

# Report on evaluation of forage sorghum genotypes

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## Executive summary

**Introduction:** During 2016-17, 4 multilocation trials, 2 on single-cut forages, 1 on multi-cut forages and 1 advanced seed yield trial were carried out across 15 locations, comprising of two zones (zone I- 8 locations in North India; zone II- 7 locations in rest of India). One basic experiment was conducted under co-ordinated forage sorghum research. The most important findings of forage breeding trials for the year are mentioned below.

### A. Multi-location trials

#### **Trial 1: Advanced Varietal and Hybrid trial (Single-cut)**

- Fourteen single-cut genotypes comprising of 4 hybrids and 10 varieties along with 2 varietal checks (CSV 21F and CSV 30F) and one hybrid check (CSH 13) and one local check were evaluated at 15 locations during kharif 2016.
- The entry in the third year of advanced testing, SPH 1752 was promising with 14% improvement in green (602 q/ha) and 20% improvement in dry (150 q/ha) fodder yields over the best check, CSH 13. Among the entries in second year of testing, SPH 1797 was superior with 5% improvement in green fodder yield (554 q/ha) and 12% improvement in dry fodder yield (140 q/ha) over the check CSH 13.
- The per day productivity and forage quality in terms of protein yield and digestible dry matter of SPH 1752 and SPH 1797 were also high.
- None of the test varieties had significant or more than 5% improvement for green and dry fodder yield.

#### **Trial 2: Initial Varietal and Hybrid trial (Single-cut)**

- Twenty single-cut genotypes comprising of 3 hybrids and 13 varieties along with 2 varietal checks (CSV 21F and CSV 30F) and one hybrid check (CSH 13) and one local check were evaluated across 15 locations during kharif 2016.
- Among all entries, the hybrid, SPH 1822 was in the first place with more than 5% increase in green fodder yield (698 q/ha) over the check, CSH 13.

- The per day productivity of SPH 1822 in terms of green fodder yield was also high, and was in first position for digestible dry matter yield (90 q/ha), 11% more over check CSH 13.
- Among varieties, none recorded significant improvement for green or dry fodder yield over the best check, CSV 21F.

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

- Nineteen entries including 13 test hybrids, three test varieties, one hybrid check (CSH 24MF) and one variety check (SSG 59-3) were evaluated over 14 locations.
- Of these, two hybrids SPH 1768 and SPH 1770 have completed 3 years of testing. None of them were superior to the check for fodder yield and related traits.
- Test hybrid SPH 1807 recorded superiority of 6.84% and 9.4% for green fodder yield and dry fodder yield respectively, along with higher per day productivity, digestibility and digestible dry matter yield.

#### ***Trial 4: Advanced seed yield trial***

- There were 11 test entries and three checks, SSG 59-3, CSV 21F and CSV 30F. The test entries include 10 single-cut varieties and one multi-cut entry SPV 2353.
- The best genotype with high grain yield was SPV 2389 (2026 kg/ha) followed by SPV 2391 (1965 kg/ha) and SPV 2375 (1680 kg/ha).
- The single-cut variety, SPV 2389 was found promising for grain yield among all the single-cut test varieties at all India level.

#### ***Trial 5: Evaluation of sorghum-maize intergeneric derivatives***

- An experiment was conducted to evaluate selected derivative lines of sorghum x maize intergeneric crosses. A total of 18 entries including checks CSV 22F SSG 59-3 as checks were tested in 2 loc. in 2 replications.
- No entry was significantly superior to the checks for fodder yield, quality and phenological traits.

#### ***Trial 6: Inter-institutional forage hybrid trial***

- This trial, aimed at evaluating the promising multi-cut forage sorghum hybrids developed at different centres across locations was planned. A total of 14 entries were tested with one check.
- Based on Hisar location data, Top hybrids with highly significant green forage yield compared to check CSH 24MF were IIHPAU-2, IIHPAU-10, IIHPAU-7 and IIHPAU-9. Significant yield were also recorded by IIHPAU-4 and IIHPAU-5.

#### ***Shortfalls***

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

#### ***Follow-up for Kharif 2017***

- Promising genotypes from initial trials of both single-cut and multi-cut types will be evaluated in the advanced trials during kharif 2016
- The promising sorghum-maize cross derivatives and inter-institutional forage hybrids identified in the trial may be utilized in the forage sorghum improvement program

## **Detailed report**

During 2016-17 emphasis was given on identification of genotypes with improved fodder yield and quality both for single-cut and multi-cut forages. Five experiments were conducted, 4 under multilocation trials and one under Co-ordinated forage sorghum research. The improved genotypes were contributed by various SAUs, ICAR institutes and private organizations for their evaluation at all India level under different eco-geographical regions of the country. Two experiments on evaluation of sorghum maize cross derivatives and inter-institutional hybrids were also conducted to identify promising new genotypes and new hybrids. New locations, Anand and Vellayani were added for the multilocation testing. The performance of test genotypes was evaluated at all India level as well as in two zones.

**Zone I:** UP, Uttaranchal, Gujarat, Rajasthan, Haryana and Punjab

**Zone II:** Maharashtra, Andhra Pradesh, Telangana, Karnataka, Tamil Nadu and Kerala

Zone I is characterized by the areas where sorghum is utilized as fodder whereas Zone II involves the states where grain and dual purpose sorghums are mainly grown. The co-ordinated trials which were conducted as per technical programme of kharif 2016 over 15 locations are listed below:

**A. Multi-location trials**

- Trial 1: Advanced Varietal and Hybrid Trial on Single-cut forage Sorghum
- Trial 2: Initial Varietal and Hybrid Trial on Single-cut forage Sorghum
- Trial 3: Initial and Advanced Varietal and Hybrid Trial on Multi-cut forage Sorghum
- Trial 4: Seed yield trial

**B. Co-ordinated forage sorghum research**

- Trial 5: Evaluation of sorghum-maize intergeneric derivatives
- Trial 6: Inter-institutional forage hybrid trial

The results of the above experiments are discussed below.

