
COMMUNICATIONS

**FORMATION OF EMBRYO SAC, DEVELOPMENT OF OVULE AND SEED
IN *HELIANTHUS CILIARIS* AND *H. TUBEROSUS* (ASTERACEAE)**

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Two perennial wild species of sunflower, *Helianthus tuberosus* L. ($2n = 102$) and *H. ciliaris* DC. ($2n = 68$), from different sections (*Divaricati* and *Ciliares*) were studied. The material was collected in the park of the Komarov Botanical Institute (*H. tuberosus*) and at the Kuban Experimental Station of VIR (*H. ciliaris*).

The processes of reproductive structures formation are similar in *H. ciliaris* and *H. tuberosus* and are comparable to those in cultivated sunflower.

The young ovule of sunflower is ortotropous, but one side of the integument is curved because of more intensive growth. The mature ovule of sunflower is anatropous, unitegmic, with integumentary tapetum, or endothelium, like in other Asteraceae. The ovule shows a zonal differentiation particularly visible in the central part. The cells of the outer zone are elongated with thin cell wall, whereas the cells of the inner zone are disintegrated and have thick cell wall intensively stained with alcian blue. The vascular bundle passes through chalaza and penetrates integument almost reaching the micropyle, like in some other Asteraceae species. The megasporocyte develops directly from archesporial cell without any mitotical division. The meiotic divisions of megasporocyte produce a linear tetrad of haploid megaspores. Three of them degenerate and Polygonum-type embryo sac is formed from one chalazal megaspore. The embryo sac is completely developed by the time of pollination. The mature embryo sac consists of the three-cellular egg apparatus, the central cell with big, fused secondary nucleus, and antipodal cells. The egg apparatus consists of three pear-shaped cells: two synergids and the egg cell. The egg cell nucleus is rather large, with obvious nucleolus, and positioned in the apical part of the cell. The synergids' nuclei are barely distinguishable and positioned in the centers of the cells. A synergid hook was found in the basal part of the cell. The large central cell's nucleus is located near the apical end of the egg cell. Antipodes are linear. Usually, there are only two antipodes in the mature embryo sac. During the antipodes formation, cell walls are laid between the newly divided nuclei, but not between the nuclei of neighboring pairs. As a result, a uninuclear antipodal cell is formed at the bottom of the embryo sac, and a binuclear cell is formed above it. Antipodal cells are strongly vacuolated. The antipodal complex as a whole takes half of the general linear size of the embryo sac.

In some *H. ciliaris* ovules, aposporous embryo sacs were observed. Aposporous embryo sac included the same elements as the main one: the egg cell, the synergids, the central cell with polar nuclei or secondary nucleus, and the antipodes.

In *H. tuberosus*, a phenomenon of the total absence of embryo sac was recorded. All the ovule structures were formed normally and phases of their development and relative positioning of elements corresponded to the stages of flower development.

Though pollination took place, fertilization hardly was observed. If fertilization failed, the integumentary tapetum became multilayered and folded, and its cells were transparent with small and poorly visible nuclei.

The embryo formation with poor endosperm development was found. In this case the integumental tapetum was quite massive and multilayered.

In our study, we were unable to trace in details all the way to the embryo formation. The available data indicate that in the studied species of sunflower the endosperm is nuclear, cell formation begins at an early stage of embryo development. The embryogenesis proceeds according to the Asterad-type (Senecio-variation). The present study and previous data (Babro, Voronova, 2018; Voronova, Babro, 2018) suggest that the initiation and development of both male and female reproductive structures in *H. ciliaris* and *H. tuberosus* pass similarly without significant deviations. At the same time, the absence of fertilization in most cases suggests that the low seed productivity noted earlier for the studied samples is determined by self-incompatibility and disturbances in pollen germination.

Keywords: ovary, ovule, seed, megagametogenesis, morphogenesis of reproductive structures, embryo sac, apospory, embryo, endosperm, *Helianthus tuberosus*, *Helianthus ciliaris*

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