Development of an efficient breeding platform for fruit trees using genome and image information

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The global demand for high-quality fruits is increasing, and fruit quality has become an essential breeding target. Cross-breeding to obtain new cultivars with high-quality fruits generally takes many years due to the long juvenile period of fruit trees. It is sensible for the breeders to evaluate as many genotypes as possible to increase the acquisition rate of the new varieties; however, the large size of the fruit trees, makes this to be difficult due to limited orchard space. Self-incompatibility in many rosaceous fruit trees also limits the combinations that can be crossbred. To overcome these obstacles in fruit tree breeding, the author has been working in cooperation with many researchers to elucidate the mechanism of self-incompatibility and to implement efficient breeding methods using genome and image information.

Identification of candidate genes of pollen-part self-incompatibility (*S*) specificity in the S-RNase-based gametophytic self-incompatibility (GSI) system in apple[1].

We isolated a lot of pollen-specific F-box genes (*Malus × domestica F-box*: *MdFBXs*) as candidates of pollen-*S* determinants from apple genome. In vitro binding assays suggest that MdFBX-containing SCF complex function in pollen of apple.

Evaluation of the potential of genomics-assisted breeding, such as genomic selection (GS) and genome-wide association analysis (GWAS) in citrus[2].

GWAS power and accuracy of genomic prediction were increased by combining the parental and breeding populations. The data collected from breeding populations are beneficial for increasing the detection power of GWAS and the prediction accuracy of GS. Both GWAS and GS would be effective for genetic improvement of citrus fruit traits.

Dissecting breeders' sense via explainable machine learning approach: application to fruit peelability and hardness in citrus[3]

We applied explainable machine learning methods to determine the relationship between fruit morphological features, which were obtained by image analysis of cross-sectional images of citrus fruits, and two sensorily evaluated fruit quality traits: easiness of peeling (Peeling) and fruit hardness (FruH). The degradation area of the central core of the fruit was significantly and directly associated with both Peeling and FruH.

Reference

1) Minamikawa M., Kakui H., Wang S., *et al.*: Plant Mol. Biol. 74: 143–154 (2010).
2) Minamikawa M. F., Nonaka K., Kaminuma E., *et al.*: Sci. Rep. 7: 4721 (2017).
3) Minamikawa M. F., Nonaka K., Hamada H., *et al.*: Front. Plant Sci. 13: 832749 (2022).