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Research Article

A new high yielding dual purpose sorghum variety CO 32 for Tamil Nadu

B. Selvi*, K. Ganesamurthy, S. Sivakumar, P. Jeyaprakash, A. Yuvaraja, D. Kavithamani, R. Latha, N. Malini, R. Kalpana, S. Manoranjitham, A. Sudha, P. Anandhi, S. Manimegalai, N. Vadivel, T. Srinivasan, P. Vennila, R. Ravikesavan and S. Geetha

Department of Millets, Centre for Plant Breeding and Genetics, TNAU, Coimbatore - 641 003, Tamil Nadu, India
***E-Mail:** bselvi@tnau.ac.in

Abstract
The sorghum culture TNS 648 (APK 1 x M35-1) recorded an average grain yield of 2445 kg/ha and fodder yield of 6490 kg/ha with an increase of 10.30 per cent and 10 per cent, respectively over CO 30 under rainfed condition. It also excelled K 12 by recording a 9.17 per cent and 13 per cent increase for grain and fodder yield, respectively. In irrigated situation, TNS 648 recorded an average grain yield of 2911 Kg/ha and fodder yield of 11710 kg/ha with a yield increase of 12 per cent and 10, respectively overruling sorghum variety CO 30. TNS 648 also performed better over K12 by recording an 11.32 per cent and 14 per cent increase for grain and fodder yield, respectively. Under AICRP on Sorghum national level testing, TNS 648 recorded a mean yield of 3100 Kg/ha and fodder yield of 11453 Kg/ha and excelled CSV 17 by recording 6.11 and 29.99 per cent increase of grain and fodder yield, respectively. It matures in 105 - 110 days, Grains are highly acceptable, yellowish white in colour, borne on medium semi-compact ear heads. The sorghum culture TNS 648 is moderately resistant to important shoot pests *viz*., shoot fly and stem borer. It is moderately resistant to downy mildew and grain mold. It has high protein (11.31-14.66 %) and fiber content (5.8 %) along with better cooking quality traits. Hence, the promising culture TNS 648 has been proposed for new release during 2020 and released as sorghum CO 32 for general cultivation in Tamil Nadu for both under rainfed and irrigated condition.

Key words
Sorghum, Sorghum bicolor, new variety, dual purpose CO 32

INTRODUCTION

Sorghum is one of the most important dryland crops grown in *kharif* and *rabi* seasons as a dual purpose crop in Tamil Nadu. It is cultivated over an area of 3.85 lakh hectares with an annual production of 4.30 lakh tones with a productivity of 1117 kg/ha of grain (2017-18). The major sorghum growing districts in Tamil Nadu are Namakkal, Dindigul, Tiruppur, Salem, Coimbatore, Trichy and Dharmapuri. More than 80 per cent of the sorghum is cultivated as a rainfed crop by the marginal farmers to meet out the demand of grain for consumption and dry fodder as animal feed. The changing food habit in view of better health, there is a demand for sorghum grain as health food. Besides sorghum is the major dry fodder to fulfil the requirement of dryland farmers. Sorghum is also prone to some of the pests like shoot and stem borer and diseases like grain mould and downy mildew.

Crop improvement is a continuous programme and better varieties in terms of productivity and resistance with the altered genetic background are developed and released

by the Department of Millets, TNAU for the benefit of the farming community. The latest variety released was TNAU sorghum variety CO 30 during the year 2010. With the objective of developing more productive varieties than CO 30, the sorghum culture TNS 648 has developed by crossing APK 1 × M35-1 and tested for its superiority in various yield trials.

MATERIALS AND METHODS

Sorghum culture TNS 648 is a hybrid derivative of the cross APK 1 × M35-1 developed at the Department of Millets, Centre for Plant Breeding and Genetics, TNAU, Coimbatore. This culture was evolved with an objective to develop dual purpose sorghum variety with improved tolerance to shoot fly and stem borer. It matures in 105 - 110 days, Grains are yellowish white in colour, borne on medium semi-compact ear heads. The culture was tested in station trial during the year 2012-13, Multi Location Trials (MLT) during the year 2014 to 2016 and Adaptive Research Trial (ART) in a farmers field in all the sorghum growing areas during the year 2017-19 both in irrigated and rainfed condition. It was also tested in All India Co-ordinated Research Projects on Sorghum (AICRP on Sorghum) during the year 2015 in *kharif* season in the name of SPV2369 in eleven locations across the nation. The culture was subjected to natural as well as artificial screening for pest and diseases. The nutritional quality of the grain and fodder was evaluated to assess the suitability of grain for consumption and fodder for invitro digestibility.

