Submergence Tolerance of selected Sri Lankan Traditional Rice (*Oryza Sativa* L) Accessions at seedling Stage

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Abstract

Micro climate of Sri Lankan rice fields varies significantly due to intermittent flooding and drying caused by changing pattern of climate. As traditional rice posse considerable biotic and abiotic stress tolerant traits, present study was carried out to screen out the selected traditional rice accessions for their submergence tolerance at the seedling stage. The experiment was conducted as randomized complete block design with four replicates and 10 plants per each replicate. Two weeks old rice seedlings were subjected to 09-day and 14-day complete submergence stress while the control was kept without submergence. Plants were evaluated after 2-week recovery period under de-submerged conditions. Submergence tolerance and mode of tolerance were identified as the survival rate and elongation/suppression respectively. Data were analyzed by ANOVA using SAS software. A significantly highest survival percentage was recorded by *Hondarawala*-4243 (80%) while *Kalukanda*-5488 was the second best (37.5%), and *Kalu wee*-4541 and *Goda heenati*-3724 scored the third highest survival rate (17.5 %) under complete submergence stress of 14-day. Survived and susceptible accessions followed both modes of survival; quiescence and elongation. The findings of the present study can be utilized for further research purposes or breeding programs in rice improvement.

Keywords: Mode of tolerance, Seedling stage, Submergence tolerance, Traditional rice
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Introduction

Rice is one of the most important crops that provide food for more than half of the world population. Rice cultivation is affected by biotic and abiotic stresses according to the place of cultivation and time of cultivation. Submergence stress is prominent among them and it generates multiple constrains on plant growth and development. Under complete submergence (CS) stress, plants are completely covered by the water level and rice plants exhibit two strategies for survival, namely elongation strategy and quiescence strategy (Setter and Laureles, 1996). Water logging has been a serious problem in the South-West coastal belt in Sri Lanka. Further, Gampaha, Colombo, Kalutara and Galle are mainly affected by flooding. Improving drainage system, timing of crop sowing and introduction of flood resistant varieties have been suggested to overcome the damage caused by flood. Sri Lanka holds a huge diversity of traditional rice accessions and some of them exhibit considerable levels of abiotic stress tolerances (Ranawake *et al.*, 2014). Green revolution in late 60's has replaced the traditional rice accessions with improved high yielding rice cultivars, which are not tolerant to particular stresses. Traditional rice accessions are low yielding and their plant architecture is not favorable. Yet, they possess many biotic and abiotic stress tolerant traits. Identification of new genotypes with submergence tolerance is important for the direct introduction of them to field or for the improvement of rice through breeding programs. Thus, submergence tolerant traditional rice cultivars could be revealed by screening them for particular stress systematically.

Materials and Methods

Thirty Sri Lankan traditional rice accessions were collected from Plant Genetic Resources Centre (PGRC), Gannoruwa. Seeds were kept at 50°C for 05 days to break the dormancy and they were dipped in 70% alcohol for 02 minutes followed by thorough washing with distilled water. Then seeds were kept in an incubator at 35°C, under dark conditions for 07 days to provide optimum germination conditions. Germinated seeds were planted in trays filled with homogenized soil collected from paddy field. The experiment was conducted as randomized complete block design (RCBD) with four replicates and 10 plants per each replicate. Two weeks old seedlings were subjected to 09-day and 14-day CS conditions, while the control was kept without submerge. After CS period, seedlings were allowed to recover under de-submerged condition for two weeks and they were evaluated. Submergence tolerance and mode of tolerance were identified as the survival rate and elongation under submergence stress respectively. plant height was measured just before and after the submergence as shown by equation 1.

$$\text{Height gain or reduction during submergence} = \text{Av. height of plants just after the submergence stress} - \text{Av. height of plants just before the submergence stress}$$

Submergence tolerance was identified as the survival percentage (equation 2).

$$\text{Survival percentage} = \frac{\text{Number of plants survived after recovery}}{\text{Number of plants before the submergence}} \times 100$$

Data were analyzed by ANOVA using SAS (2008) statistical software (SAS online version 9.1.3).

