Received: 17 May 2022 | Revised: 17 Sep 2022 | Accepted: 21 Sep 2022

Electronic Journal of Plant Breeding

Research Article

ATL 1: A high yielding Kodo millet variety

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Abstract
A high yielding, input responsive, non lodging *varagu* culture TN*Psc* 176 was developed at the Centre of Excellence in Millets, Athiyandal. It is a pure line selection from DPS 63. It is characterized by tufty and medium tall plant stature, strong and sturdy culm with regular, long panicles. It has 10-15 productive tillers/plant and non-shattering grains on the panicle. It matures in 105-110 days and has recorded 2506 and 4394 kg/ha of grain and straw yield, respectively in a total of 223 trials under rainfed conditions during the past eight years of evaluation at national and state levels. The yield was observed to be 12.5 and 13.8 per cent increase in terms of grain and 15.5 and 13.0 per cent increase in terms of straw over the check varieties, CO3 and TNAU 86, respectively. In view of the superior performance and desirable attributes *viz.,* easy threshability, synchronized maturity, non-lodging growth habit, bold and attractive light brown-coloured grains with good nutritional and cooking qualities, the *varagu* culture TN*Psc* 176 was released as ATL 1 during the year 2021, for cultivation in Ariyalur, Cuddalore, Dharmapuri, Madurai, Perambalur, Pudukottai, Salem, Vellore, Villupuram and Virudhunagar districts of Tamil Nadu.

Keywords: Kodo, *Varagu,* yield, non lodging

INTRODUCTION

Kodo millet (*Paspalum scrobiculatum* L.), otherwise known as *varagu* in Tamil, is a crop of marginal and dry land agriculture, known for its climate-resilience and better nutritional qualities (Sharma and Sharma, 2021). According to de Wet *et al*. (1983), it occurs in moist tropical and subtropical places around the world and was domesticated in India about 3000 years ago. It is widely cultivated in Madya Pradesh, Tamil Nadu, Jharkhand, Chhattisgarh, Rajasthan, Uttar Pradesh and West Bengal, with Madhya Pradesh being the leading producer (0.5 lakh tons/year) (Deshpande *et al.,* 2015 and Ganapathy, 2017). Kodo grains are characterized by protein 10.6 g /100 g, fat 4.2 %, fibre 12%, minerals 4.4 %, calcium 27 mg/100 g, phosphorus188 mg/100 g, iron 0.5 mg/100 g, riboflavin 0.09 mg/100g and niacin 2.0 mg/100 g (Hadimani *et al.,* 1995 and Devi *et al*., 2014). Among the millet crops, it has the highest free radical (DPPH) quenching activity followed by sorghum and finger millet (Deshpande *et al*., 2015). Cultivation of small millet crops is showing an increasing trend in view of their climate resilience and better consumer awareness about their nutritional qualities. Hence, breeding work was initiated to develop a short duration, high yielding, nutritionally rich, drought tolerant and uniformly maturing variety of kodo millet to ensure nutritional security of dry land, hill area and tribal farmers. It resulted in the identification of superior culture TN*PSc* 176, which was released and notified as ATL 1 *varagu* during 2021.

MATERIALS AND METHODS

The *varagu* culture TN*PSc* 176 was evolved at the Centre for Excellence in Millets, Athiyanthal. It is a pure line selection from DPS 63. Superior single plants with desirable yield contributing features were selected from the germplasm accession DPS 63 and forwarded on a progeny row basis with continuous selfing for six generations (**Fig.1**). During the period from 2012 to 2015, the culture was evaluated in different yield trials (RRYT, PYT, CYT and AYT) along with the checks CO 3 and TNAU86. During the period 2016 to 2018, it was evaluated in 10 Multi Location Trials and in 2018-2020 it was evaluated in Adaptive Research Trials in 150 locations. It was also evaluated in 24 locations from 2016 to 2019, in different parts of the country, under ICAR-All India Coordinated Research Project Trials. Simultaneously during 2017-2020, the culture was also evaluated in On Farm Trials (OFTs) in 54 locations and in large scale demonstration plots in different parts of Tamil Nadu during 2017-2020. Evaluation of grain and fodder quality parameters of *varagu* culture TN*PSc* 176 was carried out in comparison with the checks CO 3 and TNAU 86. Studies were also carried out to assess the reaction of the culture TN*PSc* 176 against important pests and diseases.

