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EFFECT OF AUXINS AND CYTOKININS FOR THE GROWTH OF KHEJRI

Dr. Nupur Prasad

Associate Professor

Dept. of Botany

Meerut College Meerut

ABSTRACT

Plant growth and development are intricately regulated by a complex network of internal and external factors, with plant hormones playing a central and pivotal role. Among these, auxins and cytokinins are two classes of hormones that work in a synergistic yet often antagonistic manner to control key developmental processes. In the context of Khejri (Prosopis cineraria), a remarkable and resilient tree species of arid and semi-arid regions, understanding the interplay of these hormones is crucial, particularly in the face of environmental challenges like drought. Auxins are primarily synthesized in the shoot apex and young leaves, where they promote cell elongation and apical dominance, which is the suppression of lateral bud growth. This leads to the characteristic upward growth of the main stem. In contrast, cytokinins are largely produced in the roots and are responsible for promoting cell division and stimulating the growth of lateral buds, thereby contributing to the bushy, branched appearance of a plant. The balance between these two hormones is critical for a plant's overall architecture. A high auxin-to-cytokinin ratio generally favors root formation, while a high cytokinin-to-auxin ratio promotes shoot proliferation. This relationship is a fundamental principle in plant tissue culture, where scientists manipulate the ratio of these hormones in a nutrient medium to induce the growth of either roots or shoots from a small piece of plant tissue (an explant).

Keywords:

Auxins, Cytokinins, Growth, Khejri

INTRODUCTION

The Khejri tree (Prosopis cineraria) is a resilient and culturally significant species native to arid and semi-arid regions of India and Western Asia. Its slow but steady growth, coupled with remarkable adaptations to harsh desert conditions, makes it a keystone species in these ecosystems. The tree's survival and growth are tied to its deep-rooted nature, which allows it to access subsoil water and nutrients that other plants cannot. (Castro, 2020)

The Khejri tree is a slow-growing, perennial species. Its growth above ground is deliberate, but it invests significantly in developing a deep and extensive root system. This deep taproot is its primary adaptation, enabling it to reach underground water sources and remain stable in sandy soils.

Propagation: Khejri primarily propagates through seed germination, but it can also regenerate from root suckers, especially after the main trunk is removed. The seeds have a hard coat, which can make natural regeneration difficult in dry climates. For cultivation, seedlings are often raised in nurseries and transplanted at the onset of the rainy season.

Young Khejri plants grow horizontally in a wide, circular, and flat bush. This unique "self-fencing" behavior protects the central, leading shot from being browsed by animals, allowing it to grow vertically and eventually form the main trunk. After a few years, the central shoot becomes a sapling and then a mature tree. A young tree can reach maturity in about 10-15 years, and its growth rate slows down after that. A mature Khejri tree can reach a height of 10-12 meters with a wide, spreading crown of similar diameter. The tree can live for hundreds of years under favorable conditions.

The Khejri tree is exceptionally well-suited to its environment. It can withstand extreme temperatures, ranging from less than 10°C in winter to over 45°C in summer. It's also highly drought-resistant, surviving in areas with as little as 100 mm of annual rainfall. Unlike many other deciduous trees, Khejri produces new leaves during the hot, dry season (March-June) when other plants are dormant, providing a vital source of fodder. (Wybouw, 2020)

The growth of the Khejri tree is crucial for the health and sustainability of desert ecosystems and the livelihoods of local communities. As a leguminous, nitrogen-fixing tree, Khejri

enriches the soil by enhancing its nitrogen content. This makes it an ideal component of agroforestry systems, where it supports the growth of crops like pearl millet and cluster beans planted around it. Its deep roots act as an effective soil binder, preventing erosion and helping to stabilize sandy soils, thus combating desertification. Khejri provides shade and a microclimate for other plants and a habitat for various animals, insects, and birds.

Its leaves, known as 'luk,' are a highly nutritious and palatable source of fodder for livestock, especially during the lean, dry season. A single mature tree can yield about 60 kg of dry fodder annually. (Nogalska, 2020)

The tree's unripe pods, called 'sangri,' are a significant source of income for farmers and are used to make a popular local dish. The mature pods, or 'kho-kha,' contain a sweet pulp and are also edible. The bark, leaves, and pods have medicinal properties and are used in traditional medicine to treat various ailments. The wood is used as a fuel source and for timber, prized for its durability and termite resistance.

The Khejri tree holds immense cultural and historical importance, particularly for the Bishnoi community in Rajasthan, who revere it. The most famous example of this reverence is the 1730 Khejarli massacre, where over 360 Bishnois, led by Amrita Devi, sacrificed their lives to protect the trees from being cut down by a local ruler. This event is considered one of the earliest instances of environmental protection and inspired movements like the Chipko Movement.

