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Identifying Drought Tolerant Genotypes of Rice (*Oryza sativa* L.) Using Participatory Research Approach for Resource Poor Farmers of Orissa

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A B S T R A C T

To encourage rice-rice cropping system, enhance yield and livelihood in rainfed areas, Drought Breeding Network, Cuttack conducted "Participatory Varietal Selection (PVS)" trial at Samian and *Berna* village under drought prone rainfed condition during wet season. The management practices were consistent with local crop husbandry used by farmers and evaluations were made by the farmers. The genotypes *viz*., CR 2624 and IR 74371-70-1-1 were stable, however IR 74371-3-1-1 was found to be suited for fragile environments. The genotypes IR 74371-70-1-1, IR 74371-3-1-1, CR 2624 and IR 55419-04 yielded maximum than best check (Khandagiri) and exhibited low DSI and high DTE for grain yield also. These genotypes registered above 4.5 t ha^{-1} yield at on-station trial, early vegetative vigour, good drought score. Both male and female farmers scored each genotype for individual traits considered important by them and CR 2624, IR 74371-70-1-1 and IR 74371-3-1-1 genotypes were top three during participatory varietal selection.

Introduction

The demand for rice in India is projected to be 128 mt by 2012 and will require a production level of 3,000 kg ha^{-1} significantly greater than the present average yield of 1,930 kg ha^{-1} (Pandey *et al.,* 2007). Indian agriculture is mainly dependent on the climate of India: a favorable southwest summer monsoon is critical in securing water for irrigating Indian crops. In some parts of India, the failure of the monsoon results in water shortage, resulting in below-average crop yield. This is particularly true of major drought-prone regions such as southern and eastern Maharashtra, northern Karnataka, Andhra Pradesh, Orissa, Gujarat, and Rajasthan.

Groundwater has been depleted at alarming rates. Out of a total 610 districts nationally, 278 districts in 11 states have been declared as drought-hit during wet season, 2009.Drought in India was also reduced production of the 2010 *Kharif* crops including rice, coarse grains and pulses in nearly half the districts of the country.

Target Environments (TPE)

Participatory Varietal Selection (PVS)" trials were conducted at *Samian* and *Berna* villages of Cuttack District, Orissa to identify adaptable variety for rainfed drought prone condition with drought tolerance and high yield potential. Most farmers of these villages are resource-poor, with limited resources for irrigation facility. Low productivity is the main cause of high poverty. The coverage of land by rice crop during wet season was 99 per cent, while the coverage of rice during dry season was only 54 per cent. The early season drought occurs in most areas, affecting the time of transplanting and the growth of direct seeded rice. The irrigation sources of villages is *Kalakala* Minor Irrigation Project which is popularly known as *Gapala Bandha* and supplies water during both wet and dry seasons. The average yield of modern varieties in up, medium and low land was 2.86, 3.67 and 3.72 t ha^{-1} at both the villages. In drought cases, no yield was obtained in majority of the fields. Therefore, to enhance yield and livelihood of target area, PVS trials under Drought Breeding Network, Cuttack were conducted at *Samia* and *Berna* to identify adaptable variety for rainfed drought prone condition with drought tolerance and high yield potential.

Materials and Methods

Plant materials

Central Rice Research Institute (CRRI), Cuttack in collaboration with International Rice Research Institute (IRRI), Philippines are striving hard with pragmatic approach to develop drought tolerant rice varieties which can mitigate the changing climatic scenario and provide good stable yield in years of drought. Four hundred fifty genotypes were tested for yield and yield attributes under irrigated and drought conditions at CRRI, Cuttack under IRRI-India drought breeding network (DBN). Out of these, 15 promising genotypes were evaluated and tested along with four checks at four farmer's field in *Samia* and *Berna* villages of district Jajpur under participatory varietal selection trials. These genotypes responded well under severe drought conditions and displayed good drought score, recovery and early vegetative vigour, simultaneously, substantial yield also.

