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Research Article

A novel high yielding dual-purpose sorghum variety GDJ 1(Banas Surya) for semi-arid region of Gujarat

R. A. Gami*, R. N. Patel, P. R. Patel and S. K. Jain

Sorghum Research Station & AICRP Sorghum,
Sardarkrushinagar Dantiwada Agricultural University, Deesa-385 535, Gujarat, India
***E-Mail:** ramangami@gmail.com

Abstract
The new sorghum variety GDJ 1 (Banas Surya) breed through pedigree selection method from the cross between SPV 2113 × GFS 5 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa, Gujarat. The variety GDJ 1 was tested in a preliminary evaluation trial (PET) in *kharif* 2016. It was found promising and further it was tested in state multilocation trials from *kharif* 2017 to 2019. It was also tested under the AICRP-sorghum IVT trial in *kharif* 2018 as SPV 2565 at fifteen locations (Zone-I, II and III) across the nation. The sorghum variety GDJ 1 was tested under a total of 20 state trials against various check varieties *viz*., CSV 20, GJ 39, GJ 42, GDJ 1 and GJ 43. The mean performance of GDJ 1 for grain yield over 21 locations, including the preliminary trial was 2506 kg/ha. In the case of dry fodder yield, the mean performance over 22 location, including the preliminary trial was 167.0 q/ha. In North Gujarat, based on seven testing trials GDJ 1 exhibited high grain yield (2576 kg/ha) with an increment of 50.0, 50.7 19.6, 21.5 and 41.8 per cent, respectively and dry fodder (228.7 q/ha) with an increment of 49.8, 52.3, 10.9, 49.6 and 34.2 per cent over the years and locations against checks GJ 39, GJ 42, GJ 43, GNJ 1 and CSV 20, respectively. It matures within 100-105 days, tall in nature, very long and broad leaves, the long symmetric semi-loose panicle have a medium neck with long branches and medium glume length. The grain is medium bold and yellow-white. From the quality point of view the released variety have a fair amount of protein in grain (10.1%) and dry fodder (9.20%) and low tannin (0.215 mg/g) in grain indicated the good quality of grain and dry fodder. It is moderately resistant to diseases like leaf blight, anthracnose, grain mold, ergot and lower infestation of shoot fly and stem borer.

Key words
Sorghum, variety, grain yield, dry fodder yield and morphological traits.

INTRODUCTION

Sorghum or Great millet [*Sorghum bicolor* (L.) Moench] is the most important food and fodder crop of the semi-arid tropics. Sorghum grains are essential as food for human being and livestock feed. In Gujarat, only grain type sorghum occupies an area of 73.6 thousand hectares with an annual production of 1.04 lakh tonnes with a productivity of 1419 kg/ha. The fodder area approximately more than 5.0 lakh hectares. Sorghum mostly is grown as dual and fodder purpose in Gujarat. The animal husbandry business is increasing, so the sorghum has an excellent opportunity to fulfil the shortage of feed and fodder. Sorghum is an important crop of semi-arid tropics in Asia and Africa. India is the 2nd leading producer of sorghum after the USA and the other sorghum producing countries *viz*., Nigeria, China, Mexico, Sudan and Argentina.

For any agriculture-based country, fodder crops are as much essential as grain crops. The livestock sector being a sub-sector of Indian agriculture contributes about 9 per cent to GDP and employs around 8 per cent of the labour power. In such a context, crops with multiple uses fetch more area as compared to others because crop residues used as animal feed and fodder. Experiential studies in India have revealed that enhancing the quality and

quantity of feed input has a more significant effect than breed improvement on increasing milk productivity (Tonapi *et al.,* 2011). India is anticipating for the white revolution, which is possible only with an adequate supply of nutritious feeds and fodders. The *livestock population in India* is nearly 512.05 million in 2019 and they produced about 165.4 million tonnes of milk annually (Anonymous, 2017-18). There are many cereal fodder crops like sorghum, maize, pearl millet for *kharif* season. High productivity, fast-growing habit and better water use efficiency under drought make it a vital forage crop of semi-arid tropics. It is extremely edible and more digestible than maize and pearl millet and uses approximately 40-50 per cent less water than corn to produce the same dry matter. As far as forage quality is concerned, it is defined as an expression of characteristics that affect consumption and is assessed by digestibility and palatability (Amigot *et al*., 2005). The demand for dual sorghum is higher in Gujarat. Sorghum is grown in almost all the districts of Gujarat to meet the grain and fodder requirement for maintaining the milch animals. The demand for dual type sorghum increasing day by day in the semi-arid region of Gujarat as it valued both for its grain as well as for its excellent fodder.

In-plant breeding, improvement of a crop concerning yield and specific traits is a continuous programme and the improved varieties in terms of productivity and resistance to biotic and abiotic stress by reformed genetic background are advanced and released for the benefit of the farming community is the prime motto of this centre. At present, cultivars GJ 42 and GNJ 1 for grain, GJ 39, GJ 43 for dual purpose are cultivating. The local varieties like *malwan* have demerits like a high infestation of pest, late maturity and poor yields both for grain and fodder. Therefore, it is a need to develop a variety having high grain as well as fodder yield potential with early to medium maturity. The released variety GDJ 1 was developed from cross SPV 2113 × GFS-5 followed by continuous evaluation and selection.