**Trial 1. Advanced varietal and Hybrid trial on Single-cut forage sorghum (AVHT-SC)**

A trial comprising of 14 single-cut forage genotypes (one test hybrid in third year, three test hybrids and three test varieties in second year of advanced trial and 7 varietal entries in first year of advanced trial, and three nationally released single cut forage sorghum checks, CSV 21F, CSV 30F and CSH 13, and one local check) was conducted under advanced varietal and hybrid single-cut forage sorghum experiment. This trial was conducted in 15 locations. The genotypes were tested for their green fodder yield, dry fodder yield, per day productivity and quality parameters. The summary of performance of checks and test entries is given in the table below (Table 1).

**Table 1. Summary results of Single-cut advanced varietal and hybrid trial**

S. No	Traits	GFY (q/ha)	DFY (q/ha)	GFY/day (q/ha)	DFY/day (q/ha)	Protein %	PY (q/ha)	IVDMD (%)	DDM (q/ha)
1	CSH 13	526.71	125.63	5.69	1.70	7.98	8.52	58.88	78.15
2	CSV 21F	517.82	125.84	6.05	1.62	8.01	8.02	57.77	76.78
3	CSV 30F	512.43	124.22	6.6	1.56	7.55	7.01	56.78	71.84
3	Mean	518.99	126.61	6.05	1.64	7.8	7.6	57.4	71.63
4	Min.	465.50	113.33	6.50	1.51	7.41	6.23	56.01	56.64
5	Max.	601.96	149.80	7.90	1.90	8.37	8.80	59.12	82.56
6	CD (0.05)	60.10	15.68	0.6	0.27	0.7			15.79
7	CV (%)	18.96	18.01	13.8	17.84	11.87	20.6		19.09
8	Lines sig. > check	SPH 1752	SPH 1752	Nil	Nil	Nil	Nil	Nil	Nil
9	Lines > best check	SPH 1752	SPH 1752	SPH 1752, SPH 1822, SPH 1797	SPH 1752, SPH 1822, SPH 1797	SPH 1752, SPV 2316, SPV 2375, SPH 1797, SPV 2389, SPV 2317	SPV 2317	Nil	SPV 2317, SPV 2385, SPH 1752
10	Data from locations (no)	15	15	14	14	5	5	4	4
11	Loc. for national av. (no)	13	11	12	10	5	3	4	3

The zone wise and all India results of the trial are presented below (Tables 1.1 to 1.20 and 1A to 1 F). The performance of promising genotypes is given in Table 2.

**Zone-I: Yield parameters**

**Green fodder yield:** Among the hybrids, SPH 1752 (653 q/ha) was the highest yielder of green fodder in this zone. Among the varieties, SPV 2385 (603 q/ha) yielded higher than the best check, CSV 21F (577 q/ha).

**Dry fodder yield:** For dry fodder yield, the hybrids, SPH 1752 (124 q/ha) and SPH 1797 (121 q/ha) were numerically superior over the hybrid check, CSH 13 (112 q/ha). None of the varieties could yield better than CSV 21F (110 q/ha) for dry fodder and the variety, SPV 2317 (111 q/ha) was just on par for dry fodder yield in this zone.

**Zone-II: Yield parameters**

**Green fodder yield:** In Zone II, the hybrid, SPH 1752 (542 q/ha) was the highest yielder for green fodder with significant improvement over the check, CSH 13 (451 q/ha). This was followed by hybrids SPH 1797 (503 q/ha). Among varieties, SPV 2388 (493 q/ha), SPV 2316 (485 q/ha) and SPV 2387(479 q/ha) recorded numerical superiority of more than 5%.

**Dry fodder yield:** For dry fodder yield, the hybrids SPH 1752 (181 q/ha), SPH 1797 (164 q/ha) and SPH 1822 (162 q/ha) yielded better than the check, CSH 13 (143 q/ha). The variety, SPV 2388 (160 q/ha) was the best among the varieties followed by SPV 2316 (155 q/ha).

**National level: Yield parameters**

**Green fodder yield:** The hybrids, SPH 1752 (602 q/ha) was in the first rank in this trial with significant improvement over the hybrid check, CSH 13 (527 q/ha). This is followed by the hybrid, SPH 1797 (554 q/ha) which showed 5% increase over CSH 13.

**Dry fodder yield:** For dry fodder yield, the hybrid, SPH 1752 (150 q/ha) was the best among all the entries with significant improvement over the check, CSH 13 (132 q/ha). Another promising hybrid SPH 1797 (141 q/ha) showed 12% improvement in dry fodder yield over CSH 13.

**Green fodder yield per day:** Per day green fodder productivity ranged from 6.5 to 7.9 q/ha. Highest per day productivity was observed in the hybrid, SPH 1752 (7.9 q/ha), significantly higher than the hybrid check CSH 13 that recorded 7.4 q/ha of green fodder per day.

**Dry fodder yield per day:** Dry fodder yield per day ranged from 1.51 to 1.90 q/ha at all India level. The hybrids, SPH 1752 (1.9 q/ha) and SPH 1797 (1.85 q/ha) recorded higher per day productivity of dry fodder compared to the hybrid check, CSH 13 (1.7 q/ha).

**Phenology and morphological parameters**

**Days to 50% flowering** ranged from 68 - 79 days. Among the test entries, SPV 2376 was the earliest to flower (70 days), followed by SPH 1822 and SPV 2389 which flowered in 70 and 72 days respectively.

**Early vigor** ranged from 2.77 to 3.54. High vigour was observed in SPV 2389 (3.54) followed by hybrid check CSH 13 (3.5). The checks recorded 3.25 (CSV 21F) and 3.23 (CSV 30F) of vigour score at all India level.

**Plant height** ranged from 191 to 251 cm. SPH 1752 was the tallest followed by SPV 2317 (243 cm) and SPH 1822 (243 cm). CSH 13 and CSV 21F recorded 228 cm and 234 cm of height at all India level.

**Quality parameters:**

**HCN content** ranged from 75 ppm (SPV 2391) to 165 ppm (SPV 2317) which is within the safe limit of <200ppm. All the entries had HCN within the safe limits.

**Protein percent** varied from 7.41 (SPV 2388) to 8.37 percent (SPH 1752). The checks have recorded protein percent of 7.98% (CSH 13), 8.01% (CSV 21F) and 7.55% (CSV 30F).

**Protein yield (q/ha)** varied from 6.23 q/ha (SPV 2388) to 8.8 q/ha (SPV 2317). None of the hybrids could yield better than the hybrid check CSH 13 (8.5 q/ha).

