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A Proposal for the Designation of Nucleus-Substitution Lines and Fertility-Restoring Genes in Wheat[1)]

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A Proposal for the Designation of Nucleus-Substitution Lines and Fertility-Restoring Genes in Wheat[1)]

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Since Kihara reported (1951) on male sterility in wheat induced by *Aegilops caudata* cytoplasm, a large number of alien cytoplasms have been successfully transferred to emmer and/or common wheat, most of them inducing male sterility. A list of these is given in Table 1.

Designation of nucleus-substitution lines

In many institutions, nucleus-substitution work to bring nuclei of various wheat cultivars into alien cytoplasms is extensively carried out. It now seems necessary to establish some common rules for the designation of nucleus-substitution lines (so-called "nucleus-cytoplasm hybrids") produced by this work. To do this the following rules are proposed.

Table 1. List of alien cytoplasms introduced into emmer and common wheat

Donor of cytoplasm		Recipient wheat	Reference
Species	Genome constitution		
Ae. caudata	C	Common wheat	Kihara (1951)
〃	〃	Emmer wheat	Kihara and Tsunewaki (1961)
Ae. speltoides	S	〃	Suemoto (1969)
Ae. umbellulata	C^u	Common wheat	Muramatsu (1965)
Ae. ovata	C^uM^o	〃	Fukasawa (1959)
〃	〃	Emmer wheat	〃 (1953)
Ae. ventricosa	DM^v	Common wheat	Oehler and Ingold (1966)
T. boeoticum	A	〃	Maan and Lucken (1969)
〃	〃	Emmer wheat	〃 (1967)
T. monococcum	〃	Common wheat	〃 (1969)
T. araraticum	AG	〃	〃 (〃)
T. timopheevi	〃	〃	Wilson and Ross (1962)
〃	〃	Emmer wheat	Kihara (1959)
T. zhukovskyi	AAG	Common wheat	Maan and Lucken (1967)

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Rule 1. Name of cytoplasm donor in italics to be shown in parentheses.

Rule 2. Name of nucleus donor is given after the name of the cytoplasm donor, with a hyphen between them.

Example: (*timopheevi*)-Bison indicates a nucleus-substitution line of *T. aestivum* cv. Bison with the cytoplasm of *T. timopheevi*.

Rule 3. The number of crosses made with the backcross parent is indicated, if necessary, by a superscript to the name of the nucleus donor.

Example: (*ovata*)-Norin 26[15] indicates the 14th backcross generation of Norin 26 with the cytoplasm of *Ae. ovata*.

A list of representative nucleus-substitution lines we have produced is given in Table 2, as further examples of this designation.

Table 2. List of nucleus-substitution lines which are available in our laboratory

(*caudata*)-T. v. e.[21]	(*umbellulata*)-T. v. e.[3]
(〃)-P 168[3]	(〃)-P 168[3]
(〃)-Salmon[10]	(〃)-Salmon[3]
(〃)-Chinese Spring[10]	(〃)-Chinese Spring[10]
(〃)-Jones Fife[9]	(〃)-Jones Fife[3]
(〃)-Compactum 44[12]	(〃)-Bison[3]
(〃)-Spelta duh.[12]	(〃)-Compactum 44[3]
(〃)-Sphaerococcum[10]	(〃)-Spelta duh.[3]
(〃)-Macha[7]	(*timopheevi*)-T. v. e.[5]
(*ovata*)-T. v. e.[6]	(〃)-P 168[5]
(〃)-P 168[6]	(〃)-Salmon[5]
(〃)-Salmon[6]	(〃)-Jones Fife[3]
(〃)-Chinese Spring[6]	(〃)-Selkirk[7]
(〃)-Jones Fife[6]	(〃)-Bison[7]
(〃)-Norin 26[15]	(〃)-Compactum 44[5]
(〃)-Selkirk[4]	(〃)-Elgin[5]
(〃)-Bison[4]	(〃)-Spelta duh.[5]
(〃)-Spelta duh.[6]	(〃)-Macha[5]

Designation of fertility restoring genes

Progress in genetic studies on cytoplasmic male sterility shows that the number of fertility-restoring genes, which are factorially analyzed and/or located on specific chromosomes, is rapidly increasing. Therefore, a set of rules is urgently needed to designate the restoring genes. The following rules are proposed for this purpose.