RESULTS AND DISCUSSION

Sorghum culture TNS 648 was tested during k*harif* 2012 and summer 2013 under irrigated condition. The mean performance of TNS 648 for grain yield was 3402 kg/ha with a yield increase of 14.5 per cent and 24 per cent over the check variety CO 30and K 8, respectively. For dry fodder the yield recorded was 11859 kg/ha with yield gain of 12.34 and 13.43 per cent over CO 30 and K8, respectively (**Table 1**).

Table 1. Performance of TNS 648 in station trial under irrigated condition

Grain yield (kg/ha)			
Trial/Culture	**TNS648**	**CO 30**	**K8**
NRRYT-*kharif* 2012	3200	2874	2734
UVT- Summer -2013	3604	3065	2732
Mean	**3402**	**2970**	**2733**
% increase over CO 30	14.5		
% increase over K8	24		
Dry fodder yield (kg/ha)			
NRRYT- *kharif* 2012	9815	8770	8600
RRYT-L *kharif* 2012	11750	11915	11000
UVT- Summer -2013	14014	10986	11766
Mean	**11859**	**10557**	**10455**
% increase over CO30	12.34		
% increase over K8	13.43		

Table 2. Performance of TNS 648 for grain yield and fodder yield (kg/ha) in MLT under rainfed condition

Grain yield (kg/ha)				
Year	**Centre**	**TNS 648**	**CO 30**	**K12**
2014-15	Kovilpatti	1944	2352	1620
	Aruppukottai	2500	600	3200
2015-16	Kovilpatti	2395	2960	2880
	Aruppukottai	1944	2311	2008
	Kovilpatti	3500	2688	2580
	Yethapur	2457	2182	2457
% increase over CO 30		12.57		
Dry fodder yield (kg/ha)				
2016-17	Aruppukottai	6048	5317	5092
	% increase over CO 30	13.75		
	% increase over K12	18.77		

MLT was conducted under both irrigated and rainfed condition in TNAU research stations. Under rainfed condition, the trial was conducted in seven locations during *rabi* season from 2014 to 2016 and the culture TNS 648 recorded a grain yield of 2456 kg/ha with a yield increase of 12.57 per cent over the check CO 30 and dry fodder yield of 6048 kg/ha with a yield advantage of 13.75 and 18.77 per cent increase over CO 30 and K12, respectively (**Table 2**).

Under the irrigated condition, TNS 648 was tested in 11 locations both in *kharif* and summer season from the year 2014 to 2016. Sorghum TNS 648 excelled the check variety CO 30 and K12 by recording an 8.75 and 11.15 per cent increase with the grain yield potential of 3238 kg/ ha. Dry fodder yield was recorded in five locations, TNS 648 recordedthe highest dry fodder yield of 11621 kg/ha with a yield advantage of 8.46 and 14.74 per cent increase over the check variety CO 30 and K12 (**Table 3**).

Table 3. Performance of TNS 648 for grain yield and fodder yield in MLT under irrigated condition

Grain yield (kg/ha)					
Season	**Year**	**Centre**	**TNS 648**	**CO 30**	**K12**
kharif	2014-15	Coimbatore	2413	2308	2154
		Bhavanisagar	2074	2241	1824
		Paiyur	3687	3787	3803
	2015-16	Coimbatore	2982	2510	2510
		Pattukottai	4320	3132	3132
		Paiyur	2420	2279	2279
	2016-17	Vaigai Dam	3701	3875	3875
Summer	2014-15	Coimbatore	3319	2854	2521
	2015-16	Coimbatore	2250	2308	2154
		Coimbatore	4200	3778	3633
	2016-17	Coimbatore	4259	3688	4167
	Mean	**11**	**3238**	**2978**	**2913**
	% increase over CO 30		**8.75**		
	% Inc. over K12		**11.15**		
Dry fodder yield (kg/ha)					
kharif	2014		11707	11657	11849
	2015		13119	11963	10884
Summer	2015		11331	11248	10946
	2016		12981	11830	11585
	2017		8967	6877	5375
	Mean		**11621**	**10715**	**10127**
	% increase over CO 30		8.46		
	% increase over K12		14.74		

The Sorghum culture TNS 648 was tested in AICRP trials during *kharif* 2015 as SPV2369 in eleven locations. The mean grain yield recorded was 3109 kg/ha with a 6.11 per cent increase over CSV 17 and fodder yield recorded was 11453 kg/ha which was a 29.99 % increase over CSV 17 (**Table 4**).

