

RESEARCH ARTICLE

A High-yielding Dual-purpose Sorghum Variety K 13, is Suitable for Rainfed Vertisol Tracts of the Southern Districts of Tamil Nadu

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ABSTRACT

The sorghum K13 is a high-yielding dual-purpose Sorghum variety high-yielding, dual-purpose sorghum of the Southern districts of Tamil Nadu. TKS_V 1036, the southern district representative of the cross ICSB 518 x SPV 1489 and evolved with an objective of development of a dual-purpose Sorghum variety suited for both grain and fodder purposes, it recorded an average grain yield of 2575 kg/ha over 118 locations, which is 10.7 per cent and 3.5 per cent increase over K12 and CO 30, respectively. TKS_V 1036 is a dual-purpose sorghum variety that yielded an average dry fodder of 11.4 tonnes/ha, a 26.6% increase over the check variety K12. It matures in 95-100 days. The crop is of a tan plant type, tolerant to drought and non-lodging. Grains are highly acceptable, creamy white in colour, borne on medium, cylindrical, semi-compact earheads. The sorghum culture TKS_V 1036 is resistant to shoot fly and stem borer and moderately resistant to midge. It is highly resistant to ergot, resistant to downy mildew and grain mould rest and showed moderate resistance to leaf blight and anthracnose. Hence, the sorghum culture TKS_V 1036 has been proposed for release in 2023 and released as sorghum K13 for general cultivation in the Southern district of Tamil Nadu.

Received: 27 Jan 2026

Revised: 18 Mar 2026

Accepted: 24 Apr 2026

Keywords: Sorghum, K 13, New variety, High yielding, Grain, Fodder.

INTRODUCTION:

Sorghum (*Sorghum bicolor* (L) is an important cereal crop grown in arid and semi-arid areas. It is widely popular among farmers due to its greater adaptability and various uses as grain, green fodder, stover, and silage. It is an important staple food grain after rice and wheat for millions of poor people, and the most important food for insecure people in the semi-arid tropics of India. Sorghum also offers great potential to supplement the fodder requirements of the growing dairy industry in India.

In Tamil Nadu, an area of 4.05 lakh hectares is grown, with an annual production of 4.27 lakh tonnes and a productivity of 1054 kg/ha of grain (Season and crop report 2020-25). Sorghum is cultivated as a rainfed crop by the marginal farmers exceeding 85 per cent of the area to meet the requirement of grain for consumption and dry fodder as animal feed. Healthy eating can transform lives to live more active and longer, which demand sorghum grain as a health food in urban areas. Besides, sorghum is the major dry

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fodder to meet the requirements of dry-land farmers. Sorghum is also prone to pests such as shoot and stem borers and diseases such as grain mould and downy mildew. This necessitates the development of an early-duration sorghum variety with high commercial value for the present-day rainfed sorghum scenario.

Crop breeding is the continuous endeavour to develop crop varieties with greater adaptability, higher productivity, and enhanced resistance to benefit the farming community. The latest rainfed sorghum variety released was K 12 in 2015. To develop more productive varieties than K 12, the sorghum culture TKS_V 1036 has been developed by crossing ICSB 518 X SPV 1489 and tested for its superiority in various yield trials.

MATERIALS AND METHODS

The sorghum culture TKS_V 1036 is a hybrid derived from the cross (ICSB 518 X SPV 1489) developed at the Agricultural Research Station, TNAU, Kovilpatti. This culture was evolved with the objective of developing a high-yielding dual-purpose sorghum variety with enhanced tolerance to shoot fly and stem borer and improved fodder quality. It has been tested for its adaptability under the Station trial during 2012-2015, the Multi Location Trial during 2015-2017, and the Adaptive Research Trial in farmers' fields across all sorghum-growing areas during 2017-2019. It was also tested under the All India Co-ordinated Research Projects on Sorghum during 2014-15, under SPV 2304, at nine locations across the nation. The culture was subjected to both natural and artificial screening for various pests and diseases. The nutritional quality of the grain and fodder was evaluated to assess the

suitability of the grain for consumption and the fodder for in vitro digestibility.

