CSV 41: A High Yielding Potential Dual Purpose Sorghum Variety

ABSTRACT

Aims: The aim of this study was development of high yielding, dual purpose sorghum variety and its acceptability by the farmers.

Study of Design: Randomized Block Design.
Place and Duration of study: The Present study was conducted at Regional Agricultural Research Station, Palem, Nagarkurnool from 2010 to 2019 and evaluated at national level.

Methodology: A high yielding, dual purpose sorghum variety was derived from a cross between SPV-86 x ICSR-89064 through Pedigree method of breeding and subsequently it was evaluated at station level from 2013 – 2015 and also at AICRP system from 2016 – 2018 for its grain and fodder yield and resistance to pests and diseases.

Results: Sorghum culture SPV 2437 recorded highest grain and fodder yield of 3179.8 kg ha^{-1} and15900.2 kg $ha^{-1}$and yielded +39.25%, +3.86% and +14.88% higher grain yield and +92.48, +13.59, and +8.46 higher fodder yield superiority than checks CSV 17, CSV 20 and CSV-27 and shown 3.67 mean field grade and 4.37 mean threshed grade showing moderately resistant reaction to grain mold disease.

Conclusion: The sorghum variety SPV 2437 with higher yield, resistance to pest and disease and good cooking quality as compared to the check varieties was released through on the name of Telangana Jonna 1/CSV 41 for Zone 1 (Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan and Gujarat states) of All India during the year 2020.

Keywords: Sorghum, Grain Yield, Fodder Yield, Grain mold, Shoot fly, Protein,

1. INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) Moench] is a C4 crop grown internationally at any type of soil can withstand to harsh climates, scanty rainfall and provides food, animal fodder, alcoholic beverages, and biofuels. It is the fifth most important cereal crop globally after wheat, maize, rice and barley. India is the fifth largest producer of sorghum in the world. It is the second cheapest source of energy and micronutrients after pearl millet, and majority of population in the central India depends on sorghum for their dietary and energy requirements [1]. It can be very well fitted in cropping system with limited irrigation facilities. Under changing climate scenario, sorghum being a drought-hardy crop will play an important role in food, feed and fodder [2].Sorghum is cultivated in an area of 40.25 mha in the world with a production of 58.70 MT and productivity of 1458 $kgha^{-1}$ [3].

It is a good source of carbohydrates (68%), proteins (10%), micronutrients and phytochemicals with nutraceutical properties and considered as “healthy cereal” [4]. It is resilient crop for the diverse environmental conditions to perform well in marginal conditions under limited water and temperature without competing with other food crops [5]. ICAR established All-India Coordinated Sorghum

Improvement Project (AICSIP) in December 1969 at IARI in New Delhi for multi-location testing of varieties. The first commercial hybrid CSH 1 was released in 1964 and it showed the way to development of more hybrids like maize. Breeding could also identify and released high yielding varieties in various states. Some of these varieties are dual purpose type. Major advantage of varieties over hybrids was their relative better grain quality and multiple resistance or tolerance against major pests and diseases [6].

Sorghum crop is attacked by more than 150 insect species which results 32% crop loss [7]. From 150 insect species, sorghum shoot fly, *Atherigona soccata* (Rondani) (Diptera: Muscidae), the important damaging pest which start damage from seedling to 5 weeks of sowing leading to 75.6% yield losses [8]. The pest severity can be minimized by adopting good management practices, and cultivating resistant cultivars. Natural enemies, insecticides and host plant resistance have been employed for shoot fly management to minimize the losses [9].

Improvement of sorghum for resistance to shootfly is most important goal for rain fed sorghum. Although several varieties and hybrids are available, the yield improvements are minimal [10]. Spotted stem borer, *Chilo partellus* attacks the sorghum crop from two weeks after germination until crop harvest and it affects all parts of plant leaving the roots. A number of genotypes resistant to *C. partellus* are available, but the levels of resistance are low to moderate. Stem borers are difficult pest to control, largely because of the nocturnal habits of the adults and the cryptic behavior of the larvae, which reside inside plant stems.

