staff and had a brief discussion with the scientific fraternity and reviewed the ongoing activities. He encouraged the scientific community to prepare for the future with greater confidence by planning to reach the goals set. He was appraised by the Director about the institute activities and all administrative matters. He was also taken to the pathology, biotechnology, MAS and alternate uses laboratories. He visited the fields on 28 October'07(Sunday) morning.

### Workshop on *"Sorghum for health & business: value-addition & commercialization of sweet sorghum"*

NRCS organized logistics for the learning workshop on *"Sorghum for health and Business: Value-addition and Commercialization of Sorghum and Sweet Sorghum"* during 29-31 October, 2007. There were 23 participants from public and private sectors. Dr. AR Sukumar, IAS, commissioner and Director of Agriculture, Govt. of AP inaugurated the programme. Resource persons were chosen from NIN, CFTRI, ITC, ASCI, ICRISAT, Rahul Malts, Jaipur and NRCS. The participants were taken to ICRISAT for a day as a part of their course. The course dealt with different aspect of alternate uses of sorghum (including sweet

sorghum). The scope for entrepreneurs including business development potential for millets, processing technologies, value-addition, health foods, ethanol production technology, poultry feed, and commercialization were discussed. This programme was coordinated by Drs. B Dayakar Rao, Ch. Shashidhar Reddy, CV Ratnavathi, HS Talwar and P Mukesh.

**Press conference on sweet sorghum**

A press conference on "*Sweet sorghum for biofuel production*" was held at NRCS on 22 October 07. Dr. N Seetharama, Director addressed the media-persons and asserted that there is a good scope for cultivation of sweet sorghum in different parts of the country for biofuel production. He projected current scenario of ethanol production and the scope enlarged with sorghum. The demand for ethanol in the light of government's decision to blend the 10 percent ethanol in petrol is high. The production of sweet sorghum would cater the demand of both food and fodder for dryland farmers, besides production of biofuel from stalks leading to additional income to rural communities. Sweet sorghum has high ability to adapt and tolerate drought and saline–alkaline soils. Water requirement is also very less when compared to sugarcane cultivation. However the scope for production of ethanol from sweet sorghum is very high and can go in supplementation with sugarcane in the sugar factories, as very high quality ethanol could be produced with sweet sorghum to supplement the biofuel utilization initiatives in India.

**DUS training for PQP trainees**

Seventeen trainees from IARI undergoing training on DUS testing to become "*Professionally qualified persons*" upon receipt of certificate by PPV&FR Authority, New Delhi, underwent the training on DUS testing in sorghum at NRCS, Hyderabad on 5th October, 2007. They were taught about intricacies and technical aspects in sorghum DUS testing through lectures and hands on experience in field with various sorghum hybrids and varieties. They also participated in a three hour practical training on sorghum DUS testing. This programme was coordinated by Drs. Vilas A. Tonapi and M Elangovan, and field and practical sessions were facilitated by D Chandrasekhar Reddy, V Shubhakar, G Srinivas and Raghunath Kulkarni.

**Sorghum field day cum AICSIP review meeting**

Sorghum field day and review meeting of AICSIP was conducted at NRCS on 6 October 2007, with a view to discuss and plan various sub-projects and modules for operation during forthcoming XI plan. A total of 40 participants from AICSIP centres, SAUs, and NRCS participated in the deliberations. The meeting started with a field visit of NRCS experimental plots. During the post-lunch session, the discussions were held mainly on shaping up of XI plan concept note and formation of new centres. Discussions were also held on national crossing programme with exchange of plant material, self-evaluation of AICSIP staff, off-season nursery requirements, status of genetic management records, DUS testing, and improvement in trials testing. The director stressed the need for submitting the reports and financial statements in-time from all the individual centres.

