



MICROSTRUCTURAL AND CYTOGENETIC DISORDERS IN ENDOSPERM OF AN *AVENA FATUA* × *A. STERILIS* HYBRID

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Abstract. A significant difference for cytogenetic and developmental stability of endosperm was discovered between two wild oat species and their hybrid progeny. The development of hybrid endosperm was regulated by apoptosis and proceeded according to a domainal pattern. Many cytogenetic anomalies were also noted, and their appearance was attributed to the activity of transposons or somatic crossing-over. The normal development of endosperm should be considered as an important factor determining viability of seedlings and their intrapopulation competitiveness.

Key words: *Avena fatua*, *Avena sterilis*, wild oats, hybrid progeny, endosperm, cytogenetics, development

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Avena fatua L. (common wild oat) and *A. sterilis* L. (sterile oat) are common weeds with a wide range of distribution (BAUM 1977; BAUM *et al.* 1972). Both hexaploid species have AACDD genomes ($2n = 42$) (RAJHATHY & MORRISON 1959). They belong to the *Avena* section, in which natural hybrids occur. Natural intercrossing between *A. fatua* and *A. sterilis* as well as between these species and cultivated oats (*A. sativa* L. and *A. byzantina* K. Koch) was observed (FLORELL 1931).

For both species and artificial hybrids from the cross between them (obtained from National Small Grains Collection, Idaho, USA), a comprehensive analysis of the endosperm was performed. The studies were conducted at mature and nuclear developmental stages of the tissue. Aleurone layers from the ripe caryopses were manually isolated. In addition, transverse sections of the kernels were made. Developmental relationships between the aleurone layer and starchy endosperm in *A. fatua*, *A. sterilis* and their hybrid were researched. It was noted that these tissues are strongly modified in the hybrid caryopses. Starchy cells occurring in the aleurone layer as well as aleurone cells appearing between starchy cells, an intrusive growth of aleurone cells into the starchy endosperm, large aleurone cells and cells with mutated globoids were

the most frequent developmental disorders. Several cases of somatic crossing-over in the hybrid aleurone layer have been found. Some abnormalities were also observed in parental species, but their frequency was significantly lower than in a hybrid progeny. Transsections of hybrid kernels revealed multicellular aleurone layer, especially in the crease area. Some examples of endospermal domains of various structure were also reported. These domains can be units of the free growth in the space released by apoptotic nuclei. Parental genomes play a different role in apoptosis of dysfunctional nuclei and cells in hybrid endosperm (TOMASZEWSKA & KOSINA 2013; KOSINA & TOMASZEWSKA 2013). These data provide evidence of correctness of the model of domainal hybrid endosperm development presented by KOSINA *et al.* (2013). The multilayered aleurone and the domainal arrangement of endosperm were not found in parental forms.

The study conducted at the nuclear stadium of endosperm showed numerous cytogenetic disorders, such as: bridges in anaphases and telophases, elimination of chromosomes in anaphases, as well as merging of nuclei. The increased micronucleus frequency (sometimes 2 or 3 in one cell), which indicates the elimination of fragments or whole

chromosomes, was observed. Some of these cytogenetic abnormalities were identified in parental species. In both hexaploids, micronuclei were also present, but not so frequent as in the hybrid.

Earlier studies on the structure of the endosperm of various grass amphiploids, conducted by a team of Prof. Romuald Kosina, showed the disturbances in the tissue development (KOSINA 2007; KOSINA & TOMASZEWSKA 2010, 2011; KOSINA & ZAJĄC 2010). Some examples of disorders in the structure of maize endosperm are also given by BECRAFT & ASUNCION-CRABB (2000) and BECRAFT *et al.* (2002). The reasons for creating of abnormal tissues in the caryopses are the subsyncytial nature of the endosperm and the hybrid stress, which can increase transposon activity and induce somatic crossing-over (KOSINA 1996, 2007). The relationships between parental genomes in endosperm may also be important for the proper development of the tissue (EHLENFELD & ORTIZ 1995; KOSINA & TOMASZEWSKA 2013). Deviations from the normal ratio of the *Polygonum* embryo sac (2 maternal genomes : 1 paternal) result in developmental disorders of kernel tissues (LIN 1984; VON WANGENHEIM & PETERSON 2004). It is proved that the frequency of cytogenetic disorders in endosperm is increased by hybridization (RUTISHAUSER & LA COUR 1956). However, there are also many examples of abnormal mitosis during endosperm development in pure species (RYCHLEWSKI 1968).