MATERIAL AND METHODS

A new sorghum variety GDJ 1 breed through pedigree selection methods from cross SPV 2113 × GFS-5 at Sorghum Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa, Gujarat with the name of DS 172. The cross was made in summer 2009 followed by pedigree selection was done from *kharif,* 2009 to 2015. This variety has advanced with main objectives were dual-purpose, *i.e.* high dry fodder yield as well as a fair amount of grain yield. The variety GDJ 1 was tested in a preliminary evaluation trial (PET) in *kharif*, 2016. It was found promising and further, it was tested in state multilocation trial from *kharif* 2017 to 2019. It was also tested under the AICRP sorghum- IVT trial in *kharif* 2018 as SPV 2565 at fifteen locations (Zone-I, II and III) across the nation. The culture was also screened for disease and pest under field condition at state as well as in AICRP trials (Anonymous 2018-19). The DNA fingerprinting of variety GDJ 1 along with four checks (GJ 43, GJ 39, GNJ 1 and CSV 20) were performed by using 11 ISSR primers (**Table 1**).

Table 1. List of primers used in fingerprinting

Sr. No.	Name of primer	Sequence of primer	Sr. No.	Name of primer	Sequence of primer
1	ISSR 1	CACACACACACACACACAGT	7	ISSR 16	CACACACACACACACACAAA
2	ISSR 2	CACACACACACACACACAGC	8	ISSR 21	GCCTCTCTCTCTCTCTCT
3	ISSR 3	CACACACACACACACACAGG	9	ISSR 22	GACTCTCTCTCTCTCTCT
4	ISSR 4	CACACACACACACACACAGA	10	ISSR 23	GTCTCTCTCTCTCTCTCT
5	ISSR 7	CACACACACACACACACATG	11	ISSR 25	GCCCTCTCTCTCTCTCTCT
6	SSR 8	CACACACACACACACACATA			

RESULTS AND DISCUSSION

The sorghum variety GDJ 1 was evaluated in PET during *kharif* 2016 against various check varieties *viz*., CSV 20 and GJ 39. The tested genotype exhibited a significantly high grain yield (3554 kg/ha) with an increment of 53.9 and 58.0 per cent over checks CSV 20 and GJ 39, respectively (**Table 2**). Similarly, in the case of dry fodder yield, the variety GDJ 1 exhibited significantly high dry fodder yield (215.8 q/ha) with an increment of 21.0 and 39.4 per cent over checks CSV 20 and GJ 39, respectively (**Table 3**).

The sorghum variety GDJ 1 was tested under a total of 20 state trial during *kharif* 2017-2019 against various check varieties *viz*., CSV 20, GJ 39, GJ 42, GNJ 1 and GJ 43. The mean performance of GDJ 1 for grain yield over 21 locations, including the preliminary trial was 2506 kg/ha. In the case of dry fodder yield the mean performance over 22 locations, including the preliminary trial was 167.0 q/ha. Based on the comparative mean analysis, it produced 12.4, 46.2 and 9.2 per cent higher grain yield against the check CSV 20, GJ 39 and GJ 42, respectively (**Table 2**). In the case of dry fodder, it produced 23.0, 36.7, 26.8, 29.0 and 8.2 per cent higher dry fodder yield against the check CSV 20, GJ 39, GJ 42, GNJ 1 and GJ 43, respectively (**Table 3**). In North Gujarat based on seven testing trials, GDJ 1 exhibited high grain yield (2576 kg/ha) with an

increment of 50.0, 50.7 19.6, 21.5 and 41.8 per cent, respectively (**Table 2**) and dry fodder (228.7 q/ha) with an increment of 49.8, 52.3, 10.9, 49.6 and 34.2 per cent over the years and locations against checks GJ 39, GJ 42, GJ 43, GNJ 1 and CSV 20, respectively (**Table 3**).

Table 2. Grain yield performance of sorghum variety GDJ 1 in comparison with check varieties in the Gujarat state

Year/ & Season	Trial	Location	Grain yield (kg/ha)						S.Em (±)	CD at 5 %	CV %
			GDJ 1	CSV 20 (NC) a	GJ 39- DS (LC) b	GJ 42 (LC) c	GNJ 1 (LC) d	GJ 43-DS- (LC) e			
Kharif 2016	PET	Deesa	3554[ab]	2310	2250				221.9	650.5	16.0
		MEAN (1)	3554	2310	2250						
		% increase over the check		**53.9**	**58.0**						
2017 *Kharif*	SSVT	Surat	2364[b]	2045	1564	2128	2218		190.0	544.0	15.9
		Dediyapada	3723[ab]	3006	1919	3345	3495		207.0	593.0	12.5
		Mangrol	2703[b]	2443	1714	2754	2809		247.0	708.0	17.3
		Achhaliya	4050[ab]	2272	1450	3687	3364		349.0	999.0	16.8
		Viramgam	1278[a]	708	1063	1220	1543		91.0	260.5	13.3
		MEAN (5)	**2824**	**2095**	**1542**	**2627**	**2686**		-	-	-
		% increase over the check		**34.8**	**83.1**	**7.5**	**5.1**				
Kharif 2018	LSVT	Deesa	3999[abcd]	2664	3071	2979	3309		218.0	629.0	11.4
		Bhiloda	2826[bc]	2480	1597	1550	2443		159.0	458.0	12.0
		Viramgam	949	1949	1971	2719	2895		140.0	405.0	9.7
		Surat	3223[ab]	2369	2275	2816	4090		294.0	849.0	14.7
		Waghai	4765[abcd]	3704	4090	3885	4106		167.0	482.0	7.1
		Mangrol	1235	2075	1602	1768	2141		130.0	375.0	12.6
		Achhaliya	1208[b]	2863	841	1051	1812		76.0	220.0	8.9
		Dediyapada	4074[abd]	3362	1923	3420	3216		229.0	661.0	11.4
		MEAN (8)	**2785**	**2683**	**2171**	**2524**	**3002**		-	-	-
		% increase over the check		**3.8**	**28.3**	**10.4**	**-**				
Kharif 2019	LSVT	Deesa	1360	847			1188	1271	147.0	427.0	23.8
		Bhiloda	1919[ad]	1376			1551	1626	95.0	277.0	10.4
		Aseda	1800[ade]	1227			1306	1348	102.0	295.0	12.6
		Surat	1782	2528			3190	2255	213.0	618.0	15.1
		Waghai	2382	2600			2279	2621	107.0	312.0	7.5
		Mangrol	2287	2261			2901	2086	229.0	666.0	15.1
		Achhaliya	1150	1743			2546	1592	161.0	467.0	13.4
		MEAN (7)	**1811**	**1797**			**2137**	**1828**	-	-	-
		% increase over the check		**0.8**			**-**	**-**	-	-	-
Comparative mean over the check CSV 20 (21)			**2506**	**2230**	-	-	-	-			
Comparative mean over the check GJ 39 (14)			**2854**	-	**1952**		**-**	**-**			
Comparative mean over the check GJ 42 (13)			**2800**	-	**-**	**2563**	**-**	**-**			
Comparative mean over the check GNJ 1 (20)			**2454**	-	**-**	**-**	**2630**	**-**			
Comparative mean over the check GJ 43 (7)			**1811**	-	**-**	**-**	**-**	**1828**			
Overall % increase over the checks in all over Gujarat state			**-**	**12.4**	**46.2**	**9.2**	**-**	**-**			
Overall % increase over the checks in north Gujarat zone (semi-arid)			**2576**	**41.8**	**50.0**	**50.7**	**21.5**	**19.6**			
Frequency of top non-significant groups			**10/21**	**2/21**	**0/14**	**3/13**	**5/20**	**2/7**			