**Digestible dry matter (DDM) yield** ranged from 56.6 q/ha (SPH 1794) to 82.6 q/ha (SPV 2317) among the entries. SPV 2317 (82.6 q/ha), SPV 2385 (80.5 q/ha), SPH 1822 (80 q/ha) and SPH 1752 (79.7 q/ha) fared better than best check CSH 13 (78.2 q/ha).

**Table 2: Performance of promising single-cut forage sorghum genotypes in AVHT-SC during 2016**

(Hybrids- 4; Varieties- 10; Checks- 3; Locations: 15)

Entry	GFY (q/ha)			DFY (q/ha)			GFY/day (q/ha)		DFY/day (q/ha)		Protein %	
		R	% +/- over CSH 13		R	% +/- over CSH 13		R		R		R
<b>Hybrids</b>												
SPH 1752	602	1	14.3	150	1	19.2	7.9	1	1.90	1	8.37	1
SPH 1797	554	2	5.2	140	2	11.6	7.7	3	1.85	2	7.93	9
<b>Checks</b>												
CSH 13	527	7		126	8		7.4	5	1.70	4	7.98	8
CD (5%)	60			16			0.83		0.21		0.70	9
CD (1%)	79			21			1.10		0.28		0.93	
C.V. (%)	18.96			18.01			19.71		17.84		11.87	

Entry	PY (q/ha)		IVDMD (%)		DDM (q/ha)	
		R		R		R
<b>Hybrids</b>						
SPH 1752	8.08	5	56.0	18	79.7	1
SPH 1797	8.46	3	58.3	4	75.3	9
<b>Checks</b>						
CSH 13	8.52	2	58.9	2	78.2	8
CD (5%)	1.93				15.79	9
CD (1%)	2.60				21.2	
C.V. (%)	20.60				19.09	

GFY- Green fodder yield, DFY- Dry fodder yield, PY – protein yield, DDM- Digestible dry matter

The hybrids, SPH 1752 was more promising for both fodder yield and quality parameters. Its per day productivity of green and dry fodders was also high. Its performance as tested in All India Co-ordinated trials during last 4 years is presented in the following table.

**Table 3: Performance of single cut forage sorghum genotypes tested in AICSIP over last 3 years**

Entry	Year	Yield								Quality			
		GFY (q/ha)		DFY (q/ha)		GFY/day (q/ha)		DFY/day (q/ha)		PY (q/ha)		DDM (q/ha)	
			R		R		R		R		R		R
SPH 1752	2013	553	1	181	1	7.04	1	2.31	1	12.7	1	89	1
	2014	564	2	166	2	6.91	3	2.03	3	13.4	2	80.8	2
	2015	517	3	153*	1	6.52	4	1.96	1	11.3	2	60.3	4
	2016	602	1	150	1	7.9		1.90	1	8.08	5	79.7	1
	<b>Av</b>	559		163		7.1		2.1		11.4		77.5	
CSH 13	2014	536	4	154	11	6.95	2	1.99	6	11.8	10	70.8	12
	2015	484	5	132	6	6.6	3	1.86	4	7.83	9	46.2	9
	2016	527	7	126	8	7.4	5	1.7	4	8.52	2	78.2	8
	<b>Av</b>	516		137		7.0		1.85		9.38		65.1	

GFY- Green fodder yield, DFY- Dry fodder yield, PY- Protein yield; DDM- Digestible dry matter,

**Conclusions:** Over three years the Hybrid SPH 1752 was found to have superiority for both green and dry fodder yields over the check, CSH 13. Its per day productivity and fodder quality in terms of protein yield and DDM were also better than the check.

**Trial 2. Initial varietal and Hybrid trial on Single-cut forage sorghum**

A trial comprising of 20 single-cut forage genotypes (three test hybrids and 13 test varieties and three nationally released single cut forage sorghum checks, CSV 21F, CSV 30F and CSH 13, and one local check) was conducted under initial varietal and hybrid single-cut forage sorghum experiment. This trial was conducted in 15 locations. The genotypes were tested for their green fodder yield, dry fodder yield, per day productivity and quality parameters. The summary of performance of checks and test entries is given in the table below (Table 3).

**Table 3. Summary results of Single-cut initial varietal and Hybrid trial**

S. No	Traits	GFY (q/ha)	DFY (q/ha)	GFY/day (q/ha)	DFY/day (q/ha)	Protein %	PY (q/ha)	IVDMD (%)	DDM (q/ha)
1	CSH 13	664	133	9.73	1.83	7.21	5.73	51.6	51.2
2	CSV 21F	641	119	9.50	1.59	7.06	5.04	52.1	51.7
3	CSV 30F	581	115	8.43	1.48	7.11	6.01	50.8	56.0
3	Mean	605	118	8.85	1.59	7.07	5.43	51.5	53.1
4	Min.	543	108	8.10	1.40	7.58	4.55	46.2	38.5
5	Max.	698	133	10.27	1.83	8.77	6.87	55.4	75.4
6	CD (0.05)	80	15	1.34	0.21	-	-	5.96	12.2
7	CV (%)	19.6	16.1	20.0	16.8	10.6	17.2	7.93	13.6
8	Lines sig. > check	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
9	Lines 5% > best check	SPH 1858	SPV 2445	SPH 1858	Nil	SPV 2453	SPH 1856; SPV 2446; SPV 2440; SPV 2433; SPV 2449	SPV 2452; SPV 2444	SPH 1858
10	Data from locations (no)	15	14	15	14	3	3	2	2
11	Loc. for national av. (no)	11	10	11	12	3	3	2	2

The zone wise and all India results of the trial are presented below (Tables 2.1 to 2.20 and 1A to 1 F).

**Zone-I:****Yield parameters**

*Green fodder yield:* While no significant differences were observed among test entries, none of the test genotypes recorded numerical superiority over the best checks.

*Dry fodder yield:* While no significant differences were observed among test entries, none of the test genotypes recorded numerical superiority over the best checks.

*Green fodder yield per day:* While no significant differences were observed among test entries similar to green fodder yield, SPH 1858 test genotypes showed 5.41% (14 q/day) numerical superiority over the best checks.

