

THE MORPHOLOGICAL STRUCTURE OF THE RENEWAL BUD IN *KNIPHOFIA NELSONII* MAST.

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Abstract

The study of the ornamental plants morphogenesis is of great importance because it allows the control of growth and development processes, and correction, adjustment and application of cultivation technology. The architecture of the bioform is determined by the vegetative organs. The vital form of the plant is an indicator of vital processes in the organism (Cernei 1994). During most of the year, physiological processes are concentrated in underground organs. Due to this aspect, research was carried out on the rhizome of Kniphofia nelsonii Mast. (red hot poker), in particular, of the buds of renewal. During this study were examined: the morphological aspects of the root; the morphological aspect of the rhizome; the type of renewal buds; its development method during the plant's vegetative and dormant periods (August, November and February); their shape and disposition; presence or absence of cataphylls; their number, shape, size and their protective role; the type of proliferation and foliation.

Key words: *Kniphofia* Mast., morphology, renewal bud.

INTRODUCTION

Currently, the sustainable use, conservation and the enrichment of the diversity of ornamental plant species cultivated *ex situ* is of vital importance. Through ornamental plants, humans ensure a pleasant life, decorating his place of residence, work, cities, rural localities, etc. The study of the behavior of plants in *ex situ* conditions, mobilized from various floristic regions of the globe in areas with pedoclimatic conditions different from those of origin, is always relevant both theoretically and practically. The above-mentioned outlines the need to study the biological potential of plants in the pedoclimatic conditions of the Republic of Moldova. The introduction of plants, appreciated as a vast ecological and phytogeographic experimentation, provides a multitude of data for the researcher, and the analysis of the data allows drawing conclusions on the adaptive potency and ecological amplitude of organisms (Cernei, 1994a).

Research on the introduction of representatives of the genus *Kniphofia* Moench in the Republic of Moldova was initiated in 1979, by acclimatizing the species *Kniphofia uvaria* (L.) Oken within the ornamental plant collection of the Al. Ciubotaru National Botanical Garden

(Institute) (NBGI), obtained through the international seed exchange (*Index Seminum*) (Chernej, 1987; Sfeclă, 2016, 2021). Later, through the *Index Seminum* and purchases, other representatives of the genus *Kniphofia* also ennobled the NBGI exhibitions, such as: *K. ensifolia* Baker; *K. tuckii* Baker; *K. nelsonii* Mast.; *K. citrina* Baker; *K. sarmentosa* Baker; *K. galpinii* Baker; *K. hirsuta* Codd; *K. thodei* Baker; *K. 'Royal Standart'* (Syrbu and Sfeclă, 2008; Syrbu et al., 2009; Sfeclă, 2016; 2017; Sfeclă and Sîrbu, 2018). As a result of the experimentation of induced mutagenesis in *K. nelsonii*, a form was selected and the variety *K. nelsonii* 'Micul Prinț' was patented (Sfeclă and Sîrbu, 2019; Sfeclă et al., 2019; Sfeclă et al., 2022, Sîrbu et al., 2023). Currently, the collection of the genus *Kniphofia* in NBGI lists 11 taxa.

In the process of introducing plants, some of the main indicators are their phenological phases, growth dynamics, ontogenesis and morphogenesis. These indicate the level of adaptability of the species to local conditions.

The study of the morphogenesis of ornamental plants is paramount, as it allows the control of both growth and development processes, including the adjustment and correct application of cultivation technology. The

architectonics of the biomorph is determined by the vegetative organs. The vital form of the plant is an indicator of the vital processes in the organism (Cernei, 1994b). For most of the year, physiological processes are concentrated in the underground organs. In this regard, research has been carried out on the rhizome, in particular, on the renewal buds.

The renewal bud represents the initial phase of the monocarpic shoot – the main element that attributes the kniphofias to the group of hemicytrophite herbaceous plants. According to the definition proposed by O. Schuepp (1938) (cited by Shilova, 1988), the bud represents the proportions unit of growth, including the development of the growth cone. According to the data presented by T. Serebrjakova (1971), in the buds, the development of leaf primordia occurs, as well as the first stages of growth of leaf blades, internodes, etc. Primary morphogenesis also takes place here.

