Root Phenotyping with Root Modeling: Towards Sustainable Rice Production

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Root system architecture (RSA) in rice production system has been shown to be important for resource acquisition, especially in the low-input conditions. Furthermore, improving RSA would have a potential to increase carbon stocks in the soil and, as a result, it would reduce atmospheric CO2 concentration without decreasing the yield. To design and develop RSA for the sustainable rice production, we need to understand the performance of RSA, i.e. the performance of individual root trait and their interactions in the actual field. However, it is extremely difficult even to determine root traits such as the root elongation rate of RSA in the field. In this presentation, two possibilities using the root model which simulates RSA on a computer are represented to understand the performance of RSA in the field.

First, it is to predict RSA in the field with the datasets of RSA in the early growth stage of rice plants in the lab-based experiments. Some lab-based experiments, such as paper or soil cultures against transparent plates, allow for non-destructive and time-lapse observations on individual plants. These experiments provide the datasets with analyzing two-dimensional images that are taken with the camera or the scanner. Running root model with the datasets from the lab-based experiments, RSA in the field could be predicted even at the end of the growth season, though there are concerns that the conditions with lab-based experiments don't simulate the field, e.g. the observed roots that grow against plates could not be same to that in the soil.

Second, it is to use several easy-measurable root traits in the field to predict the whole of RSA. Several root traits, such as the number of nodal roots in rice plants, could be easily identified from the observations around the root base. In addition, with the partial data of vertical root distribution that is taken in old but standard methods such as trench excavations and soil cores from the soil for the validation, more realistic RSA could be predicted. The vertical root distribution could exist as the legacy data since they have been taken for decades. We also would be able to use them for the validation.

Developing a mutually complementary relationship between root phenotyping and modeling should accelerate to propose a groundbreaking RSA ideotype and contribute RSA improvement for boosting up rice production and reducing environmental impacts in the future.