**Visit of FAO trainees from Iraq**

NRCS facilitated the visit of seven FAO trainees from Iraq to Hyderabad, undergoing training on "*Seed production and marketing*" at IARI New Delhi, from 10-14th October 2007. The trainees had an opportunity to learn about seed production and marketing of sorghum, pearl millet, maize, rice, castor, pigeonpea, chickpea, groundnut, cotton and forage crops. The trainees visited National Research Centre for Sorghum, Directorate of Rice Research, Directorate of Oil seeds Research, Acharya NG Ranga Agricultural University and Nuziveedu Seeds at Hyderabad. They interacted with Directors and the scientists in each of these institutes and the breeders, seed production, processing and seed testing personnel at the seed companies. The trainees were also taken to International Crops Research Institute for Semi-Arid Tropics, where they had discussion with Drs. CLL Gowda, Global Theme Leader for crop improvement, HD Upadhayaya, Principal Scientist and head Genetic Resources Unit and KN Rai, Principal Scientist and Head Pearl millet improvement. The trainees had opportunity to listen to lectures, visit museums and international gene bank, research and production fields exhibiting latest hybrids, varieties and technologies. This event was organized by Dr. Vilas A. Tonapi, who was officially nominated as programme coordinator from the council.

**NSP monitoring team visit**

The monitoring team of National Seed Project (crops) nominated by the Directorate of Seed Research (DSR) visited NRCS on 30th October 2007. The team comprising of Drs. M Ganesh, S Rajendraprasad, Prabhakaran and Francis Rose Mary reviewed the nucleus & breeder seed systems viz., coordination, production and distribution at NRCS and AICSIP centres. Also, the team discussed on the seed research areas of sorghum to be projected in future. Dr. N Kannababu explained the team about constraints like non-lifting of breeder seed by the indenting agencies and consequent problems of storing the stock in cold store. He also highlighted the very-low demand for sorghum breeder seed during Kharif 2007 due to high rainfall received at actual seed production areas of sorghum in Andhra Pradesh.

**Farmers' meet and Field days**

***Sanora*** *(Madhya Pradesh)*: NRC Sorghum, Hyderabad and IGFRI, Jhansi jointly organized a sorghum filed day and Farmers meet at village Sanora at Datiya district in Madhya Pradesh on 10 October 2007. About 160 farmers including 34 women farmers and 20 officials from IGFRI, Jhansi and NRCS, Hyderabad participated in this programme. The farmers visited frontline demonstrations laid down in the nearby villages. At village Sanora, exhibits on sorghum, and literature were also displayed. Dr. Kumar Amarendra Singh, Director IGFRI was the chief guest. The dignitaries appraised farmers about the uses of high yielding sorghum cultivars, agronomic practices and production technology. Farmers also appreciated the performance of new sorghum cultivars. On this occasion a handout on sorghum production technology was also released by the chief guest. The programme was organized in association with IGFRI, Jhansi. Drs. RN Dwivedi, Pr. Scientist, I/c TOT, SB Tripathi, Head crop Production, Dr. Sunil Kumar (Horticulturist) and others from IGFRI, and Chari Appaji, (NRC Sorghum) participated in this programme.

***Mauranipur*** *(Uttar Pradesh)***:** NRC Sorghum, Hyderabad and AICSIP centre at Mauranipur (CSAU&T) jointly organized a sorghum filed day and farmers meet on 11 October 2007 at Mauranipur in Uttar Pradesh. About 200 farmers including 60 women farmers from Bundelkhand region, 20 officials from IGFRI, Jhansi and 3 officials from NRCS, Hyderabad participated in this programme. Dr. KA Singh, Director IGFRI was the chief guest. The center's officer in-charge Dr. SP Sachan, Dr YK Singh, Agronomist, Dr. Chari Appaji (NRCS) and other dignitaries explained the farmers about the new cultivars and their performance. Dr. RN Dwivedi, Pr. Scientist (IGFRI), VK Sachan, Asst Director, Regional Soil Testing Laboratory, Jhansi also addressed the gathering. The farmers visited frontline demonstrations laid down in the farm. Farmers and women farmers also elucidated their outlook on sorghum cultivation on Dias. The farmers expressed the need for early duration varieties like CSV 17, and dual purpose varieties like CSV 20 and simple technologies for the cultivation of sorghum for more monetary returns. On this occasion one booklet entitled *"Sorghum in Bundelkhand Region"* prepared by Dr. Appaji Chari also released by the chief guest.

***Mobile Soil Testing Service*****:** The officials at Mauranipur, in a novel way arranged soil testing facility to the farmers besides a customary field day demonstrations. The officials from Regional Soil Testing Laboratory, Jhansi, during the field day at Mauranipur facilitated analysis of 250 soil samples belonging to different farmers in the Bundelkhand region. The initial soil testing results were correlated with second round of testing at Jhansi. The results are communicated to the farmers with the recommendations to follow suitable soil amendments towards the soil deficiency factors in the farmer's field to harvest the best possible yields. This facility was extended on gratis by Dr. VK Sachan. Asst. Director (Soil testing & Culture), Regional testing laboratory, Jhansi.