The species of the genus *Kniphofia* Moench do not differ in ecological and geographical characteristics and present a similar ontogenetic program. The differences are only in quantitative characteristics such as the size of the plant in certain ontogenetic stages, the number of leaves, the thickness in the area of the crown, etc. In this regard, research was carried out on the rhizome and especially on the renewal bud of *Kniphofia nelsonii*. During this study, the following were examined: morphological aspects of the root; morphological appearance of the rhizome; type of renewal buds; mode of its development during the vegetative and dormant periods of the plant (August, November and February); their shape and arrangement; presence or absence of cataphylls; number, shape, size and their protective role; type of proliferation and foliation.

***Kniphofia nelsonii* Mast.** 1892, Gardeners Chronical, 1: 554; Baker, 1896, Flora Capensis, 6: 280; Berger, 1908, Pflanzenreich, 4: 53 (Baker 1896; Berger 1908; Codd 1968, 2005) – *Kniphofia triangularis* subsp. *triangularis* (Germishuizen and Meyer, 2003) (Figure 1).

Herbaceous, acaulescent, rosulate plants. Orthotropic, thick, abbreviated rhizomes, from which the tuberized roots start laterally. Leaves in rosettes of 12-16, arranged distich-alternate,

glabrous, canaliculate-linear, rigid, erect or geniculate, green-glaucous, 40-50 cm long, 2 cm wide and ca. 2 mm thick, with three prominent veins (one central more furrowed and two lateral), V-shaped in cross section, the margin and the keel serrated. Cylindrical, simple, accreting floral peduncles, several flowerless bracts are present below the inflorescence. Inflorescences – terminal spiciform racemes, cylindrical, oblong, dense, narrowed towards the apex, acropetal flowering. Membranous, oblong-lanceolate, three-veined bracts. Floral buds first erect, then horizontal, dense, red. Actinomorphic, bisexual, pendulous, deflected flowers, looser than floral buds, yellow-green, with a green vein on each lobe of the perigone, odorless. Pedicels 2-3 mm, patent, curved, accreting in the fruiting phase. Perigone tubular, narrowed above the ovary, the 6 perigonial lacinia flat, ovate, slightly recurved. Stamens – 6, bifid, all fertile, inserted at the base of the ovary, included, exerted in anthesis. Styles exerted. Stigmata trilobate. Ovary trilocular, glabrous, ovoid, truncated at the base, narrowed at the tip. Fruit – dehiscent, subglobose capsule (Sfeclă, 2017).

Bioecology: perennial, V-VI, hemicytrophite, xeromesophyte (Pinzaru and Sirbu, 2016). n = 6, 12, 24 (Nayak, 1988).

Phytogeographic element: South Africa

General distribution: Free State, Kwa Zulu-Natal, Lesotho, Eastern Cape provinces. It is found at altitudes of 910 - 2895m. (Germishuizen and Meyer, 2003).

A characteristic of kniphofias, originating from South Africa, is the decorativeness of the flowers and leaves, which allows their use in landscape architecture and bouquet art, through the production of flowers. Within green spaces they can be framed in various elements, such as: solitary specimens, small groups around water bodies, borders and mixed borders (Sfeclă, 2015). *Kniphofia* is one of the cut flower crops that has grown in popularity in recent years, both in the floriculture industry and among consumers (Hettiarachchi and Balas, 2005). This popularity is felt globally, not locally. As a result of research into the specific ornamental assortment existing on the floricultural market in the city of Chisinau, knifofia was not highlighted (Dica et al., 2018).



Figure 1. *Kniphofia nelsonii* Mast. in the collections of the Ornamental Plants Laboratory of the NBGI
A – group of plants; B – the inflorescence in the blooming phase

MATERIALS AND METHODS

The research was carried out within the Ornamental Plants Laboratory of the NBGI.

The morphological description was carried out with the help of the works: “*Atlas po opisatel'noj morfologii vysshih rastenij*” (Fjodorov and Artjushenko, 1962); “*Lexicon Botanicum Polyglottum*” (Váczy, 1980) and “*The Kew Plant Glossary: An Illustrated Dictionary of Plant Terms*” (Beentje, 2016).