In conclusion, the intercrossing between weedy, closely related oat species can cause many cytogenetic and developmental anomalies of endosperm, which reduce the competitiveness of a seedling in the population.

References

- BAUM B.R. 1977. Oats: wild and cultivated. A monograph of the genus *Avena* L. (Poaceae). Monograph No. 14. Ottawa, Thorn Press Ltd.
- BAUM B.R., FLEISCHMANN G., MARTENS J.W., RAJHATHY T., THOMAS H. 1972. Notes on the habitat and distribution of *Avena* species in the Mediterranean and Middle East. *Can. J. Bot.* **50**: 1385–1397.
- BECRAFT P.W., ASUNCION-CRABB Y. 2000. Positional cues specify and maintain aleurone cell fate in maize endosperm development. *Development* **127**: 4039–4048.
- BECRAFT P.W., LI K., DEY N., ASUNCION-CRABB Y. 2002. The maize *dek1* gene functions in embryonic pattern formation and cell fate specification. *Development* **129**: 5217–5225.
- EHLENFELD M.K., ORTIZ R. 1995. Evidence on the nature and origins of endosperm dosage requirements in *Solanum* and other angiosperm genera. *Sex. Plant Reprod.* **8**: 189–196.
- FLORELL V.H. 1931. Inheritance of type of floret separation and other characters in interspecific crosses in oats. *J. Agric. Res.* **43**: 365–386.
- KOSINA R. 1996. Nucleolar variation in grass endosperm. *Acta Soc. Bot. Pol.* **65**: 190.
- KOSINA R. 2007. Some topics on the grass mosaics. In: FREY L. (ed.), Biological issues in grasses: 159–167. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.
- KOSINA R., BUREŚ MK, FLOREK M., GRABIŃSKA A., KAWA P., KEYK B., KOCHMAŃSKI Ł., KOZLIK A., KUREK A., SKOWROŃSKA J., TOMASZEWSKA P., ZAJĄC D. 2013. Structural characteristics of grass hybrid endosperm development. *Ann. Wheat Newslet.* **59**: 116–117.
- KOSINA R., TOMASZEWSKA P. 2010. Microstructure of endosperm in some intergeneric amphiploids and their parental species of the Triticeae tribe. *Ann. Wheat Newslet.* **56**: 200–201.
- KOSINA R., TOMASZEWSKA P. 2011. Contribution on *Avena* (Poaceae) amphiploids endosperm. In: FREY L. (ed.), Advances in grass biosystematics: 119–127. W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków.
- KOSINA R., TOMASZEWSKA P. 2013. Genomes of wheat and other grasses during the cell cycle and apoptosis. *Ann. Wheat Newslet.* **59**: 113–114.
- KOSINA R., ZAJĄC D. 2010. Instability of some endosperm traits in *Triticum/Aegilops* amphiploids. *Ann. Wheat Newslet.* **56**: 198–199.
- LIN B.-Y. 1984. Ploidy barrier to endosperm development in maize. *Genetics* **107**: 103–115.
- RAJHATHY T., MORRISON J.W. 1959. Chromosome morphology in the genus *Avena*. *Can. J. Bot.* **37**: 331–337.
- RUTISHAUSER A., LA COUR L.F. 1956. Spontaneous chromosome breakage in hybrid endosperms. *Chromosoma* **8**: 317–340.
- RYCHLEWSKI J. 1968. Kariologia endospermy roślin okrytonasiennych. I. Geneza wyjściowych liczb chromosomów. *Wiad. Bot.* **12**: 257–270.
- TOMASZEWSKA P., KOSINA R. 2013. On the different role of parental genomes in selected hybrid grasses. *Chromosome Res.* **21** (Suppl. 1): 131–132.
- VON WANGENHEIM K.-H., PETERSON H.-P. 2004. Aberrant endosperm development in interploidy crosses reveals a timer of differentiation. *Dev. Biol.* **270**: 277–289.