*Dry fodder yield per day:* While no significant differences were observed among test entries, none of the test genotypes recorded numerical superiority over the best checks.

**Zone-II:****Yield parameters**

*Green fodder yield:* In Zone II, the hybrid, SPH 1858 (482 q/ha) was the highest yielder for green fodder. Among the varieties, SPV 2451 (418q/ha), SPV 2445 (407 q/ha), SPV 2452 (401 q/ha) and SPV 2454 (308 q/ha) recorded more than 5% increase in green fodder yield over the best check, CSV 30F (377 q/ha) in this zone.

*Dry fodder yield:* For dry fodder yield, the hybrid SPH 1858 (139 q/ha) yielded better than the check, CSH 13 (129 q/ha). The varieties, SPV 2451 (121 q/ha) and SPV 2452 (120 q/ha) have yielded better than the checks, CSV 21F (106 q/ha) and CSV 30F (113 q/ha) in this zone.

*Green fodder yield per day* ranged from 4.72 to 6.55 q/ha/day in this zone. For this trait, the hybrid SPH 1858 (6.55 q/ha) was the best followed by SPV 2451 (5.97 q/ha), SPV 2454 (5.62 q/ha), SPV 2444 (5.62 q/ha), SPV 2452 (5.52 q/ha), SPV 2446 (5.52 q/ha), SPV 2453 (5.45 q/ha), SPV 2445 (5.42 q/ha), SPV 2449 (5.36 q/ha), and SPV 2450 (5.27 q/ha).

*Dry fodder yield per day*, the variety SPV 2451 (1.81 q/ha), followed by SPV 2454 (1.74 q/ha), SPV 2452 (1.69 q/ha), SPV 2453 (1.69 q/ha), SPV 2446 (1.69 q/ha), SPV 2449 (1.67), SPV 2444 (1.65 q/ha) and SPV 2450 (1.63 q/ha) varieties exceeded the better check CSV 21F (1.54 q/ha) by more than 5%. None of the hybrids exceeded CSH 13 (1.94 q/ha).

**National level:****Yield parameters**

*Green fodder yield:* The hybrid, SPH 1858 (698 q/ha) was in the first rank in this trial with numerical improvement over the hybrid check, CSH 13 (664 q/ha). Among the varieties, none exceeded the better check CSV 21 F (641 q/ha) by more than 5% at national level.

*Dry fodder yield:* For dry fodder yield, the variety SPV 2445 (126 q/ah) was more than 5% superior to best varietal check CSV 21F (119 q/ha). No other hybrid or variety exceeded their respective checks for dry fodder yield.

*Green fodder yield per day:* Per day green fodder productivity ranged from 8.1 to 10.27 q/ha. Highest per day productivity was observed in the hybrid, SPH 1858 (10.27 q/ha) while the hybrid check recorded 9.73 q/ha of green fodder per day. No test variety surpassed the checks by more than 5%.

*Dry fodder yield per day:* Dry fodder yield per day ranged from 1.4 to 1.83 q/ha at all India level. No test entry possessed more than 5% superiority to the respective check.

**Phenology and morphological parameters**

*Days to 50% flowering* ranged from 67 - 78 days. Among the test entries, SPV 2446 was the earliest to flower (67 days), followed by SPV 2450 (67 days), and SPH 1857 (68 days).

*Plant height* ranged from 209 cm (SPH 1856) to 255 cm (SPH 1857) both of which significantly differed from check hybrid CSH 13 (239 cm) Among varieties, SPV 2444 was the tallest (255 cm) but was on par with the taller check variety CSV 21F (251 cm).

**Quality parameters:** The test genotypes along with the four single-cut forage checks, CSH 13, CSV 21F, CSV 30F and local check were analyzed for quality for the samples of 2-6 locations and the results are presented below.

HCN content ranged from 85 ppm (SPV 2444) to 240 ppm (SPH 1856). All the entries except for SPH 1856, SPV 2449 (229 ppm), CSH 13 (226 ppm) SPV 2451 (219 ppm) and SPV 2452 (217 ppm) were within the safe limit of <200ppm for HCN content. If not for the unusually higher HCN values in Surat location, all the above exceptions would have been in the safer limit of 200 ppm. It may be noted that even the check hybrid was found unsafe at Surat location.

Protein percent varied from 86.84 (SPV 2443) to 7.48 percent (SPV 2453). The checks have recorded protein percent of 7.21% (CSH 13), 7.06% (CSV 21F) and 7.11% (CSV 30F).

Protein yield (q/ha) varied from 4.55 q/ha (SPV 2453) to 6.87 q/ha (SPH 1856). The checks, CSH 13, CSV 21F and CSV 30F recorded protein yield of 5.73 q/ha, 5.04q/ha and 6.01 q/ha respectively. The hybrid, SPH 1856 (6.87 q/ha) was better than the hybrid check, while SPV 2446 (6.05 q/ha) was the best among varieties.

IVDMD values ranged from 50.5 (SPV 2455) to 57.9% (SPV 2452) among the entries. The checks CSH 13, CSV 21F and CSV 30F recorded IVDMD values of 53.7%, 53.73% and 53.37% respectively.

Digestible dry matter (DDM) yield ranged from 56.46q/ha (SPV 2449) to 89.89 q/ha (SPH 1858) among the entries. SPH 1858 among hybrids and SPV 2450 among varieties numerically surpassed their respective checks.

**Table 4: Performance of promising single-cut forage sorghum genotypes in IVHT-SC during 2016**  
(Hybrids- 3; Varieties- 13; Checks- 3; Locations: 15)

Entry	GFY (q/ha)			DFY (q/ha)			GFY/day (q/ha)		DFY/day (q/ha)		Protein %	
	R	% +/- over CSH 13	R	% +/- over CSH 13	R	R	R	R	R	R		
<b>Hybrids</b>												
SPH 1858	698	1	5.1	133	1	0.6	10.27	1	1.78	3	7.18	10
<b>Checks</b>												
CSH 13	664	3		163	6		9.73	3	1.83	1	7.21	9
CD (5%)	80			15			1.34		0.21		0.68	-
CD (1%)	105			20			1.77		0.28		0.9	-
C.V. (%)	19.6			16.1			20		16.9		7.08	10.6

Entry	PY (q/ha)		IVDMD (%)		DDM (q/ha)	
	R	R	R	R	R	R
<b>Hybrids</b>						
SPH 1858	5.07	14	53.57	13	89.89	1
<b>Checks</b>						
CSH 13	5.73	5	53.7	11	80.81	4
CD (5%)	-		-		-	
CD (1%)	-		-		-	
C.V. (%)	17.2		9.3		19.3	

GFY- Green fodder yield, DFY- Dry fodder yield, DDM- Digestible dry matter,

The hybrid, SPH 1858 was relatively more promising for both fodder yield and quality parameters. Its per day productivity of green and dry fodder and DDM were also high.