The scientific name of the species is cited according to the publication “*Authors of plant names*” by R. Brummitt and C. Powell (1992) and global data networks, such as: *International Plant Names Index* (IPNI) (2020) and *Global Biodiversity Information Facility* (GBIF) (2020). The morphology of the renewal bud was analyzed in accordance with the principles of examining morphological

processes proposed by T. Serebrjakova (1971). The morphological survey was carried out according to the following model: extraction of specimens from the soil (February, August and November) and preparation of buds in laboratory conditions.

Their thorough research included morphometry, photofixation and description of the structural features of the composing elements. During the work process a manual magnifying glass, an optical microscope Biolam-D-12 and a digital microscope VWR VisiScope-BL254T1 were used.

The sections through the growth cone were manually made with a blade. The study was carried out on the basis of fresh material (Figure 2).

For a more extensive confirmation, the results of the research were consolidated with photographic fixation and analytical drawings.



Figure 2. The process of preparing renewal buds

RESULTS AND DISCUSSIONS

The rhizome is a metamorphosed, underground stem (Fjodorov and Artjushenko, 1962; Morariu, 1973). The rhizome of *Kniphofia*'s constitutes the multiannual basis of these plants. It is the organ of renewal and vegetative propagation as well as a place where the plant deposits reserve substances (Serebrjakov, 1952, 1962).

As a result of the morphological study of the rhizome, we found that it is simple, orthotropic, abbreviated, 4-6 cm thick and 3-5 cm long, reddish-brown in color, from which 12-25 tuberous roots with a diameter of 0.5-0.7 cm radially start.

This aspect suggests that the rhizome represents an effective mechanism of survival and vegetative renewal, which allowed kniphofias to adapt to the specific environmental conditions of the Republic of Moldova. The dimensions and characteristics of the rhizome, including the thickness and number of tuberous roots, indicate a resource conservation strategy, essential in variable pedoclimatic conditions.

Morphological survey of renewal buds in *Kniphofia nelsonii* was carried out in February, August and November, according to the following model: extraction of specimens from the soil, preparation of buds in laboratory conditions. Depending on the position of the

buds, in kniphofia we distinguish: apical buds, axillary buds and adventive buds (Figure 3).

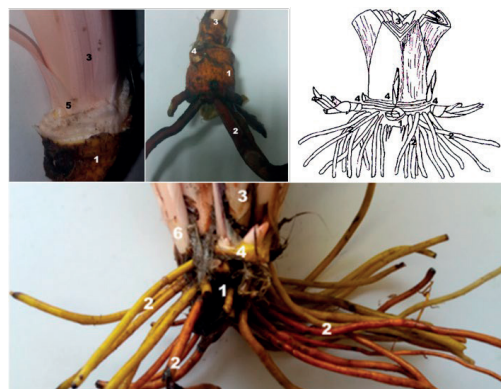


Figure 3. General appearance of the underground part of *Kniphofia nelsonii* Mast.:

1 – rhizome; 2 – tuberous roots; 3 – apical bud covered by persistent leaves; 4 – dormant buds; 5 – axillary bud; 6 – shoot developed from axillary bud

The apical bud (growth cone) (Figure 3) is mixed, solitary, open, with 2-5 leaves in the vegetative phase. It is protected by the base of the persistent leaves of the previous monocarpic shoot. In August, the apical bud has a conical shape and yellowish color. If the specimen has not flowered this year, the bud is placed on the rhizome in the center, otherwise at the base of the floral axis. At this time, leaf primordia and the apical meristem are present (Figure 4 A).