Where: Figure in parenthesis indicates the number of locations;
a, b, c, d and e indicate significantly superior to respective check variety for grain yield

Table 3. Dry fodder yield performance of proposed sorghum variety GDJ 1 in comparison with check varieties in the Gujarat state

Year/ Season	Name of Trial	Location	Dry fodder yield (q/ha)						S. Em (±)	CD at 5 %	CV %
			GDJ 1	CSV 20 (NC) a	GJ 39-DS (LC) b	GJ 42 (LC) c	GNJ 1 (LC) d	GJ 43-DS-(LC) e			
Kharif 2016	PET	Deesa	215.8[ab]	178.3	154.8				12.7	36.1	11.9
		MEAN (1)	215.8	178.3	154.8						
		% increase over the check		**21.0**	**39.4**						
Kharif 2017	SSVT	Surat	131.9	112.3	106.4	126.9	112.3		9.5	NS	13.5
		Dediyapada	248.2[abcd]	145.0	212.8	190.3	177.3		5.0	14.3	5.4
		Mangrol	93.0	138.7	91.0	136.7	143.8		8.6	24.6	12.7
		Achhaliya	104.4	96.5	96.5	89.4	94.6		6.6	18.8	11.7
		Viramgam	147.0[b]	119.0	110.0	137.0	147.0		9.9	28.3	14.5
		MEAN (5)	**144.9**	**122.3**	**123.4**	**136.1**	**135.0**		-	-	-
		% increase over the check		**18.5**	**17.5**	**6.5**	**7.3**				
Kharif 2018	LSVT	Deesa	338.8 [abcd]	244.3	207.5	207.5	228.5		18.1	52.3	13.2
		Bhiloda	219.4 [abcd]	153.0	154.5	159.1	152.2		8.4	24.3	9.3
		Viramgam	286.7 [bcd]	244.3	207.7	202.0	161.3		17.7	51.0	15.0
		Surat	192.3 [abcd]	105.3	114.8	112.7	126.6		10.2	29.5	13.7
		Waghai	117.9 [abcd]	89.9	86.9	88.4	91.6		5.6	16.2	10.9
		Mangrol	54.3	62.5	44.8	52.7	63.2		5.9	17.0	16.8
		Achhaliya	93.1	106.4	80.0	108.5	122.6		4.5	13.0	7.7
		Dediyapada	102.2 [abcd]	62.8	47.8	68.3	64.9		5.2	14.9	12.2
		MEAN (8)	**175.6**	**133.6**	**118.0**	**124.9**	**126.4**		-	-	-
		% increase over the check		**31.5**	**48.8**	**40.6**	**39.0**				
Kharif 2019	LSVT	Deesa	185.2 [ad]	115.7			113.1	167.2	11.7	34.1	14.0
		Bhiloda	188.9 [ad]	158.1			122.2	166.4	7.9	23.1	9.0
		Aseda	223.8 [ade]	172.6			156.9	205.3	13.5	39.0	13.5
		Surat	172.3 [d]	182.6			132.4	171.0	13.2	38.2	13.7
		Waghai	93.4	102.2			93.0	99.7	4.5	13.1	8.3
		Mangrol	87.8	90.2			77.3	94.3	6.6	19.2	13.5
		Achhaliya	202.9 [d]	195.0			165.1	188.0	11.5	33.5	11.2
		Viramgam	175.7 [ade]	113.7			135.0	137.7	8.2	23.9	9.7
		MEAN (8)	**166.3**	**141.3**			**124.4**	**153.7**	-	-	-
		% increase over the check		**17.7**			**33.7**	**8.2**	-	-	-
Comparative mean over the check CSV 20 (22)			**167.0**	**135.8**	-	-	-	-			
Comparative mean over the check GJ 39 (14)			**167.5**	-	**122.5**		-	-			
Comparative mean over the check GJ 42 (13)			**163.8**	-	-	**129.2**	-	-			
Comparative mean over the check GNJ 1 (21)			**164.7**	-	-	-	**127.7**	-			
Comparative mean over the check GJ 43 (8)			**166.3**	-	-	-	-	**153.7**			
Overall % increase over the checks in all over Gujarat state			-	**23.0**	**36.7**	**26.8**	**29.0**	**8.2**			
Overall % increase over the checks in north Gujarat zone (semi-arid)			**228.7**	**34.2**	**49.8**	**52.3**	**49.6**	**10.9**			
Frequency of top non-significant groups			**16/22**	**9/22**	**1/14**	**2/13**	**6/21**	**5/8**			

