Separating climate resilient crops through screening of drought tolerant rice land races in Nepal

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Abstract

Many studies have shown that local landraces are found to be better adapted to changing climatic conditions. The screening of local land races is one of important processes to detect drought tolerant behavior of crop species to further verify in similar field situation and genomic/molecular level studies. In 2009 for main season rice, a study was done to identify different land races of rice in Jhapa and Kailali districts to know their performance on drought stressed conditions by field techniques. Among the 22 rice land races studied, *Kataush* showed maximum drought tolerant efficiency (DTE) of 192.8% and minimum drought susceptibility index (DSI) of -0.88% followed by *Guthanisaro* (DTE=181% and DSI= -0.77%). Likewise, in the cluster analysis, these genotypes formed a cluster with two highest DTE and minimum DSI. Hence, these two land races could be used for drought stressed breeding program in the future to include drought resistant genes for variety impovement. Also, it was recorded that these land races could be used as the most drought tolerant variety in Terai region similar to Jhapa and Kailali, Nepal. These varieties could play important role in climate extreme situations, where farmers can adopt them as climatic resilient rice genotypes.

Key words: Land races, drought tolerant efficiency (DTE), drought tolerant index (DTI)

Introduction

Climate change is inevitable and its direct impact is on the livelihood of the farming communities. Building community's resilience to climate induced stresses has become one of the most imperative tasks for breeders and farmer's themselves. Farmers have been using their inherent knowledge to cope up with the climate variability time and again. But with the current trend of climate change and the variability in the weather patterns, poor and smallholder farmers of Nepal are facing several problems. Among them, drought is one of the major constraints which affect productivity. The recent projection on precipitation trends in Nepal shows that potential increase in variability at the spatial scale and will lead to severe cases of water stress throughout (NCVST, 2009). Farmers' capacity to cope with the negative impacts of climate change could be providing them options of varieties that are stress tolerant. Genetic improvement and variety development for adaptation to drought can be addressed through conventional approach by selecting for yield and its stability over locations over the years (Babu, 2003). Parameshwarapa and Salimath (2008) identified ICC 13124 (out of twelve genotypes) as the most drought tolerant genotypes with highest drought tolerance efficiency (DTE), least drought susceptibility index (DSI) and minimum reduction in seed yield due to stress which clearly indicated that improvement in drought tolerance is possible thorough simple selection. Based on this background the study for identifying drought tolerant rice varieties has been designed.

Rice is a semi-aquatic aquatic crop, it is more likely that rice production as well as productivity are highly affected by the unpredictable drought conditions in the rice growing season. It is the major staple cereal of Asian countries and its contribution to food security is extremely vital. Thus, research on developing stress tolerant rice varieties including drought tolerant varieties is emphasized. At the present context the drought stress is identified as significant threat to production, however, unraveling its drought tolerant traits in rice genotypes would be one of the strategies leading to development of drought resilient crops. In this context, a study was conducted to screen out rice genotyptes found in lower belt of Nepal to identify drought tolerant traits which would be useful for researches to identify the parental lines for further crop improvement.

Methodology

Drought is defined as a shortfall of water availability sufficient to cause loss in yield (Price, 2002). The attempt to measure the degree of tolerance with a single parameter has limited value because of the multiplicity of the factors and their interactive contribution to drought tolerance under field conditions. Different workers used different methods to evaluate genetic differences in drought tolerance (Bidinger *et al.,* 1982). The present investigation was therefore planned to find out the simple and precise field technique to detect genotypic differences in drought resistance and to quantify loss in yield. Farmers' suggested 24 genotypes of rice landraces were collected from the Terai region (East to west) of Nepal (from LI-BIRD projects site). These genotypes were evaluated during main season of 2009 in two Terai districts of Jhapa and Kailali. These rice varieties were treated in two conditions viz; under moisture stress conditions and under normal conditions in two sets of randomised block design with one replication. Each entry represented by 6 square meter (3 x 2 square meter) plot with row to row and plant to plant spacing as practiced by the farmers.