The variety TNS 648 was evaluated in ART both under rainfed and irrigated condition extensively. Under the rainfed condition, it was tested in 112 trials in 19 districts. The average grain yield recorded was 2429.52 kg/ha with an increase of 9.43 and 12.43 per cent increase over the ruling variety CO 30and K12, respectively. The fodder yield recorded was 6600 kg/ha with yield gain of 9.1 and 11.2 per cent over the ruling variety CO 30 and K12, respectively. Under the irrigated condition, it was tested in 20 trials during the year 2017-18 and the mean grain yield recorded was 2828 kg/ha with a grain yield advantage of 13.76 and 10.03 per cent increase over CO 30 and K12, respectively (**Table 5**).

The pooled performance of the variety TNS 648 over the year and season tested in various trials are the criterion for assessing the performance of the variety to release as a new variety. The culture TNS 648 recorded an average grain yield of 2445 kg/ ha and fodder yield of 6490 kg/ ha with an increase of 10.30 per cent and 10 per cent, respectively over CO 30 under rainfed condition. It also excelled K 12 by recording a 9.17 per cent and 13 per cent increase for grain and fodder yield, respectively. In irrigated situation, TNS 648 recorded an average grain yield of 2911 kg/ha and fodder yield of 11710 kg/ha with a per cent yield increase of 12 and 10, respectively over the ruling sorghum variety CO 30. TNS 648 also performed better over K 12 by recording an 11.32 per cent and 14.00 per cent increase for grain and fodder yield, respectively (**Table 6**).

Table 4. Performance of TNS 648 in AICRP trials for grain yield (kg/ha)

Sl. No.	Centre	SPV 2369	CSV 17	CSV 20	CSV 23	CSV 27	Local check
1	Coimbatore	2312	2618	2868	2743	4029	3824
2	Deesa	1730	2000	2132	1655	1904	2036
3	Diggi	1210	661	886	721	796	886
4	Palem	3545	2329	3087	2931	2510	2907
5	Udaipur	2539	2562	3205	2562	2242	3249
6	Akola	3345	2517	4084	3673	4054	4411
7	Chamrajnagar	3476	1114	3417	5165	4189	2427
8	Dharwad	6067	6247	6943	7295	6987	8033
9	Indore	1183	724	1440	1337	1595	3137
10	Kovilpatti	3367	4625	4272	2963	2778	3001
11	Surat	2326	3908	3084	2378	2284	3546
	Mean	3110	2930	3542	3342	3337	3746
% increase over CSV 17		6.11					
			Dry Fodder yield (kg/ha)				
Sl. No.	Centres	SPV 2369	CSV 17	CSV 20	CSV 23	CSV 27	Local check
1	Coimbatore	12863	11562	12012	12087	12337	12462
2	Deesa	9910	6306	12913	13814	16816	10511
3	Diggi	11441	7688	7387	11592	8648	6517
4	Palem	18128	8058	19835	18764	22613	23278
5	Udaipur	8875	6678	9898	8892	9634	7413
6	Akola	14039	10540	12958	12520	13030	1309
7	Chamrajnagar	8003	8860	13307	14321	13509	8517
8	Dharwad	12462	9459	16817	19369	16817	17568
9	Indore	6430	4428	8745	8488	9774	9259
10	Kovilpatti	14838	10099	16315	13213	15889	13664
11	Surat	8997	13248	12856	9165	9171	10994
	Mean	11454	8812	13004	12929	13476	12116
	% increase over CSV 17	29.99					

Table 5. Performance of TNS 648 in Adaptive Research Trials

		Grain yield kg/ha (Rainfed condition)		
Trial	Number of locations	TNS 648	CO 30	K12
Kharif (2017-2018)	37	2141	1916	1840
Rabi (2017-2018)	41	2734	2452	2383
Kharif (2018-2019)	15	2387	2179	2099
Rabi (2018-2019)	19	2456	2333	2322
Total	112	2429	2220	2161
% increase over CO 30		9.43		
% increase over K12		12.43		
		Grain yield (kg/ha) - Irrigated condition		
Summer(2017-2018)	20	2828	2486	2570
% increase over CO 30	13.76			
% increase over K12	10.03			
		Dry fodder yield (kg/ha) - Rainfed condition		
Kharif (2017-2018)	2	6450	6100	5625
Rabi (2017-2018)	2	6750	6000	6250
Total	4	6600	6050	5938
% increase over CO 30		9.1		
% increase over K12		11.2		