## November - 07

**Visit of ICAR Institute Directors to NRCS**

NRCS hosted the visit of seven ICAR Directors and six dignitaries from SAUs on 17 November 07, while they were participating in *'Directors conclave on motivation techniques'* at NAARM, Hyderabad. The Directors (ICAR institutes) who visited NRCS are: Drs. SM Ilyas (NAARM, Hyderabad; DM Hegde, (DOR, Hyderabad); TA More (CIAH, Bikaner); MM Mustaffa (NRC Banana – Thiruchirapalli); George V Thomas (CPCRI – Kasargod); KK Kumar (NRC Litchi – Muzaffarpur); Dilip kumar (CIFE –

Mumbai). The other dignitaries from SAUs were: Prof. Asit Kumar Das, Bidwan Chandra Krishi Viswavidyalaya, Mohanpur, WB; Dr. PK Mahapatra, OUAT, Bhubaneshwar; Prof (Mrs) SK Misra, Director, OUAT, Bhubaneshwar; Dr. DA Sarnaik, College of Agriculture, Bilaspur; Dr. SK Patil, GKV, Jagdalpur, Chattisgarh and Prof. AC Verma, NDUAT, Faizabad, UP. Director, NRCS explained the visitors about the new initiatives, monitoring and motivational techniques being practiced at NRCS to increase the scientific and intellectual output and social relevance. This event was hosted to mark the eve of the second decennial celebrations of the NRC Sorghum coincidently.

**DBT network project on forage biotechnology**

NRCS received two research grants on fodder biotechnology from DBT in the network on "*Biotechnological Approach towards Forage Crop Improvement*". One project is aimed at identifying QTL linked to sorghum stover quality and resistance to foliar diseases. Another project is basically to develop facility for salinity screening which will be used for screening forage crops for salinity tolerance under the project. Director, NRCS was requested to be the coordinator of the network. Other investigators from NRCS include Drs. B Venkatesh Bhat, HS Talwar, R. Madhusudhana and AV Umakanth.

**Visit of FAO trainees from Iraq**

Ten FAO trainees undergoing training on "*Seed testing and quality control*" at IARI, New Delhi visited NRCS on 28th November 2007. They were told on the mandate, research activities and the contributions of National Research Centre for Sorghum and All-India Coordinated Sorghum Improvement Project since their inception. The information on value added products and industrial uses of sorghum were provided. The visitors were taken around the campus and the facilities. The trainees were impressed with the role of sweet sorghum as a biofuel crop. The delegates were also shown the two short films produced by NRCS: "Sorghum production technology" and "Sweet sorghum and bioethanol production". Various food products from sorghum including ethanol and beer exhibits were also shown to them. Various aspects related to problems in sorghum seed production, certification, testing, quality control, storage and seed longevity were discussed. The visit concluded with a group photo session. This visit was coordinated by Drs. Vilas A. Tonapi and M Elangovan of NRCS.

**Seminar on genetic strategy to control nitrification**

Dr. GV Subba Rao, Group leader, Japan International Research Center for Agricultural Sciences. (JIRCAS), Japan, delivered a seminar on 27 November, 2007 at NRC for Sorghum on the topic: "A genetic strategy to control nitrification and $N_2O$ emissions from agricultural systems–Biological Nitrification Inhibition (BNI)". He explained the novel approach for inhibiting nitrification in the rhizosphere by utilizing the ability of plant roots to produce nitrification inhibitors. It was discovered that "*sorgoleone*" produced by sorghum roots had maximum nitrification inhibition compared to other cereals. The possibilities of NRCS collaborating with JIRCAS on exploiting BNI were discussed. Dr. HS Talwar, Sr. Scientist organized the seminar.

