PRE-SOWING SALICYLICATE SEED TREATMENTS IMPROVE THE GERMINATION AND EARLY SEEDLING GROWTH IN FINE RICE

M. Farooq, S.M.A. Basra, H. Rehman, M. Hussain and Y. Amanat
Department of Crop Physiology, University of Agriculture, Faisalabad-38040, Pakistan
(E-mail: farooqcp@gmail.com)

Pre-sowing salicylicate seed treatments were employed in fine rice to explore the possibility of improvement in germination and early seedling growth. Fine rice (cv. Super-basmati) seeds were soaked in 10, 20 and 30 ppm aerated solutions of salicylicate for 48 h at 28±2. Salicylicate seed treatments resulted in earlier, synchronized and enhanced germination. Improvement in root length, leaf score, and seedling fresh and dry weight was also recorded due to pre-sowing salicylicate seed treatments. However, lower shoot length from all the treatments and slower seedling dry weight from 10 ppm Salicylicate seed treatments was noted. Seed treatments with 30 ppm salicylicate solution was the most effective; however, root length and seedling dry weight was recorded 20 ppm salicylicate treatment.

Keywords: Fine rice, salicylicate, germination, seedling growth

INTRODUCTION

It has been estimated that half of the world's population subsists wholly or partially on rice. Rice has also emerged as a major export commodity contributing about 13% to the total valuable foreign exchange earning of Pakistan and accounts for 6.6% value added in agriculture and 1.6% in GDP in the country (Govt. of Pakistan, 2005). Poor seedling establishment is one of the major yield limiting constraints both in transplanted and direct seeded rice especially under stressful conditions (Du and Toung, 2002). Use of high-quality seed better ensures seedlings, which emerge rapidly, tolerate adverse weather conditions, and resist diseases. Various pre-sowing seed treatments have been developed to invigorate the seeds (Basra et al., 2002, 2003, 2004, 2005; Farooq et al., 2004, 2005, 2006, 2006a). The purpose of these treatments is to shorten the time between planting and emergence (Farooq et al., 2004, 2005, 2006) and to protect seeds from biotic and abiotic factors during critical phase of seedling establishment (Senaratna et al., 2000; Du and Toung, 2002; Shakirova et al., 2003). Such treatments synchronize emergence, which leads to uniform stand and improved yield (Harris et al., 2002; Du and Toung, 2002).

Improved seed performance has been achieved by incorporating plant growth regulators during pre-soaking, priming and other treatments in many crops (Jeong et al., 1994) including rice (Miyoshi and Sato, 1997). Bhatt et al. (2000) found significant reduction of MGT and substantial improvement in germination when they used 100 ppm GA3 pre-treatment in Myrica esculenta. Moreover, Qaderi and Cavers (2000) reported an increased germination rate by GA3 of four local populations of Scotch thistle. Miyoshi and Sato (1997) applied kinetin and gibberellins on dehusked seeds of indica and japonica rice to study their effects on the germination under aerobic and anaerobic conditions. They found stimulatory effects of gibberellin on the germination of indica and japonica rice seeds under both conditions, while, under anaerobic conditions, the responses of dehusked indica and japonica rice seeds to kinetin and gibberellin differed, being negative with kinetin and positive with gibberellin. Under aerobic conditions, the stimulatory effects of kinetin on germination of dehusked seeds were greater than those of gibberellin.

Salicylicate is an endogenous growth regulator of phenolic nature, which participates in the regulation of physiological processes in plants (Raskin, 1992). These include effects on ion uptake, membrane permeability, etc. (Barkosky and Einhelling, 1993). In addition, SA interacts with other signalling pathways including those regulated by jasmonic acid and ethylene (Szalai et al., 2000, Ding and Wang, 2003). SA also induces an increase in the resistance of seedlings to osmotic stress (Borsani et al., 2001), low or high temperature by activation of glutathione reductase and guaiacol peroxidase (Kang and Saltveit, 2002).

In an earlier study, Farooq et al. (2006) investigated the possibility of seed invigoration by seed treatments with salicylicate and ascorbate in coarse and fine rice. Although, ascorbate was more effective in vigor enhancement, salicylicate also improved the germination rate and seedling growth. The present experiment was therefore, planned to further explore the potential of salicylicate seed treatments for vigor enhancement in fine rice.
MATERIALS AND METHODS

Seed materials

Seeds of fine rice cultivar (Super-Basmati) were obtained from Rice Research Institute, Kala Shah Kakoo, District Sheikhupura, Pakistan. The initial seed moisture contents were 8.34% (on dry weight basis).

Seed treatments

The seeds were soaked in 10, 20 and 30 ppm aerated solution of salicylic acid solution for 48 h at 28±2°C. The ratio of seed weight to solution volume was 1:5 (g mL⁻¹) (Farooq et al., 2006). After treating, seeds were dried near to their original weight, sealed in polythene bags and then stored in refrigerator at 7°C±1 for further use.

Germination test

Seeds (15 in each) were placed in Petri dishes between layers of moist Whatman 45 at 27°C in an incubator. The completely randomized design with four replications was used. Germination was observed daily according to the AOSA method (AOSA, 1990). The time to get 50% germination (T₅₀) was calculated according to the following formula of Coolbear et al., (1984) modified by Farooq et al. (2005) as under:

\[ T_{50} = t_i + \left( \frac{N - n_i}{2} \right) \left( t_j - t_i \right) \]

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

Mean germination time (MGT) was calculated according to the equation of Ellis and Roberts (1981) as under:

\[ MGT = \frac{\sum Dn}{\sum n} \]

Where \( n \) is the number of seeds, which were germinated on day \( D \), and \( D \) is the number of days counted from the beginning of germination.

