

Effect of Pre-sowing Seed Treatments on Drought Tolerance of Rice (*Oryza sativa* L.) Seedlings

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Abstract

Drought is an important environmental constraint limiting the productivity of many crops worldwide. Seedling tolerance to drought is crucial for crop growth and development under water limited conditions. Therefore, it is needed to increase drought tolerance of rice by genetic improvements and cultivation techniques. Priming of plant seeds is easy, low cost, low risk and effective approach to enhance plant tolerance to the stressful environments. In this study various organic and inorganic treatments (coconut water, fermented milk water, fermented rice water, Ascorbic acid, KCl, KNO₃, ZnSO₄, CaCl₂) were used to investigate growth and development of rice seedlings under water stress conditions induced by manitol. Out of different solvents used, 2% KNO₃ showed greatest performances under water stress conditions by exhibiting higher plant height, root volume and dry weight than the hydroprime seeds (control). Fermented rice water also significantly increased plant height and root volume under water stressed conditions but shoot dry weight did not show significant difference compared to hydroprimed seeds. Results showed that seed priming methods used in this study can establish more drought tolerant rice seedlings, however seedling survival and yield performances under field level should be investigated.

Keywords: Drought tolerance, Rice (*Oryza sativa* L.), Seed pretreatment

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Introduction

Drought is increasingly becoming a major constraint for crop productivity worldwide (Wollenweber *et al.*, 2003) which causes retardation in plant growth and development due to impaired mitosis, nutritional imbalance, loss of turgor, stomatal closure and limitation of gas exchange. As staple food of Sri Lankans, rice (*Oryza sativa* L.) has a significant role in food security in Sri Lanka. Frequent occurrence of drought is considered as one of the major limiting factors that reduce the rice production in Sri Lanka. The situation has been predicted to be severe in future due to climate change scenarios. Drought causes big loss in both seed yield and quality, particularly in dry zone areas where rice is the main field crop. Therefore, it is needed to increase drought tolerance of rice by genetic improvements and cultivation techniques. Genetic improvements through conventional breeding are conducted by Department of Agriculture and have already released many drought tolerant varieties.

Among various agronomic techniques pre-sowing treatment and priming of plant seeds are easy, low cost, low risk and effective approaches to enhance plant tolerance to the stressful environments (Ashraf and Foolad, 2005). Priming is a controlled hydration process followed by redrying that allows metabolic activities to proceed before radical protrusion (Sivritepe *et al.*, 2005). Seed priming includes hydropriming, halopriming, osmopriming,

thermo priming, solid matrix priming, and biopriming (Ashraf and Foolad, 2005). These seed pretreatments are reported to induce pre-germination changes, which usually have beneficial effects on seed germination rate and uniformity, seedling growth and development, specifically under stressful conditions by modifying the morpho-physio-biochemical nature of seed (Ashraf and Foolad, 2005). Present study was conducted to investigate the effect of different seed hardening treatments on growth of rice seedlings under water stress conditions induced by manitol.

Materials and Methods

A pot experiment was conducted during October 2014 at the Department of Crop Science, Faculty of Agriculture under protected house conditions. The trial was laid out in CRD with three replicates. Rice variety At 362 (Samba variety) was used. Before sowing seeds were soaked overnight separately in water (control) and different chemicals and organic solutions (coconut water, fermented milk water, fermented rice water, Ascorbic acid 1 and 2%, KCl 1 and 2%, KNO₃ 1 and 2%, ZnSO₄ 1 and 2%, CaCl₂ 1 and 2%). Then seeds were toughly washed with water and soaked another 8 hrs in water before germination. After 2 days, 10 germinated seeds were planted per small pot filled with paddy field soil. Two weeks after planting drought was induced by using 100 mM and 200 mM manitol solutions. Data was collected two weeks after induction of drought.

The seedling height was recorded from base of the plant to tip of the main stem. Oven dried plants under 65°C for 72 hours were used for shoot dry weight measurements. Gravimetric method was used to measure root volume. Data were statistically analyzed using analysis of variance (ANOVA) statistical method and mean separation was done using Dunnett's test.