## December - 07

**Institute's NAIP project approved**

NAIP project on "*Creation of demand for millet foods through PCS value-chain*" under component II, led by NRCS Hyderabad is approved. The project has a total outlay of Rs 5.80 crores and starting date would be 20 December 2007 for four and half-year period.the project work-plan will be finalized very soon under the guidance of the consortium leader (Director, NRCS). Dr B Dayakar Rao is Consortium principal investigator (CPI). National institute of Nutrition (NIN), ITC Ltd, and ANGRAU( all located at Hyderabad) are the consortium partners. The associates include RDS (NGO), Sunira foods Ltd, Kolkata, Snaffy foods, Hyderabad, CIPHET, Ludhiana, Panchayat Raj institution, APARD of Govt of AP, and other ICAR units. A formal launching of the project in the first week of February 2008 is planned. The scientists participating at NRCS besides the PI are Drs. CV Ratnavathi, M Elangovan, C Sashidhar Reddy, G Shyam Prasad (Hyderabad) and MS Raut (Solapur).

**NRCS bags DBT project with TERI**

NRCS received a research grant for the project entitled "Development of an appropriate technology for efficient conversion of sweet sorghum bagasse to ethanol (DATECSE)-Phase I: Optimization of hemicellulose fractionation and hydrolysate fermentation" from DBT. Tata Energy and Resources Institute (TERI), New Delhi, the priate and has the participation of M/S Praj Industry Ltd., Pune which also partly contribute financially. Under this project, NRCS works on testing of sweet sorghum cultivars, biomass compositional analyses and screening of microbes for efficient conversion of hemicellulose derived pentose sugars to ethanol. The TERI will focus on optimization of hemicellulose pre-treatment, development of rector design for pretreatment, and development of an appropriate process for conversion of hemicellulose derived pentose sugars to ethanol. The NRCS scientists involved in the project are Drs SS Rao and CV Ratnavathi. At TERI, the project is lead by Prof VVN Kishore and Mr.Jiby Kurian.

**Meeting on "Licensing for patent search database"**

The final meeting on Licensing for patent search and database was held at NRCS on 5 December 07. Directors and the officials of sister ICAR institutes were participated in this meeting. NRCS was the convener of this meeting. The NRCS director narrated the background and emphasizedthe need for making a collective recommendation urgently to Dr. S Mauria (ADG-IPR) in view of the latest communication received. As per the agenda, the group discussed and deliberated on the issues of reference under three heads viz.the relevance/necessity of the requirement, Costs involved vis-à-vis the likely gains, and other associated requirements. DM Hegde, Project Director, DOR; KS Varaprasad, Principal Scientist, NBPGR, Reg. Station; Seseelendra Desai, Principal Scientist, CRIDA; K Murlidharan, N Shobha Rani, and SM Balachandran, (Principal Scientists, DRR); SK Soam, Sr. Scientist, NAARM ; M Ramakoti Reddy, Sr. Scientist, PDP and others participated in the deliberations along with the scientists from NRCS. Dr. Vilas Tonapi and M Elangovan were the facilitators. The proceedings and the recommendations were forwarded to the ADG (IPR) at ICAR headquarters.

**Visit of Dr Geraldo Eugenio de Franca of Brazil**

Dr Geraldo Eugenio de Franca, Executive Director, EMBRAPA, Brasilia, DF, Brazil visited NRCS on 4 December 2007 with new plans to diversify and expand their horizons to biofuel production and to discuss the possibilities for collaboration between EMBRAPA and ICAR. In particular, he was interested in growing sweet sorghum to produce alcohol and setting up a distillery. The team had a detailed discussion with the Director, and the scientists SS Rao, CV Ratnavathi, and B Dayakar Rao. Director appraised the group about the new developments in ICAR pertaining to collaborative projects with private sector for commercialization.

## January - 08

**Visit of Chairman, Maharashtra State Planning Commission, Mumbai to CRS, Solapur**

Dr. Ratnakar Mahajan, Chairman, Maharashtra State Planning Commission, Mumbai, visited Centre on Rabi Sorghum (NRCS), Solapur on 28 January 08. Dr. MS Raut, Officer In-charge and his colleagues appraised the research activities at the centre. He visited the laboratories and museum of the centre and later research fields to acquaint with latest improved cultivars of rabi sorghum. He was appraised about the procedure for the development of varieties and hybrids their seed production, improved package of practices of rabi sorghum and alternate uses of sorghum by Drs. M.S. Raut, AV Gadewar, Prabhakar and BS Rayudu. The chairman was very much impressed with the improved cultivars of rabi sorghum and possibilities on alternate uses front. He opined that the improved cultivars and new technologies generated in sorghum should reach the farmers to increase the production and productivity of rabi sorghum on dryland

