IV.2
Rice Yielding and Plant Hormones

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1 Introduction

Food shortage is a serious global problem in this century. According to FAO estimates, 852 million people worldwide were undernourished in 2000–2002 (FAO 2004). The global population, now at 6.4 billion, is still growing rapidly and is supposed to reach 8.9 billion by 2050 (UNFPA 2004). Cereals are an important source of calories for humans, both by direct intake and as the main feed for livestock. Approximately 50% of the calories consumed by the world population originate from three cereal species: rice (23%), wheat (17%), and maize (10%) (Khush 2003). However, the rate of world population growth currently exceeds the rate of growth in food production. To meet the expanding food demands, crop grain production needs to be increased by another 50% by 2025 (Khush 2001).

Rice (*Oryza sativa* L.) is one of the most important staple foods; 50% of the human population depends on rice as their main source of nutrition (White 1994). In particular, it is the dominating crop in the monsoon areas of Asia where it has a long history of cultivation; it is deeply ingrained in the daily lives of Asian peoples. As populations are rapidly growing in Asia, increases in rice production will be required to prevent widespread food scarcity.

For many years, rice has been the subject of breeding studies aiming at higher yields and better tasting cultivars. These projects were crucial in avoiding famines in the 20th century. However, in the 21st century, food problems will be more severe. The recent decades have brought dramatic advancements in the field of plant genomics (genome science). Numerous rice genome projects have been launched and are providing useful information for plant biology and plant breeding. This

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information now should be fed back to create practical benefits by enabling the
generation of new varieties with increased yield. In this chapter we review the con-
trol of rice yield by phytohormones in the light of recent discoveries.

2 Breeding of Semi-dwarf Rice Varieties Led to Dramatically
Increased Grain Production

In the 1960s, the acceleration of the world population growth rate and the decrease
in arable lands raised fears that food production would not meet the growing
demand, leading to a global food crisis. In an attempt to solve the problem, the
International Rice Research Institute (IRRI) in 1966 bred a semi-dwarf high-yielding
variety, IR8, also known as “miracle rice”. IR8 originated from crossing the
Taiwanese native semi-dwarf variety Dee-geo-woo-gen which carries the semi
dwarf 1 \((sd1)\) gene, and the Indonesian good-tasting variety Peta (Hargrove and
Cabanilla 1979; Dalrymple 1986; Khush 1999). In general, nitrogen fertilization
is essential to increasing grain production in rice, but it also induces culm elonga-
tion, resulting in an overall increase in plant height. Such tall plants are easily
lodged by wind and rain and, consequently, yield losses occur. The IR8 semi-
dwarf rice variety resolved this problem because it responded to fertilizer inputs
by increased grain yield while culm elongation was inhibited due to the activity of
the \(sd1\) allele. The widespread adoption of IR8 led to major increases in rice grain
production, giving rise to the so-called Green Revolution. Like IR8, the high-
yielding varieties Taichung Native 1 in Taiwan and Tongil in Korea, which also
contained the \(sd1\) allele from Dee-geo-woo-gen, contributed to food security in
those countries (Aquino and Jennings 1966; Suh and Heu 1978). Similarly, the
Japanese native semi-dwarf variety Jikkoku (Kikuchi et al. 1985) and the X-
ray-induced variety Reimei (Futsuhara et al. 1967), as well as the X-ray-induced
variety Calrose 76 in the United States (Foster and Rutger 1978), carried different
\(sd1\) alleles and were widely used in rice breeding programs. The fact that numer-
ous \(sd1\) alleles have been utilized in numerous rice breeding programs for both
indica and japonica varieties demonstrates that the \(sd1\) locus is suitable for con-
trolling plant height in rice.

3 Gibberellins Regulate Plant Height

The breeding of high-yielding rice varieties carrying \(sd1\) alleles doubtlessly is the
greatest success in the history of rice breeding. Insights gained from analyses of \(sd1\)
mutants have been applied in rice breeding programs (Futsuhara et al. 1967; Suge
1975; Kikuchi et al. 1985). However, for many years it has been puzzling breeders
and scientists alike what the molecular basis might be of the semi-dwarf stature of
\(SD1\) mutants.