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Priming Effect of Rice Seeds on Seedling Establishment under Adverse Soil Conditions

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ABSTRACT

An experiment was carried out to find out the priming effects of rice seeds, *Oryza sativa* L. (cv. Ilpumbyeo) on the seedling establishment and early emergence under excess soil moisture conditions. Seeds were primed by soaking in −0.6 MPa polyethylene glycol (PEG) solution at 25℃ for 4 days. The primed seeds were sown in soils with various soil moistures (60, 80, 100, 120, and 140% field capacity) at 17 and 25℃, respectively. Germination and emergence rates, plumule height, and radicle length of primed seeds were higher than those of untreated seeds at any soil moisture and temperature examined. The time from planting to 50% germination (T_{50}) of primed seeds was less than that of untreated seeds by 0.9~3.7 days. Germination rate, emergence rate, plumule height, and radicle length were highest at the soil moisture of 80% field capacity among the soil moistures. Priming effects of rice seeds on germination and emergence rates were more prominent under the unfavorable soil moistures (60, 100, 120, and 140% field capacity) than those under the optimum soil moisture condition (80% field capacity). However, priming effects on seedling growth were greater at near optimum soil moisture compared with too lower or higher soil moistures. Therefore, these findings suggest that priming of rice seeds may be a useful way for better seedling establishment under the adverse soil conditions.

Key words : priming, rice seed, soil moisture, temperature, germination rate, emergence rate, seedling growth.

In temperate Asian countries, rice seedlings are usually transplanted in irrigated paddy. However, in recent years direct seeding of rice has been extensively studied to reduce production cost by removing the expenses for growing and transplanting of seedlings. In direct seeding, either in dry or submerged fields, poor seedling stand, and delayed germination are often serious problems especially when seeds are sown early in the season. During this time, temperatures are low so seeds germinate slowly with no uniformity in individual seeds. Seeds may be subject to excess soil moisture before emergence due to rain and the seeds tend to decay under the soil due to lack of oxygen. Under the these excess soil moisture conditions, the emergence rate of rice seeds sown directly in dry field varies from 0 to 90% depending on soil moisture, temperature, and varieties and emergence may be delayed 27~34 days after sowing (Lee & Myung, 1994). However, if rice seedlings emerge rapidly before raining, they can escape the excess moisture damage because oxygen is transported from the leaves to the roots through the aerenchyma tissue.

Lack of soil moisture may also cause poor emergence of direct seeded rice in some dry years. Early development of roots in deeper soil can uptake more water thereby escaping drought damage to some degree. Therefore, it is necessary to develop techniques for seeds to tolerate either under the excess soil moisture or drought conditions, especially during low spring temperatures.

Seed priming, application of growth regulators such as GA, ABA, kinetin, and ethylene, and heat treatment of seeds are known as effective techniques for rapid, uniform seed germination of various crops (Hurly et al., 1991; Finch-Savage & McQuistan, 1989). In this experiment, the priming effect of rice seeds on the seedling establishment was studied at different soil moistures and temperatures.

MATERIALS AND METHODS

Seeds of a rice cultivar, Ilpumbyeo, grown at the Research Farm of the Kyongbuk Provincial Rural Development Administration in Taegu in 1995 were used for this experiment in 1996.

For priming, 25 g of seeds were soaked in 500 ml −0.6 MPa PEG solution at 25℃ for 4 days with air-bubbling. After priming, the seeds were washed in running tap water for 10 seconds and then dried at room temperature. Prior to testing, the dried seeds were stored in a freezer at −12℃.

To test the priming effects of seeds on the germination, emergence, and seedling growth under the adverse environmental conditions, each of 100 seeds were sown in soil with moisture content of 60, 80, 100, 120, and 140% field capacity (23.4, 31.2, 39.0, 46.8, and 54.6% of soil moisture content, respectively) at 17 and 25℃ with three replications.

To determine field capacity of the soil, three round plastic containers with tiny holes at the bottom (10 cm diameter and 25 cm height) were filled with soil, then water added until the water leaked from the bottom, and left to drain excess water for 2 days. Fifty grams of the wet soil was transferred to aluminum cans and dried

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in a oven at 105℃ for 48 hours and the dry weight measured. The calculated soil moisture content, field capacity of the soil, was 39.0%.