**Seed Day at Bellary**

A seed day was organized at Bellary on 8 January 2008 in association with Karanataka State Seed Corporation, Bangalore. The certified seed production fields of CSH 14 (138 ha), CSH 16 ( 36 ha) and CSH 23 (8 ha) were visited by 200 seed growers and farmers. The seed production has been organized

following the concept of seed village to avoid the isolation problems. Dr. Ramamoorthy, General manager (Production and Quality control), Dr. Devendrappa, Director, Karnataka State Seed Certification Agency were the chief guests. The gathering of seed growers was addressed by the chief guests. Dr. Vilas A. Tonapi, Principal Scientist, NRCS and Mr. Kuber Reddy, Head of KSSC Bellary Unit, who also organized this event described on going activities and expectations. The seed growers discussed problems of seed production, procurement and price issues. They expressed satisfaction over the performance of nationally released hybrids and they sought to have the new hybrids in seed production chain.

**Learning workshop on "Sorghum for health and business" conducted for AP government employees**

A Three day learning workshop on "Sorghum for health and business" was specially organized for ADA's/ AO's of ATMA districts on request by Commissioner of Agriculture, Govt of AP during January 21-23, 2008 at NRCS. Fourteen officers from various districts in AP participated in this training programme. The programme covered various aspects on value-addition of sorghum through food uses and alternate industrial uses including sweet sorghum for bioethanol production. Resource persons were from both private and public institutions such as ITC Ltd, NIN, MANAGE, PDP, IICT, and ICRISAT, Hyderabad. It was a participatory and interactive training with field visits to RTP- NIRD and ICRISAT. The valedictory programme was addressed by Dr. Md. Azim, Joint Director of Agriculture (Seeds) on behalf of Commissioner of Agriculture, Govt. of AP. The certificates were distributed by Dr Md. Azim, JDA and the Director, NRCS. Dr. B Dayakar Rao was the Course Director while Drs. Ch. Sashidhar Reddy, P. Mukesh, CV Ratnavathi, SS Rao and HS Talwar were coordinators of this three day learning workshop. The programme was also covered by press and visual media.

***Kisan mela* at Solapur**

The Sorghum field day was jointly organized at Mundhewadi village near Solapur by Centre on Rabi Sorghum (NRCS) and State Agriculture Department Solapur on 29 January 2008. About two hundred farmers from nearby villages attended the field day. The special theme was on understanding of sorghum as health food for all. Sh. Satyasodh Patil, senior farmer of the village was the chief guest. Dr. Bhakre, Sr. Scientist, ZARS, Solapur, Dr AN Chouhan, Agricultural Officer, Mangalvedha addressed the gathering and advised farmers to adopt improved varieties and production technology for its profitability. Dr. VR Bhagwat delivered a lecture on "Insect pests and their management in rabi sorghum" and another on "Alternate uses of sorghum for rural entrepreneurship development" in Marathi. Dr. Prabhakar briefed the farmers about the new hybrids and varieties developed exclusively for rabi season both in Hindi and Kannada.

**Planning meeting on NAIP Project at NRCS**

A planning meeting of Consortium Implementation Committee (CIC) was organized for NAIP subproject on "Creation of demand for millet foods through PCS value-chain" at NRCS on January 16, 2008 to decide the technical programme for the first six months (January- June 2008). The project has been approved by the competent committee on 20 December 2008. Director, NRCS is the Consortium Leader and the chairman of CIC. Dr. B Dayakar Rao, CPI of this consortium from lead centre presented NRCS programme encompassing the programme of other Co-PIs. Drs. CV Ratnavathi (Foods), Ch. Sashidhar Reddy (Extension), G Shyam Prasad (Entomology)and M Elangovan (Farmer Participation Research). The CoPI's from other partner institutions viz., Drs. MP Rajendra Prasad, NIN, Hyderabad; Mr Nirmal Reddy, ITC and Dr. Aum Sharma, ANGRAU (representing Dr Kamini Devi, CoPI, ANGRAU) presented their technical programmes. The likely role of the associates such as RDS (NGO) and Snaffy foods (entrepreneur) was discussed. Drs. C Aruna Reddy and HS Talwar, Members of Consortium Monitoring Unit (CMU) briefed the role of Monitoring and Evaluation (M&E) plan and importance of compliance of M&E plan. After the detailed deliberations, the technical programme was finalized. The members endorsed Dr B Dayakar Rao, CPI to consolidate and make presentation of the technical programme in the project launch programme.

