

# Breeding - Grain sorghum - Rabi 2013-14

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## Contents

<b>EXECUTIVE SUMMARY.....</b>	<b>1</b>
<b>DETAILED REPORT .....</b>	<b>5</b>
Multi-location AICSIP trials .....	5
1. <i>Advanced Varietal and Hybrid Trial (Deep soil)</i> .....	5
2. <i>Initial Hybrid Trial (Deep soil)</i> .....	6
3. <i>Initial Varietal Trial (Deep soil)</i> .....	7
4. <i>Initial Varietal and Hybrid Trial (Shallow soil)</i> .....	8
5. <i>Parental line trial</i> .....	8
Coordinated sorghum breeding research .....	9
Sorghum breeding at DSR.....	10
1. <i>Breeding for high yielding rabi cultivars</i> .....	10
2. <i>Genetic enhancement for drought tolerance in rabi sorghum genotypes</i> .....	11
3. <i>Bio-prospecting of genes and allele mining for abiotic stress tolerance</i> .....	11
4. <i>Creating new variability for developing varieties and hybrid parents in rabi sorghum (Sorghum bicolor (L.) Moench) for medium to deep soils</i> .....	13
Sorghum breeding at AICSIP centers .....	13
1. Rahuri .....	13
2. Tandur .....	15
3. Bijapur .....	16
4. Dharwad .....	17
5. Akola .....	19
6. Parbhani .....	20
<b>Publications</b> .....	<b>22</b>



## EXECUTIVE SUMMARY

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

hybrids, under which promising MS lines were shared across centers and new experimental hybrids were developed, which were tested under multi-location trials.

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

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

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

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

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

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

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

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

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

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

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

- There was good synchronization in parental lines (A/R lines) as the difference between the CMA Lines and restorers ranged from 2 to 4 days. So, they can be sown simultaneously and staggered sowing is not necessary.

- The high yielding CMS lines and R lines were 104A, 32A2, 499A, IMS-9A, SLR-75, SLR-84, SLR-92, SLR-93, AKRB-513, R-204, RSV-269, RSV-1090 and RSV-1130. It was interesting to observe that R lines were more potential than CMS lines.

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

#### **Rabi sorghum breeding at DSR**

- Evaluation of improved breeding lines in shallow-medium and deep soils separately, indicated that 48 promising varieties ( 12 in shallow-medium and 36 in deep soil) were significantly superior to checks M35-1/Mauli and CSV-22 for grain and fodder yields and grain quality with resistance to insect-pests and diseases.
- Selected varieties for shallow-medium soils were SLV-34, 40, 43, 50, 73, 91, 97, 100, 101, 111, 123 and 135 and for deep soil, the varieties were SLV-97, 118, 123, 130, 131, 133, 145, 166, 169, 172, 180, 188, 199, 202, 207, 209..
- B line improvement for diversifying genetic base led to selection of 17 B lines out of 36 lines with rabi traits. Eleven test hybrids, superior to CSH-15R for grain and fodder yields were selected.
- Selected B lines were SLB-22, 29, 35, 45, 46, 50, 56, 58, 59, 60, 73, 80, 86, 92, 97, 108 and 150.
- Twelve new CMS lines (SLA-9, 19, 29, 35, 45, 46, 56, 59, 60, 73, 82, and 150) better than the CMS 104A in respect of grain quality with resistance to insect-pests and diseases have been stabilized and they are ready for commercial exploitation
- R line improvement for diversifying genetic base led to selection of 54 R lines out of 96 lines with rabi traits. Selected R lines were SLR-27, 31, 34, 46, 57, 67, 68, 70, 80, 87, 97, 130, 133, 136, 146, .
- Twenty five genotypes were evaluated in three reliable soil moisture environments (assured irrigation, water deficit ie.irrigation only upto 50 days after sowing and rainfed ie. receding moisture conditions) along with four checks. Drought susceptible index (DSI) values for grain yield under water deficit condition ranged from 0.13 to 1.32 and under rainfed condition ranged from 0.13 to 1.24. Drought tolerance efficiency (DTE) for yield ranged from 92.84 to 29.84 per cent under water deficit condition and 90.54 to 12.58 per cent under rainfed condition.
- In studies on response of sorghum genotypes towards post-flowering drought stress, four lines, *viz.*, IS 19153, IS 23514, IS 29392 and RS 585 showed consistent better post-flowering drought response over both the years. Out of these four lines identified IS 23514; a red sorghum line recorded lowest DSI in both the years and found to be promising.
- Whole genome and candidate gene-based SNP detection in sorghum: A reference set of 96 sorghum genotypes for drought studies was subjected to Double Digestion Restriction site Associated DNA sequencing (ddRAD-seq). Alignment with the reference genome of BTx 623 led to identification of a total of 235,009 unfiltered SNPs, distributed across 10 chromosomes. Out of these 198,611 (84.5%) were located in inter-genic regions, while 36,398 (15.5%) were localized in intra-genic regions. This led to identification of 10,125 SNPs, 8,313 (82.1%) and 1,812 (17.9%) of which were located in inter- and intra-genic regions, respectively.
- From SNP database 15.1% of unfiltered and 42.5% of filtered SNPs could be confirmed. Out of the identified SNPs 2075 represented 32 reported QTLs, of which, SNPs on chromosome 2, 3, 5 and 8 were mostly associated with drought related QTLs. Sequence alignment of coding (CDS) and promoter regions of 10 candidate genes from six sorghum genotypes led to identification of total of 172 SNPs and 68 in-del mutations in the coding regions, while in promoter regions 159 SNPs and 77 in-dels were identified (Table 3). Forty two identified SNPs were converted to CAPs/dCAPs markers.
- Evaluation of diverse group of breeding material for tolerance to cold stress indicated that date of sowing significantly influenced pollen germinability and the influence of the cooler night temperatures was more than the genetic background. In contrast, pollen viability had

less phenotypic plasticity and highly heritable. The loss of grain yield was about 5g/panicle in varieties while it was 1.9g/panicle in restorer lines and about 5.7g/panicle in B-lines. The loss in grain yield was highest in the hybrid at about 22.9g. The germinability percentage was positively associated with selfed panicle weight, grain yield and harvest index while the viability percentage did not show such association. The germinability percentage was more linearly related in R-lines followed by B-lines and varieties.

#### **Rabi sorghum breeding at AICSIP centers**

- At Rahuri, rabi sorghum genotype RPASV-3 was identified for papad purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra. Identified the rabi sorghum genotype RSSGV-46 for hurda purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra.
- In Bijapur, under breeding evaluation programme at state level, 3 preliminary varietal trials, one B line trial), one R line trial and one MLT were conducted. A total of 15 lines from PVT, 10 from BLT and 13 from RLT were selected. In station breeding programme, 20 newly derived F6 generation, R lines were evaluated and of them eight were found superior. In B line programme 8 lines were found exceedingly superior to checks. In conversion programme 10 lines are at BC4 stage. In trait specific breeding programme, ten families belonging to BC2&BC1F1 were evaluated for drought stress and four were found promising. In the breeding for charcoal rot tolerance 23 lines derived from BC2F3 and straight F3 were evaluated and a total of 20 promising plants were selected. To develop medium dwarf non lodging coupled with CSV216R yielding ability 18 BC2F4 families were selected. To develop early maturing lines with maldandi yielding ability 10 F7 lines were evaluated and a total of 5 families were selected. A total of 33 F3s derived from different cross combination were grown. Of them a total of 150 plants were selected for different combination of traits.
- At Dharwad, rabi sorghum improvement work is carried out with the objective of developing varieties with good grain quality, resistance to biotic stresses like shoot fly tolerance and charcoal rot resistance. In 3 Station varietal trials, the varieties significantly better than the check DSV-4 were SVD-1251 (3278 kg/ha), SVD-1252 (3260 kg/ha), SVD-1261 (3148 kg/ha), SPV-2217 (3130 kg/ha), SVD-1277 (3852.0 kg/ha), SVD-765 (3463 kg/ha) and SVD-1229 (3389 kg/ha). In 2 station hybrid trials, the hybrids SHD-13-32 (3908 kg/ha) SHD-13-33 (3574.0 kg/ha), SHD-13-34 (3352 kg/ha), SHD-13-57 (4612 kg/ha) SHD-13-53 (4371 kg/ha) and SHD-13-54 (4185 kg/ha) recorded significantly superior grain yield compared to M 35-1 (2093 kg/ha) and DSV-4 (3760 kg/ha). As many as 67 fresh crosses were made and 226 selections were made in various generations from F1 to F6 and three M 2 progenies were evaluated for grain size and grain yield.
- At Akola, evaluation of 4000 germplasm received from the Project Directorate, Hyderabad was carried out and observations were made on shoot fly and stem borer and other agronomic characters. In Development of male sterile lines, 31 pairs in BC II, 33 pairs in BC III, 24 pairs in BC IV, 36 pairs in BC V & 21 pairs in BC VI generation have planted. In addition to this, five crosses in F<sub>8</sub> generation have been planted and selections are made. For the development of restorer lines, the centre has already developed 50 restorer lines tolerant to shoot-fly with good *rabi* adaptation. In addition to this, the unit has developed ten restorer lines with earliness. Similarly, the centre developed 25 restorer lines for high yield and its contributing traits. All these lines are being maintained and used in experimental hybrid seed programme. In generation of new material, one diallel set of 8 x 8 parents (half diallel) has been executed. Further, 28 F<sub>3</sub> crosses have been advanced and planted at Washim.

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

## DETAILED REPORT

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

- I. Multi-location AICSIP trials
- II. Coordinated sorghum breeding research
- III. Rabi sorghum breeding at DSR
- IV. Rabi sorghum breeding at AICSIP centers
- V. Publications

### ***Multi-location AICSIP trials***

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

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

#### ***1. Advanced Varietal and Hybrid Trial (Deep soil)***

In this combined trial of varieties and hybrids, 6 varieties and 5 hybrids along with 4 checks were evaluated for grain and fodder yield and other agronomic traits (Table 1).