RESULT AND DISCUSSION

The pooled performance of the variety K 13 (TKS_V 1036) across the year and season tested in various yield trials is the criterion for assessing its performance for release as a new variety. The culture TKS_V 1036 was tested at Agricultural Research Station, Kovilpatti, in various yield trials from 2012 to 2021 under rainfed conditions, revealed that TKS_V 1036 had a consistent performance with a mean grain yield of 2575 kg/ha against 2326 kg/ha and 2488 kg/ha by the checks K 12 and C o 30, respectively. The grain yield was 10.7 and 3.5 per cent higher than the check varieties K 12 and Co 30, respectively. Mean dry fodder yield of TKS_V 1036 was 11.40 t/ha as against 9.0 and 9.8 t/ha, which was 26.6.5 and 16.3 per cent increased fodder yield over the checks K 12 and C o 30, respectively (Tables 1 and 2).

The Sorghum culture TKS_V 1036 recorded an average grain yield of 2575 kg/ha, which is a 10.7% increase over the check K 12, across 118 locations in different yield trails viz., station trails, MLT, ART (2012-2018), and OFT on Kharif and Rabi 2020-21. The average dry fodder yield of 11.4 t/ha was recorded, which is a 26.6 per cent increase over the check K 12 (9.0 t/ha).

The sorghum culture TKS_V 1036 was tested during 2013 and 2014 under rainfed conditions. It recorded the highest mean grain yield of 3647 kg/ha over three years, registering a 26.6% increase over the check K8 (2879 kg/ha). Dry fodder yield was recorded at

Table 1: Overall performance of TKS_V 1036 in different yield trials. Grain Yield(kg/ha)

S. No.	Trials	No of trials conducted	Mean Grain Yield (kg/ha)			% increase over check variety	
			TKS _V 1036	K 12 (c)	C o 30(c)	K 12	C o 30
1.	Station trials (2012-15) ARS., KPT	3	3647	3084	2525	18.3	44.4
2.	Multilocation trials (2015-17) TNAU Research Stations	15	2164	1836	1990	17.8	8.7
3.	AICRP trials (2014-15)	9	2334	-	3467	-	-
4.	ART Trials conducted by the Department of Agriculture (2017-18, 2018-19)	82	2031	1809	1968	12.3	3.2
5.	OFT 2020 - 21	9	2698	2575	0	4.8	-
	Overall Mean	118	2575	2326	2488	10.7	3.5



Table 2: Overall performance of TKS_V 1036 over different yield trials Dry fodder Yield(t/ha)

S. No.	Trials	No of trials conducted	Mean straw Yield (t/ ha)			% increase over check variety	
			TKSV 1036	K 12 (c)	CO 30 (c)	K 12	CO 30
1.	Station trials (2012-15) ARS., KPT	3	8.36	7.18	6.02	6.2	38.8
2.	AICRP trials (2014-15)	9	17.2	-	14.1	-	22.1
3.	ART Trials conducted by the Department of Agriculture (2017-18)	5	9.5	9.6	9.3	-	2.1
4.	OFT 2020 - 21	6	10.4	10.2	0	1.9	-
	Overall Mean	23	11.4	9.0	9.8	26.6	16.3

Table 3: Performance of Sorghum Culture TKS_V 1036 in Station Trials

S. No. Entry	Grain Yield kg/ha				% increased Yield over K 12	Straw Yield t/ha				% increased over K 12
	2011-12	2013-14	2014-15	Mean		2011-12	2013-14	2014-15	Mean	
1. TKS _V 1036	2765	4296	3880	3647		9.97	10.4	4.7	8.36	-
2. K 8	2729	3148	2760	2879		7.37	7.20	5.7	6.76	-
3. CO 30	2492	2444	2640	2525	44.4	7.11	6.04	4.9	6.02	38.8
4. CSV 17	3711	3222	2360	3098	-	1.35	10.9	3.1	5.12	-
5. K 12	2922	3129	3200	3084	18.3	9.24	6.30	6.0	7.18	6.2

8.36 t/ha, which is a 23.6% increase over the check K 8 (6.76 t/ha) (Table 3).

