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Enhancement of flood stress tolerance for upland-adapted cereal crops by the close mixed-planting with rice

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Abstract

Recently, the occurrences of extreme flooding and drought, often in the same areas, have increased due to climate change. We tested the hypothesis that wetland species could help upland species under flood conditions; that is, the roots of wetland crops may supply O_2 to the roots of upland crops by a series of experiments conducted in both humid Japan and semi-arid Namibia (See Iijima et al, 2016 and Awala et al, 2016). Firstly, flooding tolerance of upland-adapted staple crops—pearl millet (*Pennisetum glaucum*) and sorghum (*Sorghum bicolor*) mix-cropped with rice (*Oryza spp.*) was investigated in glasshouse and laboratory experiments in Japan. We found a phenomenon that strengthens the flood tolerance of upland crops when two species—one wetland and one drought tolerant—were grown using the mixed cropping technique that results in close tangling of their root systems, hereinafter referred to “close mixed-planting”. This technique improved the photosynthetic and transpiration rates of the upland crops subjected to flood stress (O_2-deficient nutrient culture). Oxygen transfer was suggested between the two plants mix-cultured in water, implying its contribution to the phenomenon that improved the physiological status of upland crops under the simulated flood stress. Secondly, we further tested whether this phenomenon would be expressed under field flood conditions. The effects of close mixed-planting of pearl millet and sorghum with rice on their survival, growth and grain yields were evaluated under controlled field flooding in semi-arid Namibia during 2014/2015–2015/2016. Single-stand and mixed plant treatments were subjected to 11 – 22 day flood stress at the vegetative growth stage. Close Mixed-planting increased seedling survival rates in both pearl millet and sorghum. Grain yields of pearl millet and sorghum were reduced by flooding, in both the single-stand and mixed plant treatments, relative to the non-flooded upland yields, but the reduction was lower in the mixed plant treatments. In contrast, flooding increased rice yields. Both pearl millet–rice and sorghum–rice mixtures demonstrated higher land equivalent ratios, indicating a mixed planting advantage under flood conditions. These results indicate that mix-planting pearl millet or sorghum with rice could alleviate flood stress on dryland cereals. The results also suggest that with this cropping technique, rice could compensate for the dryland cereal yield losses due to field flooding. Mixed cropping of wet and dryland crops is a new concept to overcome flood stress under variable environmental conditions.

Keywords: rice, close mixed-planting, flood stress, Namibia

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