Results and Discussion

Different pre-treatments of the seeds increased the capacity of plants to adapt to abiotic stress conditions and increased tolerance of these plants (Cuartero *et al.*, 2006). In this study pre sowing seed hardening showed significant effect on plant height, root volume and shoot dry weight (Table 1). In unstressed plants significantly higher plant heights were observed in T4, T5, T9 and T10 treatments. With increase of water stress, plant height decreased. Seedlings treatment with T2, T4, T8, T9 and T12 gave significantly higher plant height than water treated seedlings (Table 1). When increasing water stress from 100 to 200mM manitol, it was observed that most of the treatments have significantly higher seedling height than water treated seedlings. Seven treatments namely T4, T5, T8, T9, T10, T12, T13 showed significantly higher plant height in 200mM manitol solution indicated that pre sowing seed treatments increase plant height by redistribution of resources leading to cell enlargement and cell division as same plant height decrease due to

reduced cell size and cell thickening.

Root volume of the seedling elevated in 100 mM manitol level however when manitol concentration increased up to 200 mM root volume reduced but still root volumes were greater than unstressed seedlings. However, the root volume dropped when manitol level was increased from 100 to 200 mM (Table 1). Although, root volumes reported in drought stress induced by 200 mM manitol were greater than unstressed seedlings. In unstressed seedlings, significant increase of root volume did not observe after pre sowing seed treatments, but significant decrease in root volume could be observe in some treatments. Seedlings from 2% KNO₃ treated seeds gave highest root volumes under stressed conditions.

Dry matter accumulation is an important parameter of photosynthetic efficiency of plants, which is evident from the improvement in the yield and yield parameters. Shoot dry weight of seedlings in this study decreased with increasing drought stress, induced by manitol in all treatments. However, significantly higher shoot dry weight compared to water treated controls could be observed. Manjunath and Dhanoji (2011), also showed significantly higher chlorophyll content, chl-a and chl-b in seed hardened with Cycocel 1000ppm followed by succinic acid 20ppm and 2%CaCl₂ as compared to control. In addition significantly higher

Table 1: Growth characteristics of rice seedlings produced by pretreated seeds under drought stress

Treatment	Plant height (cm)			Root volume (ml)			Dry weight (mg)		
	0	100 mM	200 mM	0	100 mM	200 mM	0	100 mM	200 mM
Water (T1)	42.0	37.3	20.7	3.9	11.0	5.7	0.38	0.26	0.24
Coconut water (T2)	44.0	42.7*	23.0	4.3	11.0	5.9	0.41	0.31*	0.16*
Fermented milk water (T3)	40.0	38.7	20.7	3.4	10.7	5.0	0.33*	0.32*	0.26
Fermented rice water (T4)	47.7*	44.7*	33.0*	4.4	15.3*	10.5*	0.39	0.23	0.28
Ascorbic acid 2% (T5)	46.3*	36.3	29.0*	3.1*	10.3	9.1*	0.30*	0.28	0.25
Ascorbic acid 1% (T6)	41.3	33.7	23.7	4.0	8.7	5.5	0.34*	0.25	0.17*
ZnSO ₄ 2% (T7)	40.7	36.3	19.0	3.9	10.2	4.2*	0.39	0.21*	0.16*
ZnSO ₄ 1% (T8)	41.7	43.3*	30.3*	4.2	15.3*	8.8	0.38	0.29*	0.25
KNO ₃ 2% (T9)	50.7*	45.3*	36.3*	2.4*	20.0*	13.9*	0.21*	0.26	0.29*
KNO ₃ 1% (T10)	46.3*	41.3	35.0*	2.9*	17.2*	13.0*	0.24*	0.28	0.29*
CaCl ₂ 2% (T11)	38.7	33.0	17.0	4.3	8.8	3.7*	0.42	0.21*	0.13*
CaCl ₂ 1% (T12)	42.7	42.0*	29.3*	3.3*	12.5	8.3*	0.33*	0.26	0.26
KCl 2% (T13)	44.7	35.3	31.0*	3.0*	13.3	9.8*	0.31*	0.30*	0.27
KCl 1% (T14)	41.7	37.0	22.3	3.9	10.8	5.9	0.35	0.32*	0.27
CV	3.6	4.7	8.1	6.4	9.3	5.2	4.7	4.9	7.5

*Symbol within a column represent significant difference between treatments and water treated control with p<0.05

chlorophyll stability index, higher relative water content, proline content and epicuticular wax coupled with lower specific leaf area, harvest index and yield were found when seeds were hardened with 2% CaCl₂ which was followed by Cycocel 1000ppm and succinic acid 20 ppm. All these data revealed that pre-sowing seed treatments can increase drought tolerance of rice seedlings. Leafing of the plants did not seem to be effected by drought in this study (data not shown) and similar results has been reported by several authors.

Conclusions

Results illustrated that some chemicals such as KNO₃, CaCl₂ can increase seedling performances under water stress conditions.

References

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