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The effects of rice seed dressing with *Paenibacillus yonginensis* and silicon on crop development on South Korea's reclaimed tidal land

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ABSTRACT

A field trial to investigate the effects of plant growth promoting bacteria (PGPB) *Paenibacillus yonginensis* (DCY84^T) and/or SiO_2 seed coating on rice growth (*Oryza sativa* L.) was carried out on reclaimed tidal land in Taean County in South Korea. The field test was performed twice between May–October 2014 and May–October 2015, in a randomized complete block (RCB) design with three replications. Treatments consisted of: Mock, DCY84^T-treated seeds, SiO_2-coated seeds and DCY84^T-SiO_2-treated seeds and each treatment area covered approximately 300 m^2. During the early developmental period of rice seedlings, the SiO_2 coating without DCY84^T led to the most favorable 30 DAS rice seedling parameters. Moreover, the combination of DCY84^T and SiO_2 treatments resulted in 2-fold greater fresh and dry weights of 60 DAS rice seedlings compared to Mock seedlings. DCY84^T and SiO_2, both individually and together, produced a greater grain yield and a greater total yield; specifically, DCY84^T and SiO_2 treatments yielded a 73% and 70% increase in mass compared to Mock plants, respectively. Rice treated with both DCY84^T and SiO_2 treatment contained the highest amount of Al, Fe, Ca and Mg, which were 54%, 169%, 42% and 67% higher than the Mock rice, respectively. Remarkably, DCY84^T treatment had the most phosphate [P], potassium [K] and total nitrogen [T–N]. DCY84^T and/or SiO_2 treatment highly increased the whole kernel percentage. Thus, lower its broken kernel percentage to 9.60–24.58%. The protein content of the grain with both treatments was 7.2%, which was greater than that of the Mock grain (6.0%). The content of chlorophyll a, b and carotinoid in the rice leaves which were treated with silica and DCY84 has increased more than the mock without treatment. After harvest, the GABA content of brown rice was increased to 1.9-fold (2014), 1.5 fold (2015) compared to mock grain, respectively. Overall, DCY84^T treatment and SiO_2 coating can be useful methods for promoting growth of rice under conditions of saline stress. Results from other laboratory trials and greenhouse experiments are also provided.

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1. Introduction

The exponential growth of the human population demands more food and thus enhanced crop production. During the 1960's, the Green Revolution was largely responsible for increasing food supply. Currently, two alternatives exist for increasing cereal production: (1) expanding farming into areas that are currently not used for food production or (2) attaining a higher yield per unit of land area in existing agricultural areas (Linquist et al., 2011). In South Korea, because the available farmland had been decreasing due to urbanization and industrialization, farming on reclaimed tidal land is one of the country's efforts to produce more food. However, agricultural activities on reclaimed tidal land are generally difficult due to high salinity and low amounts of nutrients (Cho et al., 2008). A "saline soil" is usually defined as soil in which the electrical conductivity (EC) of the saturation extract (EC_e) in the root zone is more than 4 dS m^{-1} at 25 °C (equal to 40 mM NaCl) and the exchangeable sodium is less than 15%. The yield of most crop plants is reduced at this EC_e, though many crops exhibit yield

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