Results and Discussion

Among the tested accessions, *Hondarawala*-4243 recorded the highest survival percentage under both CS stress of 09-day (82.5%) and 14-day (80%). *Mada El*-5522, *Kalu Wee*-4541, *Sudu Heenati*-6332, *Wel Handiran*-3735 and *Kalukanda*-5488 had survival percentage of 57.5%, 47.5%, 47.5%, 45% and 40% respectively (Table 1), while *Hondarawala*-3493, *Pokkali*-3573, *Goda El*-3846, *Goda El Wee*-4724, *Mada El*-4945 and *Pachchaperumal*-9049 were not able to survive under CS for 09-day.

Kalukanda-5488, *Kalu Wee*-4541, *Goda Heenati*-3724, *Moddaikaruppan*-3769 and *Pachchaperumal*-4641 had survival percentage of 37.5%, 17.5%, 17.5%, 15% and 10% respectively (Table 1) under CS of 14 days.

Fifty-three percent of tested traditional rice accessions were unable to survive under CS stress of 14 days. Among the survived rice accessions under CS stress of 09-day, *Wel Handiran*-3379, *Dahanala*-3924, *Kalu Heenati*-4087, *Mada El*-4293, *Pokuru Samba*-4576 and *Sudu Heenati*-6332 were not able to survive under CS stress of 14-day. Impact of CS of rice plants is much more severe than the partial submergence and large leaf damage takes place if the CS stress last for more than few days and finally whole plant may die. Among the survived traditional rice accessions under CS stress of 09-day, 60.86% of accessions had suppressed their height compared to that of control, while 39.14% of accessions had elongated (Table 1). A significantly highest height gain of 2.10 cm and 2.45 cm were recorded by *Dahanala*-3924 and *Mada El*-6274 with the survival percentage of 05% and 30% respectively under CS stress of 09-day. The highest height suppression (-3.10 cm) was recorded by *Pokuru Samba*-4576, and it had a survival percentage of 7.5%. *Hondarawala*-4243 which had a significantly highest survival percentage of 82.5%, had suppressed its' height by 2.36 cm compared to that of control.

Among the survived traditional rice accessions, 57.14% of accessions were suppressed and 42.86% of accessions were elongated under CS stress of 14-day. (Table 1). A significantly highest suppression (-4.77cm) was recorded by *Wel Handiran*-3735 with the survival percentage of 05%. *Mada El*-6274 showed a significantly highest height gain (4.36 cm) with the survival percentage of 2.5%.

Ismail *et al.* (2009) reported that submergence stress significantly encourages shoot elongation in rice seedlings. However, maintaining high levels of stored carbohydrates with minimum shoot elongation have been considered as a strategy for submergence tolerance (Fukao *et al.*, 2006). *Hondarawala*-4243 which recorded the highest survival percentage of 80% had reduced the height by 0.52 cm compared to control under CS stress of 14-day. Setter and Laureles (1996) have reported that reduced elongation during the flash flood is an advantage for seedlings because elongated seedlings tend to lodge as soon as water level decreases.

Among the submergence susceptible rice accessions, 43% of the accessions had not suppress while 57% of accessions had elongated under CS stress of 09-day. A significantly highest elongation (2.69 cm) was recorded by *Hatada Wee*-3470 and the lowest values were recorded by *Hondarawala*-3493 and *Pokkali*-3573. Among the submergence susceptible rice accessions, 43.75% accessions had suppressed their height while 56.25% of them had elongated under CS stress of 14-day. A significantly highest suppression was recorded by *Kalu Heenati*-4087. *Goda El*-3846 and *Pokuru Samba*-4576 had recorded significantly highest values (1.5 cm

Table 1: Survival rate and height gain of traditional rice accessions under complete submergence stress of 09 days and 14 days at the seedling stage