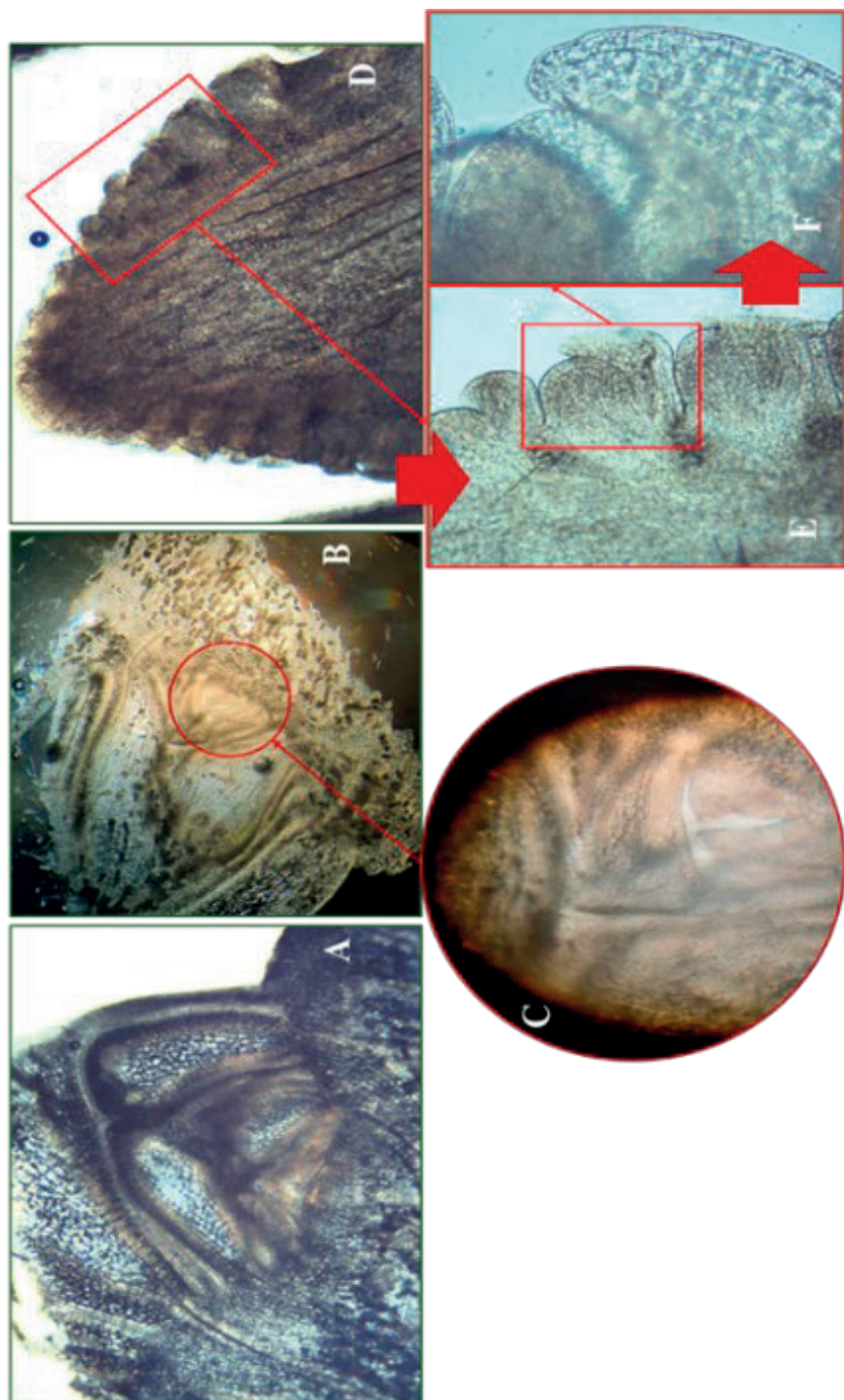


Figure 4. Anatomical structure of an apical bud:

A – apical bud examined in August (40x); B – apical bud examined in November (40x); C – differentiation of the inflorescence in the apical part (60x);

D – apical bud examined in February (40x); E – inflorescence differentiated into apical bud examined in February (40x);

F – differentiation of the floral primordium (60x); F – floral primordium and bract differentiated (90x)

The buds that were analyzed in November indicate that some essential changes have occurred, such as the presence of 4-6 yellow-green embryonic leaves. The differentiation of the inflorescence begins in the apical part (Figure 4 B-C).

For the apical renewal bud studied in February, it was found that the floral axis is differentiated. The inflorescence presents floral buds, as well as numerous elongated and thickened bracts (Figure 4 C-F).

The morphological changes observed in the apical bud, including the differentiation of inflorescences in the winter months, highlight the dynamic aspects of plant development. This information is viable for understanding the appropriate frequency in the reproductive

cycle, which may allow for the optimization of cultivation technology and more efficient planning of the flowering period.

