

Effects of AG1 and AG2 QTLs on Rice Seedling Growth and Physiological Processes during Germination in Flooded Soils

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Abstract : Anaerobic condition caused by flooding during germination in direct seeded rice systems, known as anaerobic germination (AG), severely reduces crop establishment in both rainfed and irrigated areas. Seeds germinating in flooded soils could encounter hypoxia or even anoxia in severe cases, and this hinders germination and seedling growth. This study was conducted to quantify the effects of incorporating two major QTLs, AG1 and AG2, associated with tolerance of flooding during germination and to assess their interactive effects on enhancing crop establishment. A greenhouse experiment was conducted at the International Rice Research Institute (IRRI), Los Baños, Philippines, using elite lines incorporating AG1, AG2 and AG1+AG2 in the background of the popular varieties PSBRc82 (PSBRc82-AG1, PSBRc82-AG2, PSBRc82-AG1+AG2) and Ciherang-Sub1 (Ciherang-Sub1-AG1, Ciherang-Sub1-AG2, Ciherang-Sub1-AG1+AG2), along with the donors Kho Hlan On (for AG1) and Ma-Zhan Red (AG2) and the recipients PSBRc82 and Ciherang-Sub1. The experiment was conducted using concrete tanks in an RCBD with three replications. Dry seeds were sown in seedling trays then flooded with 10 cm water depth. Seedling survival, root and shoot growth and relative growth rate were measured. The germinating seedlings were used for assaying nonstructural carbohydrate (NSC) and ascorbate concentrations, lipid peroxidation, total phenolic concentration, reactive oxygen species and total amylase enzyme activity. Flooding reduced overall survival, though survival of AG1+AG2 introgression lines was greater than other genotypes. Soluble sugars increased, while starch concentration decreased gradually under flooding especially in the tolerant checks and AG1+AG2 introgression lines. Less lipid peroxidation and higher amylase activity, reduced-ascorbate (RAAs) and total phenolic contents (TPC) were observed in the tolerant checks and in AG1+AG2 introgression lines. Lipid peroxidation correlated negatively with ascorbate and total phenolic concentrations and with reactive oxygen species (ROS). Introgression of AG1+AG2 QTLs upregulated total amylase activity causing rapid starch degradation and increase in ascorbate and total phenolic concentrations resulting in higher germination and seedling growth in flooded soils.

Keywords : amylase, anaerobic germination, ascorbate, direct-seeded rice, flooding, lipid peroxidation

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