PGRC accession number	PGRC accession name	Under complete submergence stress of 09 days			Under complete submergence stress of 14 days		
		Survival percentage %	Elongation (cm)	Suppression (cm)	Survival percentage %	Elongation (cm)	Suppression (cm)
2087	*Kalu Heenati*	25.0		-1.02^{i}	7.5^{dfe}		-0.69^{e}
3291	*Rata Wee*	17.5		-0.50^{g}	5^{fe}		-2.87^{g}
3379	*Wel Handiran*	7.5	2.10^{b}		0^{f}	2.69^{a}	
3470	*Hatada Wee*	0	2.69^{a}		2.5^{fe}		-1.34^{f}
3493	*Hondarawala*	0		-1.28^{e}	0^{f}	2.67^{a}	
3573	*Pokkali*	0		-0.94^{e}	0^{f}	0.35^{abcd}	
3652	*Buruma Thawalu*	2.5		-0.33^{f}	0^{f}		-0.40^{abcde}
3724	*Goda Heenati*	30.0		-2.98^{e}	17.5^{c}		-7.33^{i}
3735	*Wel Handiran*	45.0		-0.83^{h}	5^{fe}		-4.77^{h}
3769	*Moddaikaruppan*	32.5		-2.36^{i}	15^{cd}	0.56^{d}	
3846	*Goda El*	0		- 0.45^{cd}	0^{f}	1.50^{a}	
3924	*Dahanala*	5.0	2.10^{a}		0^{f}		-0.50^{abcde}
4087	*Kalu Heenati*	10.0	0.38^{d}		0^{f}		-3.796^{e}
4162	*Pokuru Wee*	2.5		-2.70^{j}	0^{f}		-2.547^{cde}
4171	*Rathal*	5.0		-1.10^{i}	2.5^{fe}	0.56^{d}	
4243	*Hondarawala*	82.5		-2.36^{j}	80^{a}		-0.53^{e}
4293	*Mada El*	35.0	0.39^{d}		0^{f}	1.04^{abc}	
4402	*Haththe Pas Dawase Wee*	2.5		-1.11^{i}	0^{f}		-3.08^{de}
4530	*Kaharamana*	5.0		-2.36^{k}	0^{f}	1.28^{ab}	
4541	*Kalu Wee*	47.5		-0.73^{h}	17.5^{c}		-2.98^{g}
4576	*Pokuru Samba*	7.5		-3.10^{m}	0^{f}	1.62^{a}	
4641	*Pachchaperumal*	17.5	0.50^{d}		10^{cde}	0.97^{c}	
4724	*Goda El Wee*	0	1.35^{b}		0^{f}		-0.57^{abcde}
4945	*Mada El*	0	0.97^{bc}		0^{f}		-2.49^{bcde}
5488	*Kalukanda*	40.0	0.38^{d}		37.5^{b}	2.51^{b}	
5522	*Mada El*	57.5	0.87^{c}		2.5^{fe}		-1.30^{f}
6274	*Mada El*	30.0	2.45^{a}		2.5^{fe}	4.36^{a}	
6332	*Sudu Heenati*	47.5		-2.69^{i}	0^{f}	0.35^{abcd}	
8499	*Hondarawala*	7.5	0.15^{e}		7.5^{dfe}	1.21^{c}	
9049	*Pachchaperumal*	0	0.08^{d}		0^{f}	0.56^{abcd}	

DMRT groups of each value are indicated in superscript. Means with the same letter within the same column are not significantly different ($P<0.05$).
Plus values indicate elongation of seedlings during complete submergence stress than control seedlings while minus values indicate suppression of plant height at submergence stress compared to control seedlings

and1.62 cm) for elongation with 0% of survival percentage.

Conclusion

Under CS stress, both survived and susceptible rice accessions followed both modes of survival; quiescence and elongation. There is no common single strategy for survival under submergence stress. Selected submergence tolerant rice accessions are important for the development of tolerant rice cultivars for the changing climatic conditions. Further, these rice accessions are important to buffer the modern rice cultivars to expand the diversity. Thus the findings of the present study can be utilized for further research purposes or for breeding programs in rice improvement.

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