A total of 3 kg soil with 4% soil moisture content was transferred into a 30 × 60 × 2 cm rice seedling tray (first, 2 kg of soil, then the remaining 1 kg soil was added after sowing seeds). To make 60, 80, 100, 120, and 140% field capacity, 582, 816, 1,050, 1,260, and 1,470 g water were sprayed, respectively. To maintain the soil moisture of soil, the rice seedling trays were covered with polyethylene film during the experiment.

Germination and emergence rates were observed on a

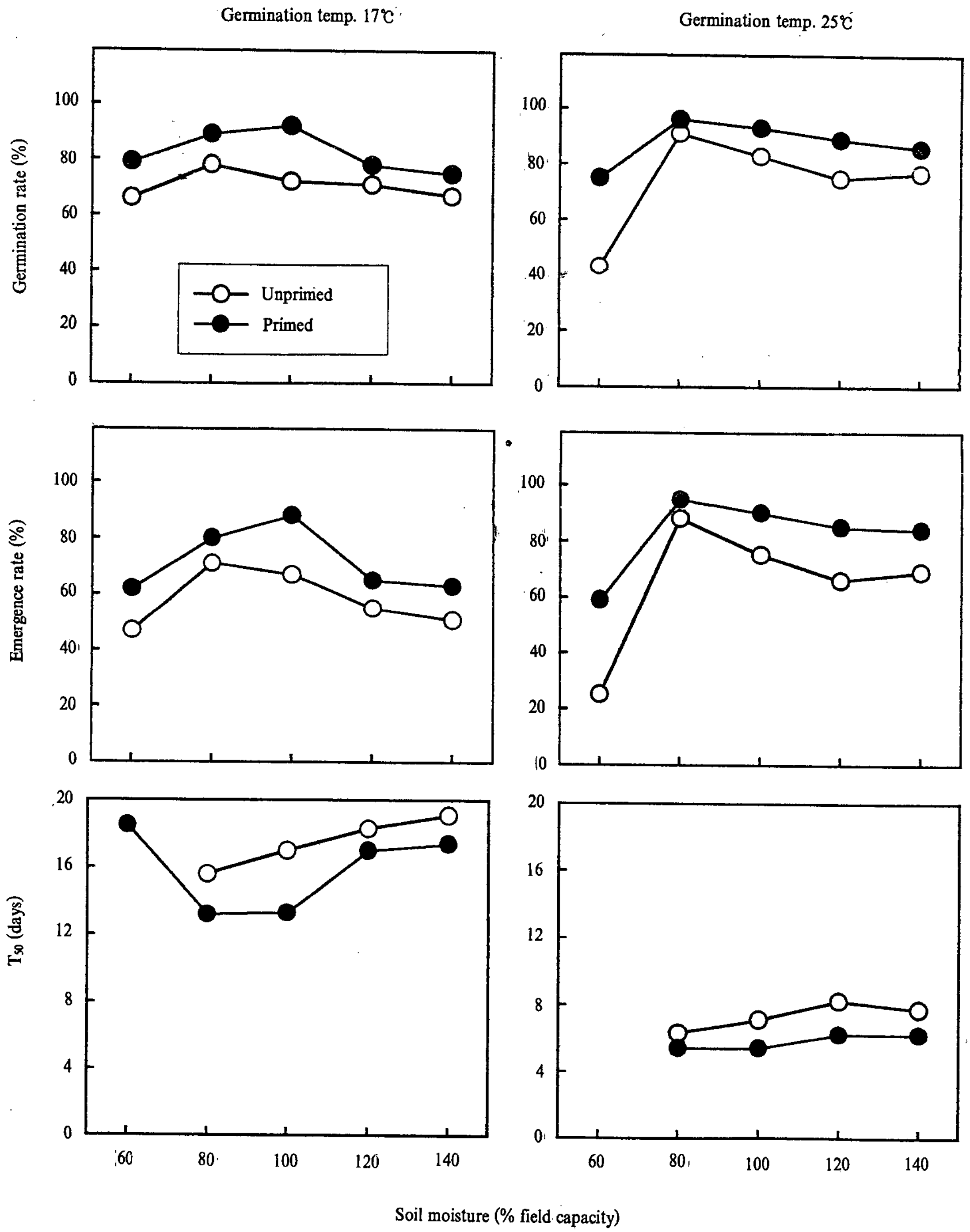

Fig. 1. Mean germination and emergence rates and T_{50} of primed and unprimed rice seeds at different soil moistures and temperatures (N=3).

daily basis according to the AOSA method (AOSA, 1990). Emergence rate was the percentage of seeds whose coleptiles emerged from the soil surface. The germination rate was calculated as the percentage of all germinated seeds, emerged and not emerged after germination in soil.

