Next Generation Cucurbit Breeding

Unisexual flower development and parthenocarpy to increase yields (Part Two)

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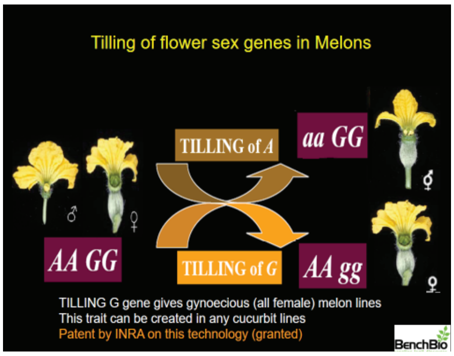

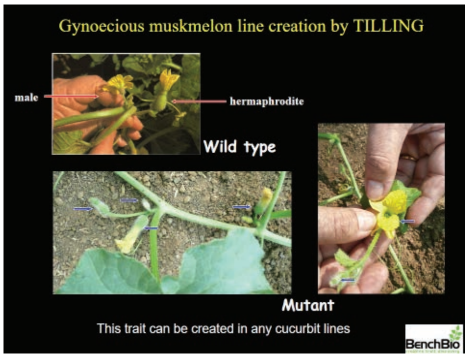

TILLING of the A and the G gene to modify flower sex type in cucurbits. Above graphics demonstrate proof-of-concept regarding creation of gynoecious lines by mutating the CmWIP1(G) gene in melons. We can use this strategy in other cucurbits for hybrid development. This trait can be stacked with the parthenocarpic (seedless) trait for higher yields – without pollination – in cucumbers.

In Part One (Gynoecy Gender Genius), published last issue, we looked at using the sexual morphology fundamentals of cucurbit flowers as a basis for increasing production. Now, we will look at several promising techniques in the field.

Higher-yielding F1 hybrid cultivars of various types of crops have made a significant contribution to the world's food supply: one of the continuing challenges of plant breeding is to master production of F1 hybrid seeds. Sex determination systems leading to unisexual flowers are attractive tools for improving production of F1 hybrid seeds, especially with cucurbits.

For instance, in Cucumis melo (melon), seed companies have exploited monoecious cultivars for F1 hybrid production. Treatment of monoecious melon plants with Ethrel, an ethylene precursor, leads transiently to plants having only female flowers.

In Cucumis sativus (cucumber), the exploitation of gynoecy to produce F1 hybrids is also an attractive system for two reasons: first, the gynoecious plants carry only female flowers, which eases tracking of the crossing and gives pure hybrid seeds; second, treatment of gynoecious plants with ethylene perception inhibitors, like silver nitrate/silver thiosulphate, induces male/hermaphrodite flower and, thus, the gynoecious lines can be maintained.

In crops that develop a low number of pistillated flowers, such as many orphan crops of the Cucurbitaceae family, gynoecy could be a practical tool for increasing yield.

In cucumber, for instance, introduction of gynoecy in breeding lines positively correlates with higher yield. In monoecious species such as Luffa cylindrica (Sponge gourd) and Lagenaria siceraria (bottlegourd) and others that show non-optimal synchronization between anther anthesis, pollen viability and pistil receptivity, fertilization is a limiting factor for yield.

In such species one would expect the co-cultivation of androecious plants with gynoecious plants to serve as a reservoir for continuous production of pollen and/or creation of andromonoecious (hermaphrodite) plant types. In other circumstances the combination of stable gynoecy with parthenocarpy is also a promising means to improve productivity.

Parthenocarpy can bypass poor fruit setting due to pollinator decline or unfavorable growth or developmental conditions (such as high temperature and drought). Combining parthenocarpy and gynoecy in cucumber has enabled large scale glasshouse production of cucumbers in countries such as the Netherlands – which is a major producer of EU cucumbers. In this case, fruit set occurs without fertilization, leading to seedless straight cucumbers, and, in the absence of bees, resulting in significantly higher yields – about 100 tonnes/ha, compared to a global average of 15t/ha.

Recently it was shown by Dr Bendahmane's lab* that in melon, sex determination is genetically governed by the interplay of alleles of the andromonoecious (M), androecious gene (A) and gynoecious (G) genes. The cloning and characterization of M, G and A genes have shown that the gynoecious (G) gene encodes a zinc finger transcription factor, the andromonoecious (M) gene encodes an ethylene biosynthesis enzyme, CmACS-7 and the androecious gene (A) encodes CmACS11. Therefore, genes controlling flower sex forms are now available.

Screening for induced mutations in CmWIP1 (G) in monoecious melon or cucumber, using the TILLING concept, demonstrably leads to gynnoecy (100% female flowers) thereby leading to increased yield.

Application of the G gene to create the gynoecious trait in any cucurbits has been patented by INRA-Transfert*. BenchBio has obtained the worldwide license for generating the gynoecious trait in any cucurbits. Hermaphrodite flower types can also be created by mutating the M gene. hermaphrodite flowers in combination with the seedless trait, can be valuable in this species (as every flower will result in fruit).

We can now engineer new plant types in Cucurbitaceae species to increase yield – which was not possible earlier – by using knowledge gained from melon and cucumber, and to develop unisexual flower and parthenocarpy fruits with uniform shape for use in production of hybrids.

This will lead to significantly higher yields. The proof of concept has already been demonstrated in melon (see image above).

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** Bendahmane A, Martin A. Boualem A, Troadec C, Dogimont C (2008) Combination of two genetic elements for controlling the floral development of a dicotyledonous plant, and use in detection and selection methods. PCT/FR2009/051510, WO/2010/012948*


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