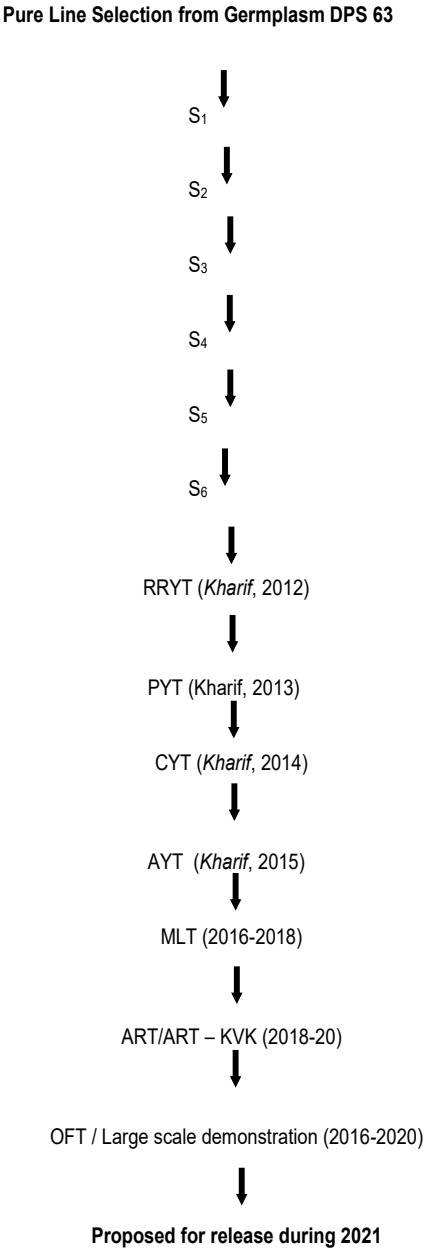

Fig. 1. Pedigree chart of Varagu culture TNPsc176

RESULTS AND DISCUSSION

In station trials (RRYT, PYT, CYT and AYT) conducted during 2012-2015, the *varagu* culture TN*PSc* 176 registered an average grain yield of 1423 kg/ha as against the best check CO 3, which recorded 1276 kg/ha. The test entry recorded a straw yield of 4148 kg/ha, which was better than the best check TNAU86, 3682 kg/ha (**Table 1**). Under MLT laid out in 10 locations during 2016 to 2018, the culture recorded a grain yield of 1728 kg per ha, which was 20.6 per cent higher than the

Table 1. Overall performance of *varagu* culture TN*Psc* 176 in trials

Name of the trials	Number of trials	Grain yield (kg/ha)			Straw yield (kg/ha)		
		TNPsc 176	CO 3 *	TNAU 86*	TNPsc 176	CO 3 *	TNAU 86*
Station Trials (2012-2015)	4	1423	1276	1245	4148	3040	3682
MLT (2016 –2018)	10	1728	1433	1286	3318	2560	2760
ART - GoTN (2018-2020)	70	2585	2307	2312	4489	3965	4051
ART - KVK (2018 -2020)	80	2220	2009	1976	4001	3428	3422
On Farm Trials (2017-2020)	54	2961	2590	2550	4955	4325	4452
Large Scale Demonstrations (2017-2020)	5	3504	3068	3142	5649	5001	5405
AICRP – SM (2016-19)	24	2760	-	2304 (19.8 %)	7521	-	6935 (8.5 %)
Mean of 223 trials		**2506**	**2228**	**2203**	**4394**	**3803**	**3888**
% increase over		**-**	**12.5**	**13.8**	**-**	**15.5**	**13.0**

* Check

Table 2. Grain and fodder quality characters of *varagu* culture TN*Psc* 176

S.No.	Quality characteristics	TNPsc176	CO 3 *	TNAU 86 *
a)	**Nutritional Quality**			
1.	Protein (g/100 g)	8.4	8.1	8.4
2.	Carbohydrate (g /100 g)	65.0	66.3	65.8
3.	Oil (g/100 g)	1.4	1.3	1.2
4.	Phosphorus (mg/100 g)	197	195	192
5.	Iron (ppm)	11.8	11.5	11.1
6.	1000 grain weight (g)	6.5	5.9	5.7
7.	1000 grain volume (ml)	5.5	5.7	5.0
b)	**Cooking qualities**			
1.	Water uptake (ml)	290	285	282
2.	Cooked volume (ml)	318	302	299
3.	Cooked weight (g)	425	418	403
c)	**Sensory evaluation score (1-10 score)**			
1.	Colour & appearance	9.4	9.1	9.0
2.	Flavour	9.0	9.0	8.5
3.	Texture	9.3	9.0	90
4.	Taste	9.5	9.0	9.5
d)	**Fodder Characteristics**			
1	Dry matter (%)	20.0	22.0	20.2
2	Crude protein (%)	9.8	9.3	9.6
3	Crude fibre (%)	17.0	18.2	17.8
4	Potassium (%)	2.1	1.8	1.7
5	Phosphorus (%)	0.7	0.5	0.6
6	Mineral matter (%)	3.0	2.8	2.9

