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FLOWER DEVELOPMENT OF GREENHOUSE CHRYSANTHEMUM

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A comparative morphogenetic study of reproductive organs of chrysanthemums is conducted using morphological analysis. Morphological changes during the development of a generative shoot and organogenesis from first through ninth phases were described. The flat apex becomes spherical in form. An inflorescence apical meristem initiates involucral bract. An initiation of floret primordia is followed an acropetal sequence. Floral meristem produces corolla, then 5 staminata primordia and two-lobed pistillata primordia. The ray floret and the disc floret both form 5-lobed corolla, but 2 lobes of the corolla of the ray floret stop their growth. Staminata primordia of the ray floret produce sterile staminodia or do not continue their development. At phase IX during flowering, 4 stages are identified. A dehiscence of introrse anthers and anthesis occur in a closed disc floret. There are protoandria and different arrangements of mature anthers and mature stigmata in disc florets .

Key words: Chrysanthemum, *Chrysanthemum* × *hortorum* hort., *Dendranthema grandiflora* hort., morphogenesis of generative shoot, organogenesis.

INTRODUCTION

Greenhouse chrysanthemums (*Chrysanthemum* × *hortorum* hort., *Dendranthema grandiflora* hort.) are herbaceous perennial plants with beautiful inflorescences, members of the composite family (Asteraceae). The basic original species are considered to be *Dendranthema indicum* (L.) des Moul. and *Dendranthema morifolium* (Ramat.) Tzvel. (Tzvelev, 1961).

Morphogenesis of a monocarpous shoot of chrysanthemum consists of three basic periods according to Borisenco (1968): (1) period "of rest" with retardation of the formation processes; (2) formation of the vegetative organs; and (3) formation of the generative organs. Vegetative development of chrysanthemums occurs under a long day condition, while flower bud formation takes place under a short day condition.

Cathey and Borthwick (1957) and Cockshull and Hughes (1972), studying development of reproductive apical meristems of chrysanthemums, described 12 stages of development of a generative shoot from a vegetative condition to the beginning of reproductive organ formation in ray florets, through five phases of organogenesis.

MATERIALS AND METHODS

Objects of study were cultivars of greenhouse chrysanthemums and intervarietal hybrids (*Chrysanthemum* × *hortorum* hort., *Dendranthema grandiflora* hort.) obtained in Central Siberian Botanical Garden (CSBG). The plants were grown in a greenhouse under natural light conditions. Methods of research were morphological and ontogenetic. Study was conducted using a light microscope studies, employing the methods suggested by Kuperman and Podolnii (1962) for studying organogenesis, and methods of Dospechov (1985) for statistical data processing were used. Cultivars with single shaped (daisy-type) and anemone shaped inflorescences were chosen for studying of flower development. The cultivar "Koreanka" with a single shaped inflorescence was an object for describing stages of flowering. The florets investigated were taken from the first, second, and third peripheral circles.

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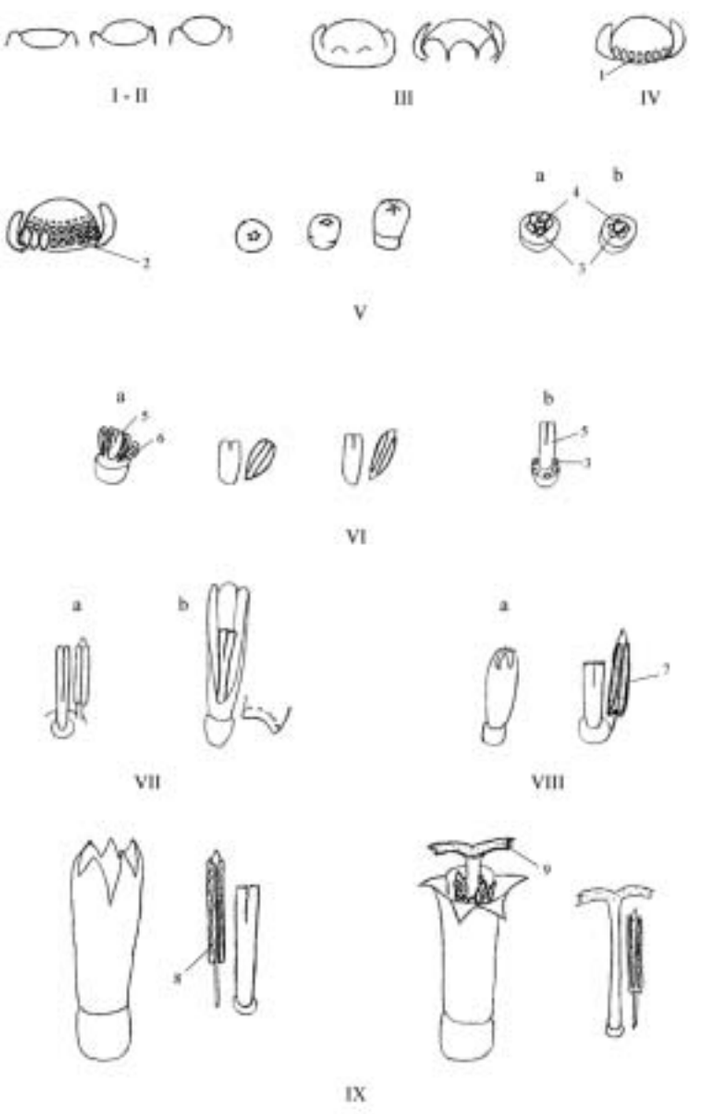