**Trial 3. Multi-cut forage sorghum: Initial & Advanced varietal and hybrid trial on Multi-cut forage sorghum**

A multi-cut forage trial comprising of 19 entries (13 test hybrids, 3 test varieties, one hybrid checks, one variety check and one local check) was conducted across 14 locations. Of these, two hybrids SPH 1768 and SPH 1770 have completed 3 years of testing. Three hybrids (SPH 1806, SPH 1807 and SPH 1809) and one variety (SPV 2353) completed one year of advanced testing. Rest eight hybrids (SPH 1838 to SPH 1845) and two varieties (SPV 2421 and SPV 2422) were in initial testing. The genotypes were tested for their green fodder yield, dry fodder yield, per day productivity at different cuts, other forage yield parameters and forage quality parameters.

**Table 5: Summary results of multi-cut trial**

S. No	Traits	GFY (q/ha)	DFY (q/ha)	GFY/day (q/ha)	DFY/day (q/ha)	Protein %	PY (q/ha)	IVDMD (%)	DDM (q/ha)
1	CSH 24MF	878.2	222.3	5.85	1.45	8.64	14.90	51.68	94.85
2	SSG 59-3	868.2	220.3	5.80	1.50	9.05	18.55	53.11	118.35
3	General Mean	882.2	221.3	5.45	1.35	8.56	16.15	53.96	108.05
4	CV(%)	18.96	22.55	15.28	20.16	7.62	16.87	7.64	18.27
5	CD(5%)	107.0	32.3	0.60	0.20	0.56	3.35	4.18	4.01
6	CD(1%)	141.0	42.6	0.75	0.25	0.74	4.50	5.61	5.37
9	Lines signi.> check	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
10	Lines 5%> check	SPH 1807	SPH 1807	Nil	SPH 1807	Nil	SPH 1807, SPV 2422, SPH 1841, SPH 1768, SPH 1842, SPH 1845	SPH 1809, SPH 1806, SPH 1807	SPH 1807, SPH 1841, SPH 1768, SPH 1806, SPV 2422, SPH 1842, SPH 1840, SPH 1839, SPH 1809
11	Data from loc. (no)	14	14	14	14	5	5	3	3
12	Loc. for national av. (no)	14	14	14	14	5	5	3	3

The results of the trial are presented below (Tables 3.1 to 3.32 and 3.A and 3.I).

### Zone-I:

#### ***Yield parameters***

**Green fodder yield:** The multicut hybrid SPV 2422 (918 q/ha) ranked first for total green fodder yield with significant improvement over the check, SSG 59-3 (808 q/ha) in this zone. Among the hybrids, SPH 1840 (831 q/ha) ranked first with 10% higher yield than check CSH 24MF (755 q/ha).

**Dry fodder yield:** For total dry fodder yield also, the variety SPV 2422 (209 q/ha) ranked first, followed by the multi-cut hybrids SPH 1840 (184 q/ha), SPH 1807 (184 q/ha) and SPH 1841 (183 q/ha).

**Green fodder yield per day:** The best among all the entries is the variety, SPV 2422 with 7 q/ha of green fodder per day.

**Dry fodder yield per day:** Per day productivity of dry fodder over all the cuts was high the variety, SPV 2422 (1.65 q/ha) followed by the hybrids SPH 1840 and SPH 1841 (1.45 q/ha each).

### Zone-II:

#### ***Yield parameters***

**Green fodder yield:** In the zone II, SPH 1807 produced highest green fodder yield across all the cuts (1162 q/ha) with more than 11% improvement over the check CSH 24MF (1045 q/ha)..

**Dry fodder yield:** For total dry fodder yield also, SPH 1807 (326 q/ha) ranked first in zone II with 7% improvement over CSH 24MF (303 q/ha).

**Green fodder yield per day:** The average green fodder yield per day over all the 3 cuts ranged from 3.95 to 6.05 q/ha, the highest being in SPH 1807, followed by SPH 1842 (5.7 q/ha).

**Dry fodder yield per day:** Per day productivity of dry fodder in this zone ranged from 1.1 q/ha to 1.7 q/ha, the highest being in SPH 1807 (1.7 q/ha), followed by SPH 1838 (1.65 q/ha).

### National level:

#### ***Yield parameters***

SPH 1807 exceeded the check CSH 24MF numerically by more than 5% for green and dry fodder yields, and per day dry fodder productivity. No other entry fared better than respective check for all these traits.

#### ***Phenology and morphological parameters***

**Days to 50% flowering** ranged from 65 to 76 days among the entries. SPH 1838 was the earliest, followed by SPH 1768 and CSH 24MF (all 65 days). SPH 1770 recorded maximum days to flowering (76 days)



Early vigour was found to be high in SPH 1841 (3.89) followed by SPH 1838 (3.88) and check CSH 24MF (3.86).

Plant height: The plant height of the entries ranged between 172 cm to 218 cm, with SPH 1806 as the tallest entry in this zone. It was followed by SSG 59-3 (216 cm) and SPH 1838 (214 cm).

Stem girth ranged from 1.59 to 2.28 cm. All the three varieties were found to have thin stems. Among the hybrids, SPH 1806 (1.85 cm) was having thin stem, followed by SPH 1838 (1.93 cm).

Regenerability score: Since regeneration is a very important trait for multi-cut forages, it was scored on a 1-5 scale, where 1 is poor regeneration and 5 is high regeneration. In this trial, it ranged from 3.6 to 4.54. SPV 2422 (4.54) had the best regeneration capacity followed by SSG 59-3 (3.74). Among the hybrids, high regeneration was observed in SPH 1838 (3.64) followed by SPH 1807 (3.6).

