Kalanche daigremontiana as a Model Plant for the Study of Auxin Effects in Plant Morphology

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The ability to regenerate a plant from a single cell is known as totipotency, and such phenomenon occurs not only in in vitro tissue and cell culture but in specialized somatic cells that are part of whole plants in ex vitro natural conditions, constituting this asexual or vegetative processes their only means of reproduction [1].

A large number of studies have been conducted in order to understand the mechanisms by which shoots, plantlets and vegetative propagules are produced. According to the first studies reported by Yarborough [2, 3], in the fern species Campylosorus rhizophyllus (which has two different kinds of leaves), shoots are produced at the tip of long acuminate leaves, while in the species Tolmiea menziesii shoots are originated in a notch near the junction of the petiole and the leaf blade; in both cases, the shoots are produced from meristematic tissue and once they are mature are naturally detached from the leaf and fall to the ground originating a new plant. Also, in the orchid Malaxis paludosa, cells at the tip of mature leaves have an intense meristic activity which originates embryo-like structures that once the mature leaf is wilted the small shoot detaches originating a new plantlet [4]. This phenomenon has been widely studied in plants of the Crassulaceae family, mainly in the genus Kalanche. According to the capacity to asexually produce such plants, species of this genus have been classified in four categories: a) plants which do not produce plantlets (K. marmorata, K. rhombopilosa, K. tomentosa and K. thysiflora), b) plants that spontaneously produce plantlets (K. daigremontiana), c) plants that produce plantlets by the action of an environmental stress (K. pinnata, K. fedtschenkoi, K. streptanthia, K. prolifera and K. crenata) and d) plants that produce spontaneously plantlets by the action of stress and/or (K. gastonis-bonnieri) [5]. According to studies conducted by Baygina et al. [6] in the species Kalanche daigremontiana (formerly called Bryophyllum daigremontianum) and Kalanche pinnata (formerly called Bryophyllum calycinum) the development of the propagules is through somatic embryogenesis where the globular, heart and torpedo stages can be recognized as they occur in zygotic embryos, however, González-Hernández [7] found that the plantlets produced in the leaf margins of K. daigremontiana are produced by two mechanisms: organogenic, in which the vascular tissue of the shoot is linked to the vascular strands of the leaf, and somatic embryogenesis where no vascular connections are present between the embryo and the mother leaf (Figure 1). Moreover, molecular studies suggest that both organogenesis and embryogenesis programs are involved in plantlet formation in the leaf notches of this species [8].

Out of all species that belong to the genus Kalanche the one that has been widely studied and used as a model plant is precisely K. daigremontiana mainly due to the high number of plantlets produced in the notches along the leaf margins as opposed to other species that produce few plantlets primarily at the leaf tip [5,8].

On the other hand, the most abundant auxin occurring in plants is indole-3-acetic acid (IAA) that is involved in a good number of physiological processes in growth and development such as embryo and fruit development, organogenesis, vascular tissue differentiation, root patterning, cell division and elongation and apical dominance [9]. There exist multiple pathways for plant and microbial IAA biosynthesis which have been discovered and elucidated by the use of modern biochemical, genetic and molecular techniques. These have demonstrated trypophan-dependent and trypophan independent paths for IAA biosynthesis. The trypophan-dependent routes have trypophan as a common initial trough different intermediates such as 3-indole-3-acetamide, tryptamine, 3-indole-3-acetaldoxime and 3-indole-3-

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been studied and showed similar results to those reported for \textit{B. juncea}. Similarly, the effect of the same compounds on \textit{K. daigremontiana} has been studied and showed similar results to those reported for \textit{B. juncea}. Furthermore, \textit{K. daigremontiana} is a good plant model in teaching the action of auxins and their inhibition on plant morphology (Figure 2).

As mentioned above, this hormone plays an important role in the life of a plant. Recently, its movement from the plant tip downward has been studied by many researchers mainly in the model plant \textit{Arabidopsis thaliana}. The polar auxin transport is an important mechanism that influences cell polarity, patterning of the embryo sac, apical development and general plant morphology, cell elongation and embryo development among many others [13-15]. There are several compounds that inhibit the polar auxin transport, among them, some of the most used in experiments for the study of the action of auxins are 9-hydroxyfluorene-9-carboxilic acid (HFCA) and 2,3,5-triiodobenzoic acid (TIBA). Liu, et al. [16] showed that auxin polar transport is essential for the establishment of bilateral symmetry in \textit{in vitro} cultured Indian mustard (\textit{Brassica juncea}) embryos with the use of TIBA and HFCA. Similarly, the effect of the same compounds on \textit{K. daigremontiana} has been studied and showed similar results to those reported for \textit{B. juncea}. Furthermore, \textit{K. daigremontiana} is a good plant model in teaching the action of auxins and their inhibition on plant morphology (Figure 2).

**References**


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