Where: Figure in parenthesis indicates the number of locations;
a, b, c , d and e indicates significantly superior to respective check variety for dry fodder yield

The variety GDJ 1 was screened for yield performance in IVT with the name SPV 2565 in sixteen locations of Zone I, II and III during *kharif* 2018. The mean performance GDJ 1 among fifteen trials of IVT, it showed 25.7, 12.8 and 19.9 per cent grain yield advantage against CSV 17 in Zone I, II and III, respectively (**Table 4**). For fodder yield, it showed 45.8, 31.1 and 88.6 per cent yield advantage against CSV 17 in Zone I, II and III, respectively (**Table 5**).

Table 4. Grain yield of proposed sorghum variety GDJ 1 in an initial varietal trial in the year *Kharif* 2018 at different Zones of India

	Locations	Grain yield (kg/ha)			CD at 5%	CV%
		GDJ 1	CSV 17 a	CSV 20 b		
Zone I	Chamarajanagar	4148	3667	4407	1247	18.8
	Coimbatore	3774[ab]	1541	2017	1208	20.0
	Dharwad	4171	4609	4981	939	12.1
	Hagari	3234	3590	5472	1482	21.1
	Palem	4946[a]	2715	4750	1451	21.9
	Nandyal#	1894	1557	2971	1115	30.7
	Mean (5)	**4055**	**3224**	**4325**	**1010**	**18.8**
	% Increase over the checks		**25.7**	**-**		
Zone II	Akola	3093	3008	3855	652	10.9
	Bhulandnagar	2870	2433	3211	977	20.3
	Indore	3592	2496	3492	918	16.6
	Parbhani	2014	1963	2244	515	13.7
	Washim	3116	3122	3781	734	12.3
	Mean (5)	**2937**	**2604**	**3317**	**502**	**14.9**
	% Increase over the checks		**12.8**	**-**		
Zone III	Deesa	2489[a]	649	2341	818	21.0
	Surat	3075	2318	2672	854	17.3
	Udaipur	2430	1657	3840	1217	20.9
	Viramgam	1508	3301	2361	668	16.2
	Mean (5)	**2376**	**1981**	**2804**	1027	19.4
	% Increase over the checks		**19.9**	**-**		
	All India Mean	**3176**	**2648**	**3530**	**491.5**	**18.09**
	% Increase over		**19.9**	**-**		

Data not considered due to high CV %,
a and b indicate significantly superior to respective check variety

Yield with quality is also of prime importance as the sorghum is being used grain as well as fodder purpose. So that it satisfies the need of both human for grain and dry fodder for animal consummation in semi-arid regions. The grain colour of released cultivar GDJ 1 is yellow-white which may be more attractive among farmers for fetching higher market price in this region and consumers point of view. The GDJ 1 have a 10.10 per cent crude protein which was higher against check cultivars *viz*., CSV 20 (7.8 %), GJ 43 (8.1 %) and GNJ 1 (7.5%). It has a low tannin content (0.215 mg/g) as compared to check varieties. The high tannin gives a bitter taste in some foods and also decline protein digestibility and feed efficiency in human and livestock. On the other hand, the released cultivar GDJ 1 has a high 0.165 (%) tryptophan as compared to check varieties *viz*., CSV 20 (0.134 %), GJ 43 (0.117%) and GNJ 1 (0.119%). The crude protein content and crude fiber of dry fodder are one of the essential components for fodder quality in sorghum. The sorghum released variety GDJ 1 was found to better concerning the crude protein content (9.2%) and crude fiber (24.24 %), which was higher against check cultivars in order to crude protein and fiber content *viz*., CSV 20 (8.2 % & 15.66), GJ 43 (7.9 & 22.39 %) and GNJ 1 (8.4 & % 20.31) (**Table 6**).

The released cultivar GDJ 1 having an attractive suture in field view (**Fig. 1**). It has yellow, green seedling anthocyanin, leaf sheath anthocyanin and leaf midrib coloration. It is tall, and it attained an average of 274.4 cm height in normal condition, very long (>80 cm) and

Table 5. Dry fodder yield performance of sorghum variety GDJ 1 in an initial varietal trial in the year *Kharif* 2018 at different Zones of India