Fig. 1. Organogenesis of generative shoot in glasshouse chrysanthemum. I–XI – phases of organogenesis; a – disc floret; b – ray floret; 1 – forming involucral bracts of a inflorescence; 2 – forming florets; 3 – staminata primordia; 4 – pistillata primordia; 5 – growing pistil; 6 – growing stamen; 7 – anther with mature pollen grains; 8 – split anther; 9 – mature stigma.

RESULTS

Nine phases (I–IX) of organogenesis of generative shoot in glasshouse chrysanthemum are presented on Figures 1–7. First, a terminal apex is differentiated. At the beginning the apex is flat, but then it enlarges and assumes a spherical form through I and II phases of organogenesis. At the base of spherical apex, involucral bracts of the inflorescence are formed by III and IV phases of organogenesis. Then, a first circle of floret primordia is formed, and differentiation of florets in inflorescence occurs in acropetal sequence. A dimple appears on the top of floret primordium, and a corolla is produced first. Inside the developing corolla 5 staminata primordia and two-lobed pistillata primordium arise. Five staminata primordia surround the pistillata primordium (phase V of organogenesis). Ray floret develop-

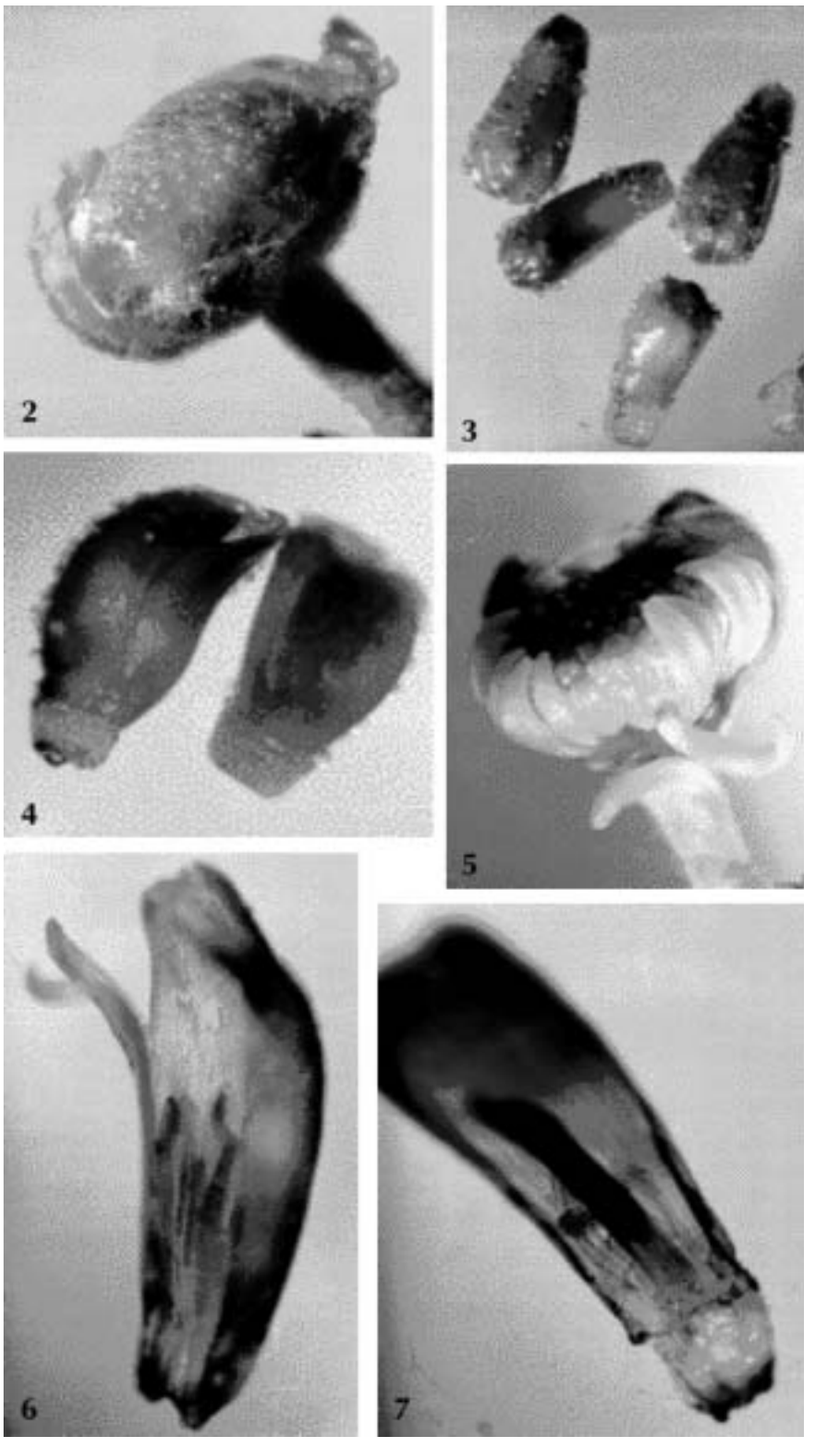

Fig. 2. An inflorescence in diameter 0.75 cm (hybrid seedling). × 12. **Fig. 3.** Disc florets from an inflorescence in diameter 0.75 cm (cultivar "Reaction"). × 24. **Fig. 4.** Ray florets from an inflorescence in diameter 0.75 cm (cultivar "Reaction"). × 24. **Fig. 5.** An inflorescence in diameter 1 cm (cultivar "Reaction"). × 6. **Fig. 6.** Disc floret with deformed stamina from an inflorescence in diameter 1.3 cm (cultivar "Reaction"). × 24. **Fig. 7.** Ray floret with deformed sterile stamina (staminodium) from an inflorescence in diameter 1.4 cm (hybrid seedling). × 24.

ment differs from the development of disc florets in that during phase V, two lobes of the corolla stop their growth and stamina stay in a primordial stage or produce sterile staminodia. Formation of pollen grains and female gametophyte occurs at phase VI (Figs. 2–4). At phase VII there is growth of the corolla, anther stalks, and style (Fig. 5). Involucral bracts open at phase VIII, and flowering and fertilization occurs at phase IX.

Morphological changes of the disc floret during phase IX were determined and subdivided into 4 stages of flowering: first stage (G1), a growth of anther stalks and maturation of pollen grains in introrse anthers; second stage (G2), dehiscence of anthers inside of a closed floret, corolla with separate petals, and the stigma located below the split anther level; third stage (G3), growing pistil is pushing mature pollen out of the whorl of 5 glued anthers by the immature stigma; and fourth stage (G4), identified by opened mature stigma (T-shape) and anthers located below the mature stigma. At this stage, the female gametophyte in the disc floret is mature (Novikova, 1981). Thus, anthesis occurs in closed floret, and the stigma is mature when it grows above the anthers and outside of the corolla.

