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RESEARCH ARTICLE

Effect of seed priming with different concentrations of potassium nitrate on the pattern of seed imbibition and germination of rice (*Oryza sativa* L.)

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Abstract

Low germination and vigor of rice seed associated with dry-seed broadcasting are common problems encountered by rice growers. The objectives of this study were to evaluate the role of potassium nitrate (KNO_3) on the pattern of seed imbibition and to determine the effect of seed priming with KNO_3 on the germination percentage, speed and uniformity of germination in rice seed. Experiment 1 compared the patterns of seed imbibition of six concentrations of KNO_3 (0, 0.25, 0.50, 1.00, 1.50, and 2.00%) in two rice cultivars — KDML105 and RD15. The results showed that soaking rice seed in KNO_3 at higher concentrations could delay the imbibition time. The higher concentrations of KNO_3 delayed the imbibition time of rice seed and took a longer time to reach the end of phases 1 and 2 compared to the lower concentrations. The patterns of seed imbibition using distilled water of both rice cultivars (KDML105 and RD15) were quite similar, but with different concentrations of KNO_3, the imbibition time taken to reach the end of phases 1 and 2 was slightly postponed in KDML105 suggesting that different rice cultivars may need different imbibition times for soaking seed in the priming process. Experiment 2 evaluated the effects of seed priming with 1.0 and 2.0% KNO_3 at different imbibition times. It was found that priming with 1.0% KNO_3 showed better seed germination than priming with 2.0% KNO_3 and seed priming with 1.0% KNO_3 at the imbibition time of early phase 2 (or 28 h for KDML105) improved seed germination and increased both the speed and uniformity of seed germination. The results of this study show promise for the use of priming with 1.0% KNO_3 soaked until early phase 2 of seed imbibition for improving the seed germination and vigor of rice in dry seed broadcasting.

Keywords: rice, water uptake, seed priming, KNO_3 solution, germination percentage, speed of germination, uniformity of germination

1. Introduction

A problem that rice growers often face is poor germination, especially under dry-seed broadcasting conditions. Seed priming is a technique that may help the rice seed to germinate better in the soil under unfavorable moisture and temperature conditions. Seed priming techniques improve the germination rate and speed of germination (Bradford 1986) are low risk technologies (Harris *et al*. 1999) and

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are low-cost solution for poor stand establishment (Farooq *et al*. 2006). Basra *et al*. (2005) reported that seed priming treatment can lead to better germination and establishment in many crops such as maize, wheat, rice and canola. Razaji *et al*. (2012) also found that seed priming of safflower increased the germination percentage and seedling dry weight under drought stress conditions. In wheat, Hussian *et al*. (2013) demonstrated that seed priming could improve the field performance of poor quality seeds. Dashtmian *et al*. (2014) reported that seed priming with salicylic acid increased photosynthesis and biochemical processes and resulted in an increase in rice seedling root and shoot growth under low temperature. Beneficial effects of seed priming include increasing the germination rate, germination percentage and the uniformity and speed of germination (Farooq *et al*. 2007); as well as increasing plant growth, accelerating plant flowering and increasing yield (Du and Tuong 2002).

The principle of seed priming is based on seed imbibition behavior, so the water uptake of seeds is an important process in the germination and growth of seeds. The imbibition of the seed can be divided into three phases (Bewley and Black 1994): phase 1 is the imbibition phase which allows the seed to imbibe water to activate enzyme activity; phase 2 is the activation phase, during which, food reserve degradation, cell membrane reorganization and starch biosynthesis occur to support root protrusion and seedling growth later in next phase; and phase 3 is the growth phase and at its commencement, radicle protrusion can be seen and then root growth and seedling growth continue. Seed priming can be categorized into three techniques; hydropriming using water, osmopriming using osmoticums, e.g., polyethylene glycol (PEG), potassium nitrate (KNO_3), potassium chloride (KCl), and solid-matrix priming using solid planting materials (Copeland and McDonald 2001; Mohammadi 2009). PEG and KNO_3 are widely used in osmopriming studies, but PEG is more expensive than KNO_3. Esmeilli and Heidarzade (2012) studied the effect of osmopriming with KNO_3 and NaCl in rice and found that the highest germination percentage, germination rate, root length, shoot length, and total dry weight were obtained from osmopriming using KNO_3. Mohammadi (2009) reported that seed priming in soybean with 1.0% KNO_3 for 24 h at 20°C increased the germination percentage. Similarly, Ahmadvand *et al*. (2012) reported that seed priming with KNO_3 of soybean at 6 g L^{-1} concentration increased the germination percentages and seedling dry weight. Moreover, Aquila and Spada (1992) reported that osmopriming of wheat seed increased the synthesis of proteins common to the phase of early embryo growth. Therefore, seed priming with KNO_3 is considered to be a promising technique to enhance the germination of rice seed. However, there are no reports on the effects of different concentrations of KNO_3 on the pattern of seed imbibition and also few reports have compared different imbibition times on seed germination in rice. In this study, the objectives were to evaluate the role of KNO_3 at different concentrations on the pattern of water uptake and imbibition of rice seed and to determine the effect of seed priming at different imbibition times with KNO_3 on the germination percentage and the speed and uniformity of seed germination in rice.

2. Materials and methods

2.1. Experiment 1: Pattern of water uptake and imbibition time of rice seed *cv*. KDML105 and RD15 under different concentrations of potassium nitrate

Experiment 1 studied the pattern of water uptake and imbibition time under different concentrations of KNO_3 of rice seed *cv*. KDML105 and RD15 which are the cultivars widely grown in Northeast Thailand where dry seed broadcasting is extensively practiced in the rainfed areas. Six seed samples (12.5 g each) were randomly drawn from each cultivar. The seed samples were then soaked in KNO_3 solution with different concentrations: 0% (deionized), 0.25% (KNO_3 2.5 g L^{-1}), 0.5% (KNO_3 5.0 g L^{-1}), 1.0% (KNO_3 10.0 g L^{-1}), 1.5% (KNO_3 15 g L^{-1}), and 2.0% (KNO_3 20.0 g L^{-1}) at (25±1)°C and the priming system was aerated throughout the period of imbibition. The seed moisture content was measured using the hot-air oven method at 1-h intervals until the radicle emerged and was about 2 mm long. Values of the seed moisture content were plotted and a curve fitting technique was used for selecting a reasonable equation. The best fitting equation was deemed to be the one that possessed the highest R^2 value. The end of phase 1 was marked by the intersection of the slope lines of phases 1 and 2 and the end of phase 2 was marked by 50% radicle emergence (visible radicle protrusion). Data of imbibition time and KNO_3 concentration from this experiment were taken into consideration for selecting the appropriate treatments to be used in the second experiment.

2.2. Experiment 2: Effect of priming with potassium nitrate at different imbibition times on the germination percentage, speed and uniformity of germination of rice seed cultivar KDML105

Experiment 2 was planned to determine the effect of seed priming with KNO_3 on the germination percentage, speed and uniformity of germination in rice cultivar KDML105. This experiment was carried out using a factorial arrangement in a completely randomized design (CRD) plus an untreated control with four replications. The first factor was the con-