Balanced Tertiary Trisomics in Barley Serve as a Pollen Source Homogeneous for a Recessive Lethal Gene

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RECESSIVE lethal and sterile genes are frequently used in barley linkage studies. Gene stocks of these types of mutants are impossible to maintain in homozygous strains. Lethal and sterile genes must be maintained in the heterozygous condition. This involves testing individuals for heterozygosity and selecting the heterozygotes. When a recessive lethal or sterile is to be used as a marker gene, crosses must be made using individuals with the dominant phenotype from a segregating population as a source of the recessive allele. One-third of the resulting crosses will not carry the recessive. From the crosses involving the recessive gene, only half of the crossed seed will be heterozygous. A pollen source homogeneous for a recessive lethal or sterile gene would greatly facilitate the use of that gene in linkage studies. A balanced tertiary trisomic offers such a pollen source.

In tertiary trisomics, the extra chromosome is made up of a segment of each of two different chromosomes. They owe their origin to a segmental interchange between non-homologous chromosomes (1). Balanced tertiary trisomics are tertiary trisomics set up so that the dominant allele of a marker gene closely linked with the interchange break point is carried on the interchanged chromosome, and the recessive allele is carried on the two normal chromosomes (Figure 1). A plant of this constitution will produce 3 types of functional female gametes but only 1 type of functional male gametes. A spore with the interchange chromosome alone is deficient for a chromosome segment and will abort. The \((n+1)\) spores rarely, if ever, function in the male. Only three types are expected in the self progeny of balanced tertiary trisomics: diploids recessive for the marker gene, primary trisomics recessive for the marker gene, and balanced tertiary trisomics dominant for the marker gene. All self progeny exhibiting the dominant character should be of the same gene and chromosome constitution as the parental trisomic. The breeding behavior of balanced tertiary trisomics allows the perpetuation of recessive lethal or sterile genes, and all functional pollen grains produced by a balanced tertiary trisomic should carry the recessive marker gene.

If a crossover occurred between the marker gene and the interchange break point, it would break up the balanced tertiary condition. Such a crossover can be detected by the ratio of dominant:recessive in the self progeny of the individual resulting from the crossover. Self progeny of a balanced tertiary trisomic should have 60 to 80% recessives, depending on type of trisomic segregation and transmission frequency of the extra chromosome. If the dominant marker gene is transferred (by crossing over) to one of the normal chromosomes, the self progeny of the resulting individual should have 20 to 25% recessives. By selecting individual plants with the dominant character from lines showing a predominance of recessives, a balanced tertiary trisomic may be maintained.

A balanced tertiary trisomic may also be set up so that the marker gene is carried on the interchanged segment of the extra chromosome (Figure 2). As such trisomics exhibit the same breeding behavior as those with the marker gene carried on the centromere segment, the search for suitable chromosomal interchanges is greatly reduced. All that is necessary is to find close linkage between the proposed marker gene and an interchange break point; it makes little difference whether the marker gene is carried on the centromere segment or the interchanged segment.

Balanced tertiary trisomics may be established from the \(F_3\) of the proposed marker gene and a suitable chromosomal interchange. The light weight seed produced by the \(F_3\) will contain a high frequency of trisomics (4). Some of the trisomics should be balanced terries. These may be isolated by examining the marker gene ratio in \(F_4\); an excess of recessives indicates the \(F_3\) trisomic was a balanced tertiary. All plants with the dominant phenotype from such an \(F_3\) progeny should be balanced tertiary trisomics.

Two balanced tertiary trisomics that illustrate the two ways in which they may be set up have been established in barley. One uses an interchanged chromosome from \(T_1-7c\) and the marker gene \(a_{alb}\) (albino seedling). In this line, the marker gene is carried on the centromere segment of chromosome 6\(^1\) (see Figure 1). The other balanced tertiary trisomic uses the same marker gene \(a_{alb}\) and an interchanged chromosome from \(T_1-6a\). In this line, the marker gene is located on the interchanged segment of chromosome 6\(^2\) (see Figure 2).

The self progeny of the balanced tertiary trisomic, \(1\) \(a_{alb}\), has a ratio of about 3 green:7 albino seedlings. There have been 1487 green plants from this balanced tertiary trisomic progeny tested. All of the progenies exhibited the expected 3:7 ratio. Pollen from the green plants has been used to produce 364 crossed seed. All were heterozygous for the gene \(a_{alb}\), indicating that all pollen used carried the recessive allele. From these data it appears that crossing...