ガンマ線によるイネ部分不対合系統の種子照射における突然変異

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MUTATIONS WITH GAMMA IRRADIATION ON DORMANT SEEDS OF A PARTIALLY ASYNAPTIC STRAIN IN RICE

HIKOYUKI YAMAGUCHI

Laboratory of Radiation Genetics, Faculty of Agriculture,
The University of Tokyo, Tokyo 113

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In the present time, it is a familiar fact that all or nearly all the initial radiation damage produced are removed as the outcome of post-irradiation processes. In rice, gamma irradiation of 60-h soaked seed produced little, if any, mutations. Thus, it has been supposed that premutational damage produced at 60-h soaking time is very efficiently repaired (Yamaguchi 1969). In the shoot apical meristem of germinating rice seeds, interphase cells incorporating tritiated thymidine appeared after 52-h soaking, increased in number to 58-h and decreased rapidly (Yamaguchi and Matsubayashi 1973). It is able to assume, therefore, that the premutational damage induced at 60-h soaking time was recovered with the post-replication repair.

The *rec*-minus mutation in addition to the *uvr*-deficient mutation of *Escherichia coli* gave a further increase in radiation sensitivity. Howard-Flanders and Boyce (1966) took this fact as indication that there was a partial overlap between the function of repair and recombination.

It has been recently proposed that homologous chromosomes of *Gramineae* lie closely in the nucleus of somatic cell (Feldman *et al.* 1966; Yoshida and Yamaguchi 1973). In asynaptic genotypes, their chromosomes fail to synapse in the first meiotic prophase so that recombination cannot take place. Thomas (1973) found that the loose association of homologous chromosomes in somatic tissue was correlated with the failure of chromosome pairing at meiosis in asynaptic plants of *Avena sativa*.

The experiments were designed to clarify whether the partially asynaptic mutant affected the repair process occurring after gamma irradiation.

MATERIALS AND METHODS

Seeds of two partially asynaptic strains, K-642 and K-648, of rice were obtained by a courtesy of Prof. T. Katayama of Kyushu University. Already, Katayama (1966) has reported that two to eight univalents were found at the first metaphase of meiosis in these partially asynaptic strains. A cultivar, Kinmaze was selected as the normal type and used throughout this experiment.

Dormant seeds of K-642, K-648 and Kinmaze were exposed to one of the following doses of ^{137}Cs gamma rays in a period of 60 minutes — 0, 5, 10, 15, 20 and 30 kR. The number of seeds used for each treatment was 300 for Kinmaze and 600 for both partially asynaptic strains, respectively. The moisture content of the seeds was about 12%.

The criteria used to compare the radiosensitivities among mutant strains and normal type were survival rate at the maturity of the X_1 plant, missing seed setting in the X_1 panicles, and frequency of chlorophyll mutations in the X_2 generation.

Immediately after irradiation, the seeds were germinated by placing in air-saturated water, and then planted in the nursery. The seedlings were transplanted to the field at the age of 40 days. The survival rate in the field was measured at harvest time. For studies of seed sterilities and mutations, the panicles were taken from four early emerged tillers on each X_1 plant. It was measured on 100 panicles chosen at random from each treatment. Each X_1 panicle was sown without threshing in a temperature-controlled chamber with constant temperature (28°C) and illumination. Chlorophyll mutations were scored when the seedlings were about 10 days old. Mutation frequency was expressed as the number of mutants per 1,000 X_2 plants.

RESULTS

The survival rate at maturity of the X_1 plant is shown in Fig. 1. Field survival was reduced to a marked extent in two partially asynaptic strains compared with a normal type, Kinmaze. Further, K-648 was more sensitive than another K-642 or a normal Kinmaze. As shown in Fig. 2, the mean seed setting in K-648 was slightly less compared with that in Kinmaze. When the frequencies of mutations were plotted against radiation dose, it was seen that with higher doses more mutations were induced in a partially asynaptic strain than in a normal cultivar, Kinmaze (Fig. 3). The incidence of mutations in Kinmaze increased linearly with the dose of gamma radiation. In contrast, the frequency of mutations in K-648 was found to increase more rapidly than a single power of the radiation dose. With 30 kR exposure, thus, yield of mutations in K-648 was about five times greater than in Kinmaze.

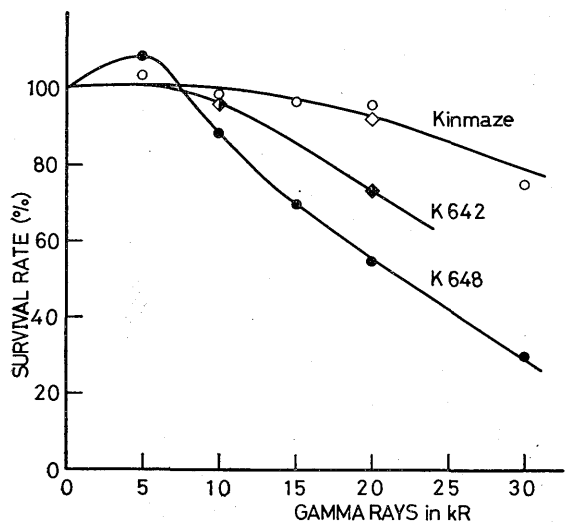

Fig. 1. Survivals at the maturity of X_1 plant after γ-irradiation of the seeds of Kinmaze, K-642 and K-648.

