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Evaluating the suitability of drought tolerant rice genotype for rainfed conditions

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Abstract
The rice culture TM 09132 is an exotic **(**IR82590-B-B-14-3) drought tolerant line developed at IRRI, Philippines and is a cross derivative of IR 55419 – 4 / Way Rarem. In the present study, performance and suitability of this culture was evaluated for its drought tolerance under rainfed upland conditions at Rice Research Station, Tirur, Tiruvallur, Tamil Nadu during 2009-11, in Multi Location Trials at various Research Stations of Tamil Nadu Agricultural University (TNAU) during 2012-14 and under Adoptive Research Trials during 2014-15 and 2015-16 in seven districts and five Krishi Vigyan Kendra (KVK). On Farm trials were conducted in farmer's holdings under rainfed situation during 2017-18. This culture has recorded overall mean grain yield of 3938 kg /ha in all the trials conducted under rainfed conditions in 97 locations which was 19.6 and 17.8 per cent increased yield over the check varieties TKM (R) 12 (3294 kg / ha) and Anna (R) 4 (3344 kg/ha). The grain type of this culture is medium slender, white with high percentage of Hulling, Milling and Head Rice Recovery.

Keywords: Rice, rainfed, drought tolerant

Introduction
Drought stress is a serious yield limiting factor in rainfed ecologies, which is mainly due to inadequate or absence of rainfall and declining water availability. About 58 per cent of the total area in India is affected by drought stress which becomes precarious year after year in terms of both area growth and severity of stress. Rice is considered one of the most drought-susceptible plants due to its small root system, thin cuticular wax, and swift stomata closure (Sahebi *et al*., 2018) [6]. Cultivating high yielding rice varieties bred for irrigated ecosystem in rainfed areas results in high yield loss during drought years and further leads to decline in the countries rice production. Lack of drought tolerant high yielding rice varieties and low rates of their adoption are the major reasons for low productivity in water limiting environments. Therefore, raising the productivity in these areas is crucial for alleviating poverty and enhancing food security.

Farmers of drought prone areas require varieties that provide higher yield in years of good rainfall and sustainable good yield in years with drought. The development of improved varieties with combined tolerance of drought stress at multiple growth stages will help farmers in rainfed rice growing regions maintain stable yields across increasingly unpredictable climatic conditions (Padmini *et al*., 2017) [4]. To reduce yield loss under rainfed condition, new rice varieties with greater adaptation to drought are essential. Since the majority of the farmers living in drought prone ecologies are socio-economically under privileged, the drought tolerant varieties, can serve as one of the most viable and deliverable technologies for eradicating poverty from these ecologies (Dar *et al*., 2020) [3]. Hence identifying drought tolerant rice varieties, with high yield potential and stable performance is the need of the hour for increasing productivity under rainfed environment and the present investigation was aiming to identify the drought lines with higher yield potential and stable performance under rainfed ecosystem.

Materials and Methods
In the present study, drought tolerant culture TM 09132 (Exotic collection - IR82590-B-B-14-3 obtained from IRRI, Phillipines) was evaluated for its drought tolerance and adoptability. Performance of this culture was tested in Initial Yield Trial, Preliminary Yield Trial and Advanced Yield Trial at Rice Research Station, Tirur, Tiruvallur district, Tamil Nadu during 2009 to 2011 along with drought tolerant check variety TKM (R) 12 and Anna (R) 4 under rainfed condition.

Under rainfed condition, the paddy seeds were sown directly in the ploughed field with the onset of monsoon and the entire crop cultivation was carried out utilizing the monsoon rain for its water requirement. Further, it was tested in Multi Location Trials (at Research Stations located at Paramakudi, Tirur, Coimbatore and Bhavanisagar) during 2012-2014 and Adoptive Research Trials in six districts of Tamil Nadu *viz*., Tiruvallur, Kancheepuram, Viruthunagar, Villupuram, Sivakangai, Ramnadapuram and four Krishi Vigyan Kendras *viz*., KVK, Tiruvallur, KVK, Aruppukottai, KVK, Tindivanam and KVK, Ramanathapuram. The performance of this culture was also tested in ten farmers holdings in On Farm Trials (OFT) during 2017 under rainfed condition.

Results and Discussion

Drought in rain-fed rice areas causes severe damage to rice crop and lowers the yield. In Tamil Nadu, the frequency and severity of droughts is increasing in recent years and in the coming years, climate is expected to become more erratic, making events such as drought increasingly common. Rice is predominantly grown during the northeast monsoon period (October – January) in the rainfed areas of the Tamil Nadu and uncertainty in seasonal rainfall affects rice cultivation to a very large extent in these fragile environments due to lack of supplementary sources of irrigation. Farmers who lack irrigation facilities and rely on rainfed production are particularly vulnerable to drought. Farmers in rainfed areas grow rice varieties that are originally bred for irrigated condition. In the years with mild to moderate drought, irrigated lowland varieties show high yield losses and in years of severe drought, these varieties may fail to flower and produce any grain. Sustainable production in drought-affected areas can only be achieved through developing drought-tolerant varieties (Banwari Lal *et al*., 2020) [2]. Despite the deficit and uneven distribution of rainfall, drought tolerant varieties withstand the stress and the farmers can get an average yield advantage. Good yield with unique drought-tolerance is an important feature of drought tolerant varieties.

