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### **Is one-line hybrid rice coming?**

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Asian cultivated rice is one of the most important cereal crops and feeds half of the world's population, especially in Eastern and Southeast Asian countries (Virmani 2002). It is estimated that about 20% or more increase in rice production would be likely needed in the next 20 years due to the growing population and environmental changes (Virmani 2002). Hybrid rice is proved to strikingly outyield other rice varieties and contributed significantly in increasing rice production by 200 million t from 1976 to 1991 in China (Yuan 1987). To meet the rising global demand for rice, further development of hybrid rice varieties for a higher yield target is still a sustainable strategy. However, hybrid rice seed production and maintenance of sterile lines requires more labor and field operation than ordinary rice cultivation. Thus, it is important to simplify the process of hybrid

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seed production. To produce clonal seeds in the absence of meiosis is a hot topic for research, called as one-line hybrid rice by Dr. Longping Yuan (Yuan 1987). In 1980-1990s, some hybrid rice scientists endeavored to the study of apomictic rice germplasm and attempted to solidify hybrid vigor from two different genetic pure lines into clonal rice seed. Although some rice precious germplasms, such as SR-1, 84-15, etc, are somewhat like apomixis plants, no one has succeeded to develop one-line hybrid rice so far (Zhou and Li 1992).

It is well-known that rice seed mainly consists of embryo and endosperm. The endosperm cells are derived from fertilized central cell and provide nutrients to embryo for the seed germination. The embryo cells with diploid genome are originated by gametic fusion between sperm and egg cells, both of which have a set of haploid genome produced by a meiotic division (Leon-Martinez and Vielle-Calzada 2019). Previously, it was reported an important finding that a simultaneous knock-down of three genes related to meiosis, *SPO11-1*, *REC8* and *OSD1*, can turn from the process of meiosis of egg cells to that of mitosis (Mitosis instead of Meiosis; MiMe) in *Arabidopsis* and rice. Namely, this demonstrated that scientists can induce egg cells carrying diploid genome by an asexual process (Mieulet et al. 2016). Further studies revealed that other two genes, such as *Babyboom1(BBM1)* and *Matrilineal (MATL)*, which are involved in parthenogenesis development of egg cells and haploid induction ability, respectively, are important for asexual development of egg cells in maize and rice (Kelliher et al. 2017; Khanday et al. 2019).

A paper from the group of Dr. Zhukuan Cheng introduced a strategy for generating rice apomixis by gene editing of three *MiMe* genes and *OsMATL* (Xie et al. 2019). In such quadruple mutants, actually, they confirmed no occurrence of meiotic recombination in the process of the development of egg cells by observing the chromosome behavior and the absence of meiotic protein markers in egg cells (Figure 1). The results reported in this paper are consistent with that of an independent study reported by another Chinese group recently (Wang et al. 2019), indicating these studies provide valuable information to point out the direction for further researches on apomictic breeding in rice (one-line hybrid rice).

For practice utilization of this one-line hybrid technique, however, we have to overcome a problem of low seed setting due to the introduction of *Osmatl* mutation in combination with *MiMe* gene, which was also mentioned in other researches. Therefore, this strategy, while is of great significance, could be

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difficult to be immediately utilized in breeding practice for one-line hybrid rice. Very recently, one group (Zhong et al. 2019) reported a novel gene involved in egg parthenogenesis development in maize, *ZmDMP*, strongly indicating that there should exist other genes for haploid induction and asexual reproduction in rice (Figure 1). It is a prospective direction for further research works to conduct large scale screening of new genes involved in the production of apomictic rice toward the creation of high yielding one-line hybrid rice.

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## Figure

Figure 1: Schematical illustration of one-line hybrid rice. (The model figure was provided by Dr. Zhukuan Cheng's group)