	Locations	Dry fodder Yield (q/ha)			CD at 5%	CV%
		GDJ 1	CSV 17 (a)	CSV 20 (b)		
Zone I	Chamarajanagar	86.1	93.3	79.6	29.1	19.1
	Coimbatore	83.9a	49.2	80.5	21.5	17.5
	Dharwad	109.9a	48.5	118.2	23.2	11.0
	Hagari	101.9	99.5	108.8	23.6	14.0
	Nandyal	129.6a	60.2	175.9	43.5	20.2
	Palem#	135.9	85.6	114.1	161.0	79.3
	Mean	**102**	**70**	**113**	**24.3**	**16.7**
	% Increase over the checks		**45.8**	**-**		
Zone II	Akola	142.7a	120.3	139.4	10.3	4.6
	Bhulandnagar	127.3	112.6	130.6	23.4	10.6
	Indore	129.6a	44.4	129.6	35.6	18.9
	Parbhani	118.7	104.3	100.7	21.9	11.9
	Washim	143a	122.9	138.9	8.6	3.8
	Mean	**132**	**101**	**128**	**16.9**	**10.7**
	% Increase over the checks		**31.1**	**3.5**		
Zone III	Deesa	318.5ab	122.2	292.6	61.8	14.4
	Surat	65.2	65.9	77.3	25.3	15.9
	Udaipur	157.5	81.7	151.3	50.8	20.5
	Viramgam	167.5	105.9	165.2	31.2	12.2
	Mean	**177**	**94**	**172**	**46.9**	**16.4**
	% Increase over the checks		**88.6**	**3.2**		
All India Mean		**134**	**88**	**134**	**16.67**	**15.17**
	% Increase over the checks		**53.2**	**0.7**		

Data not considered due to high CV %;
a and b indicate significantly superior to respective check variety

Table 6. Biochemical parameters of variety GDJ 1 (Banas Surya) with checks for grain and dry fodder

Sr. No.	Quality parameters	GDJ 1	CSV 20 (NC)	GJ 43 (C)	GNJ 1 (C)
Grain					
1	Moisture (%)	10.29	10.64	11.16	10.71
2	Crude Protein (%)	10.1	7.8	8.1	7.5
3	Fat (%)	3.6	3.5	3.6	3.5
4	Ash (%)	1.85	1.86	1.67	1.71
5	Crude fiber (%)	0.96	1.37	0.90	1.10
6	Starch (%)	50.7	51.5	51.5	57.0
7	Tannin (mg/g)	0.215	0.232	0.244	0.231
8	Phenol (g)	0.154	0.142	0.133	0.127
9	Lysine (%)	0.493	0.532	0.533	0.628
10	Tryptophan (%)	0.165	0.134	0.117	0.119
Dry Fodder					
1	Moisture (%)	12.0	10.7	11.8	11.3
2	Ash (%)	5.60	6.54	5.38	8.31
3	Crude fiber (%)	24.24	15.66	22.39	20.31
4	Crude Protein (%)	9.2	8.2	7.9	8.4

Fig.1: Field view of sorghum variety GDJ 1 (DS 172) BANAS SURYA

broadleaf blade (6.1 - 8.0). The GDJ 1 have a long panicle length (31-40 cm) with long branches (10.1-15 cm). It has semi-loose panicle compactness devoid of lemma arista formation and circular and attractive medium bold grain, with medium glume length (**Table 7 and Fig. 2 and 3**).

Table 7. Morphological characters of proposal variety GDJ 1 with check GJ 43 (As per DUS guidelines)

S. N.	Characters	GDJ 1 (DS 172)	GJ 43 (C)
1	Seedling: anthocyanin coloration	Yellow-green	Yellow-green
2	Leaf-sheath anthocyanin coloration	Yellow-green	Yellow-green
3	Leaf midrib colour	Yellow-green	Yellow-green
4	Plant: time of panicle emergence (50% of the plants with 50% anthesis)	Medium (66-75 days)	Medium (66-75 days)
5	Flag leaf yellow coloration of the midrib	Present	Present
6	Lemma arista formation	Absent	Absent
7	Plant total height	Long (226 - 300 cm)	Long (Tall)
8	Stem diameter (girth)	Medium (2 - 4 cm)	Medium (2 - 4 cm)
9	Leaf: length of the blade	**Very Long (> 80 cm)**	Long (61 – 80 cm)
10	Leaf : width of blade	Broad (6.1 - 8.0)	Broad (6.1 - 8.0)
11	Panicle length (without peduncle)	**Long (31-40 cm)**	Medium (21-30 cm)
12	Ear head compactness	**Semi loose**	loose
13	Panicle shape	Symmetric	Symmetric
14	The neck of panicle (visible length above sheath)	Medium (10.1 - 15 cm)	Medium (10.1 - 15 cm)
15	Length of branches (middle third of panicle)	**Long (10.1-15 cm)**	Medium (5.1-10 cm)
16	Glume length (% grain covered)	**Medium (75 %)**	Short (50 %)
17	Length of flower	Medium	Medium
18	Dry anther colour	Greyed orange	Greyed orange
19	Anther length	Short (<3.0 mm)	Short (<3.0 mm)
20	Stigma : Anthocyanin coloration	Absent	Absent
21	Stigma :Yellow coloration	**Present**	Absent
22	Stigma length	**Medium (1-2 mm)**	Short (<1mm)
23	Grain shape (dorsal and profile view)	**Circular**	Elliptic
24	Caryopsis colour after threshing	Yellow white	Yellow white
25	Size of a mark of germ	Medium	Medium
26	Threshability	Freely threshable	Freely threshable
27	Grain weight (1000 grain wt. in g)	Medium (26 - 35 g)	Medium (26 - 35 g)

During the cropping season, sorghum crop experiences many diseases *viz*., leaf blight, anthracnose, grain mold and ergot. In the case of disease, grain mould considered as the most important biotic factor that constraints the production as well as the quality of grain sorghum worldwide (Thakur *et al.*, 2006). On the other hands, major pests like shoofly and stem borer, which harshly distress to sorghum crop (Thakur *et al.*, 2019). Shoot fly is one of the disparaging pests and causes bare damage in sorghum at the time of the early seedling stage (7-30 days of seedling). While *C. partullus* (stem borer) is also playing a significant negative role in the decrease of sorghum production in the country. The August month is preferable in which maximum infestation (about 4-45%) occurs, but it declined gradually in later months (Singh *et al.,* 1985). The released cultivar tested in various locations in AICRP trials as well as an in-state trial for evaluating reaction toward major disease and pest. Under field condition, the cultivar GDJ 1 gave a moderately resistance reaction toward leaf blight, anthracnose, grain mold and ergot diseases (**Table 8 & 9**). It showed lesser infestation of shoot fly (29.00%) and stem borer dead heart (31.27 %) in state trials (**Table 10**). Under theAICRP trial, this cultivar also showed moderate to lesser reaction toward shoot fly (57.2%) and stem borer dead heart (19.3 %) (**Table 11**).

