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Effect of Deep Sea Water Seed Priming on the Growth of Rice (*Oryza sativa* L.) Seedlings

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Abstract - This experiment was conducted on rice (cv. 2005 Thaoi) seeds to study whether priming with deep sea water (DSW) results in enhancement of seed emergence and seedling growth and to identify the optimum concentration of Deep Sea Water (DSW) for priming. Two experiments were conducted subsequently. In experiment 1, four concentrations of the DSW (10%, 20%, 30% and 40%), and in experiment 2, five concentrations of DSW (10%, 15%, 20%, 25% and 30%) were prepared and seeds were primed for 24 hours duration at 25℃. Beside this, hydro priming with plain water was also included as a control. Experiments were laid out in Completely Randomized Design (CRD) with three replications. Result showed that 20% DSW seed priming treatment had improved the emergence, seedling height, number of roots and root length as compare to other with DSW or without DSW treatments. Beyond 20% DSW priming (i.e. 25%, 30% and 40%) were not suitable for priming the seed. On the basis of seedlings growth parameters; emergence, seedling height, root number and length, and shoot root ratio, 20% DSW priming was the best priming treatment.

Key words - Deep sea water, Seed priming, Emergence, Root, Shoot, Concentration

Introduction

Rice is life for thousands of millions of people. It is the staple food for more than half of the world population. In Asia alone, more than 2000 million people obtain 60-70 percent of their calories from rice and its products (FAO, 2004). In Republic of Korea, average annual production of rice is more than 5 million tons and being the country's most important agricultural commodity. It is also the main source of carbohydrate in people's diets with annual consumption of around 90kg per head (FAO, 2004). In Korea it occupies 980,000 hectare with the average yield of 4900kg per hectare (STAT-Korea, 2005). Sub-optimum plant population and uneven crop stand resulting from poor nursery seedlings is one of the most important yield limiting factors in the rice production system. Rice transplanting is tedious and time consuming up to 30 person-days ha^{-1}(IRRI, 2003), usually at a critical time which often results in shortage and increasing labor costs. One of the constraints of rice production is labor shortage (IRRI, 2004). Alternate methods of establishing crops, especially rice that require less labor and water without sacrificing productivity are needed. Considering water availability and opportunity cost of labor, dry seeding of rice is an appropriate alternative for transplanting method. However, early emergence and seedlings vigor are most required.

Seed priming is a controlled seed hydration treatment (Hudson *et al.*, 2002) that can reduce the time it takes for seedlings to emerge (Giri and Schillinger, 2003; Fly and Heydecker, 1981). Primed seeds will usually show higher seed vigor compared with raw seed (Shazad *et al.*, 2005). Priming can provide faster, more uniform seedlings emergence (Hudson *et al.*, 2002; Soon *et al.*, 2000; Demir, 1999; Korkmaz, 2005; Kang *et al.*, 1996; Brocklehurst *et al.*, 1987) and vigor (Shazad *et al.*, 2005; Brocklehurst *et al.*, 1987; Fly and Heydecker, 1981; Ashraf and Foolad, 2005). Hence, rapid seedling establishment might minimize crop risk due to environmental conditions or insect and disease problems during field emergence, which is an advantage of primed seeds especially under adverse condition. Rapid stand establishment may result in a shorter cycle (Passam *et al.*, 1989). It improved the water use efficiency of draught stressed plants (Ajori *et al.*, 2004) and grain yield (Shazad *et al.*, 2005; Ajori *et al.*, 2004).