- Days to flowering – The varieties and hybrid ranged for flowering from 73 to 80 days. All the varieties matured on par with the check CSV 22 (120 d) and the hybrids matured one day later than the check hybrid CSH 15R (113 d).
- Plant height – The range of plant height of varieties and hybrid was from 196 to 222 cm.
- Grain Yield – None of the varieties and hybrids were significantly superior to the checks. However, the hybrid SPH-1742 (2419 kg/ha) gave 6.70% more grain yield than the hybrid check CSH-15R (2267 kg/ha). The hybrids SPH-1746, SPH-1741 and SPH-1744 were numerically superior than the check hybrid.
- Fodder yield: The hybrid SPH-1746 (6780 kg/ha) gave significantly better fodder yield than the check CSH-15R (5778 kg/ha) and was superior by 17.34 %. Other hybrids which gave more than 5% fodder yield than the check hybrid were SPH-1741 (6286 kg/ha), SPH-1742 (6241 kg/ha). Among varieties, the variety SPV-2221 (7148 kg/ha) gave 8.5% more yield than the check CSV-22 (6587 kg/ha).
- Grain size – The variety SPV-2221 (3.64 g) was significantly superior to check CSV 22 (3.32 g). The varieties SPV-2215 (3.58 g) and SPV-2228 (3.48 g) and the hybrid SPH-1746 (3.52 g) were better in grain size than the checks.

**Remarks** – None of the varieties and hybrid was superior to the checks for grain yield. The hybrid SPH-1746 (6780 kg/ha) gave significantly better fodder yield than the check CSH-15R (5778 kg/ha) and was superior by 17.34 %. Other hybrids which gave more than 5% fodder yield than the check hybrid were SPH-1741 (6286 kg/ha), SPH-1742 (6241 kg/ha). Among varieties, the variety SPV-2221 (7148 kg/ha) gave 8.5% more yield than the check CSV-22 (6587 kg/ha). The varieties SPV-2221, SPV-2215 and SPV-2228 and the hybrid SPH-1746 were better in grain size than the checks.

**Table 1: Performance of hybrids & varieties in All India AVHT - Deep Soil: Rabi 2013-14**

S. No	Entry	Centre	GY	R	% over check*	FY	R	% over check*	DTF	DTM	PH	GW
1	SPH 1721	Solapur	2187	10	-3.50	5606	16	-2.97	74	115	204	3.42
2	SPH 1741	Solapur	2330	3	2.78	6286	12	8.80	73	114	197	3.24
3	SPH 1742	Solapur	2419	1	6.70	6241	13	8.01	75	114	205	3.33
4	SPH 1744	Dharwad	2302	4	1.54	6044	14	4.60	74	115	199	3.41
5	SPH 1746	Rahuri	2332	2	2.56	6780	5	17.34	73	115	213	3.52
6	SPV 2144	Parbhani	2121	15	-4.8	6577	10	0.00	78	120	213	3.46
7	SPV 2215	Bijapur	2177	13	-2.28	6857	3	4.09	79	121	205	3.58
8	SPV 2221	Parbhani	2257	7	1.30	7148	1	8.52	80	121	222	3.64
9	SPV 2225	Rahuri	2182	11	-2.06	6766	6	2.71	77	120	213	3.40
10	SPV 2227	Rahuri	2269	5	1.84	6501	11	-1.30	78	119	214	3.36
11	SPV 2228	Tandur	2056	16	-7.70	6831	4	3.70	78	120	214	3.48
12	CSH 15R	Solapur	2267	6	--	5778	15	--	73	113	202	3.36
13	CSV 22	Rahuri	2228	9	--	6587	9	--	79	120	211	3.32
14	CSV 29R	Bijapur	2180	12	--	6594	8	--	78	119	219	3.34
15	M35-1	Bijapur	2123	14	--	6703	7	--	75	116	196	3.56
16	Local Check		2251	8		6959	2		77	120	195	3.36
	Overall Mean		2226			6491			76	117	208	3.42
	C.V. (%)		18.25			15.81			4.46	2.86	7.97	9.07
	C.D. (5%)		247.94			810.2			2.26	2.56	9.5	0.23
	C.D. (1%)		328			1070			3	3.38	12.54	0.31
	F (Probability)		0.37			0.01			0	0.00	0	0.05

Note: R - Ranking; GY - Grain yield (kg/ha); FY - Fodder yield (kg/ha); DTF - Days to flowering; DTM - Days to maturity; PH - Plant height (cm); GW - 100 Grain weight (g); Local check varied from location to location. \*Percent over CSV 22 for varieties and CSH 15R for hybrids.

The performance of the varieties and hybrid over 2 years of testing in Rabi 2012-13 and 2013-14 (Table 1A) indicated that the hybrids SPH-1741 (2600 kg/ha), SPH-1741 (2607 kg/ha) and SPH-1746 (2534 kg/ha) gave 10.63%, 10.93% and 7.82% more grain yield, respectively, over the check CSH-15R (2350 kg/ha). For fodder yield, the hybrids SPH-1746 (6852 kg/ha), SPH1741 (6217 kg/ha) and SPH-1742 (6184 kg/ha) gave 17.95%, 7.02% and 6.45% more than the check CSH-15R (5809 kg/ha).

**Table 1A: Performance of hybrids in All India IHT (Rabi 2012-13) and AVHT-Deep soil (Rabi 2013-14)**

S No.	Entry	Centre	Grain yield (kg/ha)			% over CSH-15R	Fodder yield (kg/ha)			% over CSH-15R
			2012-13	2013-14	Mean		2012-13	2013-14	Mean	
1	SPH 1741	CRS, Solapur	2870	2330	2600	10.63	6148	6286	6217	7.02
2	SPH 1742	CRS, Solapur	2794	2419	2607	10.93	6126	6241	6184	6.45
3	SPH 1744	Devgen	2640	2302	2471	5.15	6413	6044	6229	7.23
4	SPH 1746	Rahuri	2736	2332	2534	7.82	6923	6780	6852	17.95
5	CSH-15 R (Check)	CRS, Solapur	2432	2267	2350	-	5840	5778	5809	-

## 2. Initial Hybrid Trial (Deep soil)

In this trial of varieties, 6 hybrids along with 3 checks were evaluated for grain and fodder yield and other agronomic traits (Table 2).

- Days to flowering – The hybrids ranged for flowering from 72 to 77 days. The hybrids SPH-1763, SPH-1764, SPH-1765 and SPH-1766 (116 d) were earlier to the check CSH 15R (117 d).
- Plant height – The range of plant height of varieties and hybrid was from 167 to 229 cm.
- Grain Yield – The hybrid SPH-1763 (2846 kg/ha) was significantly superior to CSH 15R (2393 kg/ha) by 18.90%. Other hybrids which gave more than 5% grain yield were SPH-1764 (2597 kg/ha) and SPH-1762 (2541 kg/ha).
- Fodder yield: None of the hybrids were significantly superior to check CSH-15R. The hybrids SPH-1765 (6374 kg/ha), SPH-1763 (6319 kg/ha), SPH-1764 (6303 kg/ha) and SPH-1762 (5909 kg/ha) gave more than 5% fodder yield than the check.
- Grain size – The hybrids SPH-1765 (3.53 g) was better in grain size than the check CSH 15R (3.49 g).

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

**Table 2: Performance of hybrids in All India IHT-Deep Soil: Rabi 2013-14**

S. No	Entry	Centre	GY	R	% over check	FY	R	% over check	DTF	DTM	PH	GW
1	SPH 1762	Rahuri	2541	3	6.18	5909	7	7.33	73	117	219	3.51
2	SPH 1763	Rahuri	2846	1	18.93	6319	5	14.78	72	116	224	3.44
3	SPH 1764	Solapur	2597	2	8.52	6303	6	14.49	72	116	215	3.43
4	SPH 1765	Devgen	2470	5	3.21	6374	4	15.78	74	116	208	3.53
5	SPH 1766	Akola	2224	10	-7.06	5140	10	-6.63	72	116	180	3.29
6	SPH 1767	Akola	2224	9	-7.06	5345	9	-2.90	76	117	167	3.04
7	CSH 15R	Solapur	2393	7	--	5505	8	--	72	117	201	3.49
8	CSV 22	Rahuri	2494	4	--	6609	3	--	77	120	223	3.48
9	CSV 29R	Bijapur	2433	6	--	6888	1	--	77	120	229	3.34
10	Local Check#		2278	8	--	6671	2	--	76	119	207	3.38
	Overall Mean		2450			6106			74	117	207	3.39
	C.V. (%)		18.93			16.56			3.28	2.11	7.17	8.20
	C.D. (5%)		406			886			2.02	2.83	12	0.27
	C.D. (1%)		538			1176			2.68	3.78	16	0.36
	F (Probability)		0.09			0.00			0.00	0.02	0.00	0.03

Note: R - Ranking; GY - Grain yield (kg/ha); FY - Fodder yield (kg/ha); DTF - Days to flowering; DTM - Days to maturity; PH - Plant height (cm); GW - 100 Grain weight (g); Local check varied from location to location. \*Percent over CSH 15R for hybrids.

### 3. Initial Varietal Trial (Deep soil)

In this trial, 14 varieties along with 3 checks were evaluated for agronomic traits (Table 3).

- Days to flowering – The flowering in varieties and hybrids ranged from 71 to 80 days. The variety SPV-2281 (116 d) matured 5 days earlier than the check CSV-22 (121 d). All other varieties and checks matured in 120 to 121 days.
- Plant height – The range of plant height of varieties and hybrids was from 172 to 228 cm.
- Grain yield: None of the varieties were significantly superior to check CSV-22. The varieties SPV-2278 and SPV-2286 (2356 kg/ha) were numerically superior to check CSV 22 (2348 kg/ha).
- Fodder yield: The variety SPV-2277 (7430 kg/ha) was significantly superior to the check CSV 22 (6461 kg/ha) by 14.90%. The variety SPV-2285 (6988 kg/ha) gave more than 5% fodder yield than the check.
- Grain size – The varieties SPV-2277 (3.86 g), SPV-2279 (3.72 g), SPV-2280 (3.59 g) and SPV-2282 (3.51 g) were significantly better than the check CSV 22 (3.26 g) for grain size.