Considering the above facts, research work was carried out at Rice Research Station, Tirur to identify high yielding drought tolerant culture. As a result, TM 09132 (Exotic collection - IR82590-B-B-14-3 obtained from IRRI, Phillipines), a promising drought tolerant genotype for rainfed was identified. The yield performance and suitability of this culture for rainfed upland conditions was assessed.

In station trials conducted at Rice Research Station, Tirur during 2009, 2010 and 2011, the culture TM 09132 (IR82590-B-B-14-3) has recorded the mean yield of 3400 kg / ha in 115 days which is 31.7% higher than the best check TKM (R) 12 (2590 kg/ha) (Table 1). Multilocation trials play an important role in plant breeding to determine the yield stability and the pattern of response of genotypes across environments and to provide reliable guidance for selecting the best genotypes. In Multilocation trials conducted in eleven locations, this culture registered the pooled mean of 3487 kg / ha manifesting the yield advantage of 27.2 and 19.4 % over the drought tolerant check varieties TKM (R) 12 and Anna (R) 4 respectively (Table 2).

In the first year of Adoptive Research Trials (ART) conducted by the Department of Agriculture, Tamil Nadu in 23 locations during 2014-15, the culture TM 09132 registered an average yield of 3787 kg / ha under rainfed condition whereas the check varieties TKM (R) 12 and Anna (R) 4 recorded the mean yield of 3421 kg/ha and 3745 kg/ ha respectively. The results from the ARTs conducted by the Krishi Vigyan Kendras of Ramanathapuram, Tirvallur, Aruppukottai and Tindivanam in 18 locations revealed the superior performance of the culture TM 09132 (4066 kg / ha) when compared to the check varieties TKM (R) 12 (3324 kg /ha) and Anna (R) 4 (3511 kg /ha) (Table 3).

Most of the technologies or varieties developed by the researchers do not reach the target end-users in most cases. On farm trials are conducted to showcase the advantages of new varieties to farmers which will help in convincing more farmers to make better choices of varieties. In order to evaluate the performance of culture TM 09132 in On Farm Trials on the basis of existing farming situations and to get feedback from farmers and field functionaries, the culture was tested in participation with the farmers. On Farm Trials were laid out in farmer's holdings under rainfed condition in Ellaburam, Pattabiram, Gummdipoondi, Poondi and Kadambathur blocks of Tiruvallur district during the year 2017. Rainfall received during the cropping period was 460mm. This culture registered an average yield of 3654 kg/ha with yield increase of 7.38 % than the check Anna (R) 4 (Table 6). Farmer's preferred this culture because of providing yield more than 3.0 t/ha under rainfed condition and has the ability to withstand water stress, early vigour, higher straw yield and medium slender grain type.

The short duration, drought tolerant culture TM 09132 matures in 119 days and has recorded overall mean grain yield of 3938 kg /ha at 97 locations which was 19.6 and 17.8 per cent increased yield over TKM (R) 12 (3294 kg / ha) and Anna (R) 4 (3344 kg/ha) (Table 7). The rice of this culture is white and medium slender. It has high hulling, milling and head rice recovery percentage and moderately resistant to Green Leaf Hopper.

With more often occurrence of drought in rainfed rice ecosystems, it is necessary to enhance the adoption of drought tolerant varieties to sustain both household food and income security as these varieties fetch higher income to the farmers and withstand water stress guaranteeing the farmers the required yield to sustaining livelihood (Selvaraj and Ramasamy, 2006). The development of rice varieties exhibiting drought tolerance similar to the culture TM 09132 along with better grain yield can serve as the most logical approach to cope up with the menaces inflicted by drought.

