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Estimation of the relationship between below-ground root and above-ground canopy development by measuring dynamic change of soil ammonium-N concentration in rice

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Abstract

In the early part of rice growth, root volume primarily limits the amount of plant-accessible nitrogen (N). Therefore, knowledge of the root development is important for modeling N uptake of rice. The timing when the volume of rhizosphere cover the whole soil is also important to carry out timely top dressing. However, information about initial root expansion and associated N uptake is limited due to intrinsic technical difficulties in assessing below-ground processes. Some studies, however, showed a close relationship between below-ground root and above-ground leaf development, suggesting a possibility that above-ground attributes could serve as surrogates for the root processes. In this study, we investigated the relationship between below-ground and above-ground development of rice. Field experiments were conducted where we cultivated Koshihikari (a leading cultivar in Japan) for four different cropping schedules in 2012. In 2016, Gimbozu (HEG4) and three flowering time mutant lines of Gimbozu (X61 (*se13*), HS276 (*ef7*), DMG9 (*se13, ef7*)) were examined for a single season. Experiments were performed with three replications in a completely randomized design. We monitored ammonium-N concentration ([NH4+-N]) in soil solution by repeatedly taking samples from a porous tubing (10-cm long) vertically inserted at the most distant point from surrounding rice hills. Samples were taken in triplicate (= triplicate tubes) and every three days from transplanting in each experimental unit. For above-ground attributes, leaf area index (LAI) was measured in 2012, whereas soil coverage ratio was estimated by image processing in 2016. Results showed that [NH4+-N] increased gradually after transplanting and then rapidly decreased from a certain day. This distinct drop in [NH4+-N] informed us the timing at which the rice root system reached the point of porous tubing and thus essentially covered the whole soil volume. The LAI at the dropping point was about 0.43 regardless of the cropping schedules in 2012 experiment. In 2016, the coverage ratio at the N dropping point was within the range of 0.12 to 0.19 for four genotypes having different growth durations. In addition, the coverage ratios at seven weeks after the transplanting showed a good correspondence to LAI across the four genotypes. We therefore conclude that both LAI and coverage ratio may serve as robust indicators for root development and might be useful to estimate the timing when the root system fully cover the soil volume. Results obtained here will also contribute to develop models that can predict not only above-ground canopy development but also associated below-ground processes.

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Keywords: rice, root development, soil ammonium-N, coverage ratio

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