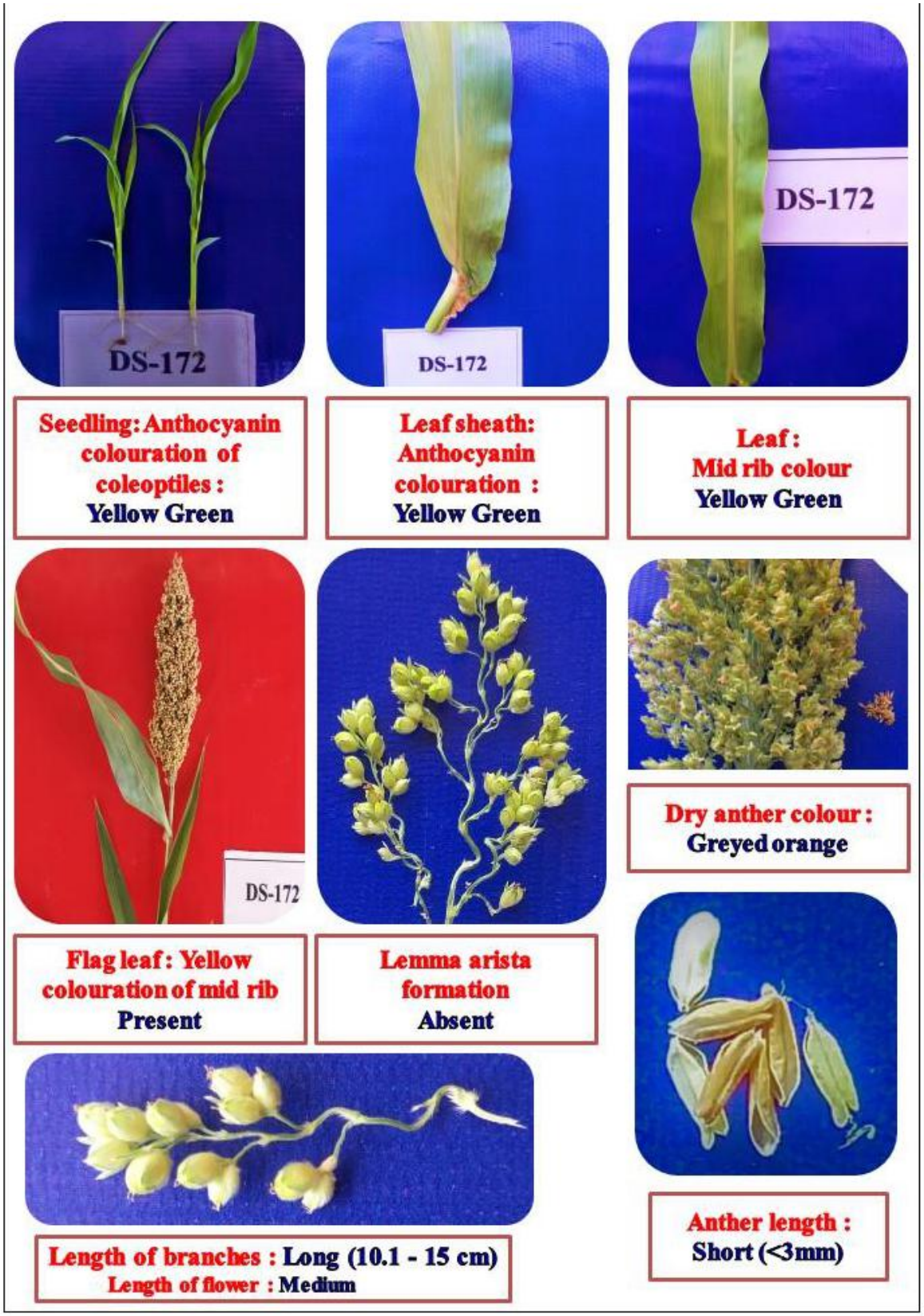

Fig. 2. Important DUS characteristics of variety GDJ 1(DS 172)

Stigma : Anthocyanin colouration : Absent
Yellow colouration : Present
Length : Medium (1-2 mm)

Leaf; length of blade: Very long (>80cm)
Width of blade: Broad (6.1-8.0 cm)

Neck of panicle (visible length above sheath) : Medium (10.1-15 cm)

Panicle density : Semi loose
Panicle Shape : Symmetric
Panicle length : Long

Caryopsis colour: Yellow white
Grain Shape (dorsal view): Circular
Grain Shape (profile view): Circular
Size of mark of germ: Medium
Weight of 1000 grains: Medium

Fig. 3. Important DUS characteristics of variety GDJ 1(DS 172)

