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Short Review

# A Brief Introduction to Adventitious Shoot Regeneration in Plants

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## Abstract

The establishment of plant adventitious shoot regeneration systems mainly has two intentions. On the one hand, an adventitious shoot regeneration system provides technology of the rapid reproduction of plants. On the other hand, they are basis of gene function research in plants. Adventitious shoots regeneration of plants is affected by internal signals and external conditions. There were many factors that affect regeneration, including plant growth regulators, the duration of dark culture, different genotypes, and basal medium components. This article mainly reviews the plant growth regulators, the duration of dark culture, and the reinvigoration phenomenon during the shoot regeneration process. These help us better understand and carry out research on adventitious bud regeneration systems in plants.

**Keywords:** Adventitious shoot regeneration; Dark culture; Plant growth regulators; Reinvigoration

## Introduction

Efficient and stable adventitious shoot regeneration systems are basis of gene transformation and gene edition in plants. Adventitious shoots regeneration of plants is affected by internal signals and external conditions. There were many factors that affect regeneration, including plant growth regulators, the duration of dark culture, different genotypes, basal medium components, and so on [1,2]. Among these factors, plant growth regulators, especially cytokinins, have an important role for on adventitious shoot regeneration in plants. Cytokinins are N6-substituted adenins with growth regulatory activity for plants that promote cell division and cell differentiation. Cytokinins, which were discovered during the 1950, play a central role during the cell cycle and influence numerous developmental programs. 6-Benzylaminopurine (BA) and Thidiazuron (TDZ) are the most frequently used cytokinins in plant adventitious regeneration. BA is a natural cytokinin and TDZ a synthetic phenylurea. TDZ was more effective than BA for adventitious shoot regeneration. Auxin plays an important role during the plant growth and development. It improved to produce adventitious root in plant tissue culture. Sometimes, combinations of cytokinins with auxin were effective for adventitious shoot regeneration [1-4].

The duration of light and darkness is an important factor in adventitious shoots regeneration. Light is a key stimulus for biological functions, gene expression, development, circadian clocks and many other activities in virtually every form of life. The duration of dark culture was a key factor for adventitious shoot regeneration in plants. Dark treatment during the initial period of culture affects shoot regeneration. Explants may undergo changes at the molecular and or cellular level during dark incubation, resulting in enhanced regeneration efficiency [5]. Degradation of auxins in culture medium occurs more rapidly under light conditions than under dark conditions. Incubation of explants in the dark may delay degradation of endogenous or exogenous PGRs, which trigger and direct plant regeneration *in vitro*. Explants kept in the dark showed an increase in the number of shoots regenerated per regenerating explant, compared with those that were not subjected to a dark treatment. It may be that some cells develop into differentiating cells in dark conditions [1,4].

The reinvigoration is an important phenomenon during the shoot regeneration process in plant species. Some plant species had no the reinvigoration. During the whole shoot regeneration process of some plant species, the explants kept green, invigorated, such as apple (*Malus hupehensis* var. *pinyiensis*), grape (*Vitis vinifera*) and commercial octoploid strawberry (*Fragaria* x *ananassa*). The leaf explants were green during regeneration. Normally, the explants showed elongation and enlargement after 1 week of culture. The shoot organogenesis from very small callus was formed from the cuts of explants after 2 weeks of culture. A large callus formed after 3 weeks of culture. Relatively small adventitious shoots and clustered shoots were observed after 4 weeks of culture. During whole shoot regeneration, the leaf explants remained green and invigorated, and adventitious shoots typically appeared after 4 weeks of culture [1,3,4].

Some plant species had the reinvigoration during the shoot regeneration process. The reinvigoration regenerating competence recovered in the nearly brownish explants and shoots were regenerated from long time culture. The reinvigoration may represent a selective process in which cells with low competence in response to the plant

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growth regulator treatment are killed, whereas a few competent cells from specific leaf tissue, potentially parenchymatic cells, start to divide and differentiate into new organs over time [6,7]. The reinvigoration also refers to the reversion of senescence and was used to describe the reversion of senescence that occurs when leaf explants are cultured in the regeneration medium. This senescence is a general response that occurs in all explants, and it is reflected by chlorosis of the explant prior to regeneration of the plant species. Normally, adventitious shoots regenerated more in browning leaf explants. The explants considerably enlarged after 2 weeks of culture. The explants turned greenish brown or yellowish brown after 4 or 5 weeks of culture. After 5 weeks of culture, produced a yellow-green callus and sporadically formed adventitious shoots around the wound edges. After 7 weeks of culture, the explants turned completely brown, but many shoots appeared. From 7 to 9 weeks of culture, adventitious shoots nearly doubled in number and elongated. After 9 weeks of culture, adventitious shoots were even more elongated. Therefore, the critical phenomenon occurred when there was reinvigoration of completely brown explants that resulted in shoot regeneration, which included 4 weeks for chlorotic leaf explants, 5 weeks for adventitious shoot appearance and 7 weeks for generation of several shoots [2]. Reinvigoration is critical for efficient shoot regeneration and lasts long time in some plant species.

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