### Quality parameters

HCN of all the test entries was within the safe limit ranging from 99.91 to 189.8 ppm during the first cut, the lowest value being in SPH 1770. Among the test entries, SPH 1841 had the highest HCN level (191.8 ppm).

Protein percent ranged from 8.37 to 9.05%, the highest being in SSG 59-3, followed by SPH 1845 (9.05%) and SPH 1838 (8.83%).

Average protein yield over all cuts was high in SPH 1807 (19 q/ha), followed by SPV 2422 (19 q/ha) and SSG 59-3 (18.6 q/ha).

IVDMD values ranged from 50.88 to 57.31%. The hybrid SPH 1809 had high IVDMD value (57.31%) followed by SPH 1806 (56.61%) and SPH 1807 (55.43%) compared to the checks, CSH 24MF (51.68%).

Total digestible dry matter (DDM) over all the cuts ranged from 82.35 to 134.8 q/ha in this trial. It was highest in the variety SPV 2422 (134.8 q/ha) followed by hybrid SPH 1807 (124.8 q/ha).

The performance of promising multi-cut genotypes tested during kharif 2015 is given in table 6.

**Table 6. Performance of promising multi-cut sorghum genotypes in initial and advanced trial**  
(Entries- 16; Checks- 3; Locations: 14)

Entry	GFY (q/ha)			DFY (q/ha)			GFY/day (q/ha)		DFY/day (q/ha)	
		R	% +/- over CSH 24MF		R	% +/- over CSH 24MF		R		R
<b>Hybrids</b>										
SPH 1807	938	1	6.84	243	1	9.4	6.10	1	1.55	1
<b>Checks</b>										
CSH 24MF	878	3		222	5		5.85	5	1.45	8
<b>Varieties</b>			% +/- over SSG 59-3			% +/- over SSG 59-3				
SPV 2422	871	6	0.37	220	1	0	5.85	3	1.50	2
SSG 59-3	868	8		220	9		5.80	8	1.50	5
CD (5%)	107.0			32.3			0.60		0.20	
CD (1%)	141.0			42.6			0.75		0.25	
C.V. (%)	18.96			22.55			15.28		20.16	

Entry	PY (q/ha)		DDM (q/ha)	
		R		R
<b>Hybrids</b>				
SPH 1807	19	1	124.8	2
<b>Checks</b>				
CSH 24MF	14.9	15	94.85	14
<b>Varieties</b>				
SPV 2422	18.95	2	134.80	1
SSG 59-3	18.55	3	118.35	4
CD (5%)	3.35		4.01	
CD (1%)	4.50		5.37	
C.V. (%)	16.87		18.27	

GFY- Green fodder yield, DFY- Dry fodder yield, PY- Protein yield; DDM- Digestible dry matter,

**Conclusions:** The hybrid SPH 1807 among the hybrids and SPV 2422 among the varieties were found promising with considerable improvement for both green and dry fodder yields over the respective hybrid and varietal checks. Their per day productivity of green and dry fodder yields was also high compared to the checks. These were promising for protein yield and DDM as well.

#### **Trial 4. Advanced seed yield trial**

The seed yield trial was taken up at 5 locations to understand the seed production ability of the varieties in advanced trials of single-cut and multi-cut sorghums. Three of these locations were from zone I (Hisar, Pantnagar and Ludhiana, and two were from zone II (Akola and Coimbatore). There were 11 test entries and three checks, SSG 59-3, CSV 21F and CSV 30F. The test entries include 10 single-cut varieties and one multi-cut entry (SPV 2353). Data was recorded on grain yield, days to 50% flowering, days to maturity and plant height (Tables 4.1 to 4.4). The results are discussed below.

Grain yield ranged from 680 kg/ha to 2026 kg/ha across entries. The best genotype with high grain yield was SPV 2389 (2026 kg/ha) followed by SPV 2391 (1965 kg/ha) and SPV 2375 (1680 kg/ha). The single-cut checks CSV 30F yielded 1202 kg/ha of grain while CSV 21F recorded 1376 kg/ha grain yield. The multi-cut variety SPV 2353 yielded less grain (680 kg/ha) compared to the check, SSG 59-3 (729 kg/ha), but was statistically on par. Days to flower ranged from 72 to 87 days at all India level. SSG 59-3 was the earliest to flower in 72 days, and SPV 2383 flowered late. All the entries have taken more time to flower in zone I compared to zone II. Days to maturity ranged from 115-130 days, with SSG 59-3 being early to mature in 115 days and SPV 2383 taking the highest number of days (130 days). High grain yielding SPV 2383 recorded lesser number of days (117 days) to maturity.

**Table 7. Seed yield potential of single-cut and multi-cut forage sorghum genotypes in advanced trial**  
(Entries- 11; Checks- 3; Locations: 5)

.Entry	Grain yield (kg/ha)	R	Days to 50% flowering	Days to maturity	Plant height (cm)
CSV 21F	1376	7	80	123	249
CSV 30F	1202	10	82	125	288
SPV 2316	1616	4	75	118	241
SPV 2317	1139	12	80	123	261
SPV 2353	680	14	77	120	276
SPV 2375	1680	3	78	120	231
SPV 2376	1449	5	76	119	260
SPV 2383	1379	6	87	130	239
SPV 2385	1245	8	84	127	246
SPV 2387	1237	9	81	125	269
SPV 2388	1186	11	82	125	260
SPV 2389	2026	1	74	117	237
SPV 2391	1965	2	77	119	227
SSG 59-3	729	13	72	115	280
General Mean	1351		79	122	255
CV(%)	14.36		4.89	2.95	11.45
SE of Difference	231		4	4	12
P-Value	0		0	0	0
CD(5%)	499		8	9	25
CD(1%)	695		11	12	33

**Conclusions:** The single-cut variety, SPV 2389 was found promising for grain yield among all the single-cut test varieties at all India level.

#### **Trial 5. Evaluation of sorghum-maize intergeneric derivatives**

An experiment was conducted to evaluate selected derivative lines of sorghum x maize intergeneric crosses. A total of 18 entries including checks CSV 22F and SSG 59-3 as checks were tested in two locations in 2 replications. The test locations were Pantnagar and Hisar.