Sorghum diseases decreases productivity, production of quality grain in grain sorghum, fodder yield and quality in forage sorghum and sugar yield in sweet sorghum. During *kharif* grain mold, downy mildew, anthracnose and ergot are major diseases [11]. The grain mold disease occurs every year in various parts of India causing considerable economic losses. It starts with infection at the time of anthesis and reaches its peak at grain maturity. Its adverse effects do not end at grain maturity and continues even after harvest and in storage [12]. Traditional plant breeding involves recombination and selection of genotypes with different genetic background (active gene banks, core collections and association panels) and depends on exploiting natural variation [13]. Sorghum is a gluten-free grain that is rich in carbohydrates, protein fibre, vitamins and minerals viz., magnesium, phosphorus, potassium, calcium, iron and antioxidants. Proteins are second significant component of sorghum and it fluctuates along with amino acid profile .Environmental variables also contribute for the variance in protein content among organisms [14].

2. MATERIALS AND METHODS

The present investigation was carried out at Regional Agricultural Research Station (RARS), Palem from *kharif* 2013 to 2019. The main objective is to develop a high yielding, dual purpose sorghum variety through the pedigree method with two parents of SPV-86 x ICSR-89064. The female parent is characterized by purple pigmented, medium juicy stem, large leaves, elliptic ear head and semi compact, grain elliptical, bold, tolerant to shootfly, charcoal rot and drought while the ICSR 89064 is a high yielding and dual purpose tolerance to grain mold disease developed at ICRISAT used as male parent. The

nature of the soil is light red and all agronomic management practices were followed to raise a good crop. Pedigree method of breeding was followed in F3, F4 and F5 populations by selecting single plant for the characters like height, strong stem, long panicle, semi compact panicle, elliptical shape grains. The same process was continued up to F6 till all these lines attained same height, panicle length, semi compact panicle and elliptic shape grains. It was subsequently evaluated in the yield trials from *kharif* 2013 to 2015 at Regional Agricultural Research Station, Palem as PSV 313 (Table 1)

3. RESULTS AND DISCUSSION

During *kharif* (June-October) season from 2013 to 2015 at Regional Agricultural Research Station, Palem sorghum culture SPV 2437 recorded a mean grain yield of 3816.33 kg ha^{-1} and fodder yield of 16594.13 kg ha^{-1} over PSV 56 check (3452 kg ha^{-1}, 15107 kg ha^{-1} (grain &fodder) and showed 10.55% (grain yield) and 9.84% (fodder yield) superiority than the check variety PSV 56 (Table 1).

3.1 GRAIN AND FODDER YIELD PERFORMANCE

The sorghum culture SPV 2437 has been tested in AICRP on sorghum from *kharif* (June - October) 2016 to 2018 along with three promised national checks *i. e.,* CSV 17, CSV 20 and CSV 27 During three years of 2016 to 2018 *kharif* seasons (June - October), SPV2437recordeda mean highest grain yield of 3179.8 kg ha^{-1} over the national checks CSV 17 (2283.5 kg ha^{-1}), CSV 20 (3061.7kg ha^{-1}) and CSV 27 (2767.9kg ha^{-1})in fifteen locations and 39.2%, 3.8% and 14.8%, superiority noticed than the national checks (Table 2).

The culture SPV 2437 was recorded highest mean fodder yield of 15900.2 kg ha^{-1} than the three national checks CSV 17 (8200.7 kg ha^{-1}), CSV 20 (14000.2 kg ha^{-1}) and CSV 27 (14600.8 kg ha^{-1}) in fifteen locations and 92.48 %, 13.59 % and 8.46 % superior than checks.

Table1.Summary of Grain yield data of SPV 2437 in station trials from kharif 2013 to 2016

Trial name	PSV 313	PSV 56	% Superiority over check	PSV 313	PSV 56	% Superiority over check
	Grain yield (Kg ha^{-1})			Fodder yield (Kg ha^{-1})		
Observation yield trial (2013-14)	3951.0	3578.0	10.4	14142.0	13453.0	5.1
Initial varietal trial (2014-15)	4061.0	3702.0	9.6	13944.4	12434.0	12.1
Advanced arietal trial (2015-16)	3437.0	3076.0	11.7	21696.0	19434.0	11.6
	3816.3	3452.0	10.5	16594.1	15107.0	9.8

Table 2.Summary of Grain yield data of SPV 2437 in Coordinated Trials from 2016 to 2018

