The Green Revolution: Wheat and Rice

The main part of the success story of the Green revolution was the new semi dwarf varieties of wheat and rice. Borlaug (1971) himself stated that the main reasons of success of these varieties, were their wide adaptation, short stature, high responsiveness to inputs and disease resistance.

The genesis of semi dwarf wheat varieties started when Japanese scientists developed the semi dwarf wheat variety Norin 10 using Daruma as the donor of the semi dwarfing trait. The recessive genes responsible for dwarfing were named rht1 and rht2. To begin with, Daruma, which was a Japanese semi-dwarf variety, was crossed to Fultz, which was a high yielding U.S. winter wheat, giving rise to Fultz-Daruma. Fultz-Daruma was later crossed with Turkey Red which was also a high yielding U.S. winter wheat. This gave rise to Norin 10 which was a semi dwarf and high yielding variety. Norin 10 semi dwarf wheat was later brought to the US and led to the breeding of the cultivar Gaines by Dr. Orville Vogel in the 1950s by crossing locally adapted lines with Norin 10. Dr. Borlaug later used the Gaines wheat to develop modern semi dwarf varieties by crossing it with local strains (Swaminathan, 2006; Dalrymple, 1978). Swaminathan (2006) further describes the shuttle breeding methodology used by Dr. Borlaug wherein alternate generations were grown at two diverse locations. As these locations differed in terms of soil, temperature, rainfall and photoperiod, the methodology resulted in production of strains possessing wide disease resistance and insensitivity to photoperiod. This, in turn, increased the adaptability of the strains in different environments.

The CIMMYT wheat program also made efforts to breed resistance to rust in wheat by utilizing the variety Hope, which had durable stem rust resistance and Frontana, which had durable resistance to leaf rust. This resistance is found to be conferred by minor genes which have an additive interaction relationship (Rajaram, 2005). The genesis of dwarf rice varieties occurred when the recessive gene, sd1, for short height was incorporated from a Chinese variety Dee-geo-woo-gen meaning short-legged (Khush, 2001).

The IRRI team developed a semi dwarf variety IR8 in 1962 by using Peta as female parent which was tall and vigorous, and Dee-geo-woo-gen as the male parent which had stiff straw and conferred the genes for semi dwarf nature. The resulting IR8 had stiff straw, was resistant to lodging and its insensitivity to photoperiod made it a very well adaptable variety. This variety became so popular that it began to be called the “miracle rice” (Hargrove et al., 1988). The success of these rice and wheat varieties is mainly attributed to their short stature. The wheat and rice varieties grown prior to the Green Revolution had tall stature, leafy nature and weak stems. These tended to grow excessively tall, lodge and yielded less when applied with high doses of nitrogenous fertilizers. Also, these earlier varieties had a harvest index of 0.3, which means the ratio of grain to straw was 30:70. They had the capacity to produce a

total biomass of 10-12 t/ha, hence their maximum yield potential was 4t/ha. While on the other hand, the improved Green Revolution semi dwarf varieties of wheat and rice had a harvest index of 0.5. Their total biomass potential was 20 t/ha, hence their maximum yield potential was 10 t/ha (Khush, 1999; Sakamoto and Matsuoka, 2004). Khush (1995) considers the improvement in the harvest index as the most important architectural change in rice and wheat varieties that was responsible for increasing their yield potential. The other factors that led to the success of the Green Revolution, apart from the improved varieties, were the utilization of high levels of inputs such as inorganic fertilizers, improvement in irrigation facilities, and the formulation and implementation of supportive government policies. The worldwide irrigated land area increased from 94 million ha in 1950 to 240 million ha in 1990, while worldwide fertilizer used rose from 14 million tons in 1950 to 140 million tons in 1990 (Khush, 1999 ; Brown, 1996).