The test entries T2, T18, T5, T3 and T14 were the top 5 entries with higher fodder yield with green fodder yield in the range of 602-692 q/ha compared to 571-576 q/ha in checks.

Entries T5, T2 and T12 also had higher numerically protein content than SSG 59-3, though not significant. Non-significant, but numerically higher digestibility of T4, T9 and T2 were also noticed. The variation for most of the phenological traits was not significant.

**Table 8: Forage yield, quality and phenological traits of sorghum-maize intergeneric derivatives**  
(Entries- 16; Checks- 2; Locations: 2)

Sl. No	Entry	GFY 2 cuts (q/ha)		DFY 2 cuts (q/ha)		TSS (%)		HCN (ppm)		Protein (%)		IVDMD(%)	
			R		R		R		R		R		R
1	T1-2251-3-8	275.5	17	54.2	17	3.75	7	68.2	7	8.03	18	55.6	8
2	T2-2251-3-12	692.2	1	160.0	2	5.75	1	64.3	8	8.80	2	56.9	3
3	T3-2252-7-1	617.3	4	127.2	8	5.25	2	54.6	17	8.37	10	53.0	15
4	T4-2252-7-2	570.8	10	120.9	12	4.75	4	79.5	2	8.30	13	57.2	1
5	T5-2252-7-8	671.5	2	141.3	4	5.00	3	56.6	15	8.80	1	55.8	7
6	T6-2253-12-2	603.4	5	125.7	9	5.00	3	55.7	16	8.40	9	56.3	6
7	T7-2253-12-6	494.7	15	112.4	14	4.75	4	58.4	12	8.57	5	56.4	5
8	T8-2253-12-16	585.9	7	131.6	6	4.50	5	63.6	9	8.25	15	52.8	16
9	T9-2254-8-?	527.0	14	111.7	15	4.50	5	54.1	18	8.26	14	57.0	2
10	T10-2254-10-3	555.2	11	124.0	10	4.00	6	57.2	14	8.49	7	54.8	9
11	T11-2254-10-8	453.6	16	104.5	16	4.50	5	73.2	5	8.24	16	53.0	13
12	T12-2254-10-12	554.6	12	119.3	13	5.75	1	74.3	4	8.77	3	54.6	10
13	T13-2276-14-1	218.7	18	43.6	18	4.75	4	86.7	1	8.05	17	56.7	4
14	T14-2316-3-3	602.0	6	149.4	3	5.00	3	75.2	3	8.51	6	53.7	12
15	T15-2316-3-7	530.1	13	121.4	11	4.75	4	57.7	13	8.34	11	54.0	11
16	T16-SSG59-3	571.3	9	128.3	7	5.00	3	71.3	6	8.67	4	53.0	14
17	T17-CSV22F	576.0	8	139.7	5	4.50	5	60.6	11	8.33	12	52.3	17
18	T18-2222-8-8	661.9	3	166.5	1	4.00	6	63.3	10	8.45	8	52.2	18
	LOC. MEAN	542.3		121.2		4.75		65.3		8.42		54.7	
	C.D. (5%)	185.6		53.4		2.21		8.2		0.71		5.4	
	C.D. (1%)	255.0		73.3		3.04		11.3		0.97		7.4	
	C.V. (%)	16.2		20.9		22.09		6.0		3.98		4.7	
	F (Probability)	0.00		0.02		0.91		0.00		0.54		0.54	

Sl. No	Entry	Early vigour (score 1-4)		Plant height (cm)		No. of leaves/plant		Number of tillers		Leaf length (cm)		Leaf breadth (cm)		Leaf stem ratio		Stem girth (cm)	
			R		R		R		R		R		R		R		R
1	T1-2251-3-8	3.25	4	163	17	16.7	16	2.45	14	74.9	17	6.00	1	0.43	2	4.95	13
2	T2-2251-3-12	4.00	1	220	1	18.2	14	3.00	12	77.2	16	5.70	3	0.34	14	6.83	1
3	T3-2252-7-1	4.00	1	202	10	24.9	1	5.08	1	80.4	10	3.85	18	0.40	8	6.25	4
4	T4-2252-7-2	3.75	2	193	15	15.8	18	4.33	3	89.4	2	4.25	15	0.41	4	5.55	9
5	T5-2252-7-8	4.00	1	204	9	23.0	2	4.33	3	79.8	13	4.95	9	0.38	10	5.13	12
6	T6-2253-12-2	4.00	1	215	3	19.4	10	3.18	10	89.4	1	4.30	14	0.42	3	6.25	4
7	T7-2253-12-6	3.50	3	215	4	19.0	12	3.60	7	79.7	14	4.40	13	0.44	1	5.13	12
8	T8-2253-12-16	4.00	1	201	11	20.7	5	3.50	8	79.5	15	4.55	12	0.36	11	5.75	7
9	T9-2254-8-?	4.00	1	201	12	21.9	4	3.65	6	81.5	9	5.15	6	0.38	9	5.33	11
10	T10-2254-10-3	3.75	2	192	16	19.9	6	3.75	5	80.3	11	4.20	16	0.38	10	5.50	10
11	T11-2254-10-8	3.25	4	195	13	16.6	17	2.50	13	84.5	5	4.88	10	0.33	15	6.23	5
12	T12-2254-10-12	3.75	2	211	7	19.7	7	3.18	10	88.0	3	5.45	4	0.32	16	6.30	3
13	T13-2276-14-1	2.25	5	130	18	19.2	11	3.15	11	64.5	18	5.08	7	0.38	9	5.63	8
14	T14-2316-3-3	3.75	2	212	5	22.1	3	4.43	2	82.1	8	5.00	8	0.41	5	6.23	5
15	T15-2316-3-7	3.75	2	212	6	19.4	9	3.33	9	83.9	6	4.70	11	0.36	12	4.95	14
16	T16-SSG59-3	3.75	2	194	14	17.5	15	3.83	4	80.0	12	4.15	17	0.40	7	4.53	15
17	T17-CSV22F	3.25	4	210	8	18.2	13	2.25	15	85.9	4	5.85	2	0.35	13	6.65	2
18	T18-2222-8-8	4.00	1	218	2	19.5	8	3.60	7	83.8	7	5.20	5	0.41	6	6.08	6
	LOC. MEAN	3.67		199		19.5		3.51		81.4		4.87		0.38		5.73	
	C.D. (5%)	0.73		48		7.0		1.57		11.8		1.32		0.11		1.85	
	C.D. (1%)	1.01		65		9.7		2.16		16.3		1.81		0.16		2.54	
	C.V. (%)	9.48		11.3		17.1		21.25		6.9		12.83		14.29		15.31	
	F (Probability)	0.01		0.10		0.51		0.09		0.06		0.08		0.63		0.43	

**Conclusions:** No entry was significantly superior to the checks for fodder yield, quality and phenological traits. Numerically, the test entries T2, T18, T5, T3 and T14 were the top 5 entries with higher fodder yield with green fodder yield in the range of 602-692 q/ha compared to 571-576 q/ha in checks.

