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Effects of Priming and Growth Regulator Treatment of Seed on Emergence and Seedling Growth of Rice

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ABSTRACT

An experiment was carried out to determine the effects of priming and growth regulator treatment of seeds on the emergence and seedling growth of rice, *Oryza sativa* L. (cv. 'Ilpumbyeo'). Normal seeds were primed in a -0.6 MPa polyethylene glycol solution at 15℃ for four days with air-bubbling. Then both primed and non-primed seeds were soaked in water, 100 ppm GA_3, 2 ppm ABA, and 10 ppm kinetin solutions for 24 hours. The seeds were planted in soil at 3 and 5 cm depths and allowed to germinate in a growth cabinet at 20℃. Generally, the emergence rate at the 3 cm seeding depth was higher and emerged faster compared with the 5 cm seeding depth. The emergence rate of primed seeds was higher and emerged faster compared to non-primed seeds. GA_3 and kinetin treatments were the most effective to improve the emergence rate of non-primed seeds. Coleoptile length at the 5 cm seeding depth was longer than that at the 3 cm seeding depth. Leaf number, plant height, and root length of primed seedlings were higher compared with non-primed seeds. GA_3 promoted the elongation of plant height and mesocotyle length.

Keywords : rice, seed priming, GA_3, ABA, kinetin, emergence rate, T_{50}, coleoptile, leaf number, mesocotyle.

The priming of seeds in a proper polyethylene glycol (PEG) solution improved the overall germination rate, synchronized germination time, and reduced the time to germination, particularly in many vegetable crops of which germination rate of normal seeds was relatively low (Drew & Dearman, 1993; Muhyaddin & Wiebe, 1989). Also, similar priming effects were observed in high quality field crop seeds planted under adverse environmental conditions such as suboptimal temperatures or inadequate soil moisture conditions (Lee et al., 1998a, 1998b; Bodsworth & Bewley, 1981).

Improved seed performance has been achieved by incorporating plant growth regulators and pesticides during presoaking, priming, and other presowing treatments of many vegetable crops (Sharples, 1973; Nakamura et al., 1982; Jeong et al., 1994). GA_3 is well known to activate β-amylase and induces α-amylase for breakdown of starch stored in seeds to be utilized by growing embryos during germination. GA_3 and ethylene stimulate the elongation of mesocotyle, coleoptile, and internodes of rice seedlings after germination (Suge, 1974; Kim et al., 1993). Also, ABA promotes elongation of the mesocotyle of rice seedlings (Kim et al., 1989; Takahashi & Sato, 1972). Therefore, exogenous supply of these growth regulators to seeds could facilitate the emergence of rice seedlings, especially under adverse environmental conditions. In fact, in the United States 'Release', a brand name containing 10% GA_3, is recommended in dry-seeded direct sowing of rice ① to promote rapid uniform emergence, ② to allow deeper planting, ③ to promote taller seedlings, ④ to allow earlier flooding, ⑤ and to improve rice competition with weeds by the elongation of mesocotyle and/or coleoptile (Hays, 1992; Coale, 1991).

In this experiment, the effects of primed and growth regulator treated seeds on seedling emergence and seedling growth were studied to improve seedling establishment in dry-seeded direct seeding of rice.

MATERIALS AND METHODS

Seeds of a rice variety, 'Ilpumbyeo', grown at the Kyongbuk Provincial Agricultural Technology Administration Farm in Taegu, Korea in 1997 were used in this experiment in 1998.

Normal seeds were primed in a -0.6 MPa polyethylene glycol #8,000 (Yakuri Pure Chemicals Co. Ltd., Osaka, Japan) solution at 15℃ for four days with air-bubbling(Lee et al., 1998a). The -0.6 MPa PEG solution was made by this equations(Michel, B. E. 1983) ; $\Psi = 1.29(PEG)^2T - 140(PEG)^2 - 4.0(PEG)$ (Ψ = bar, PEG = g PEG/g H_2O, T=℃). After priming, the seeds were washed with PEG solution in running tap water and dried at room temperature for 2 days. The primed and non-primed seeds were soaked in water, 100 ppm GA_3, 2 ppm ABA, and 10 ppm kinetin solutions for 24 hours and dried at room temperature for 48 hours. The seeds were stored in a freezer at -12℃ before use.

For the emergence test, 50 seeds were planted in soil in a plastic box (33 × 24 × 8 cm) and covered with soil at the 3 and 5 cm depths and the treatments

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replicated four times. Water was sprayed to get 35% soil moisture content considering soil weight and moisture content of soil. To maintain the soil moisture during the experiment, the box was covered with a lid and placed in a growth chamber at a constant temperature of 20℃ under light.

Emergence rate was observed daily according to the AOSA method (AOSA, 1990). Emergence rate was the percentage of seed whose coleoptile appeared from the soil surface. The time from sowing to 50% emergence (T_{50}) was calculated by the Coolbear method (Coolbear et al., 1984);

$$T_{50} = t_1 + \frac{(N+1)/2 + n_i}{(n_j - n_i)}(t_j - t_i)$$

where N is the final number of germination and n_i, n_j cumulative numbers of seeds germinated by adjacent counts at times t_i and t_j when $n_i < (N+1)/2 < n_j$.