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

**Table 3: Performance of varieties in All India IVT - Deep Soil: Rabi 2013-14**

S. No	Entry	Centre	GY	R	% over check*	FY	R	% over check*	DTF	DTM	PH	GW
1	SPV 2274	Rahuri	2264	6	-3.50	6217	10	-3.70	79	121	223	3.25
2	SPV 2275	Rahuri	2149	11	-8.40	6029	14	-6.68	78	120	216	3.22
3	SPV 2276	Parbhani	2151	10	0.00	6371	8	-1.39	78	122	210	3.43
4	SPV 2277	Parbhani	1909	17	-18.69	7430	1	14.99	80	123	216	3.86
5	SPV 2278	Nirmal Seeds	2356	2	0.34	6063	13	-6.16	78	122	219	3.33
6	SPV 2279	Solapur	2186	7	-6.80	6778	3	4.90	77	120	203	3.72
7	SPV 2280	Solapur	2138	12	-8.90	6511	4	0.77	78	120	211	3.59
8	SPV 2281	Kovilpatti	2173	9	-7.40	4637	18	-28.23	71	116	172	2.60
9	SPV 2282	DSR	2077	16	-11.54	6444	6	-0.26	77	120	205	3.51
10	SPV 2283	Akola	2088	15	-11.07	6289	9	-2.66	78	121	205	3.35
11	SPV 2284	Akola	2102	14	-10.47	5855	15	-9.37	78	121	205	3.36
12	SPV 2285	Bijapur	2176	8	-7.32	6988	2	8.15	79	122	209	3.20
13	SPV 2286	Bijapur	2356	2	0.34	6099	12	-5.60	78	121	228	3.18
14	SPV 2287	DSR	2272	5	-3.23	5782	16	-10.50	78	121	225	3.34
15	CSH 15R	Solapur	2416	1	--	5517	17	--	72	116	203	3.31
16	CSV 22	Rahuri	2348	3	--	6461	5	--	78	121	222	3.26
17	CSV 29R	DSR	2308	4	--	6107	11	--	78	121	224	3.22
18	Local Check#		2114	13	--	6404	7	--	76	120	203	3.23
	Overall Mean		2198.94			6221.27			77	120	211	3.33

S. No	Entry	Centre	GY	R	% over check*	FY	R	% over check*	DTF	DTM	PH	GW
	C.V. (%)		18.46			15.69			2.7	2.14	7.97	8.02
	C.D. (5%)		254.54			901.3			1.74	2.43	10.76	0.22
	C.D. (1%)		336.52			1189.98			2.3	3.22	14.21	0.29
	F (Probability)		0.02			0.00			0.00	0.00	0.00	0

Note: R - Ranking; GY - Grain yield (kg/ha); FY - Fodder yield (kg/ha); DTF - Days to flowering; DTM - Days to maturity; PH - Plant height (cm); GW - 100 Grain weight (g); Local check varied from location to location. \*Percent over CSV 22 for varieties

#### 4. Initial Varietal and Hybrid Trial (Shallow soil)

In this combined trial of varieties and hybrids, 4 varieties and 2 hybrids along with 5 checks were evaluated for agronomic traits (Table 4).

- Days to flowering – The varieties and hybrid ranged for flowering from 67 to 78 days. None of the entries were earlier to check Phule Anuradha (110 d).
- Plant height – The range of plant height of varieties and hybrids was from 168 to 199 cm.
- Grain yield: None of the varieties/hybrids were significantly superior to the check. The hybrid SPH-1768 (812 kg/ha) gave 4.90% more yield than the check hybrid CSH-15R (774 kg/ha). Among varieties, the variety SPV-2291 (768 kg/ha) was better than the check Phule Anuradha (715 kg/ha) by 7.41%.
- Fodder yield: None of the varieties/hybrids were significantly superior to the check. The variety SPV-2289 (5909 kg/ha) was better than the check Phule Anuradha (5550 kg/ha) by 6.47%.
- Grain size – The hybrid SPH-1769 (3.37 g) was bolder than the check CSH-15R (3.02 g).

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

Table 4: Performance of hybrids & varieties in All India IVHT - Shallow Soil: Rabi 2013-14

S. No	Entry	Centre	GY	R	% over check	FY	R	% over check	DTF	DTM	PH	GW
1	SPH 1768	Rahuri	812	1	4.90	5582	7	-5.94	70	113	178	2.77
2	SPH 1769	Rahuri	628	12	-18.86	6219	1	4.78	74	117	199	3.37
3	SPV 2288	Rahuri	697	9	-2.51	5740	6	3.52	76	118	185	2.89
4	SPV 2289	Rahuri	737	5	3.07	5909	4	6.47	76	119	185	2.80
5	SPV 2290	Gulberga	673	10	-5.87	5204	11	-6.23	73	116	168	3.03
6	SPV 2291	Solapur	768	3	7.41	4783	12	-13.81	71	113	168	2.90
7	CSH 15R	Solapur	774	2	--	5935	3	--	70	114	184	3.02
8	CSV 26	Solapur	699	8	--	6183	2	--	78	120	183	2.83
9	M 35-1	Bijapur	717	6	--	5574	8	--	75	118	177	3.06
10	Phule Anuradha	Rahuri	715	7	--	5550	9	--	67	110	177	3.03
11	Phule Maullee	Rahuri	661	11	--	5218	10	--	69	112	184	2.99
12	Local Check#		764	4		5742	5		73	117	183	3.07
	Overall Mean		720			5637			73	116	181	2.98
	C.V. (%)		15.18			19.69			3.72	2.58	9.81	8.43
	C.D. (5%)		132			1034			3.59	4.88	17.43	0.20
	C.D. (1%)		180			1382			4.78	6.50	23.21	0.27
	F (Probability)		0.24			0.24			0.00	0.00	0.07	0.00

Note: R - Ranking; GY - Grain yield (kg/ha); FY - Fodder yield (kg/ha); DTF - Days to flowering; DTM - Days to maturity; PH - Plant height (cm); GW - 100 Grain weight (g); Local check varied from location to location. \*Percent over Maui for varieties and CSH 15R for hybrids.

#### 5. Parental line trial

A combined (kharif & rabi) parental line trial consisting of 35 parents (14 A lines and 21 R lines) was conducted at Nandyal, Parbhani and Hagari (Table 5). There was good synchronization in parental lines (A/R lines) as the difference between the CMA Lines and restorers ranged from 2 to 4 days. So, they can be sown simultaneously and staggered sowing is not necessary. The high yielding CMS lines and R lines were 104A, 32A2, 499A, IMS-9A, SLR-75, SLR-84, SLR-92, SLR-93, AKRB-513, R-204, RSV-269, RSV-1090 and RSV-1130. It was interesting to observe that R lines were more potential than CMS lines.



Table 5: Performance of parental lines across locations: Rabi 2013-14

Parental lines	Centre	Grain Yield						All India mean							
		Hagari		Nandyal		Parbhani		DTF		DTM		PH		GW	
		Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	Mean	R	Mean	R
104A	CRS, Solapur	4206	10	1728	21	2268	23	67	20	109	23	136	23	3.63	9
185A	Rahuri	3896	17	2393	11	2783	19	68	23	110	29	152	16	3.71	7
3216A	DSR	4020	13	1656	22	1816	26	64	6	106	10	126	27	3.61	11
32A2	DSR	6193	3	1273	30	.	.	64	5	101	1	172	12	2.90	22
473A	DSR	3422	23	1416	26	2465	21	64	3	104	4	114	31	3.10	18
479A	DSR	4030	12	3126	3	3885	9	67	16	108	18	152	16	2.99	20
AKMS 30A	Akola	3904	16	1354	29	2951	18	68	24	110	32	126	24	2.76	25
AKMS 66-2A	Akola	3010	27	933	34	2562	20	66	14	107	15	114	32	3.11	17
AKMS 80-1A	Akola	3442	21	1580	25	3787	10	67	17	110	29	115	30	2.99	20
AKR 504	Akola	2519	32	1184	32	1740	28	73	33	113	33	142	19	2.51	30
AKRB 369-1	Akola	3891	19	1994	18	4418	7	70	32	110	28	141	22	2.75	26
AKRB 513	Akola	3185	25	2644	8	6526	1	69	27	110	31	155	15	3.18	15
CB 132	DSR	2963	30	2208	14	2361	22	67	19	108	21	121	29	2.02	32
CB I 27	DSR	1333	34	2782	7	1933	24	69	26	109	24	114	33	2.53	29
ICSA 34	ICRISAT	3907	15	1409	27	1630	30	67	21	108	20	104	34	2.60	28
ICSA 474	ICRISAT	2405	33	1966	19	1551	32	65	11	107	14	160	14	3.83	4
IMS 9A	Indore	4963	5	2322	13	1735	29	67	17	108	17	126	25	2.71	27
NARI SS 15A	Phaltan	2978	29	1383	28	3026	16	73	34	113	34	126	26	3.27	14
NTJ 2	ICRISAT	2881	31	2148	16	1361	33	65	8	105	7	147	18	3.07	19
PC 6	Pantnagar	4648	6	1255	31	1562	31	66	13	105	6	180	10	1.86	34
Pant Chari 6	Pantnagar	3896	17	1115	33	1775	27	66	12	106	11	173	11	1.95	33
R 204	DSR	3062	26	2855	5	3179	14	65	8	105	8	124	28	2.21	31
RS 585	CRS, Solapur	3005	28	2121	17	2961	17	67	22	109	24	162	13	3.66	8
RSSV 269	Rahuri	4528	7	2523	10	3251	13	62	1	104	2	141	21	2.89	23
RSV 1059	Rahuri	4277	8	1654	23	4303	8	69	27	107	15	205	1	3.13	16
RSV 1090	Rahuri	3499	20	2376	12	4470	6	69	29	108	21	191	9	3.73	6
RSV 1130	Rahuri	5528	4	2853	6	5490	3	70	31	109	26	198	4	3.62	10
RSV 1830	Rahuri	3440	22	1962	20	6316	2	70	30	109	26	198	7	3.55	12
SLR 75	CRS, Solapur	4230	9	2899	4	5095	4	63	2	104	3	200	2	4.13	2
SLR 84	CRS, Solapur	6553	2	4384	1	3783	11	64	4	105	9	194	8	3.81	5
SLR 92	CRS, Solapur	3985	14	4251	2	3040	15	66	14	106	13	198	5	4.26	1
SLR 93	CRS, Solapur	7437	1	2535	9	3426	12	64	7	105	5	198	6	3.88	3
SPV 1549	Rahuri	4168	11	1592	24	4604	5	69	25	108	18	199	3	3.36	13
SSV 84	DSR	3390	24	2179	15	1932	25	65	10	106	12	142	20	2.81	24
General Mean		3935		2108		3125		67		107		178		3.14	
CV(%)		41.3		47.9		40.8		5.2		4.2		8.8		20.0	
CD(5%)		2659		1646		2079		6		6		30		0.76	
CD(1%)		3538		2185		2761		8		9		40		1.02	
P-Value		0.11		0.01		0.00		0.32		0.70		0.00		0.00	

Note: R - Ranking; GY - Grain yield (kg/ha); FY - Fodder yield (kg/ha); DTF - Days to flowering; DTM - Days to maturity; PH - Plant height (cm); GW - 100 Grain weight (g).