Year of testing	No. of locations	SPV2437	CSV 17	CSV 20	CSV 27
2016	2	3288.0	2307.0	3136.0	2469.0
2017	7	3327.0	2513.0	3035.0	2837.0
2018	6	2972.0	2008.0	3068.0	2787.0
Mean grain yield kg ha^{-1}		3179.8	2283.5	3061.7	2767.9
2016			42.5	4.8	33.1
2017			32.3	9.6	17.2
2018			48.0	-3.1	6.6
Grain yield superiority			39.2 %	3.8%	14.8%

Table3. Summary of fodder yield data of SPV 2437 in Coordinated Trials from 2016 to 2018

Year of testing	No. of locations	SPV 2437	CSV 17	CSV 20	CSV 27
2016	2	160.0	85.0	158.0	164.7
2017	8	158.4	87.8	137.8	140.3
2018	5	160.3	73.6	136.9	150.1
Mean fodder yield q ha^{-1}		159.2	82.7	140.2	146.8
2016			88.3	1.3	-2.8
2017			80.4	14.9	12.9
2018			117.8	17.0	6.8
Fodder yield superiority			92.4 %	13.5 %	8.4 %

3.2 AGRONOMIC STUDIES

Agronomic variables trial, among three recommended dose of fertilizers (F1: 50% RDF, F2: 100% RDF and F3: 125% RDF) SPV 2437 recorded highest grain yield 3200.0 kg ha^{-1}under 125% recommended dose of fertilizers compared to the checks CSV 31 (2.9 t ha^{-1}) SPV 2423 (2.9 kg ha^{-1}) and SPV 2433 (2.9 kg ha^{-1}). The percent superiority of SPV 2437 recorded 8.1% over the check the CSV 31 (Table 4).

The proposed promising high yielding sorghum genotype, SPV 2437 is a dual purpose variety with high grain and fodder yield potential of (3179.8 kg ha^{-1} & 159.2 q ha^{-1}) having moderate resistance to grain mold disease anthracnose, rust and leaf blight diseases and having better adaptability and high keeping quality. It has been released through Central Varietal Release Committee on the name of Telangana Jonna 1/ CSV 41 for Zone 1 **(**Andhra Pradesh, Telangana, Tamil Nadu, Rajasthan and Gujarat states)

during 2020. It is medium duration variety, with total growth duration of about 106–108 days with long flower with pedicle and having yellow green midrib colour and stigma length is medium and having short anther length and dry anthers having grayed orange colour, stigma colouration is absent, colour of the glumes grayed orange, plant height is long with medium stem diameter, length of blade is long, leaf blade width is very broad, medium panicle with mediun length branches, semi compact and Symmetric panicle and its neck was short with short glumes and easy threshability of grains, Caryopsis color after threshing was yellow white, elliptic shape grains with medium weight of 1000 grains weight and non lustrous grain (Table 5).

Table 4. Interaction effect of nitrogen levels on grain yield (t ha-1) of SPV 2437 during *kharif* season (Pooled data of 2017-18 and 2018 - 29)

Expt.	Item	SPV 2437	CSV 31	SPV2423	SPV 2433
Fertilizer experiments	Yield (t/ha) under recommended dose (F3)	3.20	2.96	2.95	2.99
	t/ha & Percentage gain or loss under other doses	2.90 (-9.37)	2.54 (-14.18)	2.55 (-13.55)	2.58 (-13.71)

Table 5: Distinguishing morphological characters of sorghum variety SPV 2437

Seedling: anthocyanin colouration of Coleoptile	Yellow-green
Leaf Sheath: anthocyanin Colouration	Yellow-green
Leaf: midrib color (5^{th} fully developed leaf)	Yellow-green
Time of panicle emergence (50% of the plants with 50% anthesis)	Medium
Plant: natural height of plant up to base of flag leaf (cm)	Medium
Flag leaf: Yellow coloration of mid rib	Absent
Lemma: Arista formation	Absent
Stigma: anthocyanin colouration	Present
Stigma: Yellow colouration	Absent
Stigma: length (mm)	Medium
Flower with pedicel; length of flower	Long
Anther : Length (mm)	Short
Anther: color of dry anther	Grayed orange
Glume : colour	Grayed orange
Plant: total height	Long
Stem : diameter (at lower one third height of plant) (mm)	Medium
Leaf: length of blade (the third leaf from top including flag leaf) (cm)	Long
Leaf: width of blade (the third leaf from top including flag leaf) (cm)	Very Broad
Panicle : length without peduncle (cm)	Medium
Panicle : length of branches (middle third of panicle) (cm)	Medium
Panicle : density at maturity (ear head compactness)	Semi compact
Panicle : shape	Symmetric