### Trial 6. Inter-institutional forage hybrid trial

This trial, aimed at evaluating the promising multi-cut forage sorghum hybrids developed at different centres across locations was planned at three locations in 2 replications. However, data was received from only two centres and the data from Ludhiana centre was not replicated. Akola centre did not report data. In effect, the data from Hisar centre is presented here (Table 8).

Top hybrids with highly significant green forage yield compared to check CSH 24MF were IIHPAU-2, IIHPAU-10, IIHPAU-7 and IIHPAU-9. Significant yield were also recorded by IIHPAU-4 and IIHPAU-5. IIHPAU-1 was inferior to check. AKMS lines based hybrids were on par to the check, though recorded numerically higher yields. Protein content was highest in AKMS30A x CB72 (10.8%), followed by AKMS14A x CB74 and IIHPAU-2 (10.7% each). Digestibility was high in AKMS30A x UPMC539 (57.7%), followed by IIHPAU-6 (55.9%) and IIHPAU-8 (55.7%).

**Table 8: Forage yield and quality traits of inter-institutional forage sorghum hybrids**

(Entries- 14; Checks- 1; Location: Hisar)

Sl. No	Entry	GFY (q/ha)		DFY (q/ha)		TSS (%)		HCN (ppm)		Protein (%)		IVDMD (%)	
			R		R		R		R		R		R
1	IIHPAU-1	331.3	15	63.0	14	5.50	3	151	3	9.9	11	53.8	9
2	IIHPAU-2	781.3	1	117.7	2	3.75	9	122	11	10.7	3	53.7	10
3	IIHPAU-3	491.7	7	71.7	13	4.75	6	189	1	10.2	9	53.0	12
4	IIHPAU-4	596.9	5	93.4	5	4.50	7	133	9	10.4	7	55.6	4
5	IIHPAU-5	567.7	6	82.4	9	4.75	6	148	6	10.6	4	51.9	14
6	IIHPAU-6	457.3	8	83.5	8	4.75	6	128	10	10.4	7	55.9	2
7	IIHPAU-7	736.5	3	112.0	3	4.00	8	150	4	9.7	12	53.5	11
8	IIHPAU-8	341.7	14	55.1	15	3.50	10	117	12	9.6	13	55.7	3
9	IIHPAU-9	633.3	4	108.9	4	4.00	8	104	15	10.4	7	54.8	6
10	IIHPAU-10	760.4	2	130.7	1	5.00	5	141	7	10.5	6	54.6	7
11	AKMS30A x UPMC539	443.8	9	90.9	6	3.50	10	115	14	10.1	10	57.7	1
12	AKMS14A x CB74	379.2	13	78.8	12	5.25	4	148	5	10.7	2	53.8	9
13	AKMS30A x CB74	397.9	11	82.3	10	6.25	1	138	8	10.3	8	55.5	5
14	AKMS30A x CB72	408.3	10	80.0	11	6.00	2	178	2	10.8	1	52.6	13
15	CSH 24MF	396.9	12	85.8	7	5.50	3	116	13	10.6	5	54.5	8
	LOC. MEAN	514.9		89.1		4.73		138		10.3		54.4	
	C.D. (5%)	155.1		31.0		2.04		92		1.3		2.6	
	C.D. (1%)	215.3		43.0		2.84		128		1.8		3.6	
	C.V. (%)	14.1		16.2		20.14		31		5.8		2.2	
	F (Probability)	0.00		0.00		0.00		0.00		0.00		0.00	

**Conclusions:** IIHPAU-2, IIHPAU-10, IIHPAU-7 and IIHPAU-9 hybrids recorded highly significant forage yield compared to check CSH 24MF at Hisar location.

#### Shortfalls

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

#### Follow-up for Kharif 2017

- Promising genotypes from initial trials of both single-cut and multi-cut types will be evaluated in the advanced trials during kharif 2016
- The promising sorghum-maize cross derivatives and inter-institutional forage hybrids identified in the trial will be utilized in the forage sorghum improvement program

## Publications during 2016-17

### Journal papers

1. Aruna, S. Rakshit, P.K. Shrotria, S.K.P. Shiva Kumar, N.D. Modi, D.T. Deshmukh, R.Kapoor and J.V. Patil (2016). Assessing genotype-by-environment interactions and trait associations in forage sorghum using GGE biplot analysis. *J. Agricultural Sciences* 154 (1),73-86.
2. Balakrishna, D., Venkatesh Bhat, B., Ranjini Warriar, Govilla, O.P., Michael Wach and Vibha Ahuja 2016. Biology of Sorghum bicolor (Sorghum). Ministry of Environment, Forest and Climate Change (MoEF&CC) and ICAR-Indian Institute of Millets Research (IIMR) under UNEP/GEF supported Phase II Capacity Building Project on Biosafety.
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**Paper presentation:**

1. Dr. S.K. Pahuja had presented a paper entitled "Combining ability and heterosis studies in forage sorghum hybrids for yield, quality and their related traits" in 7<sup>th</sup> International Seminar, on Sustainable Res. Management towards Food, Energy, Environment and Livelihood. Nov, 27-29, 2016, Gottingen, Germany.
2. Dr. Pummy Kumari had presented a paper entitled " Evaluation of forage sorghum brown midrib lines for quality biomass production" in International Conference on Science, Technology, Women Studies, Business & Social Sciences, November 03-05, 2016; Pajifond, Margao, Goa, India