Experimental design

Tested genotypes were grown under rainfed conditions representing a sample of environments during wet season, 2009 at four farmer's field. The rain fall during the cropping season was less and erratic in these parts of Orissa and faced early and late season drought stress. Rice varieties at farmer's field 1: upland area (E_1) were directly sown at 2-3 cm soil depth in dry and pulverized soil by hand plough with the seed rate of 60 Kg ha^{-1} to maintain 3-4 seeds per hill. This method gave uniform seedling emergence for all the plots in 6-8 days. Each plot was 4 m long and 5.0 m wide, row to row distance was 15 cm and plant to plant distance was 10 cm each plot. Fertilizer was applied at the rate of 80, 40, and 40 kg ha^{-1} of N, P_2O_5, and K_2O, respectively. One third of nitrogen and entire dose of P_2O_5 and K_2O were given as basal dressing and remaining N was split into two doses applied at maximum tillering and flowering stages. Weeds were controlled by treating plot by pre-emergence herbicide (Petrilachlore) after three days of sowing followed by two hand weeding. At farmer's field 2: lowland (E_2) and farmer's field 3 and 4: medium land (E_3 and E_4), seeds were sown in the nursery and 21-day-old seedlings were transplanted to the main field. One seedling was transplanted per hill at a spacing of 15 cm between hills in plots 18 m^2.

Inorganic NPK fertilizer was applied at the rate of 100: 60: 40 kg ha^{-1}. Weeds were controlled by application of pre emergence herbicide Pretilachlor 4 days after transplanting (DAT) and hand weeding. The other trial management practices were consistent with local crop husbandry used by the farmers and evaluations were made by the farmers (male and female).

Observations and evaluation

Observations on days to 50 per cent flowering (DFF) and grain yield (GY) were recorded on the plot basis. The effect of drought was assessed as percentage reduction in mean performance of characteristics under rain-fed condition relatively to the performance of the same trait under irrigated condition.

Drought susceptibility index (DSI) for grain yield and other characters was calculated using the following formula (Fischer and Maurer, 1978). Drought tolerance efficiency (DTE) was estimated by the equation of Fischer and Wood (1981).

Results and Discussion

Drought Susceptible Index (DSI)

The DSI and DTE for the grain yield are presented in table 1. Large values indicate greater drought susceptibility (Winter *et al.*, 1988). Differences in DSI between genotypes were estimated for days to 50 per cent flowering and grain yield in this study (Fig. 1). The mean values of DSI for grain yield were below one, indicating the relative tolerance of this trait to drought while genotypes showed delay in flowering and more prone to drought stress.

Based upon the value and direction of desirability, ranking was done for different genotypes as highly drought tolerant (DSI<0.50), drought tolerant (DSI: 0.51-0.75), moderately drought tolerant (DSI: 0.76-1.00) and drought susceptible (DSI>1.00). Seven genotypes (63% of total) at all farmer's field were identified as drought tolerant genotypes (DSI<1) while, rest of the genotypes were identified as susceptible genotypes (DSI>1) for grain yield. An overall appraisal revealed that IR 74371-3-1-1 and IR 78877-181-B-1-2 emerged as highly tolerant genotypes while six genotypes *viz*., IR 79906-B-5-3-3, IR 72267-16-B-B-1, IR 55419-04 and CR 2624 grouped into moderately tolerant group. Furthermore, IR 74371-70-1-1 (0.74) recorded as drought tolerant on pool basis. Comparison across the farmer's field indicated that the genotypes IR 74371-3-1-1 emerged as highly tolerant genotypes for grain yield.

Earlier Prakash (2007) and Bandyopadhyay (2008) reported similar findings. The reduction in grain yield was observed under farmer's field for the different genotypes while experimental mean reduce up to 30.43 per cent. The similar findings were found by (Wonprasaid *et al.,* 1996). Differences among genotypes in yield under stress were partitioned into differences in yield potential, drought escape, and drought tolerance. Phenotypic traits related to yield under stress were divided into those reflecting drought escape and those reflecting drought tolerance.

However, the field data also indicated that considerable progress in yield under stress should be possible by selection for earlier flowering and improved yield potential alone (Fussell *et al.,* 1991).

In present study, depletion of soil moisture, which was associated with forced maturity during dough stage, might have resulted in decreased grain yield.

The present study revealed that among the seven genotypes are drought tolerant genotypes, as indicated by their relatively low DSI values for grain yield at farmer's field. Genotypes with lowest DSI, particularly for grain yield would serve as useful donors for drought breeding programme. The use of DSI is likely to be most beneficial in selecting parents for development of drought tolerant populations, especially when yield potential vary greatly among the tested genotypes.