Table 6. Mean performance of sorghum culture TNS 648

Trial	Number of locations	TNS 648	CO 30	K12	Per cent increase over CO 30	Per cent increase over K12
Grain yield under irrigated condition (kg/ha)						
Station trial	2	3402	2970	2733	14.6	24.5
MLT-Irrigated	11	3239	2978	2914	8.8	11.2
ART-Summer (2017-18)	20	2828	2486	2570	13.8	10.0
AICRP-Sorghum	11	3110	2930	-	6.1	-
Mean	44	2911	2601	2615	12.0	11.32
Grain yield under rainfed condition (kg/ha)						
MLT-*Rabi*	5	2457	2182	2458	12.6	0.0
ART-*Kharif* (2017-18)	37	2141	1916	1840	11.8	16.4
ART-*Rabi* (2017-18)	41	2734	2452	2383	11.5	14.8
ART-*Kharif* (2018-19)	15	2387	2179	2099	9.6	13.8
ART-*Rabi* (2018-19)	19	2456	2333	2322	5.2	5.0
Mean	**117**	**2445**	**2217**	**2240**	**10.3**	**9.17**
Dry fodder yield under irrigated condition (kg/ha)						
Station Trials	3	11860	10557	10455	12.0	13.0
MLT	5	11621	10715	10128	8.0	15.0
AICRP-sorghum	11	11453	8812	-	30.0	-
Mean	**19**	**11711**	**10656**	**10251**	**10.0**	**14.0**
Dry fodder yield under rainfed Condition (kg/ha)						
MLT	1	6048	5317	5092	14.0	19.0
ART *Kharif* (2017-18)	2	6450	6100	5625	6.0	15.0
ART- *Rabi* (2017-18)	2	6750	6000	6250	13.0	8.0
Mean	**5**	**6490**	**5903**	**5768**	**10.0**	**13.0**

The major pests are shoot fly and stem borer in sorghum. Sorghum shoot fly, *Atherigona soccata* Rondani (Diptera: Muscidae) and stem borer, *Chilo partellus* Swinhoe (Lepidoptera: Pyralidae) is the major insect pests that severely devastate to sorghum crop (Thakur, 2019). Shoot fly is the most destructive one and causes severe damage in the early seedling stage at 7-30 days after seedling emergence. On the other hand, stem borer is also playing an important role in the reduction of sorghum production. The infestation of *C. partullus* is about 4-45 per cent in sorghum and maximum infestation occurred during August, which declined gradually in September and October (Singh, 1985). It was screened for both natural as well as under artificial condition along with checks and was found to be moderately resistant to both shoot fly and stem borer (**Table 7**).

Table 7. Reaction of sorghum culture TNS 648 to pest Incidence

Pest / Season	Shoot fly (Dead heart %)				Stem borer (Dead heart %)			
	TNS 648	CO 30 (CV)*	IS18551 (RC)*	DJ 6514 (SC)*	TNS 648	CO 30 (CV)*	IS18551 (RC)*	DJ 6514 (SC)*
Kharif 2015	36.8	22.9	2.2	45.3	14.22	7.64	3.33	12.49
Rabi 2016	18.26	-	9.09	38.25	6.25	-	11.36	14.58
Kharif 2019 (AS)*	No incidence was noted in all the entries				35	35	10	60
Mean	27.53 (MR)	22.9 (MR)	5.65	41.78	18.49 (MR)	21.32 (MR)	8.23	29.02

(AS)* - Artificial screening; (CV)* - Check Variety; (RC)*- Resistant Check; (SC)* - Susceptible Check

Reaction of sorghum cultures TNS 648 to diseases

Among the diseases, grain mold is one of the most important biotic constraints to the production of grain sorghum worldwide (Thakur *et al.*, 2006 and Williams *et al.,* 1981). Sorghum downy mildew is economically important and widespread in many tropical and subtropical regions of the world where sorghum and maize are grown (Jegera *et al.,* 1998 and Williams, 1984). The sorghum culture was screened for both grain mold and downy mildew along with checks. TNS 648 recorded a moderately resistant reaction for both grain mould (10.23 %) and downy mildew (7.43 %) (**Table 8**).