### Coordinated sorghum breeding research

Multi-location evaluation of segregating material (Sujoy Rakshit, Prabhakar, SR Gadakh and HV Kalpande) F2 populations of 11 crosses were provided by four centers (Kovilpatti, Dharwad, Akola and Parbhani). Seeds were provided to 9 centers for evaluation and selection. Details of the programme are given in Table 6 and single plants selections made at various centers are given in Table 7.

Table 6: Summary of multi-location evaluation of segregating materials

Sl. No.	Cross	Developing center	Trait	Evaluated at
1	RSLG 2367 x SSRG 373	Rahuri	Grain quality	Solapur, Bijapur, Tandur, Dharwad
2	SPV 2048 x RSLG 229	Rahuri	Grain quality	Solapur, Bijapur, Tandur, Dharwad
3	PVR 658 x PVR 10538	Parbhani	Grain quality	Solapur, Bijapur, Tandur, Dharwad
4	PMS 8B x PMS 71B	Parbhani	Grain quality	Solapur, Bijapur, Tandur, Dharwad

Table 7: Selections made from different crosses at various centers

Sl. No.	Cross	Number of selections		
		Solapur	Bijapur	Dharwad
1	RSLG 2367 x SSRG 373	4	40	6
2	SPV 2048 x RSLG 229	6	32	4
3	PVR 658 x PVR 10538	3	20	5
4	PMS 8B x PMS 71B	3	22	5

## **Sorghum breeding at DSR**

### **1. Breeding for high yielding rabi cultivars**

(Prabhakar, MY Samdur, N Kannababu)

#### **1: Varietal improvement**

**a) Evaluation of improved breeding lines in shallow-medium and deep soils:** Evaluation of improved breeding lines in shallow-medium and deep soils separately, indicated that 48 promising varieties ( 12 in shallow-medium and 36 in deep soil) were significantly superior to checks M35-1/Mauli and CSV-22 for grain and fodder yields and grain quality with resistance to insect-pests and diseases.

Selected varieties for shallow-medium soils were SLV-34, 40, 43, 50, 73, 91, 97, 100, 101, 111, 123 and 135 and for deep soil, the varieties were SLV-97, 118, 123, 130, 131, 133, 145, 166, 169, 172, 180, 188, 199, 202, 207, 209..

**b) Performance of hybrids and varieties contributed from Solapur in AICSIP trials of Rabi 2013-14:** Four new entries (Shallow soil: CRS-41, Deep soil: CRS-40, 42, 43) are contributed for testing in IVHT and 4 Restorer lines in PLT, during Rabi 2013-14. Besides, 3 entries (SPH-1721, 1741 and 1742) are tested in AVHT during Rabi 2013-14 and the results are updated PC Report.

**2. Development of new CMS lines and parental lines using exotic/indigenous lines:** Conversion programme was continued for 99 pairs in various backcross generations (indigenous and exotic) and out of them, a total of 28 pairs were selected and characterized. The main characters considered for selection were grain color, quality, size, and luster and sterility/fertility reactions.

Backcross generations	No. of pairs	Sterile/Fertile	Selected pairs
BC 6 (A/B)	13 pairs	Fully sterile	2
BC 5 (A/B)	8 pairs	Fully sterile	4
BC 4 (A/B)	5 pairs	Fully sterile	1
BC 3 (A/B)	18 pairs	Fully sterile	3
BC 2 (A/B)	37 pairs	Fully sterile	12
BC 1 (A/B) Best St/F	18 pairs	Sterile/fertile	6
<b>Total</b>	<b>99</b>		<b>28</b>

**3: B line improvement:** B line improvement for diversifying genetic base led to selection of 17 B lines out of 36 lines with rabi traits. Eleven test hybrids, superior to CSH-15R for grain and fodder yields were selected. Selected B lines were SLB-22, 29, 35, 45, 46, 50, 56, 58, 59, 60, 73, 80, 86, 92, 97, 108 and 150. Twelve new CMS lines (SLA-9, 19, 29, 35, 45, 46, 56, 59, 60, 73, 82, and 150) better than the CMS 104A in respect of grain quality with resistance to insect-pests and diseases have been stabilized and they are ready for commercial exploitation

**4. R line improvement:** R line improvement for diversifying genetic base led to selection of 54 R lines out of 96 lines with rabi traits. Selected R lines were SLR-27, 31, 34, 46, 57, 67, 68, 70, 80, 87, 97, 130, 133, 136, 146, .

#### **5: Evaluation of Experimental Hybrids (EHT)**

**Evaluation of newly developed experimental hybrids under team efforts:** A total of 40 newly developed experimental hybrids were evaluated in 2 trials at 3 locations (Solapur, Bijapur and Rahuri). Promising hybrids were 104 A x SLR-31, 104A x SLR-57, 104A x SLR-70, 104A x SLR-125, 104A x SLR-67, 104A x SLR-72, 104A x SLR-75, SLA-19 x SLR-67, SLA-46 x SLR-70, 104A x SLR 28, 104A x SLR 88, 104A x SLR 143, SLA 9 x SLR 57, SLA 9 x SLR 67, 104A x SLR 81, 104A x SLR 91, 104 A x SLR 144, 104A x SLR 83.

**6. Identification of donors for insect-pests and diseases:** The improved breeding lines were screened for insect-pests and diseases at multi-locations under AICSIP. The results are to be received from AICSIP Rabi centres and it will be updated once it appears in PC Report.

#### **7: Nucleus and breeder seed production of parental lines of CSH-15R**

- Nucleus (5 kg each) and Breeder seed production of parental lines (104A, 104B and RS-585) of rabi hybrid CSH-15R have been produced and the targets are met. There was proper synchronization of

flowering and perfect seed setting in plots of A/B and A/R lines. The quantities of seed of 104A, 104B, RS-585 and the hybrid were 20 kg, 25 kg, 30 kg and 32 kg, respectively.

- Under mega seed project, seed multiplication of newly released rabi variety CSV-26 has been undertaken in farmers fields..

## 2. Genetic enhancement for drought tolerance in rabi sorghum genotypes

(DSR/CI/2012-17/43) (M.Y. Samdur, Prabhakar, H.S. Talwar and N. Kannababu)

**Evaluation of breeding lines for drought tolerance and identification of traits associated with it:** Twenty five genotypes were evaluated in three reliable soil moisture environments (assured irrigation, water deficit ie. irrigation only upto 50 days after sowing and rainfed ie. receding moisture conditions) along with four checks (M35-1, Phule Anuradha, CSV 22 and CSV 26). High phenotypic variation was observed for grain yield (g per plant), biomass (g per plant), panicle emergence per cent, plant height (cm), Panicle length (cm), peduncle length (cm), days to 50 per cent flowering and days to maturity. Drought susceptible index (DSI) values for grain yield under water deficit condition ranged from 0.13 to 1.32 and under rainfed condition ranged from 0.13 to 1.24. DSI values for biomass under water deficit condition ranged from 0.26 to 1.24 and under rainfed condition ranged from 0.10 to 1.27. Drought tolerance efficiency (DTE) for yield ranged from 92.84 to 29.84 per cent under water deficit condition and 90.54 to 12.58 per cent under rainfed condition. Genotype IC-392124 recorded the highest DTE 92.84 and 90.54 per cent under both water deficit and rainfed conditions respectively. Based on DSI and DTE values genotypes IC-392124, IC-392147, IC 343584 and IC 343573 were found to be drought tolerant. The correlation analysis suggests that identification of genotypes should be desirable based on traits like early flowering and long peduncle length for improving drought tolerance in *rabi* sorghum.

## 3. Bio-prospecting of genes and allele mining for abiotic stress tolerance

(Sujay Rakshit, HS Talwar and KN Ganapathy)

**Studies on response of sorghum genotypes towards post-flowering drought stress:** To study the post-flowering drought response 21 genotypes were evaluated under rainout shelter under well watered (WW) and water stressed (WS) conditions during the rabi seasons of 2011-12 and 2012-13. Based on the grain yield under WW and WS conditions drought susceptibility indices of the genotypes were calculated (Table 1). Genotype, treatment and year effects as well as all interaction effects except year × treatment and year × treatment × genotype were significant. In 2011-12 rabi six genotypes, viz., IS 19153, IS 23514, IS 29392, IS 3158, M 35-1 and RS 585 recorded low DSI (<1.0) and above average grain yield (1041 kg ha<sup>-1</sup>) under WW situation. In 2012-13 rabi season five genotypes, viz., IS 19153, IS 23514, IS 29392, Phule Chitra and RS 585 were detected with low DSI (<1.0) and above average grain yield (1072 kg ha<sup>-1</sup>) under irrigation. Four lines, viz., IS 19153, IS 23514, IS 29392 and RS 585 showed consistent better post-flowering drought response over both the years. Out of these four lines identified IS 23514, a red sorghum line recorded lowest DSI in both the years and found to be promising.