The time from sowing to 50% germination (T_{50}) was calculated by the Coolbear method (Coolbear et al., 1984);

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

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

Plumule height and radicle lenght were observed 10 and 20 days after sowing at 17 and 25℃, respectively.

RESULTS AND DISCUSSION

Germination and emergence rates and T_{50} of primed and unprimed control seeds at different soil moistures and temperatures are shown in Fig. 1. Germination and emergence rates of primed seeds were higher than those of unprimed seeds by 5~34% depending on soil moistures and temperatures.

At 17℃ germination and emergence rates of primed seeds were lowest at 60% and increased up to 100% field capacity and then decreased with further higher soil moistures. However, germination and emergence rates of unprimed seeds at 17℃ and those of both primed and unprimed seeds at 25℃ were lowest at the soil moisture of 60% and highest at 80% field capacity, then decreased with further higher soil moistures.

Generally, priming effects (differences between primed and unprimed control seeds) on germination and emergence rates were greater at too lower or higher soil moistures compared with at optimum soil moisture of 80% field capacity.

T_{50} of primed seeds at the soil moisture 60% field capacity at 17℃ was 18.5 days due to lack of soil moisture. But germination rates of unprimed seeds at 17℃ and both primed and unprimed seeds at 25℃ are not shown,

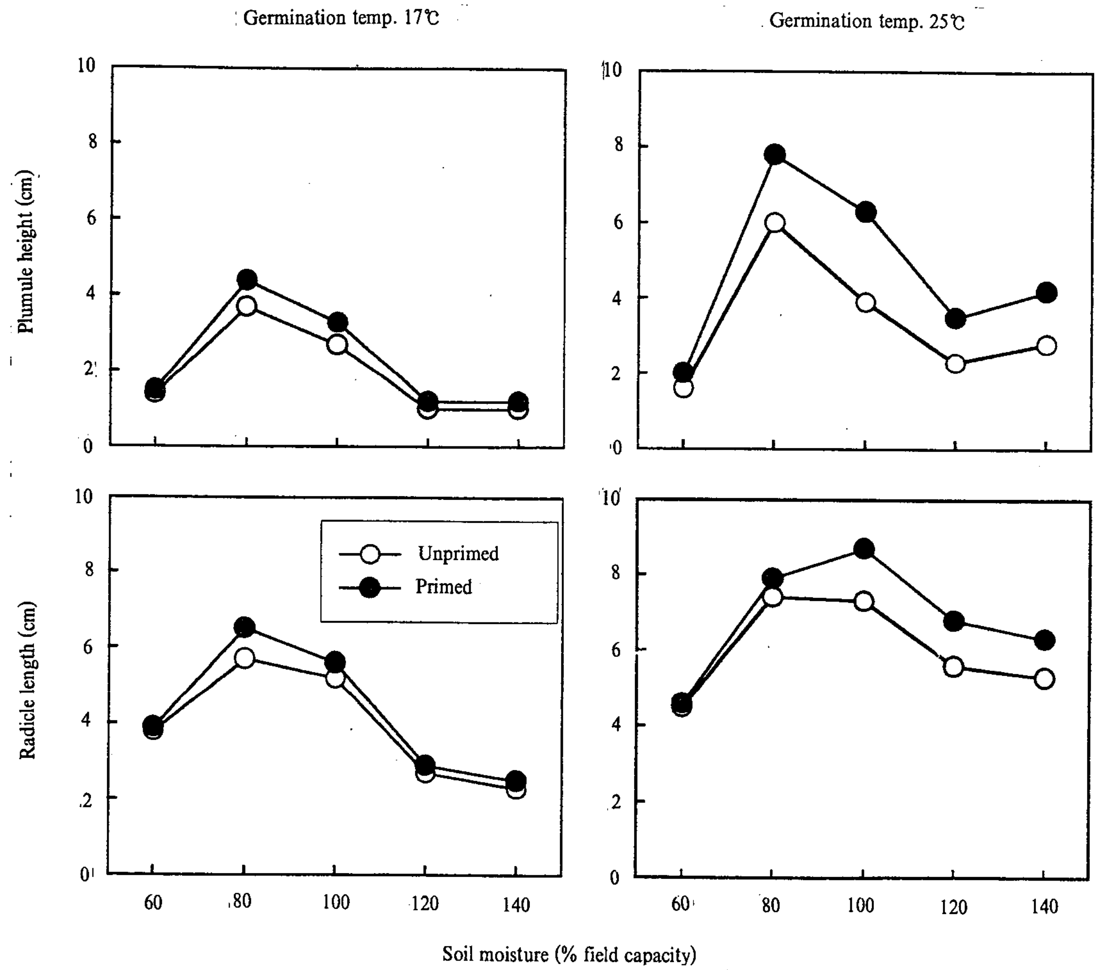

Fig. 2. Mean plumule height and radicle length of primed and unprimed rice seeds at different soil moistures and temperatures (N=3).

because germination was less than 50%. At 17℃ T_{50} of primed seeds were lower (faster germination) compared with unprimed seeds by 1.3~3.7 days and 0.9~2.0 days at 25℃ depending on soil moistures. T_{50} of both primed and unprimed seeds were lowest at the optimum soil moisture of 80% field capacity, then they increased with further higher soil moistures.

At 17℃ the priming effects on T_{50} were greater at the soil moistures of 80 and 100% field capacity than at the higher soil moistures. This may indicate that germination speed of primed seeds is faster than that of unprimed seeds, but even primed seeds germination speed is slowed down under the excess soil moisture conditions due to lack of oxygen. However, the prime effects on T_{50} were relatively small at 25℃ probably due to faster biochemical processes at the near optimum germination temperature.