Stress timing is critical and the decision when to induce stress has implications for the level of stress imposed and the timing of stress may be constrained by weather conditions (Pinheiro, 2003). Thus irrigated control (normal condition) was supplied with continuous surface irrigation while the stress plots were rainfed from sowing to harvest (Babu et al., 2003). Based on IRRI Standard Evaluation System; among 9 growth stages of rice' tillering and booting were the most critical stages for drought. In the stressed condition treatment, each stressed period lasted for fifteen days. Therefore, in the stress plots care was taken to maintain stress during these two stages in which rain water was immediately drained out and experiment site was selected in such a location that it truly represents stress condition as far as possible. Five plants were sampled from each plot for recording stress related parameters.

With this design, the quantification of drought traits in selected rice genotypes were estimated and calculated with following indicator i.e. i. the drought tolerance efficiency (Fischer and wood 1981) and
ii. drought susceptibility index (Fischer and Maurer,1978). The following is the formula used for calculation.

Drought tolerance efficiency (DTE) is given by:

$$DTE\ \% = \frac{Yield\ under\ stress}{Yield\ under\ non\ stress} \times 100$$

Drought susceptibility index (DSI) is given by:

DSI = (1-Yd / Yp) / D

Where, Yd = Grain yield of the genotype under moisture stress condition
Yp = Grain yield of the genotypes under irrigated condition

$$D = \frac{\text{Mean yield of all strains under moisture stress condition}}{Mean\ yield\ of\ all\ strains\ under\ irrigated\ condition}$$

Results and discussion

Among twenty four genotypes of rice, *Dosara* and *Katar* were removed from the analysis due to late maturity. The data obtained from both Jhapa and Kailali districts were combined to analyze the results. Among the 22 lines analysed, *Kataush* showed maximum drought tolerant efficiency (192.8%) and minimum drought susceptibility index (-0.88%) followed by *Guthanisaro* (DTE=181% and DSI= -0.77%) (Table 1). Deshmukh *et. al.*, (2004) reported that the drought resistant genotype had highest drought tolerance efficiency, minimum drought susceptible index and minimum reduction in grain yield due to moisture stress.Considering the assimilate partitioning in component traits of rice, landrace *Kataush* increased the grain yield. Further, it had the highest DTE, least DSI and highest percentage increase in the grain yield due to stress. So, the preliminary findings showed *Kataush* was the most drought tolerant genotype among the tested ones. In order to identify the similarities and differences of the traits recorded in the analyzed rice genotypes, cluster analysis was carried out to allocate set of rice genotypes to set of mutually exclusive rice genotypes groups. The dendrogram formed (Figure 1) with the three parameters

Table 1. Grain yield of rice land races affected by by drought tolerance related characters in Jhapa and Kailali, Nepal