Table 1. Response of sorghum genotypes towards post-flowering drought stress

Genotype	Grain yield (kg/ha)				DSI	
	2012		2013		2012	2013
	<i>Dr</i>	<i>Irri</i>	<i>Dr</i>	<i>Irri</i>		
B 35	461	720	666	1061	0.92	0.96
BTX 623	639	972	572	777	0.88	0.68
CSV 216R	967	1783	824	1523	1.17	1.18
IS 10696	539	1039	675	1103	1.23	1.00
IS 12804	570	1233	578	1006	1.38	1.10
IS 19153	717	1100	861	1239	0.89	0.79
IS 20697	617	938	589	1000	0.88	1.06
IS 20740	355	528	433	814	0.84	1.21
IS 23514	983	1200	982	1302	0.46	0.63
IS 2397	500	806	511	983	0.97	1.24
IS 29392	727	1105	772	1164	0.88	0.87
IS 29441	178	672	389	883	1.88	1.44
IS 30536	372	472	398	650	0.54	1.00
IS 3158	688	1089	583	1044	0.94	1.14
IS 3971	477	833	578	951	1.09	1.01
IS 473	372	866	434	856	1.46	1.27

Genotype	Grain yield (kg/ha)				DSI	
	2012		2013		2012	2013
	<i>Dr</i>	<i>Irr</i>	<i>Dr</i>	<i>Irr</i>		
M 35-1	722	1177	683	1267	0.99	1.19
PC	956	1572	1017	1406	1.00	0.71
PM	1028	1683	844	1378	1.00	1.00
R 16	694	916	586	879	0.62	0.86
RS 585	767	1161	794	1222	0.87	0.90

**Whole genome and candidate gene-based SNP detection in sorghum:** A reference set of 96 sorghum genotypes for drought studies was subjected to Double Digestion Restriction site Associated DNA sequencing (ddRAD-seq), which generated 221,665,772 reads, 83.91% of which had Fred score  $\geq 30$  leading to 19.45 Gb data. Alignment with the reference genome of BTx 623 led to identification of a total of 235,009 unfiltered SNPs, distributed across 10 chromosomes. Out of these 198,611 (84.5%) were located in inter-genic regions, while 36,398 (15.5%) were localized in intra-genic regions. Generated data were filtered for variants with less than 30% missing data and minor allele frequency of  $>0.3$ . This led to identification of 10,125 SNPs, 8,313 (82.1%) and 1,812 (17.9%) of which were located in inter- and intra-genic regions, respectively (Table 2). From SNP database 15.1% of unfiltered and 42.5% of filtered SNPs could be confirmed. Among intra-genic unfiltered sequence variations, a total of 10784, 23085 and 2529 SNPs corresponded to exonic, intronic and UTR (3'&5') regions, respectively, while among filtered variants 554, 1114 and 144 were in the exonic, intronic and UTR specific, respectively. Out of the unfiltered intra-genic SNPs 32.0%, 18.8% and 1.2%, respectively were mis-sense, same sense and non-sense in nature, while 29.8%, 19.5% and 0.36% of filtered intra-genic SNPs were mis-sense, same sense and non-sense in nature. Out of the identified SNPs 2075 represented 32 reported QTLs, of which, SNPs on chromosome 2, 3, 5 and 8 were mostly associated with drought related QTLs. Sequence alignment of coding (CDS) and promoter regions of 10 candidate genes, viz., *AP37* (*Apetela2* gene), *DREB1* (Dehydration responsive element binding protein 1), *LEA* (Late embryogenesis abundant protein 3), *NAC* (NAM, TAF and CUC (NAC) transcription factor), *NF* (Nuclear factor Y), *PYL 5* (Pyroabactin resistant 1 like), *STZ* (Salt tolerant zink finger protein), *VP14* (Viviparous14), *AREB* (Abscisic acid-responsive element binding protein) and *AHK1* (histidine kinase) from six sorghum genotypes led to identification of total of 172 SNPs and 68 in-del mutations in the coding regions, while in promoter regions 159 SNPs and 77 in-dels were identified (Table 3). Forty two identified SNPs were converted to CAPs/dCAPs markers.

**Table 2: Percent of sequence variants in different categories identified across 10 chromosomes of sorghum through RAD sequencing**

Chr. No.	Total	Intergenic	Intragenic			Confirmed	No. of SNPs associated with known QTLs & traits
			Exonic	Intronic	UTR		
1	11.2 (11.1)	10.4 (9.7)	13.6 (17.5)	16.9 (16.4)	17.0 (21.5)	11.3 (12.3)	98 (Ma, Seed wt.)
2	12.0 (14.4)	12.0 (14.7)	11.9 (10.3)	12.8 (14.8)	11.2 (10.4)	17.7 (15.3)	230 (Pan lgth., Root wt., stg3)
3	11.3 (10.3)	11.1 (9.8)	11.4 (7.9)	12.9 (13.6)	14.2 (17.4)	14.4 (9.1)	139 (Leaf spot, Zonate leaf spot, stg2)
4	11.0 (11.5)	11.0 (11.6)	10.9 (12.6)	10.9 (10.0)	12.4 (13.2)	15.1 (9.4)	27 (Anthracnose)
5	10.3 (8.1)	10.6 (8.1)	11.9 (9.4)	7.9 (8.3)	7.2 (5.6)	16.2 (9.1)	527 (Gloss, nodal root angle, root & shoot dry wt., stg4)
6	9.5 (10.7)	9.6 (11.3)	9.5 (10.3)	9.2 (7.5)	7.9 (5.6)	13.5 (9.9)	482 (Five foliar dis, Plant ht.)
7	8.2 (6.4)	8.4 (6.1)	7.6 (9.2)	6.9 (6.2)	8.4 (13.2)	10.0 (6.6)	17 (Plant ht, Panicle length)
8	8.4 (8.2)	8.8 (8.8)	7.4 (8.5)	6.1 (4.8)	5.6 (1.4)	12.6 (7.8)	443 (root angle & dry wt., Lf ar)
9	9.0 (9.9)	9.1 (10.0)	8.0 (7.2)	9.0 (10.9)	8.0 (3.5)	14.5 (10.8)	41 (Plant ht., Leaf No., Test wt.)
10	9.0 (9.3)	9.2 (9.7)	7.8 (7.0)	7.7 (7.5)	8.1 (8.3)	14.1 (9.6)	71 (Egg Nos, Dead heart, Trichome density, root angle)
Total (No.)	235009 (10125)	198611 (8313)	10784 (554)	23085 (1114)	2529 (144)	35437 (4298)	2075

Values in parenthesis shows information on filtered sequence variants

**Table 3. Summary of sequence variants detected in candidate genes across sorghum genotypes**

Sl. No.	Gene	Size (kb)	Promoter			Gene			Total	CAPs/ dCAPs
			SNP	In-del	Total	SNP	In-del	Total		
1	AP37	2.44	15 (0)	6 (0)	21 (0)	7 (0)	0 (1)	7 (1)	28 (1)	6
2	AREB	5.36	10 (24)	7 (6)	17 (30)	15 (5)	12 (4)	27 (9)	44 (39)	8
3	DREB	2.89	8 (0)	4 (0)	12 (0)	10 (1)	3 (3)	13 (4)	25 (4)	3
4	LEA	2.45	17 (10)	8 (8)	25 (18)	5 (8)	0 (2)	5 (10)	30 (28)	9
5	NAC	2.66	5 (13)	9 (7)	14 (20)	1 (3)	2 (3)	3 (6)	17 (26)	0
6	NF	3.78	5 (4)	2 (0)	7 (4)	5 (40)	0 (20)	5 (60)	12 (64)	5
7	PYL5	2.34	5 (10)	1 (4)	6 (14)	1 (6)	1 (2)	2 (8)	8 (22)	6
8	STZ	2.73	13 (4)	5 (4)	18 (7)	13 (3)	1 (0)	14 (3)	32 (10)	5
9	VP14	3.32	0 (0)	0 (0)	0 (0)	1 (43)	0 (11)	1 (54)	1 (54)	0
10	AHK1	8.73	16 (0)	6 (0)	22 (0)	5 (0)	3 (0)	8 (0)	30 (0)	0
	Total	36.7	94 (65)	48 (29)	142 (93)	63 (109)	22 (46)	85 (155)	227 (248)	42

Values in parenthesis show the alleles identified in *S. halepense* alone

#### **4. Creating new variability for developing varieties and hybrid parents in rabi sorghum (*Sorghum bicolor* (L.) Moench) for medium to deep soils**

(P. Sanjana Reddy, Prabhakar, Sunil Gomashe and JV Patil)

Diverse group of breeding material that included 8 varieties, 7 maintainer lines, 5 restorer lines and a hybrid were screened for tolerance to cold stress in RBD design in two dates of sowing. The genotypes were evaluated for pollen viability and germinability apart from other agronomic traits. The low night temperature was 15°C and below during anthesis. Date of sowing significantly influenced pollen germinability and the influence of the cooler night temperatures was more than the genetic background. In contrast, pollen viability had less phenotypic plasticity and highly heritable. The loss of grain yield (open panicle grain yield – selfed panicle grain yield) was about 5g/panicle in varieties while it was 1.9g/panicle in restorer lines and about 5.7g/panicle in B-lines. The loss in grain yield was highest in the hybrid at about 22.9g. Higher grain yields in the hybrid with improvement in the pollen quality. The germinability percentage was positively associated with selfed panicle weight, grain yield and harvest index while the viability percentage did not show such association. The germinability percentage was more linearly related in R-lines followed by B-lines and varieties.

#### **Sorghum breeding at AICSIP centers**

##### **1. Rahuri**

The AICSIP MPKV, Rahuri is working on both kharf and rabi season. During rabi season, due to better moisture conservation practices and timely sowing this center has recorded satisfactory yield level in all the experimental plots. In general rabi season is quite favorable to rabi sorghum crop. Identified the rabi sorghum genotype RPASV-3 for papad purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra. Identified the rabi sorghum genotype RSSGV-46 for hurda purpose. The pre release proposal of this variety has been submitted to the University RRC meeting during 2013-14. This variety is proposed for rabi season for western Maharashtra.

