

Induced Mutations for Food and Energy Security: Challenge of Inducing Unique Mutants for New Cultivars and Molecular Research

Hitoshi NAKAGAWA^{*1} and Hiroshi KATO

Abstract

Following the construction of the Gamma Field at the Institute of Radiation Breeding (IRB) in 1960, mutation breeding was accelerated in Japan. The facility is used to artificially induce mutations with a higher radiation dose (up to 2 Gy/day, that is *ca.* 300,000 times that of natural background) at a higher frequency than occurs in nature. Since the unit became operational, the number of mutant cultivars generated in Japan increased until 2000–2010 and has since decreased. There have been 295 direct-use mutant cultivars representing 70 species generated through irradiation utilizing gamma-rays, X-rays, ion beams and chemical mutagenesis and *in vitro* culture. Each cultivar has been registered and released in Japan, with approximately 79% of these induced by radiation. There have been 335 indirect-use mutant cultivars, including 298 rice, of which 150 cultivars (50.3%) were derived from the semi-dwarf mutant cv. “Reimei” or its offspring. The economic impact of these mutant cultivars, primarily of rice and soybean, is very large. Some useful mutations are discussed for rice, such as low digestible-protein content, low amylose content, giant embryo and non-shattering. Useful mutations in soybean such as radio-sensitivity, fatty acid composition, lipoxygenase lacking, glycinin rich and super-nodulation have been identified. A similar series of advantageous mutations have been found in Japanese pear and other crops through various screening methods. The achievements of biological researches such as characterization and determination of deletion size generated by gamma-rays, the effect of deletion size and the location are identified. Similarly, genetic studies generated through the use of gamma-ray induced mutations, such as phytochrome research, aluminum tolerance and epicuticular wax have also been conducted in Japan. A unique mutation induction technique for outcrossing Italian ryegrass is also explained. Mutation breeding is a very interesting and useful technology for isolating genes and for elucidating gene functions and metabolic pathways in various crops. Records show that mutation induction is a very useful conventional breeding tool for developing superior cultivars. The IRB is well equipped with appropriate facilities and equipment that will contribute to future mutation breeding developments and it will be a contributor in solving various genomic, proteomic and metabolic problems.

Keyword: genetic analysis, gamma-ray irradiation, Gamma Field, mutation breeding, mutant cultivar

Accepted on March 22, 2017

*¹ Current affiliation: Central Research Laboratory, Hamamatsu Photonics K.K., 5000 Hirakuchi, Hamakita-ku, Hamamatsu, Shizuoka, 434-8601