Number of leaves, plant height, length of coleoptiles, mesocotyles, and roots of rice seedlings were observed 15 days after seeding.

RESULTS AND DISCUSSION

The analysis of variance for the emergence rate, T_{50}, the number of leaves, plant height, and length of coleoptile, mesocotyle, and roots of rice seedlings 15 days after seeding at 20℃ are shown in Table 1. Effects of seeding depth were significant in the emergence rate, T_{50}, and the length of coleoptile. Priming effects were significant in emergence rate, T_{50}, leaf number, plant height, and root length, and the effects of growth regulator treatments were significant in emergence rate, plant height, and mesocotyle length. The results were averaged for each factor to compare the effects of seedling depth, priming, and growth regulator treatment except the emergence rate where there was a significant interaction between priming and growth regulator treatments.

The emergence rate of primed and non-primed growth regulator treated rice seeds after 15 days after seeding at 20℃ are shown in Table 2 and Fig. 1. The emergence rate of rice at the 3 cm seeding depth was higher than that at the 5 cm seeding depth. Also, the emergence rate of primed seeds was higher compared with non-primed seeds (Table 2). Growth regulator treatments were not effective on the emergence rate of primed seeds, while soaking of non-primed seeds in water, GA_3, ABA, and kinetin solutions increased the emergence rate compared with control seeds (Fig. 1). Among the growth regulators GA_3 and kinetin were most effective to increase emergence rate in non-primed seeds.

The effects of seed priming and growth regulator treatments were different depending on the seed of crops. Seed soaking in GA_3 solution increased the emergence rate in rice (Kim et al., 1993; Coale, 1991; Hays, 1992). Both seed priming and GA_3 treatment also increased gemination rate in pepper (Jeong et al., 1994) and in lettuce and celery seeds (Khan and Samimy,

Table 1. Analysis of variance for emergence rate, T_{50}, the number of leaves, plant height, and the length of coleoptile, mesocotyle, and root of rice seedlings 15 days after seeding at 20℃.

Source of variation	df	Mean squares						
		Emergence rate	T_{50}	Leaf number	Plant height (cm)	Coleoptile length (cm)	Mesocotyle length (cm)	Root length (cm)
Main plot								
Replication	2	29.067	0.023	0.087	0.213	0.022	0.003	0.150
Seeding depth, S	1	504.600*	20.172*	0.209	0.001	15.342**	0.001	6.647
Error	2	9.800	0.748	0.065	0.925	0.029	0.001	0.584
Subplot								
Priming, P	1	851.267**	23.928**	1.498**	33.555**	0.228	0.003	3.705*
P × S	1	0.267	0.001	0.093	0.098	0.103	0.009	1.230
Error	4	39.767	0.865	0.015	0.665	0.080	0.001	0.307
Sub-subplot								
Growth regulator, G	4	56.558*	1.557	0.077	3.485**	0.016	0.058**	1.212
S × G	4	4.225	0.184	0.051	0.163	0.046	0.001	0.243
P × G	4	76.725**	0.897	0.063	0.151	0.010	0.003	0.206
S × P × G	4	7.058	0.037	0.025	0.140	0.069	0.001	0.251
Error	32	14.767	0.628	0.029	0.518	0.035	0.001	0.208

*, ** : Significant at the 5, and 1% levels, respectively.

Table 2. Emergence rate, T_{50}, the number of leaves, plant height, and length of coleoptile, mesocotyle, and root of rice seedlings 15 days after seeding at 20℃.

Treatment	Emergence rate (%)	T_{50}	Leaf number	Pla height (cm)	Coleoptile length (cm)	Mesocotyle length (cm)	Root length (cm)
3 cm depth	73.6 a[1)]	12.0 b	1.72 ns	4.04 ns	2.74 b	0.17 ns	5.27 ns
5 cm depth	67.8 b	13.2 a	1.84	4.04	3.75 a	0.16	5.94
Non-primed	67.0 b	13.2 a	1.62 b	3.29 b	3.18 ns	0.16 ns	5.35 b
Primed	74.5 a	12.0 b	1.94 a	4.79 a	3.30	0.17	5.86 a
Control	67.5 [2)]	13.1 ns	1.67 ns	3.37 b	3.18 ns	0.14 b	5.13 ns
Water	71.2	12.5	1.78	3.97 ab	3.27	0.12 b	5.80
GA_3	72.8	12.2	1.73	4.84 a	3.25	0.29 a	5.59
ABA	69.8	12.8	1.85	3.83 ab	3.24	0.13 b	5.53
Kinetin	72.4	12.4	1.85	4.19 ab	3.27	0.13 b	5.97

1) Means within a column followed by the same letters are not significantly different at the 5% level by Duncan's New Multiple Range Test.
2) Emergence rate of growth regulators was compared within a priming factor in Fig. 1 because of interaction between priming and growth regulator in Table 1.