Neck of panicle : visible length above sheath (cm)	Short
Glume : length	Short
Thresh ability	Freely threshable
Caryopsis : color after threshing	Yellow white
Grain : weight of 1000 grains (g)	Medium
Grain: shape (in dorsal view)	Elliptic
Grain: shape in profile view	Elliptic
Grain: size of mark of germ	Medium
Grain: texture of endosperm (in longitudinal section)	¾ farinaceous
Grain: colour of vitreous albumen	Greyed yellow
Grain : luster	Non lustrous

3.3 PEST RESISTANCE

The sorghum culture SPV 2437 percent of shoot fly dead hearts were 54.43 % compared to national checks CSV 17 (52.0 %), CSV 20 (53.4 %) and CSV 27 (51.6 %) whereas dead hearts caused by stem borer recorded 22.2 % in SPV 2437 and checks recorded CSV 17 (22.27 %), CSV 20 (27.17%), and CSV 27 (21.60 %).The culture SPV 2437 was screened along with checks under both natural as well as artificial condition and was found to be moderately resistant to both shoot fly and stem borer. For stem borer tunneling SPV 2437 recorded less damage (31.23%) whereas in checks CSV 17 (32.13 %)and CSV 20 (34.23%). Ear Head bug panicle damage rating lowest was observed on SPV 2437 (2.15) as compared to the checks CSV 17 (2.69), CSV 20 (3.00) and in CSV 27 (2.9) of 1-9 damage rating scale (Table 6).

Table 6. Reaction of SPV 2437 to different Insect Pests

Pest name	Year	SPV 2437	CSV 17	CSV 20	CSV 27
Shoot fly (dead hearts)28 days after emergence	2016	62.0	64.9	60.8	54.5
	2017	47.4	42.0	46.6	48.1
	2018	53.9	49.1	53.0	52.2
	Mean	**54.43**	**52.0**	**53.4**	**51.6**
Stem borer (dead hearts)	2016	14.3	16.7	22.9	13.3
	2017	24.9	21.5	25.1	22.3
	2018	27.6	30.1	33.5	29.2
	Mean	**22.27**	**22.77**	**27.17**	**21.6**
Stem borer (stem tunneling)	2016	36.6	39.4	41	31.9
	2017	20.5	15.6	21.1	16.8
	2018	36.6	41.4	40.6	43.8
	Mean	**31.23**	**32.13**	**34.23**	**30.83**
Pest 3	2016	2.1	3.0	2.1	2.1
Head Bug (panicle	2017	2.0	2.6	3.0	3.6

damage rating 1 - 9 at milk stage)	2018	2.3	2.7	3.0	2.3
	Mean	**2.1**	**2.6**	**3.0**	**2.9**

3.4 DISEASE RESISTANCE

Sorghum culture SPV 2437 was evaluated from *khar*if 2016 to *kharif* 2018 along with checks for diseases like Grain mold, leaf blight, anthracnose and downy mildew which were most common during *kharif* season. The panicle of sorghum culture SPV 2437 is semi compact, symmetric grains are elliptic in shape, awn less, and during the three years evaluation SPV 2437 showed 3.6 Grain mold field grade score and 4.3 of Grain mold field grade score of 1-9 scale showing resistance against grain mold disease and for anthracnose disease 3.4 of 1-9 scale was observed in SPV 2437 where 26−50% leaf area covered with small, restricted lesions showing moderate susceptible reaction and in checks it was noticed CSV 17 (3.6) CSV 20 (3.2) and CSV 27 (3.3). For leaf blight disease SPV 2437 was shown resistance reaction of 2.7 of 1-9 scale and 1-5% leaf area covered with hypersensitive small lesions whereas in checks it was recorded CSV 17 (2.3) CSV 20 (2.6) and CSV 27 (2.5) (Table 10).