Drought Tolerance Efficiency (DTE)

Drought tolerance efficiency (DTE) value which was one of the drought resistance parameters were ranged from 55-90 per cent in F_1, 58-96 in F_2, 55-89 in F_3 and 59-93 in F_4. Thus, IR 74371-3-1-1, IR 78877-181-B-1-2, IR 78875-53-2-2-2, CR 2624, IR 55419-04, IR 72267-16-B-B-1 and IR 79906-B-5-3-3 showed high DTE at all four farmer's field. On the other hand, IR 74371-3-1-1 and IR 78877-181-B-1-2 had lowest DSI. Results of this study have showed a parallelism with Parameshwarappa *et al.,* (2008) findings. They reported that minimum yield reduction was realized in the genotypes which had the highest DTE and the lowest DSI. While, IR 74371-3-1-1, CR 2624 and IR 74371-70-1-1 were most drought resistant genotypes with the minimum yield reduction and also highest DTE and lowest DSI; IR 78875-131-B-14-1 and IR 74371-46-1-1 and all the checks were the most drought susceptible genotypes with maximum yield losses and lowest DTE, also the highest DSI. Desmukh *et al.,* (2004) reported that the drought resistant genotypes had highest DTE, minimum DSI and minimum reduction in grain yield due to moisture stress. Considering the assimilate partitioning in component traits of rice, tolerant genotypes increased the grain yield.

Fig.1 Drought Susceptibility Index (DSI) for days to 50 per cent flowering and grain yield

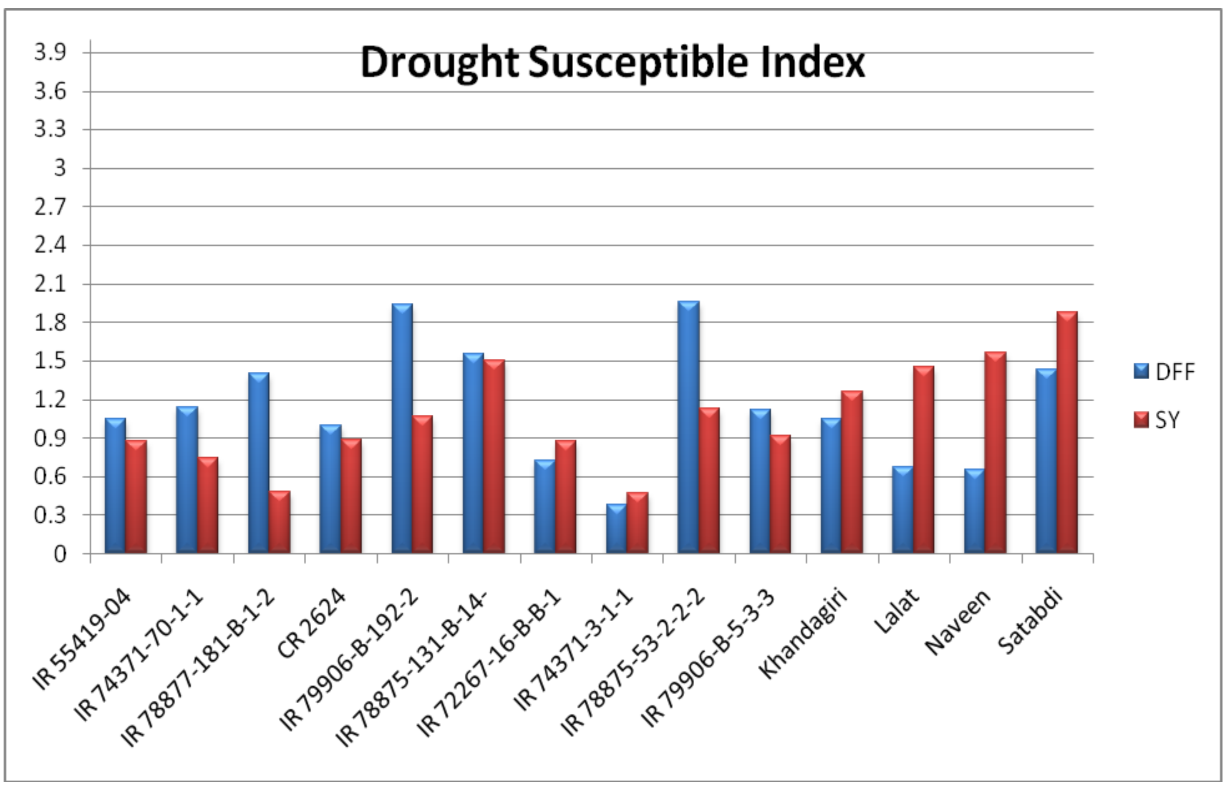

Table.1 Mean yield and drought susceptible index and tolerance efficiency of 15 genotypes grown at four farmer's field

