Chapter 6
Cytogenetics of $F_1$ and Their Progenies

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6.1 Introduction

In this chapter we attempt to enumerate the main cytological phenomena taking place during meiosis in $F_1$ hybrids and their progenies obtained from distant hybridization.

The main objective in using interspecific hybridization in plant breeding is to expand the gene pool to introduce alien genes carried by wild species into cultivated varieties (Lacadena 1977). To obtain $F_1$ hybrids is highly complicated and depends on the genotypes of the parental species and the techniques available for handling gametophytes, embryos, and seeds. The cytological instability of the hybrids imposes an important limitation in species hybridization. This chapter will discuss various aspects of cytological abnormality events taking place in distant hybridization.

6.2 Cytology of the $F_1$ Hybrids During the Premeiotic Stages

6.2.1 Rates of Cell Development in the Embryo and Endosperm

The relationship between chromosome numbers in maternal, embryonic, and endospermic tissues is important for the success of interspecific hybrids. East (1935) suggested that the species with the larger chromosome number is usually an allopolyploid, easily crossed with other species. Boyes and Thompson (1937) crossed *Triticum* with *Secale* and found abnormal cytology of the endosperm, difference in nuclei size, abnormal chromatin structure, and absence of cytoplasm in some cells when the parent with the lower chromosome number was used as female. Nevertheless, Katayama (1933) found no consistent relationship between the chromosome number and seed setting in either of the parents in the cross *Aegilops × Triticum*. Our experience in crosses involving *Aegilops*,

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_Triticum, Secale_, and _Hordeum_ is that the latter is always the best female, independent of chromosome number in either cultivated or wild plants. It is difficult to predict the feasibility of an interspecific hybrid on the basis of the chromosome number of the parents. Johnston et al. (1980) suggested the hypothesis of the Endosperm Balance Number (EBN) to explain endosperm development in interspecific hybrids. This hypothesis attributes the responsibility to the ratio 2:1 female: male genes, which previously was assigned to genomes. This rule seems to explain some cases in _Solanum_ and _Trifolium_ (Johnston et al. 1980; Parrot and Smith 1986) but not in Triticeae. The crosses between the tetraploids _Aegilops squarrosa_ and _Secale cereale_ and _Hordeum chilense_ showed perfect endosperm, suggesting, according to the EBN hypothesis, that the three species shared the same EBN. Nevertheless, when _Triticum aestivum_ was pollinated with the diploids of these species the results were not as expected. The hybrid with _squarrosa_ has almost normal endosperm, that with rye shows poor endosperm, while in crosses with barley the endosperm was absent. Even more, the hybrid 4x- _Hordeum chilense_ × 4x- _Secale cereale_ showed no endosperm (Martin and Jouve, unpubl. data).

The growth rate of the endosperm may affect the development of the embryo. Bennett et al. (1976) observed differential rates of growth in _Hordeum vulgare_ × _H. bulbosum_ depending on the genotype. Two varieties of _vulgare_ showed a different rate of cell development in the embryos, one similar to the female parent, the other significantly slower. Similar results were obtained for the endosperm. Brink and Cooper (1939) designated as somatoplastic sterility, the seed failure due to hyperplasia of the nucellus or inner integuments leading to impaired capacity for growth of the endosperm. The immediate cause of collapse is starvation of this organ as a result of excessive development of the adjacent maternal tissue. They found essentially the same phenomenon following self-pollination associated with inbreeding in _Medicago sativa_, interspecific hybrids in _Nicotiana_, and in intergeneric crosses involving _Nicotiana_, _Petunia_, and _Lycopersicon_ (Cooper and Brink 1940). Kostoff (1939) also found hyperplasia of the nucellus in crosses of _Nicotiana_ showing seed abortion, as did Renner (1915) in _Oenothera muricata_ × _Oe. biennis_. In general, these authors found that among the four principal tissues in the young seed (embryo, endosperm, nucellus, and integument) the embryo is least altered in form and mass by hybridization. This result is also observed in wide crosses in the Triticeae.

6.2.2 Premeiotic Chromosome Behavior

Interspecific crosses are seldom fertile if the whole genomes of both parents reach the generative tissue. As a first step, after fertilization, both genomes have to replicate themselves and this is probably the first step which has to be done coordinately. If one of the genomes fails to fulfill the process of DNA replication, the hybrid is inviable, and a possible result is the elimination of chromosomes contributed by one of the species.