Rule 4. As the common, basic symbol, Rf *meaning restored fertility to be used.*

The symbol *Rf*, has already been adopted by several workers (Livers 1964, Robertson and Curtis 1967, Kihara 1969, Tahir and Tsunewaki 1969). I offer the use of this symbol as a common, basic symbol for all kinds of restoring genes.

Rule 5. A third letter indicating the name of the cytoplasm, in which the designated gene

functions as a restorer, is added after the common symbol.

Example: *Rfc* is used for a restoring gene to *Ae. caudata* cytoplasm.

As already pointed out by Kihara and Tsunewaki (1967), the function of a fertility-restoring gene is, in general, specific to a certain cytoplasm, and an effective gene for one cytoplasm does not necessarily function in other cytoplasms. Therefore, in designating the restoring gene, it is necessary to indicate the name of cytoplasm, in which the gene functions as a restorer. However, we should retain the symbol, *Rf*, for restoring genes in *T. timopheevi* cytoplasm, because this cytoplasm has been studied so extensively and, at least, three restoring genes for this have already been designated by this symbol (Livers 1964, Tahir and Tsunewaki 1969).

Rule 6. Non-allelic genes to the same cytoplasm are distinguished from each other by Arabic numerals given as subscripts to the symbol. Serial numbers starting from 1 should be given in the order of discovery.

Example: Rf_1, Rf_2, Rf_3, ····· for non-allelic restoring genes to *T. timopheevi* cytoplasm.

Rule 7. When the same gene functions as a restorer to more than one cytoplasm, the symbol first given is retained.

A restoring gene for one cytoplasm may be occasionally found to function in another cytoplasm. A possible case of this is P 168, a 6x derivative from the cross, *T. aestivum* × (*Ae. caudata* × *T. aestivum*) F_1, having 20 pairs of wheat chromosomes and one pair of *Ae. caudata* chromosomes (Kihara 1959). This strain restores pollen fertility in both *Ae. caudata* and *Ae. ovata* cytoplasms. Restoration is completely performed by a single dose of the gene in *Ae. ovata* cytoplasm, while a double dose is required to restore high fertility in *Ae. caudata* cytoplasm (Kihara and Tsunewaki 1967). Because the gene(s) for both cytoplasms is located on a *caudata* chromosome 1C (previously called as C-sat-2), it appears likely that the restoring gene to the two cytoplasms is the same. In such a case, the symbol first given will be retained unchanged. For example, the restoring gene of P 168 was first found in *Ae. caudata* cytoplasm (Kihara 1951), and its function to *Ae.*

Table 3. Proposed symbols for fertility-restoring genes in common wheat

Symbol	Location (chromosome)	Source	Male sterile cytoplasm	Reference
Rf_1	1A	*T. timopheevi*	*T. timopheevi*	Livers (1964), Robertson and Curtis(1967)
Rf_2	7D	〃	〃	Livers (1964), Maan and Lucken (unpubl.)
Rf_3	1B	*T. spelta* var. *duh.*	〃	Tahir and Tsunewaki (1969)
Rfc_1	1C	*Ae. caudata*	*Ae. caudata* and *Ae. ovata*	Kihara (1951), Kihara and Tsunewaki (1965)
Rfc_2	?	*T. compactum* cv. No. 44	*Ae. caudata*	Tsunewaki (1963)
Rfo_1	?	*T. aestivum* cv. Chinese Spring	*Ae. ovata*	(our unpubl. data)
Rfu_1	?	*T. aestivum* cv. Jones Fife	*Ae. umbellulata*	(our unpubl. data)

?: Chromosomal location unknown.

ovata cytoplasm was proved later (Kihara and Tsunewaki 1965). Accordingly, this gene should be designated as Rfc_1, with the remark that it also functions in *Ae. ovata* cytoplasm.

Applying these rules the known restoring genes, on a factorial basis, will be designated as shown in Table 3.

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