Table 8. Rating of incidence of diseases at Surat and Deesa centre

i. Leaf blight (1-9)								
Trial	**Year**	**Locations**	**GDJ 1**	**GJ 39**	**GJ 42**	**GNJ 1**	**GJ 43**	**CSV 20**
LSVT	K-2018	Surat	**4.3**	4.7	3.7	4.3	-	4.3
LSVT	K-2019	Surat	**4.3**	-	-	4.3	4.7	5.0
		Mean	**4.3**	4.7	3.7	4.3	4.7	4.65
		Range	**-**	-	-	-	-	4.3-5.0
LSVT	K-2019	Deesa	**3.3**	-	-	5.0	3.7	4.7
		Mean	**3.3**	-	-	5.0	3.7	4.7
		Over all mean	**4.0 (MR)**	**4.7**	**3.7**	**4.5**	**4.2**	**4.7**
ii. Anthracnose (1-9)								
LSVT	K-2018	Surat	**3.3**	4.7	4.0	4.0	-	4.3
LSVT	K-2019	Surat	**4.3**	-	-	4.7	4.7	4.7
		Mean	**3.8**	**4.7**	**4.0**		**4.7**	**4.5**
		Range	**3.3-4.3**	-	-	4.0-4.7	-	4.3-4.7
LSVT	K-2019	Deesa	**4.3**	-	-	4.7	3.7	4.7
		Mean	**4.3**	**-**	**-**	**4.7**	**3.7**	**4.7**
		Over all mean	**4.0 (MR)**	**4.7**	**4.0**	**4.5**	**4.2**	**4.6**
iii. Grain mold disease score (1-9)								
LSVT	K-2018	Surat	**4.0**	3.3	4.0	3.7	-	4.0
LSVT	K-2019	Surat	**4.3**			4.7	4.3	4.7
		Mean	**4.2 (MR)**	**3.3**	**4.0**	**4.2**	**4.3**	**4.4**
iv. Ergot disease score (1-9)								
LSVT	K-2018	Surat	**3.7**	5.7	4.0	3.7	-	5.3
LSVT	K-2019	Surat	**4.3**			4.3	4.7	5.3
		Mean	**4.0 (MR)**	**5.7**	**4.0**	**4.0**	**4.7**	**5.3**

Where MR= moderately resistant

Table 9. Rating of incidence of diseases in the initial varietal trial (IVT) in the year *Kharif* 2018 at different Zones of India

i. Leaf blight (1-9)				ii. Grain mould disease score (1-9)			
Locations	**GDJ 1**	**CSV 17**	**CSV 20**	**Locations**	**GDJ 1**	**CSV 17**	**CSV 20**
Parbhani	**3.0**	2.0	2.3	Parbhani	**4.7**	6.0	4.7
Akola	**1.0**	1.0	1.0	Akola	**3.7**	4.0	3.0
Dharwad	**1.3**	1.7	1.0	Dharwad	**2.7**	4.0	3.3
Range	**1.0-3.0**	1.0-2.0	1.0-2.3	Range	**2.7-4.7**	**4.0-6.0**	**3.0-4.7**
Mean	**1.8 (R)**	**1.6**	**1.4**	**Mean**	**3.7 (MR)**	**4.7**	**3.7**
iii. Anthracnose (1-9)				**iv. Ergot disease score (1-9)**			
Pantnagar	5.5	6.5	5.8	Dharwad	**2.0**	3.0	8.0
Mean	**5.5**	**6.5**	**5.8**	**Mean**	**2.0 (R)**	**3.0**	**8.0**

Where R= Resistant; MR= moderately resistant

DNA fingerprinting of variety GDJ 1 along with four checks (GJ 43, GJ 39, GNJ 1 and CSV 20) was performed using 11 ISSR primers. Out of 11 primers, 7 primers (ISSR 2, ISSR 3, ISSR 7, ISSR 8, ISSR 22, ISSR 23 and ISSR 25) were showed polymorphic bands between DS-172 and checks used in fingerprinting. Polymorphic bands were demonstrated using the arrow symbol in **Fig. 4**.

The variety GDJ 1 (Banas Surya) found superior against checks GJ 39, GJ 42, GJ 43, GNJ 1 and CSV 20 for grain yield with an average increment of 50.0, 50.7 19.6, 21.5 and 41.8 per cent, respectively over the years and locations. It was also found superior against respective checks for dry fodder yield with an average increment of 49.8, 52.3, 10.9, 49.6 and 34.2 per cent, respectively over the years

Table 10. Rating of incidence of Insect-pests at Surat and Deesa centre

i. Shoot fly dead heart (%)								
Trial	**Year**	**Locations**	**GDJ 1**	**GJ 39**	**GJ 42**	**GNJ 1**	**GJ 43**	**CSV 20**
LSVT	K-2018	Surat	**38.12**	30.59	31.31	28.84	-	36.03
		Mean	**38.12**	30.59	31.31	28.84	-	36.03
LSVT	K-2019	Deesa	**26.82**	-	-	28.69	32.13	41.40
LSVT	K-2019	Surat	**22.07**	-	-	22.35	29.90	31.56
		Mean	**24.45**			**25.52**	**31.02**	**36.48**
		Range	**22.07-26.82**	**-**	**-**	**22.35-28.69**	**29.90-32.13**	**31.56-41.40**
		Over all mean	**29.00**	**30.59**	**31.31**	**26.31**	**31.02**	**36.33**
ii. Stem borer dead heart (%)								
LSVT	K-2018	Surat	**37.14**	34.74	29.73	32.51	-	36.65
LSVT	K-2019	Surat	**25.10**	-	-	27.20	29.50	36.33
		Mean	**31.12**	**34.74**	**29.73**	**29.86**	**29.50**	**36.49**
		Range	**25.10-37.14**	**-**	**-**	**27.20-32.51**	**-**	**36.33-36.65**
LSVT	K-2019	Deesa	**31.57**	-	-	36.61	34.23	44.47
		Mean	**31.57**	-	-	36.61	34.23	44.47
		Over all mean	**31.27**	**34.74**	**29.73**	**31.11**	**31.87**	**39.15**