Table 8. Reaction of sorghum variety TNS 648 (SPV 2369) to diseases

Disease/ Season	Grain mold field grade (1-9 scale)			Grain mold threshed grade (1-9 scale)			Downy mildew (%)		
	TNS 648	CO 30	K12	TNS 648	CO 30	K12	TNS 648	CO 30	K12
AICRP 2015	6.7	7.3	-	6.0	5.3	-	14.0	1.0	-
Kharif 2018	10.5	12.0	11.9	10.9	13.0	10.9	4.10	9.30	3.50
Kharif 2019 (AS*)	13.5	12.9	13.5	13.5	12.5	14.0	4.20	9.50	4.00
Mean	**10.23**	**10.73**	**12.7**	10.13	10.26	12.45	7.43	6.60	3.75
Reaction	MR*			MR*			MR*		

AS*- Artificial screening; MR*- Moderately resistant

Sorghum is a dual purpose crop that satisfies both the need of grain for consumption and dry fodder for animals in dryland ecosystem. The grain quality of TNS 648 was better than CO 30 for protein content (11.31-14.66 %) fat content (2.26-2.34 %) ancrude fiber content(4.95-5.80 %). With respect to tannin content TNS 648 (88.56-89.60 %) was on par with the check variety CO 30 (88.56-89.60). TNS 648 excelled the check variety CO 30 by recording a higher cooking grade of 9 and found to be suitable for consumption. Sorghum is traditionally consumed by lower segments of society. Now it is moving up the ladder and is being consumed by economically well of sections also. The higher grain quality of this variety will make it desirable for 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 components for quality in fodder sorghum. The culture TNS 648 was found to better with a high IVDMD of 54 to 58 per cent and crude fiber of 29 per cent with 6.15 per cent protein content (**Table 9**).

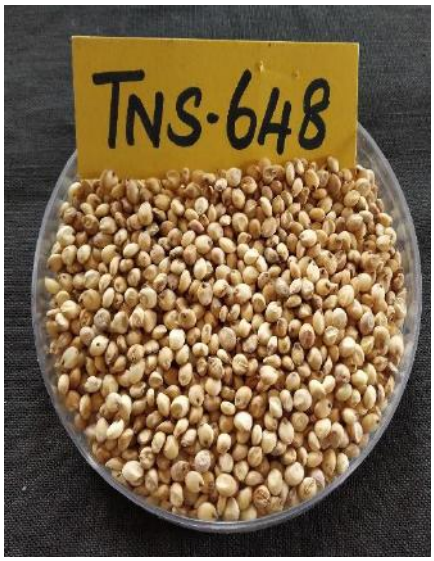
Table 9. Grain and fodder quality traits of Sorghum culture TNS 648

Description	TNS 648	CO 30
Grain quality		
Protein (%)	11.31-14.66	9.44 - 12.26
Fat %	2.26-2.34	2.06-2.29
Crude fibre %	4.95-5.80	4.70- 5.50
Tannin (mg/100 g)	88.56-89.60	87.12-87.50
Cooking grade-Overall	9	7
Fodder quality		
Stover Crude Protein (%)	6.15	7.09
IVDMD (%)	54-58	50-56
Crude fibre (%)	29.0	29.0

In any breeding programme, the primary objective of the breeder is the identification of superior entries in terms of yield potential. 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 TNS 648 recorded superior grain and fodder yield and excelled the check variety CO 30 and K12. Besides 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 TNS 648. Hence, the culture TNS 648 was proposed as a new sorghum variety during the year 2020 and released as CO 32 for the benefit of marginal, small and tribal farmers.

Field view of sorghum variety CO 32

Panicle of Sorghum CO 32



Seeds of Sorghum CO 32

REFERENCES

Jegera, M. J., Gilijamsea, E., Bockb, C. H. and Frinkinga, H. D. 1998. The epidemiology, variability and control of the downy mildews of pearl millet and sorghum, with particular reference to Africa. *Plant Pathol*. 47:544-569. [Cross Ref]

Singh, U. C., Mirsa, U. S., Dhamdhere, S. V. and Dwivedi, U. S. 1985. Carryover of stalk borer Chilo partellus (Swinhoe.) in off season in different crops. *Journal of Entomological Research*, 9: 170- 173

Thakur,S R, Devasthali, S., Upadhayay, S. N. and R S Marabi, 2019. Field Screening of Sorghum Genotypes for Resistance to Shoot fly, *Atherigona soccata* and Stem borer, *Chilo partellus* . Bulletin of Environment, Pharmacology and Life Sciences Bull. *Env. Pharmacol. Life Sci.,* 8 (5): 62-67.

Thakur, R. P., Reddy, B. V. S., Indira, S., Rao, V. P., Navi, S.S., Yang, X. B. and Ramesh, S. 2006. Sorghum grain mould. In: Inf. Bull. No. 72. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502324, Andhra Pradesh, India.

Williams, R. J., and Rao, K. N. 1981. A review of sorghum grain molds. *Trop. Pest Manage.* 27:200-21. [Cross Ref]

Williams, R. 1984. Downy mildew of tropical cereals. *Adv. Plant Pathol*. 3:1-103.