Axillary buds (Figure 3) which develop in the leaf axil, are solitary, and closed. Of all these type of buds developed by the plant in a vegetative season, only a few will develop seedlings in the following year. The others turn into dormant buds (Figures 3, 4, 5 A-B) and remain in the latent phase indefinitely. As a result of the morpho-anatomical analysis of the axillary buds, it was found that they are vegetative (Figure 5 E-F) and present 5-7 protective membranes (Figure 5 C). The distichous arrangement of the leaves is evident when examining the cross-section of the apical and axillary buds (Figure 5 E).

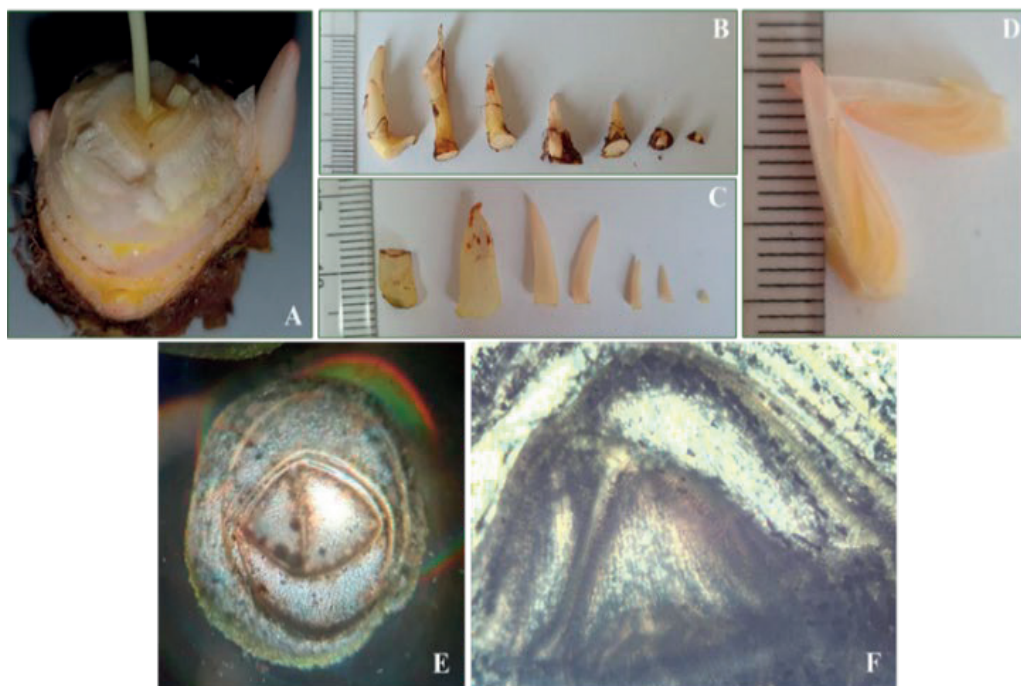


Figure 5. Axillary bud:

A – general appearance of the rhizome with apical bud and axillary buds; B – axillary buds at different stages of development; C – protective membranes of axillary buds; D – axillary bud in longitudinal section; E – axillary bud in transverse section (20x); F – anatomical structure of an axillary bud (40x)

Observations on the morphogenesis of renewal buds suggest that *Kniphofia* species, such as *K. nelsonii*, exhibit increased adaptability to environmental conditions. The identification of apical and axillary buds at different stages of

development demonstrates the ability of plants to cyclically adapt to seasonal variability. The presence of dormant and active buds suggests an efficient strategy for managing reserve

substances, which could influence the success of these plants under environmental stress.

CONCLUSIONS

In the pedoclimatic conditions of the Republic of Moldova, *Kniphofia nelsonii* Mast. retains its biomorph (perennial, hemicryptophyte), which is an important indicator of the species' adaptation. This adaptability suggests an increased ecological efficiency, relevant for the use of this ornamental species in landscaping green spaces.

Observations on renewal buds in different periods of the year (February, August and November) revealed processes of inflorescence differentiation, confirming that *Kniphofia nelsonii* presents a clear seasonal cyclicality in morphological development. These data substantiate the technology of cultivation of this species in *ex situ* conditions.

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