Linkage Analysis of Fg^{H}ia in the Short Arm of Chromosome 3

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Summary

The gene order and map distance of the Fg ia linkage in the short arm of chromosome 3 is Fg 30 ia 30 centromere.

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In 1979 it was determined that the genes for the linked characters frego bracts (fg) and accessory involucres (ia) were located in the short arm of chromosome 3 of the A subgenome. The only linkage association available for cytogenetic analyses consists of the dominant frego allele Fg^{H} with the recessive accessory involucres ia. Kohel et al. (1965 Crop Sci. 5:582) has reported that Fg^{H} and ia are separated by 31 map units. The dominant Fg^{H} allele is a semilethal, and when homozygous causes the plant to be extremely rosetted and to attain a maximum height of 2 to 4 inches, which cannot be scored for accessory involucres. Because of the sublethal nature of the $Fh^{H}Fg^{H}$ genotype, the coupling linkage Fg^{H}ia is maintained as a heterozygote, Fg^{H}ia/+Ia.

Plants that are heterozygous for Fg^{H} are normally slender, with abnormally developed terminals consisting of fasciated branches and contorted, leathery leaves with fused veins. Heterozygotes of Ia ia can be distinguished by the presence of rudimentary forms of the accessory involucres.

A marker line containing the Fg ia linkage was crossed to monotelodisomic-3S (25"tl") for mapping the Fg and ia loci in the short arm of chromosome 3 in relation to the centromere. When crossing to the monotelodisomic-3S, two kinds of F_1 progeny are recovered which are the disomes and monotelodisomes, both of which are heterozygous for the two marker genes in the repulsion phase, Fg ia/+Ia. The two types of F_1's were testcrossed to TMI (+Ia) to obtain segregating populations for genetic mapping. The testcross data obtained with the disomic F_1 (Table 1) provided the standard linkage map of Fg ia to be compared with the linkage map of Fg ia obtained with the monotelodisomic F_1 (Table 2).

The testcross population of TMI, +Ia x 26" Fg ia/+ Ia consisted of 329 plants of which 98 were recombinants, giving a recombination percent of 29.8 ± 2.52 between the Fg and ia loci (Table 1). This recombination value is not different from the 30.7 reported by Kohel et al. (1965).

Table 2 contains the testcross results of TMI, + ia x 25"tl", Fg ia/+Ia. The Fg ia loci are located in the short arm of chromosome 3. The telocentric chromosome in the F_1 monotelodisomic is for the short arm of chromosome 3; thus for the Fg ia linkage, the gene-centromere order may be Fg ia-centromere or ia-Fg-centromere. Which of the two loci is in the proximal position can be determined by the differential transmission of their alleles in the testcross. The closer that a specific allele is to the centromere, the higher the frequency that that allele will behave as a centromere marker.

In the monotelodisomic F_1, the standard chromosome carries the Fg and ia alleles, while the telocentric chromosome carries the + Ia alleles. Thus, to determine which of the two loci is in the proximal position, one can observe the frequency of association of the Fg ia alleles with standard chromosome and/or the frequency of association of the + Ia alleles with the telocentric chromosomes. In Table 2, it can be seen that the alleles at the Fg^{H} locus are segregating independently of the centromeres of the two chromosome types indicating that the locus is 50 or more map units from the centromere. The Ia, ia alleles on the other hand did not segregate independently of the centromere. For example, in the disomic class of Table 2, it can be observed that 71% (264/371) of the plants had the ia allele, and the remaining 29 plants had the Ia allele, showing that the ia allele is closely linked with the centromere and the Ia allele is closely linked to the centromere of the telocentric chromosome. Likewise, in the monotelodisomic class, 61% of the plants had the Ia allele and the remaining 39% had the ia allele, showing the close association of the ia and the Ia with the centromeres of, respectively, the standard and the telocentric chromosomes. Recombination analysis shows that the Ia locus is 29.7 ± 2.3 map units from the centromere. Thus, the gene-centromere order and map distans are Fg 24 ia 30 centromere.

Table 1. Segregation of Frego (Fg^H) and accessory involucres (ia) in a testcross of TMI (+ Ia) x 26" $\frac{Fg^H\ ia}{+\ Ia}$

Number of plants in each class				
Fg^Hia	Fg^HIa	+ia	+Ia	Total
128	49	49	103	329

Percent recombination Fg^Hia = $\frac{98}{329}$ (100) = 29.8 ± 2.52

Table 2. Segregation of Frego (Fg^H) and accessory involucres (ia) in a testcross of TMI (+ Ia) x 25" tl" F_1 $\frac{Fg^H ia}{1\ \ 2^*}$ / + Ia

G7 - G23 - 1982

Number of plants in each class									
Disomic progeny					Monotelodisomic progeny				
nco+ Fg^Hia	sco[1] +ia	sco[2] +Ia	dco Fg^HIa	Total	nco +Ia	sco[1] Fg^HIa	sco[2] Fg^Hia	dco +ia	Total
188	76	94	13	371	17	5	11	3	36

Percent recombination Fg^Hia = $\frac{76 + 13 + 5 + 3}{371 + 36}$ (100) = 23.8 ± 2.1

Percent recombination Fg^H-cmere =

$$\frac{76 + 94 + 2(13) + 5 + 11 + 2(3)}{407} (100) = \frac{218}{407} = 53.56 \pm 2.47$$

Percent recombination ia-cmere =

$$\frac{94 + 13 + 11 + 3}{407} (100) = 29.73 \pm 2.265$$

Percent male transmission of telocentric chromosome = $\frac{36}{407}$ (100) = 8.845

* 1 = genetic region between Fg^H and ia loci; 2 = genetic region between the ia locus and the centromere.

+ nco, sco[1], sco[2], dco = noncrossover, single crossover in region 1, single crossover in region 2 and double crossover chromosomes, respectively.