The most frequently used seed priming techniques involve polyethylene glycol (PEG) and sodium chloride (NaCl) or potassium nitrate (KNO_3). One method of increasing crop resistance to NaCl levels in soil is salt priming of the seeds before planting (Milligan *et al.*, 2003). The use of NaCl pretreatments could be a useful strategy to increase the salt tolerance of melon plants in long term and also to permit the establishment of melon crop by direct sowing in a saline medium (Sivritepe *et al.*, 2004). There is a possibility to increase plant tolerance for these abiotic stresses through effective priming of preexisting defense pathways without resorting to genetic alterations (Metraux and Mani, 2005). Hence, pre-sowing seed treatment had become a common practice in the seed industry (Hudson *et al.*, 2002) and on-farm seed priming is a 'key' technology that is a low cost with

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low risk to produce an immediate benefit unlocking the farming system and giving the farmer reasonable access to further benefits (Harris *et al.*, 2001).

Currently, the utilization of deep sea water is receiving much attention due to high productivity, large quantity, and potential for recycling energy. Deep sea water from a depth of more than 200m has cold temperature, abundant nutrients, and good water quality that is pathogen-free and stable (Nakasone and Sadamitsu, 1997). Application of deep sea water for agriculture is performed at NELHA in Hawai, U.S.A., where they have succeeded in producing various cold season vegetables and crops in the tropics (Daniel, 1994). Various foods and beverage are being produced using desalinized or concentrated deep sea water (Histake, 1997).

The main objective of this experiment was to study whether priming with deep sea water results in enhancement of seed germination, and to identify the optimum concentration of the deep sea water for priming solution. The optimization of seed priming techniques becomes very important to seed priming. Second experiment was conducted to verify the first experiment.

Materials and Methods

The experiment was conducted in the glass house of of Kangwon National University in summer season of 2006. Rice seeds of cv. 2005 Thaoi Was used in the experiment. Following pre-sowing seed treatments were included in the experiment.

Treatments

Experiment 1.	**Experiment 2.**
Control (priming with water)	Control (priming with water)
10% Deep sea water	10% Deep sea water
20% Deep sea water	15% Deep sea water
30% Deep sea water	20% Deep sea water
40% Deep sea water	25% Deep sea water
	30% Deep sea water

Ten numbers of seeds were used in each treatment. Required concentrations of the Deep sea water were prepared and seeds were primed for above mentioned duration and concentration at 25℃. After the priming, seeds were rinsed with distilled water three times. Experiment was laid out in Completely Randomized Design (CRD). The treated seeds were compared with control ones for germination, shoot and root growth, number of roots.

Vigor evaluation

Emergence of seed was evaluated on test tubes filled with soil up to the 2cm below from the mouth of the test tube. One seed per test tubes were sown and the experiment was replicated three times. These test tubes were kept in the glass house where temperature was range from 25 to 35℃. The data of emergence percentage (%), number of roots, shoot length (cm), root length (cm) were recorded up to 31 days after sowing. Observations which were done two times at an interval of two weeks were recorded. All measurements were taken on individual plants and averaged. Emergence was recorded by counting the seedlings emerged above the soil surface. Plant height was measured from the base of the stem to its top (in centimeter). For the measurement of root length and number, seedlings were uprooted with soil media and cleaned with water. Then the longest root of the seedling was measured whereas all the roots coming from the base of the stem with more than 2 centimeter were counted.

The data collected was analyzed using the Fisher's analysis of variance technique under completely randomized design (CRD) with MSTAT software program and the treatments means were compared by Least Significant Difference (LSD) test at 0.05 probability level (Steel and Torri, 1984).

Results and Discussion

Experiment 1

Effect on emergence

Emergence percentage was lowest in plain water priming (87%) in both the 9DAS and 15DAS. Even though the effect of priming on the emergence was not significant, priming with DSW had improved the emergence percentage. In all the deep sea water priming treatments, it was recorded 97% (Table 1). As sub-optimum plant population and uneven crop stand resulting from poor nursery seedlings is one of the most important yield limiting factors in the rice production system, seed priming improved the uneven crop stand by providing higher and early emergence.

Effect on root and shoot growth

In early days (9DAS), effect of priming on seedlings height was not significant. However, highest plant height (5.0cm) was measured in 20% DSW priming treatment but later on 15DAS, effect was significant where plants in 20% DSW treatment were tallest (12.0cm) followed by 10% DSW (11.9cm) and control (11.8cm) respectively. Plants in 30% DSW (10.6cm) and 40% DSW (10.2cm) treatments were shorter than other treatments (Table 1).

