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X-ray Induced Mutations in Einkorn Wheats With Special Reference to Their Complex Nature

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Two species of Einkorn wheats, namely *Triticum aegilopoides* and *T. monococcum*, have been used in the present investigation. These species are diploid with 7 pairs of chromosomes. Dormant seeds of these species were subjected to X-ray irradiation and consequently various chromosome alterations and morphological and physiological mutations have been obtained. Genetical analyses have revealed that these mutations are all Mendelian recessives (Kihara and Yamashita 1947, Yamashita 1953). Thirty-four mutants have been obtained in *T. monococcum*, while only two in *T. aegilopoides*. This indicates that the species difference regarding the sensitivity to X-rays is controlled by genetic factors. The induced mutations are listed in Table 1 and some of them are illustrated in Figs. 1 and 2.

First of all, I whould like to mention about the recurrence of identical mutations.

Namely, "early" induced by Smith is considered to be allelic to our "early" (# 16 in the list), since the F_2 generation from crosses showed no

Table 1. List of morphological and physiological mutations*

Triticum monococcum var. *vulgare*

# 1.	dwarf	# 18.	dwarf
# 2.	chlorophyll deficient (lethal)	# 19.	spiral culm, *sp* 2
# 3.	light green (striped)	# 20.	lethal-2
# 4.	chlorophyll deficient	# 21.	oldrose
# 5.	spiral culm (dwarf), *sp* 3	# 22.	lethal-1
# 6.	light green (dwarf)	# 23.	albino
# 7.	dwarf	# 24.	narrow leaf, *nar*
# 8.	dwarf	# 25.	non-hardy, *nh*
# 9.	light green (dwarf)	# 26.	light green, *lg* 1
# 10.	anthocyanin-less (striped)	# 27.	anthocyanin deficient
# 11.	chlorophyll deficient	# 28.	irregular ear (dwarf)
# 12.	tiger band	# 29.	light green (striped)
# 13.	fused primary leaf, *fus*	# 30.	orange (lethal)
# 14.	spiral culm, *sp* 1	# 31.	chlorophyll deficient
# 15.	spiral culm (striped)	# 32.	ligule-less
# 16.	early maturation, *e*	# 33.	duck neck
# 17.	irregular ear, *irr*	# 34.	sterile anther

T. aegilopoides var. *boeoticum*

# 35.	tiger band
# 36.	albino

* Symbols are given only for established genes.

segregation. A similar relationship has been verified for Smith's "short glume" and our "dwarf" (# 18). Among our mutations, "*tig* 1" (# 35) induced in *T. aegilopoides* is identical to "*tig* 2" (# 12) in *T. monococcum*, and so is "spiral 1" (# 14) to "spiral 3" (# 15) in *T. monococcum*. The present data, however, are not sufficient enough to discuss which locus is more sensitive to X-rays than others.

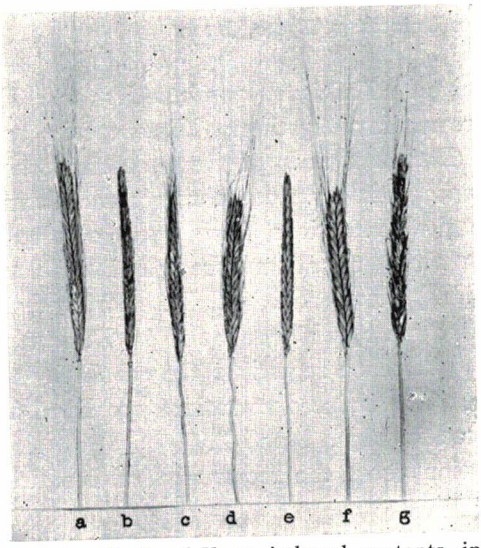

Fig. 1. Heads of X-ray induced mutants in *T. monococcum*.
a, normal. b, *fus*. c, *sp* 1. d, *sp* 2. e, *nar*. f, *e*. g, *irr*.

According to their haploid chromosome number 7, seven linkage groups have been established as given in Table 2.