Plumule height and radicle length of primed and unprimed seeds at different soil moistures and temperatures are shown in Fig. 2. At a soil moisture of 60% field capacity, plumule and radicle of both primed and unprimed seeds grew very little and there were no significant differences between primed and unprimed seeds. However, at soil moisture higher than 80% field capacity, plumule height and radicle length of primed seeds were greater than those of unprimed seeds.

The priming effects of seeds on the growth of plumules and radicles were greater at and near the optimum soil moistures (80 and 100% field capacity) compared with lack or excess soil moisture (60, 120, and 140% field capacity). At the soil moisture of 60% field capacity shortage of available water could be the most limiting factor for the growth, while at soil moistures higher than 120% field capacity oxygen deficiency could be the most limiting factor for the growth of plumules and radicles.

In this study, germination and emergence rates of primed seeds were higher than those of unprimed seeds by 5~34% depending on soil moistures and temperatures. However, Lee et al. (1998) reported that primed rice seeds did not improve the germination rate when high quality seeds were germinated under the optimum germination conditions although germination rate of artificially aged seeds were improved. These two results indicate that priming of rice seeds may not improve the germination rate of high quality seeds whose germination rate approaches 100% under the optimum germination conditions, but it may increase germination and emergence rates when subjected to the adverse soil conditions in the field.

Earlier germination of primed rice seeds (Fig. 1) was also reported by other research workers (Lee et al., 1988). Therefore, higher germination and emergence rates, early uniform germination of primed rice seeds under the adverse soil conditions could be beneficial in direct seedling, especially at early planting when seeds are subjected to low or high soil moisture and low temperature.

The positive priming effects on seed germination, seedling growth, emergence rate and some times yield were reported in peanuts (Fu et al., 1988), celery (Drew & Dearman, 1993; Rennick & Tiernan, 1978), onion (Furutani et al, 1986), and leek (Nienow et al, 1991), while negative effects were also reported in tomato (Coolbear et al., 1980) and wheat (Dell'Aquila & Tritto, 1991). Therefore, priming effects on germination seem to be different depending on species (Bradford, 1986) and quality of seeds (Lee et al., 1998), and further researches are needed for rice seeds.

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