Genotype	Grain yield (kg/ha)						Combined mean	% reduction in yield	DTE %	DSI %
	Drought condition (Jhapa)	Drought condition (Kailali)	Mean	Normal condition (Jhapa)	Normal condition (Kailali)	Mean				
Anjana	1000.00	3000.00	2000.00	3000.00	1666.67	2333.33	4333.33	7.69	85.71	0.13
Bagari	833.33	2333.33	1583.33	2333.33	3166.67	2750.00	4333.33	26.92	57.58	0.40
Bagari 2	1666.67	1833.33	1750.00	1833.33	2666.67	2250.00	4000.00	12.50	77.78	0.21
Bhelasaro	2500.00	2000.00	2250.00	2000.00	1833.33	1916.67	4166.67	-8.00	117.39	-0.16
Dhunmuniya seto	1666.67	1833.33	1750.00	1833.33	2500.00	2166.67	3916.67	10.64	80.77	0.18
Dudhisaro	2333.33	2833.33	2583.33	2833.33	2500.00	2666.67	5250.00	1.59	96.88	0.03
Gajargaul	2000.00	2166.67	2083.33	2166.67	3000.00	2583.33	4666.67	10.71	80.65	0.18
Guthanisaro	2166.67	2666.67	2416.67	2666.67	0.00	1333.33	3750.00	-28.89	181.25	-0.77
Jharlajhi	2000.00	3166.67	2583.33	3166.67	2333.33	2750.00	5333.33	3.13	93.94	0.06
Karangi	2166.67	2500.00	2333.33	2500.00	2166.67	2333.33	4666.67	0.00	100.00	0.00
Kataush	2166.67	2333.33	2250.00	2333.33	0.00	1166.67	3416.67	-31.71	192.86	-0.88
Mutmur	2500.00	1000.00	1750.00	1000.00	1833.33	1416.67	3166.67	-10.53	123.53	-0.22
Nakkhisaro	3166.67	2333.33	2750.00	2333.33	1000.00	1666.67	4416.67	-24.53	165.00	-0.61
Nimow	2166.67	3000.00	2583.33	3000.00	2166.67	2583.33	5166.67	0.00	100.00	0.00
Rango	3000.00	2333.33	2666.67	2333.33	2166.67	2250.00	4916.67	-8.47	118.52	-0.17
Satha kalo	833.33	1500.00	1166.67	1500.00	0.00	750.00	1916.67	-21.74	155.56	-0.52
Satha seto	1166.67	1000.00	1083.33	1000.00	833.33	916.67	2000.00	-8.33	118.18	-0.17
Sathi	1833.33	2166.67	2000.00	2166.67	1666.67	1916.67	3916.67	-2.13	104.35	-0.04
Seto dalle	2666.67	3500.00	3083.33	3500.00	1166.67	2333.33	5416.67	-13.85	132.14	-0.30
Sikichan	1833.33	2833.33	2333.33	2833.33	1166.67	2000.00	4333.33	-7.69	116.67	-0.16
Sotwa	1166.67	3000.00	2083.33	3000.00	3000.00	3000.00	5083.33	18.03	69.44	0.29
Southyari	3000.00	2500.00	2750.00	2500.00	833.33	1666.67	4416.67	-24.53	165.00	-0.61

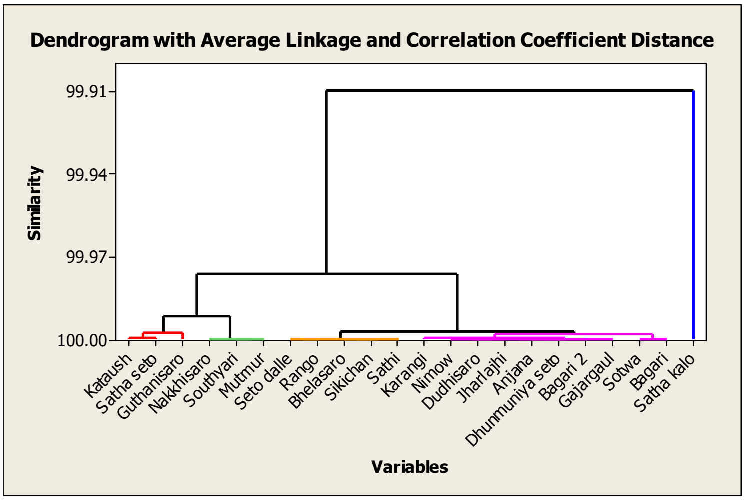

Figure 1. Clustering of rice landraces with percentage increase in grain yield

(DTE, DSI, percentage increase in grain yield) matched with the earlier findings. *Kataush* and *Guthanisaro* formed a cluster with two highest DTE and minimum DSI. Further simplifed clustering of rice genotypes are shown (Table 2). So, the genotypes with highest DTE on one side and least DTE genotypes on the other hand can easily be predicted and used for the genetic improvement of the crops under drought stressed condition in order to address the with the target objectives.

Table 2. Simplified clustered rice land races Rice land races collected from Jhapa and Kailali with respect to DTE and DSI

Cluster	Rice Genotypes
1	*Kataush Guthanisaro Satha seto*
2	*Nakkhisaro Southyari Mutmur*
3	*Satha kalo*
4	*Seto dalle Rango Bhelasaro Sikichan Sathi*
5	*Karangi Nimow Dudhisaro Jharlajhi Anjana Dhunmuniya seto Gajargaul Bagari 2 Sotwa Bagari*

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