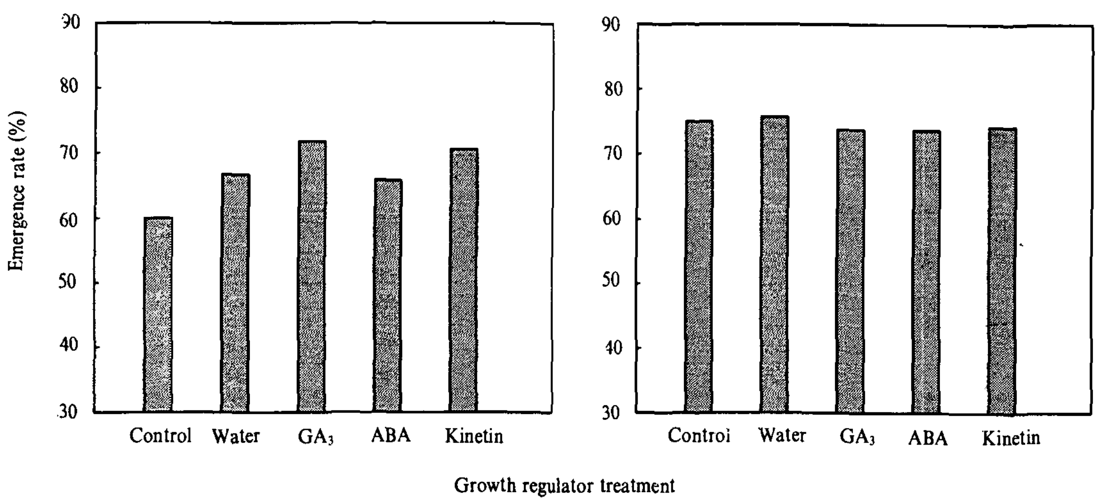

Fig. 1. Emergence rates of primed and growth regulator treated rice seeds 15 days after seeding at 20℃.

1982). However, Nakamura et al. (1982) reported that priming of celery seeds improved the germination rate, while GA_3 had no effect on the germination rate.

The time to 50% emergence (T_{50}), the number of leaves, plant height and length of coleoptile, mesocotyle, and root of rice seedlings 15 days after seeding at 20℃ are shown in Table 2. T_{50} was lower (faster germination) at the 3 cm seeding depth compared with the 5 cm seeding depth, and primed seeds emerged faster than non-primed seeds, while growth regulator treatments did not influence the emergence time significantly.

Seeds planted deeper showed delayed emergence of seedlings compared with seeds planted shallower (Lee et al., 1993), especially under the unfavorable germinating conditions due to slower seedling growth. Also, earlier emergence of primed seeds was reported by other research workers in rice (Lee et al., 1998a; Lee et al., 1998b) and celery (Nakamura et al., 1982). The priming of seeds with GA_3 and benzyl adenine (BA) enhanced seedling emergence in pepper (Jeong et al., 1994) and celery (Nakamura et al., 1982), while priming of seeds with GA_4 did not affect emergence time.

In rice, GA_3 treatment without seed priming enhanced the time of seedling emergence by 1-2 days depending on GA_3 concentrations by the elongation of mesocotyle (Kim et al., 1993).

Between seeding depths, the number of leaves, plant height, mesocotyle length, and root length were similar. However, the length of coleoptile at the 5 cm seeding depth was longer than that at the 3 cm seeding depth. When seeds are planted deeper, the mesocotyle elongates significantly in corn, while in rice, the coleoptile elongated instead of mesocotyle in 11 rice varieties out of 12 varieties. Only one variety, 'Tebonnet' elongated both mesocotyle and coleoptile (Lee et al., 1993) and the characteristics may be desirable in direct seeding where seeding depth is not uniform.

Comparing non-primed and primed seeds, coleoptile length and mesocotyle length were similar, while the number of leaves, plant height, and root length of primed seedlings were greater than those of non-primed seedlings. This indicates that seed priming promotes early seedling growth in rice.

Among the growth regulators, the number of leaves and the length of coleoptile and root were similar, while plant height and mesocotyle length of GA_3 treated seeds were highest. This GA_3 stimulating mesocotyle growth will be beneficial in direct seeding because deeper planted seeds can emerge by both mesocotyle and coleoptile elongation.

Growth stimulation of plant height and the length of both mesocotyle and coleoptile by GA_3 in rice seedlings was already reported (Kim et al., 1993; Helms et al., 1990). However, effects of ABA on rice seedling growth were different depending on research workers. ABA or ABA plus GA_3 induced a marked elongation of the mesocotyle in rice (Kim et al., 1989; Takahashi & Sato, 1972), while the elongation of the shoot above the coleoptile node was significantly retarded by ABA, but stimulated by GA_3. Some different growth regulator responses on rice seedling growth may be due to different seeds.

In conclusion preplanting seed treatments such as priming or soaking in GA_3 solution could be utilized to improve the seedling emergence rate and to reduce the emergence time in dry seeded direct seeding of rice, especially in unfavorable environments.

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