Energy of germination was recorded at 4th day after planting. It is the percentage of germinating seeds 4 days after planting relative to the total number of seeds tested (Farooq et al., 2005).

Seedling emergence

Control and treated seeds were sown in 20 x 20 cm plastic trays (25 in each) having moist sand, replicated four times and were placed in growth chamber (Vindon, England) in completely randomized design. Day and night lengths were kept 15 and 9 h with 30°C and 24°C temperatures, respectively (Farooq et al., 2005). Relative humidity was maintained at 70%. Root and shoot length, and seedling fresh and dry weights were recorded 16 days after sowing. Number of leaves at harvest was designated as leaf score (Farooq et al., 2006a).

RESULTS

Pre-sowing salicylic acid seed treatments significantly (p < 0.05) affected the germination and seedling growth in fine rice (Fig. 1-4).

All the salicylic acid seed treatments resulted in earlier germination compared with untreated seeds as shown by lower values of time to start germination (Fig. 1a), T₅₀ (Fig. 1b) and MGT (Fig. 1c). Although, seeds treated with salicylic acid of different concentrations started germination on the same day (Fig. 1a) lowest T₅₀ and MGT were recorded in seeds soaked in 30 ppm salicylic acid solution (Fig. 1b, 1c) (highly confusing). Similarly, all the salicylic acid seed treatments enhanced the energy of germination (GE) (Fig. 2a) and final germination percentage (FGP) (Fig. 2b) than that of untreated seeds. Maximum GE and FGP were recorded from the seeds soaked in 30 ppm salicylic acid solution (Fig. 2) followed by 20 ppm that was similar to the seeds soaked in 10 ppm salicylic acid solution.

Maximum shoot length was measured from the untreated seeds. All the salicylic acid seed treatments resulted in lower shoot length being minimum from the seeds soaked in 30 ppm salicylic acid solution (Fig. 3a).

However, maximum root length was recorded from the seeds treated with 20 ppm salicylic acid (Fig. 3b) followed by that of 30 ppm. Minimum root length was noted from untreated seeds that was similar to that of seeds treated with 10 ppm salicylic acid (Fig. 3b). Salicylic acid seed treatments also resulted in statistically similar and higher leaf score than untreated seeds (Fig. 3c). All the seed treatments resulted in improved seedling fresh weight than that of untreated seeds (Fig. 4a) being maximum from the seeds soaked in 30 ppm salicylic acid solution followed by 20 ppm (Fig. 4a). However, minimum seedling dry weight was recorded from the seeds treated with 10 ppm salicylic acid solution followed by untreated ones (Fig. 4b), while other treatments resulted in higher seedling dry weight being maximum from the seeds treated with 20 ppm salicylic acid solution (Fig. 4b).

DISCUSSION

Pre-sowing salicylic acid seed treatments significantly (p < 0.05) improved the germination and early seedling growth in fine rice.
Rice seed invigoration

Fig. 1. Influence of Pre-sowing salicylate seed treatments on the (a) time to start germination, (b) time to 50% germination and (c) mean germination time
Fig. 2. Influence of Pre-sowing salicylate seed treatments on the (a) energy of germination and (b) final germination percentage.
Rice seed invigoration

Fig. 3. Influence of Pre-sowing salicylate seed treatments on the (a) shoot, (b) root length and (c) leaf score
Fig. 4. Influence of Pre-sowing salicylicate seed treatments on the (a) seedling fresh weight and (b) seedling dry weight
This study revealed that employing salicylate seed treatments could invigorate fine rice seeds. Earliest and most uniform germination was observed in seeds treated with 30 ppm salicylate as indicated by lesser time to start germination, MGT and T_{50}, and higher GE and FGP, root length, leaf score and seedling fresh and dry weight (Fig. 1-4). Lesser treatments could invigorate fine rice seeds. Earliest spread over the time (Fig. 1-2). Earlier, Al-Hakimi and Hamada (2001) reported improved germination rate and percentage by ascorbate and sodium salicylate treatments in wheat. Increase in germination and percentage after treatment might be the consequence of breakdown of dormancy as fresh seeds were used during the investigations. The earlier and synchronized germination might be attributed to increased metabolic activities in the treated seeds (Shakirova et al., 2003; Basra et al., 2005). Seed treatments not only improved the germination rate and time but also enhanced the seedling vigor as indicated by higher leaf score, root length and seedling fresh and dry weights (Fig. 3, 4). It is worth noting that salicylate seed treatments increased the root length but not the shoot length that might be explained by the fact that salicylate enhances the replication in root tips (Senaratna et al., 2000; Shakirova et al., 2003). Reduction in shoot length might be due to increased lateral growth as indicated by increased shoot weight which might have utilized the major part of food (Metwally et al., 2003).

This is confirmed by the fact that although shoot length was reduced (Fig. 3a), both seedling fresh and dry weights were increased due to salicylate treatments (Fig. 4). Improved seedling fresh and dry weights might be due to increased cell division within the apical meristem of seedling roots, which caused an increase in plant growth. Moreover, salicylate treatment maintains the IAA and cytokinin levels in the plant tissues, which enhances the cell division (Sakhabutdinova et al., 2003).

It may be concluded from the present studies that pre-sowing salicylate seed treatments improves the germination and early seedling growth in fine rice. However, seed soaking in 30 ppm salicylate solution was the most effective.

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LITERATURE CITED