There was significant difference on roots number in the first observation (15DAS). In early days (15DAS), highest root number (14.7) was counted in 20% DSW treated plants whereas the lowest was in 40% DSW (9.2cm). In this way, in 30% DSW and 40% DSW treated seedlings, roots number were significantly decreased as compare to 20% DSW treatment. It showed that priming with higher concentration had negative effect. But on 28 DAS, control (with out DSW treatment) gave the highest root number (35.5) followed by 40% DSW (33.6) (Table 1).

As far as the effect on root length is concerned, 20% DSW primed seedlings produced longest root in both the observation days (15DAS and 28DAS). On 15DAS, the longest root (15.1cm) was recorded in 20% DSW treatment which was significantly higher than in 30% and 40% DSW treatment. Likewise, on 28DAS, longest root (17.2cm) was measured in 20% DSW followed by 10% DSW (16.5cm) and shortest (15.5cm) was in 40% DSW treatment (Table 1).

When shoot and root length was calculated, the highest ratio (0.84) was obtained in the control followed by 30%DSW (0.83). If we look after the shoot height and root length on 15DAS, 20% DSW treatment had highest shoot and root length. It showed that 20% DSW treatment gave superior performance (Fig. 1).

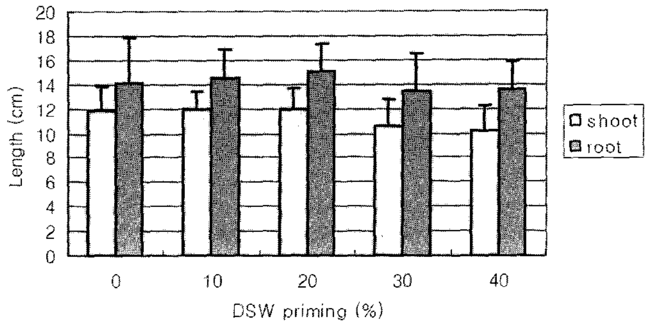

Fig. 1. Effect of various concentrations of DSW priming on shoot and root growth. 20% DSW improved the shoot and root growth followed by 10%. Vertical bar represents SD.

In this way on the basis of above mentioned characteristics, 20% DSW priming is the best priming treatment followed by 10% DSW. This result supports the finding of Demir (1999) who had mentioned that salt priming could be useful for improving germination, seedling growth and uniformity of heterogeneously matured water melons. However, to verify the best treatment between 20% and 30% DSW priming, a further experiment should be conducted.

Table 1. Effect of deep sea water priming on rice seedlings growth

Treatments	Emergence (%) 9DAS	Survival (%) 15DAS	Height (cm) 9DAS	Height (cm) 15DAS	Root (#) 15DAS	Root (#) 28DAS	Root (cm) 15DAS	Root (cm) 28DAS	Shoot root ratio (15DAS)
0% DSW	87	87	4.1	11.8 a	13.1 ab	35.5	14.1 ab	16.2 ab	0.84
10% DSW	97	97	4.5	11.9 a	12.4 abc	33.2	14.5 ab	16.5 ab	0.82
20% DSW	97	97	5.0	12.0 a	14.7 a	31.6	15.1 a	17.2 a	0.79
30%DSW	97	97	4.0	10.6 b	11.2 bc	31.9	13.4 b	16.2 ab	0.83
40%DSW	97	97	3.6	10.2 b	9.2 c	33.6	13.6 b	15.5 b	0.75
CV%	8.5	9.7	12.7	5.6	15.0	5.98	4.95	4.12	
F-test	ns	ns	ns	*	*	ns	*	*	
LSD (.05)	1.52	1.70	1.02	1.19	3.43	3.73	1.32	1.26	