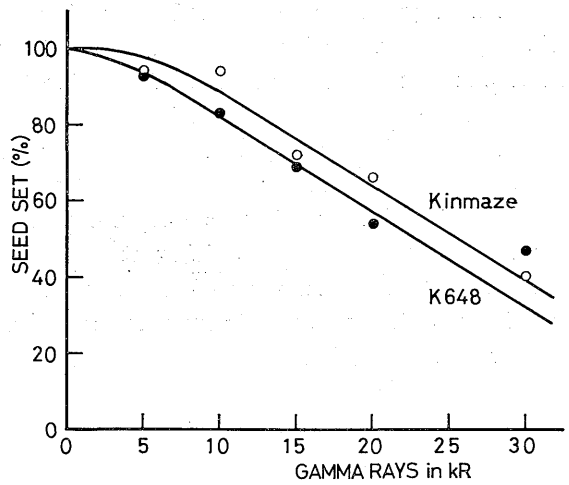

Fig. 2. Seed-setting in the X_1 generation after γ-irradiation of the seeds of Kinmaze and K-648.

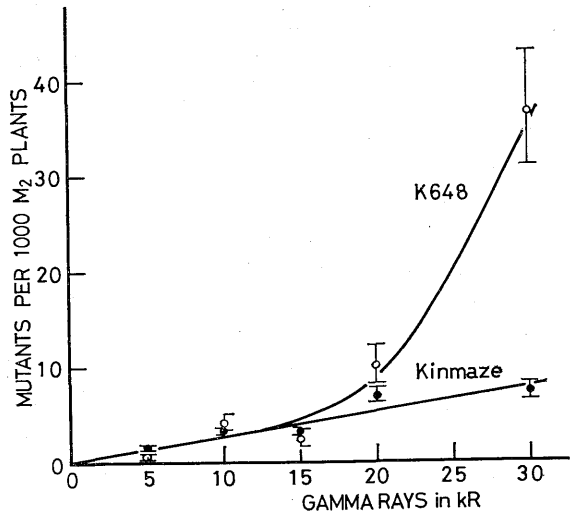

Fig. 3. Mutational response of the seeds to γ-rays in a normal Kinmaze and a partially asynaptic K-648.

DISCUSSION

In *Drosophilla melanogaster*, c3G$^+$ allele is responsible only for the formation of the synaptonemal complex in the oocytes, so that the effect of the c3G allele is produced by its absence. Dominant lethal studies carried out following irradiation of stage-7 and stage-14 oocytes of such c3G mutant provided a strong evidence that it was more radiosensitive than wild type (Watson 1969). When mature sperm of the mutant c3G were treated with X-rays, furthermore, higher frequencies of sex-linked lethals and

translocations compared to wild type were found, and these differences were significant (Watson 1972). In this experiment, the irradiation of seeds of the partially asynaptic strain K-648 indicated that it was also more radiation sensitive than normal-type rice.

Thomas (1973) measured the distances between homologous chromosomes in root tip cells of synaptic and asynaptic genotypes of *Avena sativa*. The distances in the asynaptic genotype were significantly greater than in synaptic plants. Thus, he concluded that the loose association of homologous chromosomes in somatic cell was correspondent with the failure of chromosome pairing at meiosis in asynaptic plants.

If the chromosomes failed to synapse, recombination could not take place. Thus, higher radiosensitivity of the partially asynaptic mutant seems to provide evidence of a common basis for repair and recombination mechanisms even in higher plants.

While a differential radiosensitivity between a partially asynaptic strain and a normal cultivar was a small quantity on seed setting (Fig. 2), it was remarkable on the incidence of chlorophyll mutations (Fig. 3). It is generally assumed that chromosome aberrations are the main source for seed sterility. Although translocations are the only type of aberrations that can be readily detected in meiosis, there are some evidences that the radiation-induced sterility in X_1 plant is mainly caused by small deficiencies (Gaul 1963). On the other hand, most of radiation-induced mutants in higher plants are very likely structural alterations in the chromosome rather than point mutations (Stadler and Roman 1948; Amano 1968, 1972; Mottinger 1970; Chourey and Schwarz 1971). The proportion of mutants emerging within X_1-panicle-branch progenies after 5 kR exposure of rice seeds agreed with the expected 0.25, whereas for 10 and 15 kR irradiations the observed and the expected values did not agree. Namely, both the ratios were significantly less than the expected 3:1. Consequently, the chlorophyll mutants produced after the irradiation of higher doses might be accompanied by chromosomal damage of considerable extent (Yamaguchi 1963). As far as the present experiment is concerned, therefore, it is evident that the repair system, which has been revealed by using a partially asynaptic strain, come into effect for the chromosomal damage associating with mutations rather than for the small deficiencies causing seed sterility.

SUMMARY

Dormant seeds of two partially asynaptic strains, K-642 and K-648, in which 2 to 8 univalents were present at the first metaphase of meiosis, and a normal cultivar Kinmaze were irradiated with gamma rays of 0 to 30 kR. The survival rate at maturity of the X_1 plant was reduced to a marked extent in K-642 and K-648 compared with Kinmaze. The mean seed setting in K-648 was slightly less than in Kinmaze. The incidence of chlorophyll mutations in Kinmaze increased linearly with the radiation dose. In contrast, the mutation frequency in K-648 was found to increase more rapidly than a single power of the dose of gamma rays. Supposing that the loose association of homologous chromosomes in somatic cell is correspondent with the failure of chromosome pairing at meiosis, the results obtained in this experiment provide the evidence of a common basis for repair and recombination mechanisms even in rice.

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