A multilocation trial was conducted under both irrigated and rainfed conditions at TNAU Research stations. Under rainfed conditions, the trial was conducted during the rabi season from 2015 to 2016. The high-yielding sorghum culture TKS_V 1036 was recorded with a mean grain yield of 2164 kg/ha over two years (2015-16 and 2016-17), registering 17.8% and 8.7% increases in yield over the checks K 12 and Co 30 (Table 4).

The sorghum culture TKS_V 1036 was tested in AICRP trials during 2014 as SPV 2304 in nine locations. The culture TKS_V1036 recorded a mean grain yield of

2334 kg/ha and a fodder yield of 17189 kg/ha, and excelled CSV 17 and Co 30 by recording 103.5 and 22.1 percent increases in fodder yield, respectively (Table 5).

The sorghum culture was evaluated in ART extensively under both rainfed and irrigated conditions. It was tested in 82 trials in 15 districts. The average grain yield of 2031 kg/ha with an increased yield of 12.27 per cent over the check variety K 12 (1809 kg/ha) in two years of ART (82 locations) (Table 6). The fodder yield was also recorded at 9547 kg/ha, with a yield gain of 2.1 percent over the ruling variety Co 30 (Table 7).

Table 4: Performance of Sorghum Culture TKS_V 1036 in Multi-Location Trial

Cultures	2015-16 Grain Yield kg/ha	2016-17 Grain Yield kg/ha	Mean Grain Yield kg/ha	% increased over check K 12	% increased over Check CO 30
TKSV 1036	2682	1646	2164	17.8	8.7
K 12	2359	1312	1836		
CO 30	2470	1510	1990		



Table 5: Performance of Sorghum culture TKS 1036 (SPV 2304) in All India Co-ordinated research Trials (2014 - 2015)

S. No.	Centre	Grain yield kg/ha			Dry fodder yield kg/ha		
		TKSV 1036	CSV 17	Local check	TKSV 1036	CSV 17	Local check
1.	Coimbatore	2823	2678	4229	19084	8829	11627
2.	Deesa	2084	2775	3598	15616	8709	14715
3.	Palem	3282	1922	5115	18559	5285	11802
4.	Udaipur	1485	2815	2886	19063	7711	10695
5.	Akola	2667	2252	3279	14583	11123	14853
6.	Dharwad	3399	4233	3585	20090	8814	17447
7.	Indore	2443	1955	4054	21091	4887	16461
8.	Parbhani	1960	2879	2592	20777	13851	19572
9.	Surat	865	1195	1862	5838	6818	9511
	Mean	2334	2523	3467	17189	8447	14076
	% increase over CSV 17	-	-	-	-	103.5	-
	% increase over C 0 30	-	-	-	-	-	22.1

Table 6: Overall Performance of grain yield in ART trials conducted by the Department of Agriculture (2017 -2018 and 2018- 2019)

Cultures	Mean	% increased over Check K 12 and C o 30
TKSV 1036	2031	
K 12	1809	12.27
CO 30	1968	3.20

Table 7. Performance of fodder yield in ART trials conducted by the Department of Agriculture (2017 -2018 and 2018- 2019)

Seasons/Locations	TKSV1036 (kg/ha)	C030 (kg/ha)	K12 (kg/ha)
Kharif 2017			
1. KVK, Sirugamani	5400	6100	5625
Kharif 2018			
2. Thoothukudi	11210	11360	13400
3. KVK, Vridhachalm	11700	11750	11050
4. KVK, Sirugamani	5825	6000	6250
Rabi 2018			
5. Thoothukudi	13600.00	11130.00	12100.00
Mean	9547	9268	9685

The major pests in sorghum are shoot fly and stemborer. Sorghum shoot fly, *Atherigona soccata* Rondani, and Stemborer *Chilo partellus* are the major insect pests that severely damage the sorghum crop (Thakur, 2019). Shoot fly is the most destructive one, causing severe damage in the early seedling stage at 7-30 days after seedling emergence. The other pest, the stemborer is also playing an important role

in reducing sorghum production. The infestation of *Chilo partellus* is about 4-45 per cent in sorghum, with maximum infestation occurring during August, declining gradually in September and October (Singh, 1985). It was screened for both natural and artificial conditions, along with checks.