## February - 08

### NAIP Project launch at NRCS

The launching meeting of NAIP sub-project entitled "Creation of Demand for Millet foods through PCS Value-chain" held at NRCS, on 5 February, 2008. Dr. NGP Rao, the chairman of the Consortium Advisory Committee (CAC) chaired the meeting. The participants included the CAC members - Prof. JP Mittal (National Coordinator, NAIP), Dr. SV Singh (Ex-Director, DMD), Dr. G Pakki Reddy (Agribiotech Consortium, ANGRAU), Mrs. Chinnamma Thomas (RDS, Wanaparthy), Drs N Seetharam (Consortium leader). B. Dayakar Rao (CPI), Project associates Drs. Kamini Devi, K Suhasini (ANGRAU), and Hymavath, besides the NRCS Scientists associated with the project Drs. CV Ratnavathi, G Shyam Prasad, MS Raut, Ch Sashidhar Reddy, M Elangovan, HS Talwar, and C Aruna also participated in this meeting. Dr. Illyas Ahmed, Director, NAARM. Dr. Nirmal Reddy, ITC also graced the occasion. The main objective of this project is to generate demand through value-addition of processed foods, feed and industrial products through reorientation of R&D efforts on millets in the wake of disincentives resulting from PDS for fine cereals at very low cost to consumers, and other practices. During this occasion, the recipe book on sorghum foods entitled 'Delicious sorghum foods' authored by Dr. CV Ratnavathi et al and a brochure on the project details in brief were also released. Dr. Nirmal Reddy, partner representing ITC delivered a lecture on public private partnership and food business.

### Press conference on Creation of demand for millet foods

A press conference on "Creation of Demand for Millet foods" was held at NRCS on 5 February 08. Dr. N Seetharama, Director addressed the media-persons and asserted that there is an increasing acceptability of millet foods if available in ready-to-cook form or as convenient ready to eat foods in urban areas. At NRCS, the model framework for revival of millet economy-based on promotion as health and convenient food will be carried out using sorghum. He also told that the production of sweet sorghum would cater to the demand of both food and fodder for dry land farmers, besides production of biofuel from stalks leading to additional income to rural communities. Dr. Mittal narrated activities under NAIP, and Dr. NGP Rao on the "goodness" of the millets for the health benefit of all.

### Meeting on DBT Project

First planning meeting of technical programme for DBT funded project entitled "Ligno-cellulosic ethanol production from sweet sorghum bagasse" was held at NRCS on 18th February, 2008. The meeting was chaired by the Director, NRCS and attended by Dr VVN Kishore and Mr. Jiby Kurian from Tata Energy Research Institute (TERI), New Delhi, Dr. S V Ramakrishna, group advisor from Praj Industries, Pune and scientists Drs. SS Rao,CV Ratnavathi, AV Umakanth, B Venkatesh Bhat from NRCS. The activity milestones for the project were finalized.

### National Science Day Celebrations

The National Science Day was celebrated with great enthusiasm on 28th February 2008 at NRCS. This day is celebrated every year to commemorate the invention of Raman's effect was invented by the Nobel Laureate, Prof C.V. Raman at Indian Institute of Science (IISC), Bangalore. Three competitions comprising Quiz programme on "Science 2008", the presentation on "Innovative ideas to - "Cool the Global Warming" and debate on the topic on "Jowar 2050":the future of sorghum" were conducted to mark the occasion. All the research scholars and scientists actively participated in all the programmes. Dr SL Kaul, Principal Scientist distributed the prizes to the winners and delivered the Science Day address. The day also remembered the renowned scientists and great botanist Carol Linnaeus on his 300th anniversary. Dr SV Rao, Principal Scientist also addressed the gathering. On this occasion, NRCS has published a full length article in the popular English daily - Indian Express, on its achievements and progress to communicate to the public and the industry about its achievements, goals and future plans on sorghum for food, fodder, feed, and fuel security. Dr. M Elangovan, senior germplasm botanist organized this function.

# Annexure-I: AICSIP plan and instructions for the year 2008-09

Zone-wise testing during 2008 will have all test-entries coded. Besides field performance and, screening for resistances to major biotic stress factors, the additional data on grain and stover quality, market-price, and wherever possible even on food quality will be obtained, analyzed and documented.