S. No.	Genotypes	Mean yield (Kg ha^{-1})	Drought Susceptibility Index (DSI)					Drought Tolerance Efficiency (DTE)				
			Pooled	E_1	E_2	E_3	E_4	Pooled	E_1	E_2	E_3	E_4
1	**IR 72267-16-B-B-1**	3243.33	0.87	0.85	0.82	0.66	0.82	80	77	80	83	80
2	**IR 74371-46-1-1**	3187.50	1.18	0.93	1.22	0.96	1.21	73	75	71	75	71
3	**IR 74371-3-1-1**	3521.67	0.47	0.37	0.60	0.41	0.36	89	90	86	89	91
4	**IR 79906-B-192-2**	3237.50	1.07	1.06	0.56	1.07	1.18	75	71	86	72	72
5	**IR 78875-53-2-2-2**	3338.33	1.13	1.07	1.03	0.99	0.99	83	79	81	83	88
6	**IR 55419-04**	3437.50	0.88	0.76	0.84	0.78	0.83	80	79	80	80	80
7	**IR 74371-70-1-1**	3523.33	0.74	0.79	0.78	0.64	0.51	74	71	75	74	76
8	**IR 78875-131-B-14-1**	2878.33	1.50	1.34	1.21	1.31	1.60	66	64	71	66	62
9	**IR 78877-181-B-1-2**	3349.17	0.48	0.66	0.17	0.63	0.28	89	82	96	84	93
10	**IR 79906-B-5-3-3**	3105.83	0.92	0.76	0.91	0.83	0.87	79	79	78	78	79
11	**CR 2624**	3503.33	0.89	0.82	0.80	0.79	0.84	80	78	81	80	80
12	**Khandagiri**	3200.50	1.26	1.19	1.09	1.19	1.11	71	68	74	69	73
13	**Lalat**	2953.83	1.45	1.25	1.47	1.32	1.26	67	66	65	66	70
14	**Satabdi**	2441.67	1.88	1.66	1.76	1.75	1.70	57	55	58	55	59
15	**Naveen**	2606.67	1.56	1.48	1.42	1.32	1.47	64	60	66	66	65
Mean		43.67.33	1.09	1.00	0.98	0.98	1.01	75	73	77	75	76

Table.2 Ranking of varieties in Participatory Varietal Selection (PVS) trial at *Samian* and *Berna*

Varieties	**First**	**Second**	**Third**
	Figures in per cent		
CR 2624	30	12	33
IR 74371-70-1-1	23	38	5
IR 74371-3-1-1	17	20	17
Khandagiri	7	2	12
IR 55419-04	7	2	8

Participatory varietal selection

Participatory varietal selection is a farmer participatory approach for identifying farmer-preferred varieties. However, in the formal testing system varieties are identified for their superiority over the existing released varieties and much attention is given to grain yield and adaptability in the target area for promotion or release (Virk and Witcombe, 2008). Farmer-relevant traits other than yield are rarely considered while, promoting an entry although farmers are known to tradeoff multiple traits while selecting a variety. Participatory approaches that relied on focus group discussions (FGD) provided farmers' perceptions that were not obtained in the on-station trials and researcher managed FFTs, particularly those from women members of farming households. The grain yield of CR 2624, IR 74371-70-1-1 and IR 74371-3-1-1 were higher than the local check and farmers preferred CR 2624 for a range of other pre and post-harvest traits even though they disliked its late maturity (Table 2). Farmers of target environments selected cultivars on the basis of mid early/or medium duration (up to 110 days), grains panicle^{-1}, effective tillers hill^{-1}, less number of chaffy and grain type.

Grain yield selection is based on results from multi-location trials and more attention is given to testing under on-farm conditions. Farmer participatory plant breeding approaches have been integrated into the on-farm testing program to ensure that farmers will accept new cultivars. The visual combined assessment of performance and its stability is an important advantage, and adds confidence in the decision to promote a superior genotype. In the view of above discussion, the genotypes IR 74371-70-1-1 and CR 2624 recommended for cultivation under target environment in drought condition. Sahbhagi dhan (IR 74371-70-1-1), a drought-tolerant rice variety jointly developed by International Rice Research Institute, Philippines and Central Rainfed Upland Rice Research Station, Hazaribagh and CR 2624 (Pyari) for Aerobic condition by CRRI, Cuttack were released for cultivation.

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