*Check

Table 3a. Reaction of *varagu* culture TN*Psc* 176 to major pest

S. No.	Entry	Shootfly incidence (%) (30-45 DAS)	Dead heart symptom (%) (90 DAS)
1	TNPsc 176	2.50	1.25
2	CO 3	6.00	3.50
3	TNAU 86	5.25	4.00

Table 3b. Reaction of *varagu* culture TN*Psc* 176 to major diseases

S. No.	Entry	Sheath blight (%)	Brown spot (G)	Head smut (%)
1.	TNPsc 176	1.50	2	1.00
2.	CO 3	5.00	5	3.75
3.	TNAU 86	6.15	6	4.50
4.	RK 390-25 (R)	7.12	5	5.10
5.	JK 76 (S)	6.78	5	7.60

Table 4. Salient features of *varagu* culture TN*Psc* 176

S. No.	Character	TN*Psc*176	
		Range	Mean
1	Days to 50% flowering	68-73	70
2	Days to maturity	108-113	110
3	Plant height (cm)	65-70	68
4	Number of productive tillers	20-30	30
5	Flag leaf length (cm)	12.3-15.2	15.0
6	Flag leaf width (cm)	1.3-1.7	1.5
7	Length of inflorescence (cm)	5.5-8.2	8.0
8	Number of racemes above thumb	6-10	8.0
9	Length of longest raceme (cm)	11.5-13.0	12.0
10	Grain yield per plant (g)	16-30	21.0
11	Straw yield per plant (g)	18-32	23.0
12	Harvest index	0.31-0.35	0.33
13	1000 grain weight (g)	4.8-5.7	5.6
14	Plant habit	Erect	
15	Plant pigmentation at flowering	Absent	
16	Culm branching	Low	
17	Degree of lodging at maturity	Low	
18	Inflorescence compactness	Open	
19	Grain arrangement in inflorescence	Regular	
20	Shattering of inflorescence	Absent	
21	Fruit colour	Brown	
22	Grain shape	Oval	
23	Grain size	Bold	
24	Milling percentage	54	

best check CO 3 (1433 kg/ha). The culture TN*PSc* 176 was observed to record an average yield of 2585 kg/ha under ARTs conducted by the Department of Agriculture in 70 locations spread across Tamil Nadu. The superior performance of the culture was also observed in ARTs conducted in 80 locations throughout the state by KVKs. Under OFT and large-scale demonstrations conducted in five locations during 2017-2020, the culture was observed to record 3504 kg/ha, while the checks CO 3 and TNAU 86 recorded 3068 and 3142 kg/ha grain yield, respectively.

The culture was observed to record 19.8 per cent higher yield than the check TNAU 86 in All India Coordinated Trials conducted in 24 locations throughout the country during the period 2016 to 2019.

The *varagu* culture TN*Psc* 176 was observed to possess bold grains with a 1000 grain weight of 5.6 g. With respect to cooking qualities also, the culture TN*Psc* 176 was observed to possess favorable features with better water uptake, cooked volume and cooked weight. Nutritionally also the culture TN*PSc* 176 was observed to be superior. With respect to protein content, it recorded 8.4 g/100 g, which was on par with the check TNAU 86 and better than CO 3. It was also observed to contain better oil content (1.4 g/100g), phosphorus (197 mg/100g) and iron (12 ppm) (**Table 2**). It also recorded a good organoleptic score of 9 out of 10.

Small millets, being crops of marginal and drylands, play a great role in meeting the nutritional security of not only the farmers in the area but also their livestock. The superior nutritional quality of *varagu* culture TN*Psc* 176, as compared to the checks, was evident in terms of the higher protein content (9.8%), potassium content (2.1%), phosphorous (0.7%) and mineral content (3.0%).

The *varagu* culture TN*Psc* 176 recorded low shoot fly incidence which was evident from lesser dead heart occurrence as compared to the check varieties CO 3 and TNAU 86. The culture TN*Psc* 176 was observed to record less incidence of brown spot, sheath blight and head smut when compared with the check varieties CO 3 and TNAU 86 under controlled conditions (**Table 3a & 3b**).

The *varagu* culture TN*Psc* 176 completes 50 per cent flowering in 70 days and the crop attains maturity in 110 days. It has an erect plant type with an average height of 68 cm and also is highly tillering, with an average of 30 tillers (**Table 4**). It has long open panicles with an average inflorescence length of 8.0 cm. Grains are arranged regularly in the rachis. It possesses bold grains (1000 grain weight of 5.6 g) with brown colour and a better milling percentage (54%).

In view of the above superior performances of the culture TN*Psc* 176 over the qualifying checks TNAU 86 and CO 3, it was released as ATL 1, by the state variety release committee in the year 2021 and the same has been notified as ATL 1 in gazette notification number SO 8(E) dt.24.12.2021.

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