**A. The trials and nurseries of 2008**

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. **Dual purpose:** 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. **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)
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 the entries will go to breeding, pathology and entomology, based on zones and soil types.

**B. Calendar**

- **Submission on entries :** Kharif & Late Kharif: 1st April, 2008; Rabi: 30th June, 2008
- **Dispatch of seeds to centres:** 20th May, 2008 (Kharif); 20th June, 2008 (Late kharif) and 15th August, 2008 (Rabi)
- **Report on sowings and plant stand:** 30th June, 2008 (Kharif); 30th August, 2008 (Late kharif) and 30th September, 2008 (Rabi)
- **Shoot fly data to reach immediately** after data recording as per supplied plan
- **Submission of final data sheets:** 5th November, 2008 (Kharif); 15th January, 2009 (Late kharif and Rabi)
- **Completion of statistical analysis of the data:** 1st March, 2009 and data uploaded to internet
- **Completion of all reports in bound form:** 30th March, 2009
- **AGM 2008- XXXVIII Annual group meeting:** First fortnight of April, 2009
- **Proceedings of XXXVIII Annual group meeting circulated :** 1st May, 2009

**C. Special instructions and specific actions**

- **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.
- **Detailed pedigree of a test entry is a must:** Without which no entry will be included in trials
- **Submission of all parental lines (A and R) of all advanced entries:** is a must for conducting parental line trials. Without parental lines for PLT trials, entries for AHT will not be accepted.

**D. Sources of errors and how to avoid them**

- **Don't treat the seeds of entries:** seed treatments influence the pest and disease resistance data. All treated entries are 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.
- **Entry seeds should have good germination:** The seeds with low germinability leads to poor plant stand and vitiates the experiment. Seeds having less than 80% germination will be straight away rejected.

## Annexure-II: Proforma for submission of entries for AICSIP trials

To
The Project Coordinator (AICSIP)
National research centre for Sorghum
Rajendranagar
Hyderabad - 500 030

**Sub: Details regarding submission of entries for AICSIP Trials**

Kindly find attached here with the details, in the enclosed proforma, of our entries (*including detailed pedigree for all centres, and Testing fees# @ Rs. 30,000/- 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)**. It is certified that the information submitted is true to the best of my knowledge.

Thanking you,

Sincerely,

**(Signature & Date)** **(Seal/ Stamp)**

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

* Strikeout which is not applicable

****IVT**: Initial Varietal Trial; **AVT**: Advanced Varietal Trial; **IHT**: Initial Hybrid Trial; **AHT**: Advanced Hybrid Trial

1) **Please note that no entries should not be treated with any chemical Treated seeds are summarily rejected**

2) **Seed quantity to be submitted without fail: IVT- 10 Kg ; IHT- 10 Kg; AVT- 10 Kg ; AHT- 10 Kg : For large plot Agronomy trials of advanced entries: 25kg**

## Annexure-III: Proforma for submission of entries for testing in AICSIP trials

**Season: Kharif/ Late Kharif/ Rabi***

### 1. Name and address of the person and organization submitting entries

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

### 2. Name of the entry and detailed pedigree

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

| S. No | Name of the entry (station code) | Name of the trial and the Zone for which it is a entry§ | Deatiled Pedigree** | Quantity of seed submitted (Kg) | Testing fees total (Rs.) | DD No. and date; Name of bank on which DD is drawn# |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

** Entries without detailed pedigree are not accepted; # Private entries are accepted only along with DD for testing fees @ Rs.30,000/- per trial/season as per ICAR norms

**Please note that no entries should not be treated with any chemical Ttreated seeds are summarily rejected Seed quantity to be submitted without fail: IVT- 10 Kg ; IHT- 10 Kg; AVT- 10 Kg ; AHT- 10 Kg; For large plot agronomy trials of advanced entries: 25kg**

**(Signature & Date)** **(Seal/ Stamp)**

## Annexure -IV: Additional information on entries of AICSIP trials

| S. No. | Genotype | Pedigree | Year/Season of production | Seed grading done? Yes/No | Seed treatment done? If yes, with what chemical and concentration |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |

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

**Signature** : _____

**Name** : _____

**Centre/company** : _____

**Address** : _____

_____

_____

**Telephone** : _____

**Fax** : _____

**E-mail** : _____

(**Signature & Date)**

# N o t e s