The Use of A–B Translocations to Locate Genes in Maize

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In addition to the standard monoploid complement of 10 A-type chromosomes, some strains of corn also carry supernumerary or B-type chromosomes. The latter, as Randolph (2) has shown, do not have specific genetic effects and do not impair the viability of the plant even when present in relatively large numbers. The B-type chromosome is essentially orthodox in its behavior in meiosis and mitosis, except for the division of the generative nucleus in the microspore. In this division, the chromosome frequently fails to disjoin, with the result that one of the sperms nuclei receives both chromatids. Thus, if nondisjunction occurs, a microspore with one B-type will develop into a pollen grain in which one sperm has two B-types and the other has none.

A study of translocations between A-type and B-type chromosomes (A–B translocations) has provided evidence (3) that the nondisjunctional behavior of the B-type chromosome is due to a malfunction of its centromere. In each of 11 interchanges, the translocation chromosome (B^A) which bears the B-type centromere is the nondisjunctional chromosome. The complementary translocation chromosome (A^B), bearing the centromere of the A-type chromosome involved, rejoins regularly. As a result, a plant homozygous for an A–B translocation produces two types of pollen grains. In one of these, the nondisjunctional type, one of the gametes carries two B^A chromosomes while the other gamete is deficient for this chromosome. In the other pollen type, resulting from normal disjunction, the two gametes of the pollen grain are identical, each carrying a single B^A chromosome. The A^B chromosome is present in both gametes of both pollen types, as are the nine A-type chromosomes not involved in the translocation.

The production of deficient gametes by plants carrying A–B translocations provides the basis for a new method of locating gene loci. In comparison with other techniques commonly employed, this method offers the advantage of supplying information in a single generation which can be used to assign a locus to a specific chromosomal segment. As Table 1 shows, three classes of seeds are obtained when a normal seed parent is pollinated by a plant homozygous for an A–B translocation. Classes I and II are the result of fertilization involving the gametes of a nondisjunctional pollen grain; Class III is the product of fertilization with gametes from normal disjunction. Both Class I and the endosperm of Class II are formed by the B^A chromosome. When the three classes are grown, any phenotype associated exclusively with plants from Class I seeds can be attributed to the absence of an allele or alleles located in the segment of the missing B^A chromosome. Some tests showed that the effects appearing only among Class II plants due to genes located in this region. As the deficient F_1 plants also are of value for information on linkage between a gene and the points of reference within the chromosome.

Observations and Discussion

1. Crosses Involving TB–1a

Plants homozygous for TB–1a and resistant to H. carbonum Race I were used as pollen parents in crosses with a hybrid between the susceptible lines K61 and Pr. A diagrammatic representation of this translocation is shown in Fig. 1. The nondisjunctional chromosome (B^1)a, contains the B-type centromere.