Table 7. Visual grain mold severity rating scale (1-9 scale)

Severity Grade	Percent grains infected in a panicle/ threshed sample	Disease Reaction
1	<1	Highly Resistant
2	1-5	Resistant
3	6-10	Resistant
4	11-20	Moderately Resistant
5	21-30	Moderately Resistant
6	31-40	Susceptible
7	41-50	Susceptible
8	51-75	Highly Susceptible

Table 8: Disease severity scale of anthracnose disease

Severity Ratings	Symptoms and Lesion Type on the Leaves	Disease reaction
1	No visible symptoms/chlorotic flecks	Resistant
2	1–25% leaf area covered with small, restricted lesions	Moderate Resistant
3	26−50% leaf area covered with small, restricted lesions	Moderate Susceptible
4	51−75% leaf area covered with large, coalescing lesions	Susceptible
5	>75% leaf area covered with large, coalescing lesions	Highly Susceptible

Table 9. Disease severity scale for turcicum leaf blight in sorghum

Severity rating	Symptom and lesion types (on top four leaves)
1	0 to <1 % leaf area with mild yellow flecks
2	1-5% leaf area covered with hypersensitive small lesions
3	6-10% leaf area covered with hypersensitive small lesions
4	11-20% leaf area covered with small necrotic lesions
5	21-30% area covered with small necrotic coalescing lesions
6	31-40% area covered with large coalescing necrotic lesions
7	41-50% leaf area covered with large coalescing necrotic lesions
8	51-75% leaf area covered with large coalescing necrotic lesions
9	76-100% leaf area covered with large coalescing necrotic lesions

Table 10. Reaction of SPV 2437 to different diseases

Disease name		Year of testing	SPV 2437	CSV 17	CSV 20	CSV 27
Grain mold Field grade	Artificial	2016	3.8	3.2	3.3	3.3
		2017	2.9	3.2	3.1	3
		2018	4.3	3.8	4.2	4.3
		Mean	3.6	3.4	3.5	3.5
Grain mold threshed grade	Natural	2016	4.0	4.7	3.9	3.6
		2017	3.8	4.0	3.4	3.8
		2018	5.3	4.2	5.1	5.2
		Mean	4.3	4.3	4.1	4.2
Anthracnose	Natural	2016	4.2	3.9	4.1	3.8
		2017	1.7	1.8	1.9	1.8
		2018	4.3	5.1	3.7	4.3
		Mean	3.4	3.6	3.2	3.3
Leaf blight	Natural	2016	1.9	2.2	2.6	2.0
		2017	3.8	3.0	2.8	3.2
		2018	2.5	1.8	2.5	2.3

		Mean	2.7	2.3	2.6	2.5

3.5 NUTRITIONAL QUALITY

During 2017-18 and 2018-19 the percent protein and starch of SPV 2437 was analyzed by quality profiling test at Indian Institute of Millets Research and exhibited mean protein content of 10.97% and mean starch content of 62.67 % , where as in checks it was recorded CSV 20 (61.56 %) and CSV 27 (65.97 %)Yellow sorghum has a high protein level (12- 13%) than white sorghum (10-11). Generally higher protein content was observed in yellow sorghum (11.57%) as compared to white sorghum (9.57%).

Table 11. Summary of Data on Quality Characteristics of SPV 2437

Quality Characteristic	Year	SPV 2437	CSV 17	CSV 20	CSV 27
Protein	2017	10.44	11.98	11.31	10.95
	2018	9.72	11.30	9.75	9.07
Mean		10.08	11.64	10.53	10.01
Starch	2017	58.11	62.10	57.72	64.39
	2018	67.24	65.65	65.41	67.55
Mean		62.675	63.875	61.565	65.97

4. CONCLUSION

In any breeding programme, the breeder's primary objective is the development of superior entries in terms of yield potential and also for biotic stresses. Since sorghum is a dual purpose crop for food and feed, the grain yield and fodder yield were considered in assessing its performance. The culture SPV 2437 recorded superior grain and fodder yield and excelled the national check varieties CSV 17, CSV 20 and CSV 27. It also possessed many desirable traits viz., high protein content in the gain with better cooking quality. The quality of the dry fodder was also found to be better in terms of digestibility. Besides pest and disease resistance is optimal in SPV 2437. Hence, the culture SPV 2437 was proposed as a new sorghum variety during the year 2020 and released as CSV 41 for the benefit of marginal, small and tribal farmers for the Zone I.

DATA AVAILABILITY STATEMENT

The data sets generated during and/or analysed during the current study are available with the corresponding author on reasonable request

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