A STUDY OF TRITICALE - WHEAT CROSSES

by

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SUMMARY

The objective of the research conducted for this thesis was to develop methods which plant breeders could use to introduce genetic material from the genetically-improved bread wheat (Triticum aestivum L.) into triticale (x Triticosecale Wittmack). The transfer of this improved germplasm has been recommended by triticale workers (Sanchez-Monge, 1958; Kiss, 1966b; Larter, 1973 and Merker, 1975) as one of the ways of improving triticale.

Initial experiments with wheat ♀ X triticale ♂ resulted in severe problems due to endosperm incompatibility in the initial cross. Experiments conducted on the culturing of embryos from the above cross produced two changes in technique which significantly improved efficiency.

Firstly, only removal of the endosperm is necessary for successful culturing of the embryo. The additional removal of the enveloping pericarp and scutellum is harmful, due to the increased sensitivity of the embryo to the micro-environment.

Secondly, the problem of post-germination callusing can be overcome by the addition of activated carbon which acts as a buffering agent by stabilizing fluctuating hormone levels.

Embryo culturing, using even the most efficient techniques is very time and labour consuming. Alternatively, the reciprocal cross (triticale ♀ X wheat ♂) produces the same number of F_1 plants per head (emasculated and pollinated) without the use of embryo culturing. This is due to the presence of more endosperm in the F_1 seed.

The conclusion of the author is that the introduction of Triticum aestivum germplasm into triticale, whether for a specific

purpose (disease resistance genes) or simply to increase the genetic variance, does not require embryo culturing. Embryo culturing is not efficient in terms of time or materials compared to methods described later in this summary.

Hybrid plants from the triticale-wheat cross were found to be self-sterile under glasshouse conditions and required backcrossing with hexaploid triticale pollen to set seed. Plants resulting from the backcrossing of the hybrid were studied and the following observations were noted: a) mitotic chromosome count; b) meiosis (univalent count); c) seed set; d) germination percentage of selfed seed; e) dosage of hairy peduncle; f) height; g) tillering and spikelet number. Correlations were attempted between certain of the observations:

mitotic chromosome count/total seed per plant

mitotic chromosome count/average seed per tiller

mitotic chromosome count/height

height/seed per plant

height/tiller number

tiller number/seed per plant

All were found to be non-significant.

Observations of the transmission frequency of the Hp gene (.461) to the BC_1 generation was not significantly different from the expected transmission rate calculated for univalents (.465) using the BC_1 mitotic chromosome counts of the plants with Triticum timopheevi cytoplasm.

Selfing of the BC_1 plants was carried out to the BC_1F_4 generation and observations noted at each generation of the seed set and genetic segregation. Results indicate that stable fertile lines are produced

in the BC_1F_3 generation. Maintenance of all lines was possible from the BC_1F_2 generation onwards, although fertility did vary from 5 seed per head to complete seed set in all primary, secondary and tertiary florets. Recovery of some self-fertility (seed set when selfed) was unexpectedly rapid, increasing from only 55% of the BC_1 plants to 100% of BC_1F_2 plants. Phenotypic segregation was as great within a line derived from a single BC_1 plant when observed in the BC_1F_3 generation as between lines derived from differing BC_1 plants.

Inferences about the female gametes produced by the hybrid plants (triticale X wheat) were made from observations recorded on the BC_1 plants. The findings thus inferred about the female gametes suggested that very high selection occurred for eggs with five or more univalent chromosomes present. It was found that Triticum timopheevi cytoplasm produced greater numbers of viable eggs per thousand florets compared to Triticum aestivum cytoplasm. This is attributed to the lowering of selection pressures for viability in eggs having 4 to 7 transmitted univalents. Selection coefficients were calculated on the basis of assumptions of a univalent transmission frequency of .25 and transmission of any univalent is independent of the transmission of any other univalent. This, together with a simple binomial expansion, $C_I^{14}\left(P^I Q^{(14-I)}\right)$, gives an expected frequency of any class I (number of transmitted univalents).

The derived frequencies of viable eggs was considered to conform with the observed frequencies if a further assumption was made requiring that the transmitted univalents fit into the maximum number of homoeologous groups. For example, an egg having the chromosomal constitution of 14 A and B genome chromosomes, plus the following

five transmitted univalents - 1R, 1D, 2R, 2D, 3R, chromosomes - would not be viable because only three homoeologous groups are represented by transmitted univalents. A possibly viable example is where the five transmitted univalents are the following - 1R, 2D, 3R, 5D, 7R chromosomes. Here five homoeologous groups are present and only two are missing.

A test of the above assumption was conducted where a triticale, having two or three D genome chromosomes, was crossed with wheat. The D chromosomes pair at meiosis in the F_1, producing eggs with a high frequency of two or three homoeologous groups present in the third genome, which, plus the .25 transmission frequency of the univalents, gives an average of about 5.0 homoeologous groups being represented in the female gametes. F_1 plants of the above chromosome constitution, when backcrossed with any triticale, would then have 50% viable eggs, based on the above hypothesis.

The triticale Arabian (ITYN-5-13), having two or three D genome chromosomes in its third genome, was crossed to two wheat varieties and backcrossed with a triticale. The egg viability obtained from the hybrid was .46, which agrees with that expected on the basis that at least five homoeologous groups must be present in the third genome for an egg resulting from a triticale-wheat cross to be viable.

The integrated triticale ITYN-5-13 was found to cause only partial endosperm incompatibility when crossed as male to wheat. A brief study was conducted of this line in reciprocal crosses with wheat, and in backcrosses of the hybrid plants with integrated third genome and full rye genome triticales.

Germination of the hybrid seed was 57% using wheat as the female in the cross, compared with 100% using ITYN-5-13 as the female, and

In spite of the superiority of triticale as the female parent in the introgression of hexaploid wheat germplasm into triticale, the large-scale use of triticale as the female parent is limited due to the lack of an available male-sterility system. Therefore large-scale field crossing of triticale and wheat will require the use of wheat as the female because of available genetic male-sterility and cytoplasmic male-sterility systems.

seed set, when backcrossed with full rye genome triticales, was 44% with a BC_1 seed germination of 85%.

With these latter findings, it is suggested by the author that large scale introgression of bread wheat germplasm is possible, using a bread wheat population segregating for genetic male sterility maintained at a frequency of 1 fertile : 1 sterile. Wind pollination of the male sterile plants with triticale pollen from varieties found to cause only partial endosperm incompatibility and pollination of the resulting F_1 plants using any triticale, would result in massive amounts of germplasm being introduced into triticale with little effort by the breeder.

Alternatively, hand emasculation of the integrated triticale and hand pollination with wheat pollen is more labour intensive, but the resulting germplasm transfer into triticale will be no more difficult than standard intraspecific transfer of germplasm carried out by crop breeders.

AUTHOR'S DECLARATION

This thesis contains no material which has been accepted for the award of any other Degree or Diploma in any University and that, to the best of my knowledge and belief, contains no material previously published or written by any other person, except when due reference is made in the text of the thesis.

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