Table 2. Effect of deep sea water priming on rice seedlings growth

Treatments	Emergence (%) 10DAS	Emergence (%) 17DAS	Height (cm) 17DAS	Height (cm) 31DAS	Root (#) 17DAS	Root (#) 31DAS	Root (cm) 17DAS	Root (cm) 31DAS	Tillers (#) 31DAS
0% DSW	95	100	5.3	12.5 ab	5.3	23.0	13.7	15.5	2.5
10% DSW	88	100	4.5	12.4 ab	5.0	21.1	10.7	15.9	2.6
15% DSW	88	100	4.5	8.8 b	5.5	20.9	12.17	15.8	2.9
20% DSW	100	100	5.0	13.1 a	6.2	26.3	12.4	16.4	2.9
25%DSW	83	88	4.9	13.1 a	6.2	21.0	10.1	15.2	2.3
30%DSW	88	83	4.5	11.5 ab	6.0	21.1	12.7	15.9	2.5
CV%	14.5	12.6	12.6	18.7	14.8	10.9	14.3	4.6	15.6
F-test	ns	ns	ns	Ns	Ns	Ns	ns	Ns	ns
LSD (.05)	1.43	1.31	1.10	4.06	1.54	4.41	3.12	1.31	.74

Experiment 2

Effect on emergence

The highest emergence percentage (100%) was obtained in 20% DSW priming treatment in early days (10DAS) whereas in later on (17DAS), from 0% DSW to 20% DSW treatment had 100 percentage emergence but beyond 20%; i.e. 25% and 30% DSW treatments gave 88% and 83% emergence respectively in decreasing order (Table 2).

Effect on root and shoot growth

Highest seedlings height (13.1cm) was measured in 20% DSW and 25% DSW priming treatments on 31DAS followed by 0% DSW (12.5cm) but in early days (17DAS), seedlings in 0% DSW (5.3cm) were little bit taller than in 20% DSW (5.0cm). However, 20% DSW had provided highest number of roots (6.2 and 26.3cm) per plant in both the time of observations; early (17DAS) and late (31DAS) respectively. Number of roots was not different between 20% DSW and 25% DSW treatments on 17DAS but in later stage (31DAS), 20% DSW had significantly higher number of roots as compare to 25% DSW. Number of roots had been decreased beyond 20% DSW treatments; i.e. 25% and 30% DSW (Table 2).

Effect of priming on root length was on the same trend as on plant height. On 31DAS, highest root length was obtained on 20% DSW treatment (16.4cm) followed by 10% DSW and 30% DSW treatment (15.9cm). All the DSW treatments had given longer root length on 31DAS except 25% DSW but on 17DAS, 0% DSW treatment had longest root. Number of tillers was ranged from 2.3 (25% DSW) to 2.9 (15% and 20% DSW) (Table 2). Thus, 20% DSW priming had improved the shoot and root growth of the rice seedlings (Fig. 2).

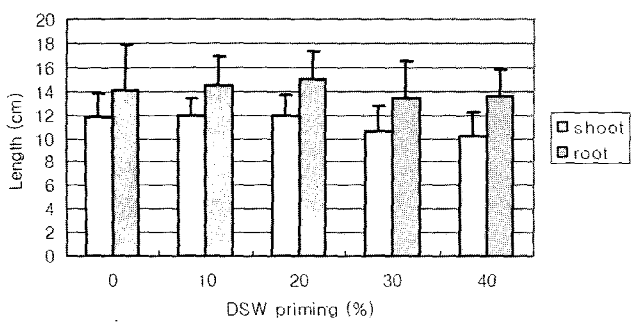

Fig. 2. Effect of various concentrations of DSW priming on shoot and root growth. 20% DSW priming improved the shoot and root growth of the rice seedlings. Vertical bar represents SD.

In this way, 20% DSW had shown superior performance as compare to other treatments. It verified that beyond 20% DSW concentration was not favorable for priming treatment.

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