Table 8. Reaction to major pests under field conditions

S.No	Entries	Sorghum shoot fly (% infestation)			Stem borer infestation (% dead heart)
		14 DAE	21 DAE	Mean	
1.	TSKV 1036	20.8	17.3	19.0	18.7
2.	K12 (C)	35.6	47.5	41.6	18.5
3.	Co 32 (C)	17.4	18.9	18.2	30.0

Table 8.1 Reaction to major pests under Artificial conditions

Shoot fly (Dead heart %)	TKSV 1036	K12	IS18551	DJ 6514
<i>Rabi 2020-21</i>	24.0	27.1	6.8	33.5
<i>Kharif 2021</i>	20.1	41.6	8.0	32.4
Mean	22.1	34.4	7.4	33.0
Category	MR	MR	R	MR
Stem borer (Dead Heart %)				
<i>Rabi 2020-21</i>	24.0	33.3	8.1	34.2
<i>Kharif 2021*</i>	26.3	23.5	18.3	32.7
Mean	25.2	28.4	13.2	33.5
Category	MR	MR	R	S

* Done under artificial infestation conditions

The Sorghum culture TKS V 1036 was screened for its reaction to major sorghum pests in the kharif season, along with two check varieties, under field conditions. The culture TKS V1036 showed resistance to shoot fly and stemborer (Table 8).

The sorghum culture TKS V 1036 was also screened for two seasons under artificial conditions. The mean per cent shoot fly investigation revealed that TKS V 1036 registered 22.1 per cent infestation, and the standard check K12 registered 34.4 per cent infestation (MR). The resistant and susceptible checks, viz., IS 18551 and DJ 6514, registered 7.4 (R) and 33.3 (MR) per cent infestation, respectively. With regard to the stem borer infestation, the percentage of dead hearts was 25.2 in TKS V 1036 (MR), and K12 registered 28.4 per cent infestation (MR). IS 18551 (Resistant check) and DJ6514 (Susceptible check)

recorded 13.2 (R) and 33.5 per cent (S) stem borer infestation, respectively (Table 8.1).

Among the diseases, grain mould is the most important biotic constraint to the production of grain sorghum worldwide (Thakur *et al.*, 2006; Williams *et al.*, 1981). Sorghum downy mildew is economically important and widespread in many tropical and sub-tropical regions of the world, where sorghum and maize are grown (Jegera *et al.* 1998 and Williams, 1984). The Sorghum culture TKS V 1036 was screened for its reaction to major diseases of sorghum in the kharif season, along with two check varieties, under field conditions. The culture TKS V1036 showed high resistance to ergot (0.0% incidence), downy mildew (4.60% incidence), grain mould (9.90% incidence), and rust, and for Leaf blight and anthracnose, it shows moderate resistance (Table 9, 9.1).

Table 9: Screening of disease under field conditions

S. No	Entries	Downy mildew		Grain mould		Ergot		Leaf Blight	Anthracnose	Rust
		(% I)	D, R	(% I)	D, R	(% I)	D, R	S.G	S.G	S.G
1.	TKSV 1036	4.60	R	9.90	R	0.0	HR	4 (MR)	4 (MR)	3 (R)
2.	K12 (c)	0.0	R	0.0	HR	0.0	HR	2 (R)	2 (R)	2 (R)
3.	CO 32 (c)	5.56	MR	10.30	MR	0.0	HR	3 (MR)	3 (R)	2 (R)



Table 9.1. Screening for diseases under artificial conditions during kharif 2020-21

S.No	Entries	Downy mildew		Grain mould		Ergot	
		(%)	Disease reaction	(% severity grade)	Disease reaction	(% Panicle infected)	Disease reaction
1	CO 32 (c)	10.50	MR	12.30	MR	7.5	R
2	TKSV1036	13.50	MR	4.70	R	6.5	R
3	K12 (c)	0.0	I	0.0	HR	0.0	HR