**1. Varietal development programme:** In order to develop varieties as per soil types, crossing programme for shallow/medium and deep soil has been initiated through 7 x 7 half diallel mating system. About 42 crosses has been effected during the rabi season and straight six crosses has been effected for *hurda* purpose. The F<sub>1</sub> to F<sub>6</sub> generations were evaluated and promising IPS was selected.

Generation	No. of crosses evaluated	No. of progenies evaluated	No. of Families /IPS selected
F <sub>1</sub>	54	-	F <sub>1</sub> grown
F <sub>2</sub>	44	-	410
F <sub>3</sub>	58	580	231
F <sub>4</sub>	18	197	93
F <sub>5</sub>	25	253	178
F <sub>6</sub>	47	168	168
<b>Total</b>	<b>246</b>	<b>1198</b>	<b>670</b>

2. **R line development programme:** To develop restorer, 10 straight crosses has been effected during rabi season. The F<sub>1</sub> to F<sub>6</sub> generations were evaluated and promising IPS were selected.

Generation	No. of crosses evaluated	No. of progenies evaluated	No. of Families /IPS selected
F <sub>1</sub>	7	-	F <sub>1</sub> grown
F <sub>2</sub>	9	-	45
F <sub>3</sub>	28	140	76
F <sub>5</sub>	31	45	24
F <sub>6</sub>	18	18	16
<b>Total</b>	<b>93</b>	<b>203</b>	<b>161</b>

3. **B line development programme:** To develop good combining B lines with round and pearly white grains, four crosses has been effected during rabi season. The F<sub>1</sub> to F<sub>6</sub> generations were evaluated and promising IPS were selected.

Generation	No. of crosses evaluated	No. of progenies evaluated	No. of Families /IPS selected
F <sub>1</sub>	6	-	F <sub>1</sub> grown
F <sub>2</sub>	10	-	50
F <sub>3</sub>	6	30	20
F <sub>4</sub>	6	39	31
F <sub>5</sub>	7	10	10
F <sub>6</sub>	4	36	27
<b>Total</b>	<b>33</b>	<b>115</b>	<b>138</b>

4. **Development of resistant sources to biotic and abiotic stresses:**

a. *Shoot fly resistant line development programme:* To develop shootfly tolerant donors 22 crosses has been effected during rabi season. The F<sub>1</sub> to F<sub>6</sub> generations were evaluated and promising IPS were selected.

Generation	No. of crosses evaluated	No. of progenies evaluated	No. of Families /IPS selected
F <sub>1</sub>	22	-	F <sub>1</sub> grown
F <sub>2</sub>	9	-	90
F <sub>3</sub>	27	270	105
F <sub>4</sub>	4	35	17
F <sub>5</sub>	2	33	15
F <sub>6</sub>	5	31	12
<b>Total</b>	<b>69</b>	<b>369</b>	<b>239</b>

b. *Drought tolerant line development programme:* To develop drought tolerant donors 12 crosses has been effected during rabi season. The F<sub>1</sub> to F<sub>6</sub> generations were evaluated and promising IPS was selected.

Generation	No. of crosses evaluated	No. of progenies evaluated	No. of Families /IPS selected
F <sub>1</sub>	12	-	F <sub>1</sub> grown
F <sub>2</sub>	11	-	110
F <sub>3</sub>	23	230	95
F <sub>4</sub>	9	94	44
F <sub>5</sub>	3	55	17
F <sub>6</sub>	11	42	29
<b>Total</b>	<b>69</b>	<b>421</b>	<b>295</b>

5. **Development of rabi sorghum hybrids:** A total of 80 experimental hybrids has been developed on CMS lines, viz., CMS185A, RMS 2010-10A, RMS 2010-16A and RMS 2010-24A by utilizing elite restorers.

6. **Maintenance Breeding:** The rabi CMS 2010-10A&B, RMS 2010-16A&B, RMS 2010-24A&B, 185A&B, 1409A&B, 104A&B, 479A&B and 38A&B has been maintained through hand pollination.

7. **Station trials:** The state level multilocation trial conducted under rainfed and irrigated situation at 9 and 6 locations respectively in Maharashtra during rabi season. The details of entries tested along with checks used and promising genotypes to checks are given below. The University level multilocation trial conducted on Shallow, medium, deep and alternate uses under rainfed situation at 4 locations in the jurisdiction of MPKV, Rahuri during rabi season. The details of entries tested along with checks used and promising genotypes to checks are given below. The 11 sets of Station varietal trial conducted under rainfed situation at Rahuri during rabi season. The details of entries tested along with checks used and promising genotypes to checks are given

below. The one set of Station Hybrid trial conducted under rainfed situation at Rahuri during rabi season. The details of entries tested along with checks used and promising genotypes to checks are given below.

Name of trial	Entries tested	Checks	Promising genotype
<b>State MLT</b>			
State Multilocation varietal cum-hybrid trial (Rainfed)	20	P.Vasudha, PKV,Kranti, P.Moti, M 35-1	SVT (R) 1317, SVT (R) 1312
State Multilocation varietal cum-hybrid trial (Irrigated)	20	P.Revati, CSV 18, CSH 15R, M 35-1	SVT (I) 1304, SVT (I) 1308
<b>University MLT</b>			
UMLT (Shallow soil)	20	P.Anuradha, M 35-1	MSV 101, RSV 1561
UMLT (Medium soil)	20	P.Suchitra, M 35-1	RSV 1620, RSV 1544
UMLT (Deep soil)	20	P.Vasudha, M 35-1	MSV 101, RSV 1542
UMLT (Alternate Uses)	14	P.Uttara, P.Panchami	RSSGV 46, RSSGV 71
<b>Station varietal trials</b>			
Station Trial Set I (Drought)	20	P.Anuradha, M 35-1	RSV 1512, RSV 1660
Station Trial Set II (CG-Deep)	20	P.Vasudha, M 35-1	RSV 1674, RSV 1676
Station Trial Set III (CG -Medium)	20	P.Suchitra, M 35-1	RSV 1676, RSV 1674
Station Trial Set IV (CG -Shallow)	20	P.Anuradha, M 35-1	RSV 1614, RSV 1676
Station Trial Set V (SFR)	20	P.Anuradha, M 35-1, IS 2312	RSV 1628, RSV 1647
Station Trial Set VI (HY-I).	20	P.Vasudha, CSV 22, M 35-1	RSV 1715, RSV 1718
Station Trial Set VII (HY-II).	20	P.Vasudha, CSV 22, M 35-1	RSV 1721, RSV 1720
Station Trial Set VIII (HY-III).	20	P.Vasudha, CSV 22, M 35-1	RSV 1749, RSV 1737
Station Trial Set IX (HY-IV).	20	P.Vasudha, CSV 22, M 35-1	RSV 1767, RSV 1765
Station Trial Set X (HY-V).	20	P.Vasudha, CSV 22, M 35-1	RSV 1784, RSV 1781
Station Trial Set XI (HY-VI).	30	P.Vasudha, CSV 22, M 35-1	RSV 1801, RSV 1800
<b>Station Hybrid trial</b>			
Hybrid Trial	24	CSH 15R; M 35-1	RSH 1195, RSH 1209

8. AICSIP Trials:: The total three coordinated trials of rabi sorghum, one CRS hybrid trial, one coordinated sweet sorghum trial and 4000 germplasm were allotted and conducted successfully.

## 9. Nucleus and breeder seeds produced

Name of cultivar	Nucleus seed (kg)	Breeder seed(kg)	Name of cultivar	Nucleus seed (kg)	Breeder seed(kg)
CSV 216	2	-	P.Revati	30	1000
P.Maulee	4	-	Sel 3	2	-
P.Amruta	10	-	SSV 84	2	-
P.Uttara	4	-	Swati	2	-
P.Chitra	4	-	CSV 19SS	10	-
P.Vasudha	30	500	P.Panchami	5	20
CSV 22	10	20	P.Suchitra	30	1000
P.Anuradha	10	-	CSV 30F	30	400

## 2. Tandur

### 1. Station hybrid/varietal trial

Name of trial	No. of entries tested	Checks used	Superior entries
AxR Experimental Hybrid trial	7+1	M35-1	Data is yet to be analysed

### 2. Other activities

1. Pre season training and identification of Rabi sorghum FLD beneficiary farmers was organized at Navalga village of Basheerabad mandal on 22<sup>nd</sup> September 2013.
2. Mid season training programme on improved Rabi sorghum production technology at Navalga village of Basheerabad mandal on 17<sup>th</sup> November 2013.
3. Rabi sorghum farmers field day was organized at Navalga village of Basheerabad mandal on 22<sup>nd</sup> February 2014.

### Other points regarding the breeding material

Maintaince of A B lines- Nil      No. of Restorer lines- Nil      No. of experimental hybrids-7

### No. of varietal selections- Breeding material handled during Rabi 2013-14

S.No.	GENERATION	CROSSES	OBJECTIVE
1	F <sub>2</sub> (DSR)	4	GRAIN QUALITY AND YIELD
2	F <sub>3</sub>	4	HIGH GRAIN AND FODDER YIELD
3	F <sub>4</sub>	13	HIGH GRAIN AND FODDER YIELD
4	F <sub>5</sub>	12	HIGH GRAIN AND FODDER YIELD
5	F <sub>6</sub>	12	HIGH GRAIN AND FODDER YIELD
6	F <sub>7</sub>	9	HIGH GRAIN AND FODDER YIELD

**Other important points:** Scientists at ARS, Tandur attended the field day organized by ICRISAT on 17<sup>th</sup> and 18<sup>th</sup> February 2014 and made some promising germplasm selections to be used in breeding programme.