For locating certain genes in certain chromosomes, in other words in testing the independence of linkage groups, the RT-method (Reciprocal Translocation Method) has been used very successfully as reported elsewhere (Yamashita 1949). Namely, a mutant was crossed by an RT-type with a known chromosome rearrangement, and a linkage relationship between the gene and the chromosomes involved in the reciprocal translocation was analyzed. This has largely shortened the time for the establishment of the linkage groups.

Each gene symbol in the above given tables stands for a representative character of the mutant. Through careful obervations following the developmental stages, however, it was found that the majority of the mutants manifested a complex nature, as was announced before by Nilsson-Ehle (1920) in speltoid mutation. As for instance, "*nar*" (# 24) is characterized with an extra coleoptyle, narrow leaf, elongated constriction on leaf base, awnless glume, slender and short culm, late maturation and extra stamens in place of an ovary and pistils (Fig. 2). This plant is, therefore, practically a male! These characters are always completely linked and inherited as a complex with no crossing over. This is general to all the induced mutations, but one exceptional case was found in "*fus*" (# 13)

Table 2. Seven linkage groups

Chromosomes	Gene symbols or characteristics
a	*fus*, *sp* 1, *sp* 2, winter habit
b	*lg* 1
c	*nar*
d	*e*, *old*, lethal-1
e	*Hr* 2
f	*irr*, lethal-2
g	*Hn*, *Hl* 1, *Hr* 1, *tig* 1, *tig* 2

(Established by Kihara and Yamashita)

Hl_1, Hl_2, *Hn*, *Hr* 1 and *Hr* 2 are the genes for the spontaneous characteristics found in *T. aegilopoides*.

which bears a fused primary leaf, velvety leaf surface due to elongated processes, short leaf blade and a short awn. In the hybrid progeny of its cross, individuals appeared with a normal primary leaf together with the remaining characteristics of the "*fus*." In this case the fused character of the primary leaf is considered to have been eliminated by crossing over.

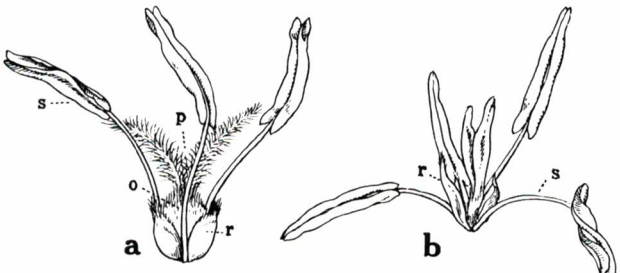

Fig. 2. Floral organs in *T. monococcum*.
a, normal extra-stamens without ovary and pistil.
b, *nar*.

Questions arise here, why the majority of the induced mutants are complex mutations and why crossing over is inhibited between mutated genes. It could possibly be ascribed to the multiple effect or pleiotropism of the mutated gene or to the inactivation of the suppressor. It could also be attributed to the deficiency which does not affect the viability. By these hypotheses, however, the

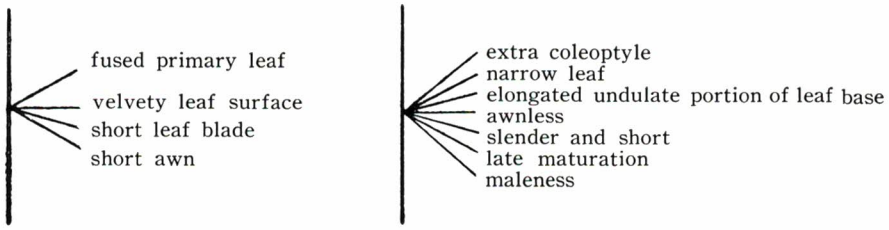

Fig. 3. Diagramatic illustration of two mutations.

above mentioned case of a crossing over in "*fus*" could not be explained. Inversion could be responsible, but no cytological evidence has been obtained as yet. Could it be attributed to the mutation of a gene group between the genes in which crossing over is intensely inhibited (Fig. 3)? It could be explained by this assumption, but further investigations will be required.

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