Biometric data were processed for cultivar "Koreanka." At the first stage the length of stamina becomes 4.48 ± 0.06 mm (N = 30). At the second stage when the anthesis occurs, the length of pistil is 3.18 $\pm$ 0.05 mm (N = 30), i.e. stamina are 1.4 times as longer as the pistil. At the fourth stage, the length of pistil is 7.17 ± 0.08 mm (N = 30) and the pistil is 1.6 times as large as stamina.

DISCUSSION

The development of the generative organs of a shoot occurs in the following sequence: change of form of the apex; initiation of involucral bracts; initiation of floret primordia; initiation of a corolla; initiation of androecium and gynoecium; growth of the floral organs; differentiation of pollen grains; dehiscence of mature anthers and anthesis; and maturation of a stigma.

In an analysis of disc floret morphogenesis in dahlias (*Dahlia* × *cultorum* Thorsr. et Reis., Asteraceae), Shumichin (1998) identified 4 stages during flowering. In development of disc florets of chrysanthemum, there are similar stages, and the basic difference is that anthesis occurs in a closed floret.

Protandrous flowering of disc floret and a functionally female ray floret were displayed. Stages G1–G2, when disc floret reaches the anthesis, is staminata phase and when disk floret finishes anthesis, the stigma begins to open. As a result, pistillata phase is followed staminata phase in each disc floret. However, flowering period of the inflorescence is enough long when there are disc florets with mature pollen on the top of the inflorescence and at the same time there are disc florets with mature stigma at the base of the inflorescence.

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REFERENCES

BORISENCO TP. 1968. A biology of glasshouse chrysanthemums *Dendranthema indicum* and *Dendranthema morifolium* and some problems of agriculture. Ph.D. dissertation. Leningrad (in Russian).

CATHEY HM, and BORTHWICK HA. 1957. Photoreversibility of floral initiation in chrysanthemum. *Botanical Gazette* 119: 71–76.

COCKSHULL KE, and HUGHES AP. 1972. Flower formation in *Chrysanthemum morifolium*: the influence of light level. *Journal of Horticultural Science* 47: 113–127.

DOSPECHOV BA. 1985. *Methodology of a field experiment*. Agropromisdat, Moscow (in Russian).

KUPERMAN FM, and PODOLNII WW. 1962. The biological control of development and growth of sunflower. In: Kuperman FM [ed.], *The biological control in an agriculture,* 139–144. University of Moscow Press, Moscow (in Russian).

NOVIKOVA WM. 1981. Embryology of garden chrysanthemum. *Bull. of Nikitskii botanical garden* 3: 91–93 (in Russian).

SHUMICHIN SA. 1998. A dalia from seed. Studying cultivars and hybrid mixes, microcloning. Ph.D. dissertation. University of Perm (in Russian).

TZVELEV NN. 1961. A kind *Dendranthema* (DC). Des Moul. *Flora of USSR,* vol. 26, 364–388 (in Russian).