### 3. Bijapur

A total of five AICRP trials were allotted and five were conducted successfully. In station Breeding evaluation programme three preliminary varietal trials (PVT), one B line trial (BLT), one R line trial (RLT) and one MLT were conducted. In addition A public cum private hybrid trial was conducted. A total of 15 lines from PVT, 10 from BLT and 13 from RLT were selected. In station breeding programme, 20 newly derived F<sub>6</sub> generation R lines were evaluated and of them eight were found superior and retained. In B line programme 8 lines were found exceedingly superior to checks. In conversion programme 10 lines are at BC<sub>4</sub> stage. In trait specific breeding programme, ten families belonging to BC<sub>2</sub>&BC<sub>1</sub>F<sub>1</sub> were evaluated for drought stress and four were found promising. In the breeding for charcoal rot tolerance 23 lines derived from BC<sub>2</sub>F<sub>3</sub> and straight F<sub>3</sub> were evaluated and a total of 20 promising plants were selected. To develop medium dwarf non lodging coupled with CSV216R yielding ability 18 BC<sub>2</sub>F<sub>4</sub> families were selected. To develop early maturing lines with maldandi yielding ability 10 F<sub>7</sub> lines were evaluated and a total of 5 families were selected. A total of 33 F<sub>3</sub>s derived from different cross combination were grown. Of them a total of 150 plants were selected for different combination of traits. Four F<sub>2</sub>s contributed by different centers were grown and 30 plants were selected. A total of 650 germplasm were maintained.

- R line development programme:** In restorer line development programme 24 newly derived F<sub>6</sub> generation lines were evaluated and of them thirteen families were found superior and retained

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
F <sub>6</sub>	24+2CHECKS	13 families

- B line development programme:** With an objective of developing maldandi grain quality B lines 18 F<sub>6</sub> lines were evaluated and 10 families were found exceedingly superior to checks.

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
F <sub>6</sub>	18+2CHECKS	10 families

- MS Conversion programme:** Ten promising B lines with near maldandi grain quality types were advanced to backcross 4 generation

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
BC <sub>4</sub>	10	10 lines

#### 4. Development of lines resistant to various stresses

- Trait 1: Yield improvement under drought:** Ten families belonging to BC<sub>2</sub>&BC<sub>1</sub> F<sub>1</sub> were evaluated for drought stress and of them four families were found superior.

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
BC <sub>2</sub> &BC <sub>1</sub> F <sub>1</sub>	10+2checks&parents	04 families

- Trait 2: Charcoal rot tolerance** To derive charcoal rot tolerant lines 23 families&crosses derived from BC<sub>2</sub>F<sub>2</sub> and straight F<sub>2</sub> were subjected to evaluation. A total of 20 plants were selected.

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
BC <sub>2</sub> F <sub>2</sub> &Straight F <sub>2</sub>	23 +2checks&parents	20 plants selected



- iii. **CSV216R yielding ability +non lodging medium dwarf:** With an objective of developing medium dwarf and CSV216R yielding ability 20BC2F3 families were evaluated along with checks. A total of 18 plants were selected.

Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
BC2F3	20+5checks&parents	18 plants selected

- iv. **Yield and earliness:** To develop early maturing lines with maldandi yielding ability 10F7 generation lines were evaluated and total of 5 families selected.

Sl. No.	Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
	F6	10+3checks	5 families selected

- v. **Yield and charcoal rot tolerance:** To develop high yielding lines with charcoal rot tolerance 40 F7 generation lines were evaluated and a total of 20 plants were selected.

Sl. No.	Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
	F4	40(lines parents +checks)	20 plants selected

- vi. **Combination of traits(yield +charcoal rot +earliness +SF tolerance):** To develop early charcoal rot tolerance and SF tolerance with maldandi yielding ability 20F3 of different cross combinations were grown. A total of 150 plants were selected with different combination of traits.

Sl. No.	Generation	No. of families (No. of crosses) evaluated	No. of families/single plant selected
	F2	20F3+5checks&parents	150 plants selected

#### Station hybrid/variatal trial

Sl. No.	Trial name	entries	checks	No. of families superior to checks
	PVT-I	14	Dsv5,M35-1 BJV44	05
	PVT-II	14	---do---	07
	PVTIII	14	Dsv4,dsv5,M31-2B,BJV44	03
	BLT	20	104B,CSV22,BJV44,BRJ204B	10
	RLT	26	R354,BJV44 &M35-1	13
	PPHT	10	BJV44,CSV22	Yet to be ascertained
	MLT	15	CSV22,BJV44	Yet to be ascertained

## 4. Dharwad

**Summary:** Rabi sorghum improvement work is carried out with the objective of developing varieties with good grain quality, resistance to biotic stresses like shoot fly tolerance and charcoal rot resistance. In order to achieve set objectives, as many as three ICAR Viz., AVHT, IVT and IHT trials (coded) were conducted apart from eight station trials.

**Station varietal trial I:** Among entries tried with DSV-4 as check variety, as many as six varieties recorded significantly superior grain yield over check DSV-4 (1908 kg/ha). Out of these, SVD-1251 (3278 kg/ha), SVD-1252 (3260 kg/ha), SVD-1261 (3148 kg/ha) and SPV-2217 (3130 kg/ha) were top performing entries for grain yield.

**Station varietal trial II:** Among test entries evaluated along with two checks, SVD-1277 recorded highest grain yield of 3852.0 kg/ha compared to M 35-1 (3223 kg/ha). In general many entries recorded higher seed weight compared to DSV-4 check.

**Station varietal trial III:** Among entries tested in station varietal trial-III, an advance entry SPV-2217 recorded significantly superior grain yield of 3852 kg/ha compared to DSV-4 (2908 kg/ha) and other two entries SVD-765 (3463 kg/ha) and SVD-1229 (3389 kg/ha) have also recorded superior grain yield.

**Local Varietal Trial:** None of local varieties tried were superior when compared to an advance entry SPV-2217 which recorded highest grain yield of 4982.0 kg/ha compared to highest yielding local variety Barsi zoot (3723.0 kg/ha). Among local varieties, Barsi zoot exhibited significantly superior grain yield over high yielding check M 35-1 (2963 kg/ha).

**Station Hybrid Trial-I:** Out of 10 hybrids tested, SHD-13-32 (3908 kg/ha) SHD-13-33 (3574.0 kg/ha) and SHD-13-34 (3352 kg/ha) recorded significantly superior grain yield compared to M 35-1 (2093 kg/ha) with superior seed mass.

**Station Hybrid Trial- II:** Among new hybrids tested, SHD-13-57 (4612 kg/ha) SHD-13-53 (4371 kg/ha) and SHD-13-54 (4185 kg/ha) recorded higher grain yield compared to DSV-4 (3760 kg/ha).

**Generation of breeding material:** As many as 67 fresh crosses were made and 226 selections were made in various generations from F1 to F6 and three M 2 progenies were evaluated for grain size and grain yield.

**1. Number of fresh crosses made: 67**

Sl. No.	Traits	No. of crosses
1	Grain yield	37
2	Grain quality	9
3	Micro nutrient content	21
	Total	67

**2. Trait-specific programme**

**Trait 1: Grain yield and grain quality**

Sl. No.	Generation	No. of crosses evaluated	No. of families/single plant selected
1	F1	29	67
2	F2 (DSR)	4	20
3	F3	35	108
4	F5	5	7
5	F6	15	24
6	M2	15 progenies	45

**Trait 2: Grain micro (Fe & Zn) content.**

Sl. No.	Generation	No. of crosses evaluated	No. of families/single plant selected
1	F1	9	To be analyzed for content

**A. Station hybrid/variety trial**

S.No	Name of trial	No. of entries	Checks used	Superior entries
1	Station Varietal trial-I	18	DSV-4	SVD-1251,SVD-1252,SVD-1261AND SPV-2217
2	Station Varietal trial-II	18	M 35-1, DSV-4	SVD-1277
3	Station Varietal trial-II	15	M 35-1, DSV-4	SVD-765, SVD-1229
4	Local Varietal Trial	18	M 35-1, DSV-4	Barsi zoot,Lakmapur local and Mudde moti
5	Station Hybrid trial-I	11	M 35-1, DSV-4	SHD-13-32,SHD-13-33 AND SHD-13-33
6	Station Hybrid trial-II	13	M 35-1, DSV-4	SHD-13-57 AND SHD-13-54
7	Multilocation Varietal trial	15	M 35-1, DSV-4	DRS-15, DRS-8
8	Demonstration of promising varieties.	5	M 35-1, DSV-4	SPV-2217 and SVD-808

**B. Other activities**

**Seed production - Nucleus seed production**

Sl. No.	Variety/ line	Quantity (Kg)
1	M148-138	5.0
2	DSV-4	20.0
3	DSV-6	10.0
4	SSV-74	10.0
5	AKR-150	5.0

## Breeding material

Maintenance of A B lines - 12

No. of experimental hybrids - 22

No. of Restorer lines - 15

No. of varietal selections - 24

## Other Important Points

- As many as 3 M2 progenies were evaluated for grain size apart from productivity related traits.
- Germplasm (90), red grain types (22) and mini core (153) lines were grown and maintained.
- Out of 4000 germplasm lines, 103 promising selections were made based on their grain quality, size and plant height.
- A field day on SPV-2217 (post rainy) was organized in farmers field on 3-3-2014 at Narendra village, nearly 107 farmers from in and around village attended field day and expressed their satisfaction about new variety developed by our centre. The performance this variety has been appreciated by Hon'ble Vice Chancellor, UAS Dharwad, Director, DSR Hyderabad & Director of Research, UAS Dharwad. Later breeders from ICRISAT also visited large scale trials in the farmers field and expressed their satisfaction about new variety and willingness to spread new variety in farmers' field.
- Five large scale varietal trials were conducted on SPV-2217 vs. M 35-1 in farmer's field in Narendra and Lakamapur villages and SPV-2217 recorded grain yield ranging from 11-12 q/ acre compared to 6-8 q/ac of M 35-1 and local variety.

## 5. Akola

**Evaluation of germplasm:** Germplasm evaluation trial of 4000 genotypes received from the Project Directorate, Hyderabad was carried out the observations were made on shoot fly and stem borer and other agronomic characters.

**A. Development of male sterile lines:** In this programme, 31 pairs in BC II, 33 pairs in BC III, 24 pairs in BC IV, 36 pairs in BC V & 21 pairs in BC VI generation have planted. In addition to this, five crosses in F<sub>8</sub> generation have been planted.