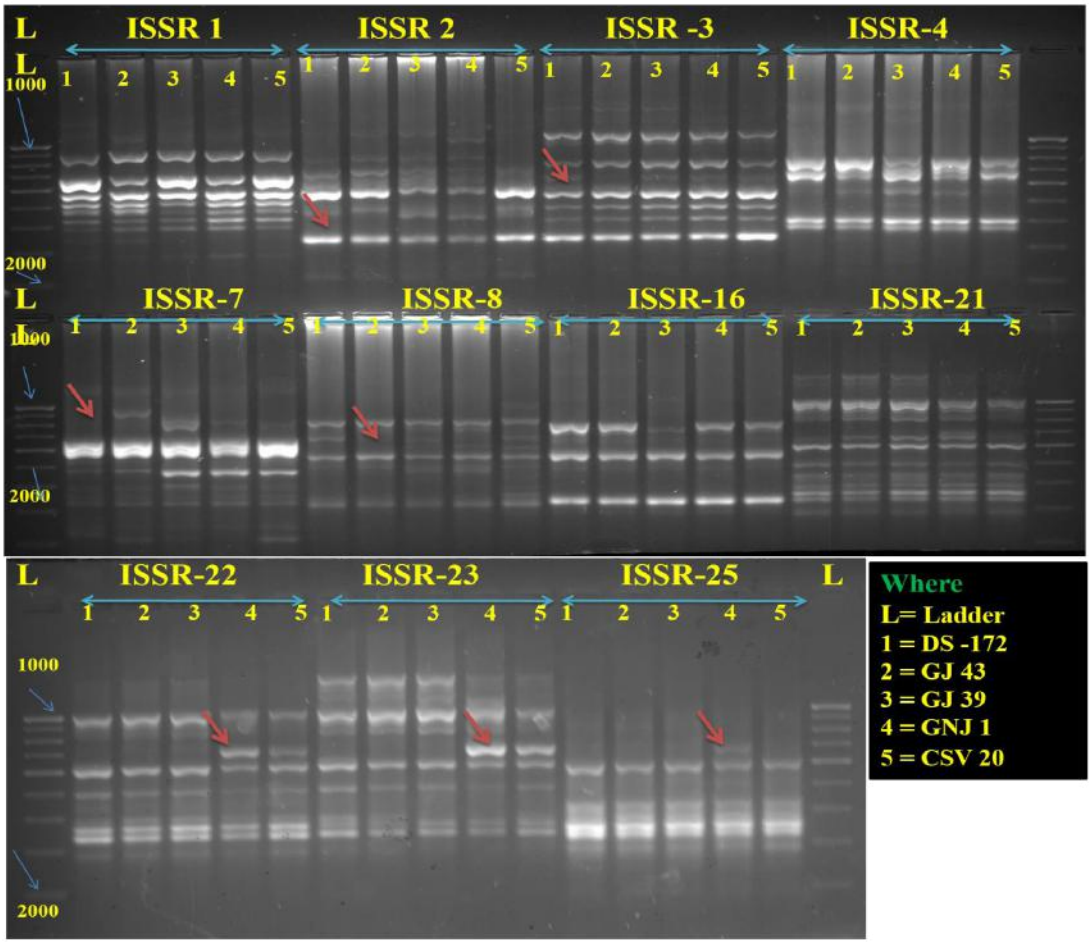

Fig. 4. DNA profiling of variety GDJ 1 with Checks.

Table 11. Rating of incidence of insect-pests in the initial varietal trial (IVT) in the year Kharif 2018 at different Zones of India

	Shoot fly dead heart (%)			Stem borer dead heart (%)		
Locations	**GDJ 1**	**CSV 17**	**CSV 20**	**DS 172**	**CSV 17**	**CSV 20**
Akola	67.9	57.6	65.7	3.5	3.7	3.6
Coimbatore	22.2	26.1	20.5	20.6	39.5	40.0
Dharwad	55.5	55.5	57.2	62.2	55.5	57.2
Indore	63.1	68.3	59.0	26.2	50.6	36.1
Palem	58.0	46.9	54.7	17.6	17.4	20.3
Parbhani	77.9	60.1	68.8	3.9	0.0	0.0
Rahuri	95.5	93.6	91.9	4.5	5.0	0.0
Surat	37.9	24.9	63.9	31.2	20.2	15.3
Udaipur	36.4	24.9	29.7	4.3	5.9	5.3
Range	**22.2-95.5**	**24.9-93.6**	**20.5-91.9**	**3.5-62.2**	**0.0-55.5**	**0.0-57.2**
Mean	**57.2**	50.9	56.8	**19.3**	**21.9**	**19.7**

and locations in the north Gujarat semi-arid zone. Further, this genotype has desirable characteristics like the tall stature of the plant with very long and broad leaves. The long symmetric semi-loose panicle has a medium neck with long branches and medium glume length. The grain is medium bold and yellow-white. It is moderately resistant to diseases like leaf blight, anthracnose, grain mold, ergot and lower infestation of shoot fly and stem borer than checks. It exhibited more crude protein in both grain (10.10 %) and dry fodder (9.20%), grain having low tannin (0.215 mg/g), while the rest of quality traits more or less similar in compare to check.

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