Under artificial screening, the entry TKS1036 showed resistance to grain mould (4.70 % severity grade) and ergot (6.5 % severity grade) and was moderately resistant to downy mildew. In rabi season, the entry TKS1036 showed moderate resistance to downy mildew (18.50 % Panicle infected), grain mould (10.20 % severity grade), and ergot (13.50 % Panicle infected), and resistance to other foliar diseases (rust, anthracnose, leaf blight). Drought is a significant stress affecting sorghum cultivation in semi-arid regions. It is an epidemic stress common in semi-arid regions due to insufficient, unevenly distributed, and unpredictable rainfall (Rajarajan *et al.*, 2021). Climate change projections indicate that there will be abrupt changes in rainfall patterns over the next four decades, along with an increased risk of high temperatures, which

will intensify drought stress (Prasad *et al.*, 2021). Physiological and morphological traits contribute to drought tolerance in sorghum. The Sorghum culture TKS1036 was screened for drought tolerance along with the check K 12. The culture TKS1036 was recorded as moderately tolerant to drought, compared to the check K 12 (Table 10).

Sorghum is a dual-purpose crop that meets both the need for grain for human consumption and dry fodder for animals in dryland ecosystems. The grain quality of TKS1036 was better than K 12 for protein content (10.9 g), fat content (3.36 g), crude fibre (3.20 g), and amylose content (10.41 g). Sorghum is traditionally consumed by the lower social classes. Now it is moving up the ladder and is being consumed

Table 10. Performance of sorghum culture TKS1036 for drought tolerance

S. No.	Entry	Plant height (cm)		Leaf area (cm ² /plant)		Photosynthetic rate (µ mol m ⁻² s ⁻¹)		Stomatal conductance [mol H ₂ O m ⁻² s ⁻¹]		Length of stomata (µm)		Width of stomata (µm)	
		C	D	C	D	C	D	C	D	C	D	C	D
1	TKSV 1036	245	230	360.2	334.6	37.5	34.6	0.40	0.37	8.18	7.80	7.59	7.04
2	K 12	280	266	400.0	370.8	46.9	43.5	0.51	0.46	12.0	11.47	10.24	10.0



Field view of sorghum variety K 13

Table 11. Grain Quality Tests of Sorghum Culture TKS V 1036

S.No.	Nutrient analysis	TKSV 1036	K 12
1.	Protein (g)	10.9	10.5
2.	Fat (g)	3.36	3.16
3.	Crude fibre (g)	3.20	3.06
4.	Starch (g)	46.17	47.88
5.	Amylose (g)	10.41	10.03
6.	Tannin (mg)	0.06	0.05
Fodder quality result of sorghum culture TKS V 1036			
1.	Crude protein	4.08	4.31
2.	Crude fibre	29.71	30.48
3.	NDF	61.36	64.75
4.	ADF	36.09	39.01
5.	IVDMD -24 hours	34.44	32.77
6.	IVDMD -48 hours	46.77	43.39

The sorghum culture TKS V 1036 was released as K 13 in 2023 for the benefit of the farming community in the Southern district.



Panicle of sorghum K 13

by economically well-off sections as well. The higher grain quality of this variety will make it desirable in the high-end market, which will benefit the marginal-producing farmer by fetching a higher price. Protein content and digestibility of fodder are two important characteristics for quality in fodder sorghum. The sorghum culture was found to perform better, with a high IVDMD of 34-46 per cent (Table 11).

ACKNOWLEDGMENTS

Conflict of Interests

Funding and Acknowledgment:

The authors should acknowledge any financial

support received during the research process. For instance, if the research was funded by a specific organization or grant, it should be mentioned here. Similarly, acknowledgment of any collaborators or institutions that contributed to the research must also be included.

Ethics Statement:

This section should indicate whether ethical approval was needed for the research. If no ethical approval was required (for example, in studies involving only plants or inanimate objects), this should be clearly stated.



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Competing Interests:

Authors should declare any potential conflicts of interest, financial or otherwise, that could affect the research or its interpretation.

Data Availability:

It is essential to mention where the data supporting the manuscript's conclusions can be found. If the data is included within the manuscript, this should be stated. If additional data is required, contact information for the corresponding author should be provided.

Author Contributions:

Clearly define each author's contribution to the research and writing of the manuscript. For example, who conceived the research idea, who performed experiments, who wrote the manuscript, etc.

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