### Development of male sterile lines

S. No.	Generation	Crosses	No. of IPS planted
1.	F8 (B x B)	(104B x 422B x 296B x 104B) X (422B x 296B) 9.1	1
2		( Akms 68.1B x 422B x 296B) X (104B x 296B x 23B)	2
3		( Akms 45B x 296B x 1409B	1
4		( Akms 69B x AKRms 75B)	2
5.		( Akms 69B x AKRms 66B)	1
		Total	7

**B. Development of restorer lines:** Desirable restorer lines in *rabi* programme required earliness, good fertility restoration in winter season, better grain and fodder yield, good grain qualities and good combining ability. This research unit has already developed 50 restorer lines tolerant to shoot-fly with good *rabi* adaptation. In addition to this, the unit has developed ten restorer lines with earliness. Similarly, this unit has developed 25 restorer lines for high yield and its contributing traits. All these lines are being maintained and used in experimental hybrid seed programme. Seven promising IPS in four R x R crosses in F<sub>11</sub> generation have been planted.

### Rabi breeding material planted during rabi 2013

Generation	Crosses	No. of IPS planted
F <sub>11</sub> (R x R)	(AKRb 354 x CSV 216R)	1
	(48365 A3R x SPV 1457) x (SPV 1201 x Ringani)	4
	(AKSV 13R x SPV 1404) x ICSR 3607	1
	(AKSV 13R x RS 673)	2
	Total	7

Further in F<sub>9</sub> generation, 7 selections among 4 crosses have been planted for further advancement.

### Rabi breeding material planted during rabi 2013.

Generation	Crosses	No. of IPS planted
F <sub>9</sub> (R x R)	SPV-1380 x Ringani x M35-1	1
	SPV-1595 x M35-1	2

Generation	Crosses	No. of IPS planted
	SPV-504 x AKR-354	3
	SPV-504 x Raichur	1
	Total	7

Similarly three selections have been planted in F<sub>7</sub> generation for further advancement in restorer development programme.

**Rabi breeding material planted during Rabi 2013**

Generation	Crosses	No. of IPS planted
F7 (R x R)	SPV-504 x SPV-1595	1
	P. moti x Sind-23	1
	P. moti x AKSV-13 R	1
	Total	3

Further, from following eight crosses in F<sub>5</sub> generation 35 selections have been planted for advanced to further generation.

**Rabi breeding material planted during Rabi 2013.**

Generation	Crosses	No. of IPS Planted
F <sub>5</sub> (R x R)	P. Moti x SPV 504	3
	P. Moti x CSV 216 R	5
	P. Moti x AKSV- 13 R	9
	CSV- 18 R x M 35-1	6
	M35-1 x CSV – 18 R	5
	CSV – 216 R x CSV – 18 R	2
	SPV- 504 x Raichour	1
	SPV- 504 x P. Moti	4
	Total	35

**Generation of new material:** One diallel set of 8 x 8 parents (half diallel) has been executed during rabi 2010-11 and resulting 28 F<sub>3</sub> crosses have been advanced and planted at Washim during Rabi 2012-13. From this material 406 progenies have been planted at ARS Washim during Rabi 2013 for further selection

**Segregating generations: F<sub>3</sub>-F<sub>4</sub>)**

S. No.	Name of crosses	Selections Planted	S. No.	Name of crosses	Selections Planted
1	Ringni x m-35-1	6	15	AKSV-13R X ms-104B	10
2	Ringni x AKSV-13R	4	16	AKSV-13R X ms-45B	10
3	Ringni x ms-45B	24	17	AKSV-13R X CSV-18R	10
4	Ringni x IS-18551	33	18	AKSV-13R X IS-18551	7
5	M-35-1 x SPV-504	20	19	ms-104B x ms-45B	9
6	M-35-1 x AKSV-13R	7	20	ms-104B x CSV-18R	10
7	M-35-1 x CSV-18R	24	21	ms-104B x IS-2312	10
8	M-35-1 x IS-18551	12	22	ms-104B x IS-18551	9
9	SPV-504 X AKSV-13R	19	23	ms-45B x CSV-18R	10
10	SPV-504 X ms-104B	44	24	ms-45B x IS-2312	8
11	SPV-504 X ms-45B	30	25	ms-45B x IS-18551	10
12	SPV-504 X CSV-18R	40	26	CSV-18R X IS-2312	6
13	SPV-504 X IS-2312	7	27	CSV-18R X IS-18551	3
14	SPV-504 X IS-18551	10	28	IS-2312 X IS-18551	14
15	AKSV-13R X ms-104B	10		<b>Total</b>	<b>406</b>

**6. Parbhani**

During *Rabi* 2013-14 total 7 project trials (AICSIP), 2 state level trials and 6 station trials were conducted during *rabi*. Two genotypes viz., SPV 2144 and SPV 2221 from SRS, Parbhani are in advance testing trial. 4000 germplasm lines received from DSR were evaluated during *rabi* 2014 for shoot fly reaction, grain and fodder yield and yield attributing traits. 137 accessions for shoot fly tolerance, 45 accessions for grain quality and 62 accessions for yield potential and agronomic performance were selected.

**A. Breeding programme**

1. Development of male sterile lines: Five iso lines of PMS 20 B genetic background, differ for shoot fly resistant QTLs were crossed with PMS 20A. 29 pair wise crosses were made in BC1F1 generation of 5 F1s.

Name of back cross	BC generation	No. of pairs
{(PMS 20A X MAS 1076-1) X MAS 1076-1}	BC1 F1	5
{(PMS 20A X MAS 1062-5) X MAS 1062-5}	BC1 F1	4
{(PMS 20A X MAS 1261-3) X MAS 1261-3}	BC1 F1	6
{(PMS 20A X MAS 1061-4) X MAS 1061-4}	BC1 F1	5
{(PMS 20A X MAS 1071-1) X MAS 1071-1}	BC1 F1	4
{(PMS 20A X MAS 1264-3) X MAS 1264-3}	BC1 F1	5
TOTAL	6	29

2. **R line Development programme** 205 single plant selection/progenies are selected in 57 crosses of F<sub>2</sub>, F<sub>3</sub> and F<sub>4</sub> generation for high grain and fodder yield, grain quality and shoot fly tolerance.

**Rabi breeding material planted during 2013-14**

S No.	Generation	Crosses	No of IPS/families selected
1	F <sub>2</sub>	10704 x 10511	28
2		10511 x 9825 REC	30
3		PVR 658 X 10538	30
4		PVR 904 X PVR 802	25
5		SPV1411 X P. Vasudha	24
6		Barshi Zoot x SPV 1411	35
7		SPV 1411 X T 1000	30
8		SPV 1411 X RSV 1150	28
9		Bashi zoot x 104 B	35
10		P. Vasudha x M-35-1	22
		<b>Total</b>	<b>287</b>

**Rabi breeding material planted during 2013-14**

S. No.	Generation	Crosses	No of progenies planted	No of selection made
1	F <sub>3</sub>	P. Vasudha x 10538	7	5
2		DSV 4 x 10538	6	2
3		M-35-1X P. Chitra	5	3
4		RSV 1130 X DSV 4	6	3
5		PKV Kranti x RSV 1130	5	2
6		DSV 4 X PVR 652	3	1
7		Dagdi X PVR 652	4	2
		<b>Total</b>	<b>36</b>	<b>18</b>

**Rabi breeding material planted during 2013-14**

S. No.	Generation	Crosses	No of progenies planted	No of selection made
1	F <sub>4</sub>	SPV 1411 x RPVT 31	3	2
2		PVR 906 X PVR 1057	4	2
3		Dagdi X PVR 906	2	2
4		RSV 1130 X DSV 4	2	1
		<b>Total</b>	<b>11</b>	<b>7</b>

13 F<sub>1</sub>s were also evaluated for grain quality, grain and fodder yield and shootfly tolerance. 15 new crosses (F<sub>0</sub>) are produced by using CRS 19 BJV 204, Phule Anuradha, M 35-1 and CRS 15 for generating drought tolerant material.

3. **B Line development programme** : Total 165 individual plant selections were made in 43 segregating populations for grain quality, shootfly tolerance and yield attributing parameters in F<sub>2</sub>, F<sub>3</sub> and F<sub>4</sub> generation.

Sr. No.	Generation	Crosses	No of IPS/families selected
1		104 B X 22528B	35
2		104 B X 20 B	25

Sr. No.	Generation	Crosses	No of IPS/families selected
3	F <sub>2</sub>	104 B X 411 B	28
4		20 B X 26625 B	32
5		20 B X 104 B	22
		<b>Total</b>	<b>142</b>

#### **Rabi breeding material planted during 2013-14**

Sr. No.	Generation	Crosses	No of progenies planted	No of selection made
1	F <sub>3</sub>	20 B X 32 B	7	4
2		20 B X 29 B	9	5
3		91004 B X 104 B	12	7
		<b>Total</b>	<b>28</b>	<b>16</b>

#### **Rabi breeding material planted during 2013-14**

S. No.	Generation	Crosses	No of progenies planted	No of selection made
1	F <sub>3</sub>	(20 B X 104 B ) X 20 B	7	4
2		104 B X 132 B	3	2
		<b>Total</b>	<b>10</b>	<b>6</b>

#### **B. Station trials**

Sr. No.	Name of trial	No. of entries	checks
1	State Multilocation Varietal cum Hybrid Trial (rainfed)	20	P.Vasudha, P.Rewati, SPV1411
2	State Multilocation Varietal cum Hybrid Trial (irrigated)	20	P.Anuradha, P.vasudha, P. rewati, CSV 18
3	Preliminary Varietal Evaluation trial	21	SPV 1411, SPV 1595, M-35-1
4	Preliminary Varietal Evaluation trial – I	69	SPV 1411, SPV 1595, M-35-1
5	Preliminary Varietal Evaluation trial – II	85	SPV 1411, SPV 1595, M-35-1
6	Preliminary Varietal Evaluation trial – III	15	SPV 1411, SPV 1595, M-35-1
7	Evaluation of F1s for grain and fodder yield and shootfly tolerance.	61	SPV 1411, SPV 1595, M-35-1
8	Evaluation of F1s for grain, fodder yield and shootfly & drought tolerance.	15	SPV 1411, SPV 1595, M-35-1

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