

Sex Determination Mechanisms in Tree Crops

Takeshi Akagi (Graduate School of Environmental and Life Science, Okayama Univ.)

takashia@okayama-u.ac.jp

Sexuality, a main strategy to maintain genetic diversity within a species, has long been a major focus in biology, and is an important trait in agriculture. Notwithstanding, in plants, mechanisms underlying sex determination have been little unveiled. In our studies, we have elucidated the molecular mechanisms of sex determination in two tree crop species; persimmons (*Diospyros* spp.), in which the first finding of the sex determinant in plants was made, and kiwifruits (*Actinidia* spp.).

In persimmons, by developing novel approaches based on massive sequencing technologies, we rapidly found a Y-encoded small-RNA gene, named *OGI*, which can repress the female-determining gene *MeGI*¹. Here, we also present two evolutionary scenarios involving transitions of sexual systems, which were triggered by ancient or recent genome wide duplication (polyploidization) events. The recent hexaploidization in cultivated persimmon (*D. kaki*) derived “flexible” sexuality in flower units via establishing epigenetic layers on the two sex determinants, *OGI* and *MeGI*. On the other hand, the *Diospyros*-specific paleo-genome wide duplication enabled neofunctionalization in the proto-*MeGI*, via positive selection, to establish a new function as a sex determinant.

In kiwifruits, we identified two sex determinants in the Y-chromosome, *Shy Girl* and *Friendly Boy*, which can act for repression of gynoecium development and maintenance of androecium function, respectively^{2,3}. The molecular functions and evolutionary paths of these two genes verified a representative theory for plant sex evolution, called “two-mutations model” proposed over 40 years ago³. Importantly, the evolution of *Shy Girl* was thought to be derived from an *Actinidia*-specific genome-wide duplication event, which is consistent with the concept of sexual transitions in persimmons, as described. Furthermore, using transformation and gene-editing with *Shy Girl* and *Friendly Boy*, we were successful to artificially develop “hermaphrodite kiwifruits”, which would directly contribute to actual cultivations.

These findings unveiled diversified molecular mechanisms to determine sexualities in tree crops, and exemplified how plant-specific numerous duplication events can drive flexible genetic material whose variation can be selected for development of new sexual systems.

Reference

- 1) Akagi T., Henry I. M., Tao R., Comai L. (2014) *Science* 346: 646-650.
- 2) Akagi T. et al. (2016) *Plant Cell* 28: 2905-2915.
- 3) Akagi T. et al. (2019) *Nature Plants* 5: 801-809.