Table 1: Performance of TM 09132 at Rice Research Station, Tirur under rainfed condition

S. No.	Year	Trial	Yield (Kg/ha)		
			TM 09132	TKM (R) 12	Anna (R) 4
1.	2009	Initial Yield Trial	3555	2730	2375
2.	2010	Preliminary Yield Trial	3430	2610	2115
3.	2011	Advanced Yield Trial	3215	2430	1983
		Mean	3400	2590	2158

Table 2: Pooled Mean in MLT Drought (2012-13 & 2013-14)

S. No.	Year (locations)	Grain yield (kg/ha)		
		TM 09132	TKM (R) 12	Anna (R) 4
1.	2012-13 (4)	3636	2041	2629
2.	2013-14 (7)	3388	3206	3116
	Mean (11)	3487	2740	2921
	% increase over the checks		27.2	19.4

Table 3: Performance of TM 09132 in Adaptive Research Trial – Rice 10/2014-15 under rainfed condition

Sl. No	Location	TM 09132		TKM (R) 12		Anna (R) 4	
		yield (kg/ha)	Days	yield (kg/ha)	Days	yield (kg/ha)	Days
I.	**ART DoA**						
1.	Tiruvallur (5)	4282	115	3590	115	4942	115
2.	Kancheepuram (5)	4340	125	3704	127	4198	122
3.	Ramanathapuram (4)	4283	121	3593	124	4569	104
4.	Virudhunagar (5)	2815	116	2977	116	2929	116
5.	Sivagangai (4)	3214	121	3239	118	2622	119
	Mean (23)	3787	120	3421	120	3745	115
II	**ART KVK**						
1.	KVK**,** Ramanathapuram (5)	4134	128	3832	128	4042	128
2.	KVK, Tiruvallur (3)	3778	118	2325	120	2406	115
3.	KVK, Aruppukottai (5)	3690	117	2985	122	3463	110
4.	KVK, Tindivanam (5)	4651		4156		4134	
	Mean	4066		3324		3511	

Table 4: Performance of TM 09132 in Adaptive Research Trial – Rice 10/2014-15 under rainfed condition

Sl. No	Location	TM 09132		TKM (R) 12		Anna (R) 4	
		yield (kg/ha)	Days	yield (kg/ha)	Days	yield (kg/ha)	Days
I.	**ART DoA**						
1.	Tiruvallur (5)	5258	115	4717	115	4663	112
2.	Kancheepuram (5)	4677	133	4125	132	4393	120
3.	Ramanathapuram(3)	3865	115	3647	115	4094	117
4.	Virudhunagar (5)	3873	125	3510	125	3930	125
5.	Sivagangai(3)	3512	135	3442	127	4094	117
6.	Viillupuram (3)	6605	124	6597	123	6702	120
	Mean (24)	4632	125	4340	123	4646	119
II	**ART KVK**						
1.	KVK**,** Ramanathapuram (5)	4108	128	3734	128	4000	128
2.	KVK, Tirur (5)	3749	119	2518	107	2255	105
3.	KVK, Aruppukottai (3)	3686		1781		2067	
4.	KVK, Tindivanam (5)	4589	118	4241	118	4015	118
	Mean (18)	4033		3069		3084	

Table 5: Pooled Mean in Adaptive Research Trials (2014-15 and 2015-16)

S. No.	Year	Grain Yield (kg/ha)		
		TM 09132	TKM (R) 12	Anna (R) 4
1.	ART DoA 2014-15 (23)	3787	3421	3745
2.	ART KVK 2014-15 (18)	4066	3324	3511
3.	ART DoA 2015-16 (24)	4852	4622	4646
4.	ART KVK 2015-16 (18)	4033	3069	3084
Overall mean (94)		4265	3609	3747
% inc. over checks			18.2	13.8

Table 6: Performance of TM 09132 in On-farm trials under rainfed condition

S .No.	Name & Address	Grain Yield (kg /ha)	
		TM 09132	Anna (R) 4
2016-17			
1.	Vadamathurai, Uthukkottai	2750	2280
2017-18			
2.	Pattabiram, Tiruvallur	3100	3060
3	Ventkatapuram, Tiruvallur	3600	3425
4.	Gummudipoondi, Tiruvallur	3100	3270
5.	Gummdipoondi, Tiruvallur	3250	3380
6.	Irayamangalam, Thitruvallur	3370	3015
7.	Thandurai, Tiruvallur	6563	5240
8.	Anntaikattuchteri, Patabiram	4125	4085
9	Pinjivakkam Kandigai, Thiruvallur	3400	3270
10.	Kadampathtur, Thtiruvallur	3285	3000
	Overall Mean	3654	3403
	% increase over check	7.38	

Table 7: Overall Performance of the drought tolerant culture TM 09132 under rainfed condition

Trials	Location	Grain yield (kg/ha)			Duration (days)		
		TM 09132	TKM (R) 12	Anna (R) 4	TM 09132	TKM (R) 12	Anna (R) 4
On-Station trial (2009 - 2011)	3	3400	2590	2158	115	120	114
MLT (2012-2014)	11	3487	2740	2921	116	129	116
ART- DoA (2014-2015)	23	3787	3421	3745	120	120	115
ART –DoA (2015-2016)	24	4852	4622	4646	123	122	117
ART - KVK (2014 -2015)	18	4066	3324	3511	118	119	115
ART - KVK (2015 -2016)	18	4033	3069	3084	122	118	117
Overall Mean	97	3938	3294	3344	119	121	116
% increase over the checks			19.6	17.8			

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