II.4 Hybrid Rice in China – Techniques and Production

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1 Introduction

The phenomenon of heterosis in cereal crops is expressed mainly in the first hybrid generation (F1). In order to utilize rice hybrids in commercial production, it is first necessary to produce a large amount of F1 hybrid seeds. However, rice is a strictly self-pollinated crop with tiny florets, so that it is impossible to produce bulk quantities of F1 hybrid seeds by hand emasculation. This is the primary reason why heterosis in rice has not been utilized in commercial production. To solve this problem, the most effective way, as proved by other self-pollinated crops, is to exploit the phenomenon of cytoplasmic male sterility.

Since Jones (1926) first observed heterosis in rice, suggestions for exploiting heterosis commercially by developing F1 rice hybrids have been made from time to time (Stansel and Craigmiles 1966; Shinjo and Omura 1966; Yuan 1966; Athwat and Virmani 1972; Swaminathan et al. 1972). However, difficulties in hybrid seed production discouraged most of the researchers from continuing their efforts, the notable exception being Chinese scientists (Yuan 1966, 1972).

In China hybrid rice research work was started by L.P. Yuan in 1964, and later a male sterile plant in wild rice was found by his assistant, B.F. Li, in 1970. This male sterile plant was named wild abortive or WA type. This discovery was a breakthrough in hybrid rice breeding. Through wide test crosses and successive back-crossing, the first set of WA type cytoplasmic male sterile (CMS) lines and their maintainers was soon developed in 1972. In the next year, the first restorer lines were identified by screening existing varieties introduced from southeast Asian countries. In 1974, some rice hybrids with strong heterosis were developed and a complete procedure of hybrid seed production technology was established in 1975. In 1976, hybrid rice in China was released for commercial use on a large scale (Lin and Yuan 1980). From 1976 to 1988, the additional growing area of hybrid rice in China was about 84 million ha, and an increase of more than 125 million tons of grain was achieved. In 1989, the hybrid rice growing area in China (total growing area = 15.27 million ha) was enlarged by 14 million hectares (Fig. 1).

Outside China, hybrid rice research work has been initiated in India, Indonesia, the United States, Japan, the Philippines, South Korea, Malaysia, Thailand, Vietnam, Brazil, Mexico, and the International Rice Research Institute (IRRI). Experimental data show the possibility of a yield increase in rice hybrids by 15–20% over the best semi-dwarf inbred rice varieties. Promising CMS lines and R lines have

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been developed in some countries, and hybrid seed production has been successful on a small scale in the United States, Philippines, Thailand, Japan, Indonesia, and South Korea in recent years. More and more countries have recognized the importance of hybrid rice in food production strategy, and are initiating national hybrid rice programs.

2 Heterosis in Rice

The term heterosis in rice refers to the phenomenon in which the $F_1$ population obtained by the crossing of two genetically dissimilar parents shows superiority to both parents in growth vigor, vitality, reproductive capacity, stress resistance, adaptability, grain yields, and other characters. Jones (1926) observed that some $F_1$ rice hybrids had more culms and a higher yield than their parents. The extent of heterosis can be estimated in terms of certain parameters. The following three formulas are usual for the estimation of heterosis in rice, as well as in other crops.

Mid-parent heterosis or heterosis over the mean parental (MP) value

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= \frac{F_1 - MP}{MP} \times 100\%
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