Despite its resilience, the Khejri tree faces threats from human activities such as excessive lopping, cutting for fuel and land clearing for new developments, and a decreasing underground water table. Conservation efforts, including promoting sustainable agroforestry practices and protecting ancient trees, are crucial to ensure the continued growth and survival of this "wonder tree of the desert. (Flasiński, 2022)

iterature Review

Synkova et al. (2020): The deep and extensive root system of the Khejri tree is a key adaptation to its arid environment. This is where auxins play a vital role. By promoting root initiation and development, auxins enable the plant to penetrate deep into the soil to access

subsoil water. This is especially important for Khejri, which can withstand extreme drought and grow in areas with very low rainfall.

Jakubowska et al. (2021): The presence of a well-developed root system is crucial for its survival and its ability to act as a soil binder, stabilizing sand dunes in desert ecosystems.

Menzel et al. (2022): Cytokinins, on the other hand, contribute to the above-ground growth and development of Khejri. They promote the growth of the canopy and lateral branching, which provides shade and a dense crown. In Khejri, which is highly valued for its leaves ("loong") and pods, the promotion of shoot and lateral bud growth by cytokinins is essential for maximizing its yield as a source of fodder and food.

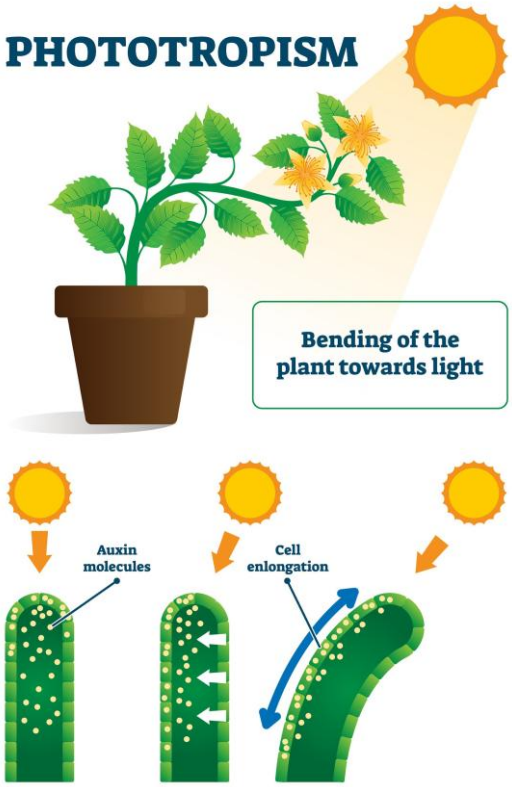
Leyser et al. (2021): The antagonistic relationship with auxins helps the tree balance its resources, ensuring both a strong root system for water acquisition and a healthy canopy for photosynthesis.

Czapla et al. (2021): Plants, much like animals, use chemical messengers called phytohormones or plant growth regulators to coordinate their growth, development, and responses to their environment. These hormones are effective in minute concentrations and regulate a wide range of processes, from cell division and elongation to flowering and senescence.

EFFECT OF Auxins and Cytokinins for the Growth of Khejri

Auxins are primarily known for their role in cell elongation, particularly in shoots. They are synthesized in the actively growing regions of the plant, such as the shoot apex and young leaves, and are transported unidirectionally downwards. This polar transport creates a concentration gradient that influences various developmental processes.

A classic function of auxin is its promotion of apical dominance. Auxin produced by the main shoot tip travels downwards, inhibiting the growth of lateral buds. This results in the plant growing taller with a dominant central stem. Removing the shoot tip (a process called decapitation), as is often done in horticulture, eliminates this source of auxin and allows the lateral buds to grow, leading to a bushier plant.



While auxins promote shoot elongation, they have the opposite effect on roots. Low concentrations of auxin stimulate root growth, making them essential for the initiation of adventitious roots on stem cuttings. However, high concentrations can inhibit root elongation. Among the most fundamental and extensively studied are auxins and cytokinins, which act as key regulators of plant architecture, often working in an elegant and complex interplay. Their dynamic balance and distribution within a plant determine the fate of cells and the overall form of the organism.

Auxin plays a critical role in directional growth in response to external stimuli. In phototropism, when light hits a plant from one side, auxin migrates to the shaded side of the stem, causing the cells on that side to elongate more rapidly. This differential growth bends the stem towards the light. In gravitropism (or geotropism), auxin accumulates on the lower side of a horizontally placed root, where its high concentration inhibits cell elongation, causing the root to curve downwards.

Cytokinins are a class of plant hormones that are essential for cell division (cytokinesis) and differentiation. They are primarily synthesized in the root tips and transported upwards

through the xylem to other parts of the plant. Cytokinins are the primary drivers of cell division. Their interaction with auxins is crucial in plant tissue culture, where the ratio of the two hormones dictates the developmental outcome. A high cytokinin-to-auxin ratio promotes the development of shoots, while a high auxin-to-cytokinin ratio induces root formation. If both are in equal concentrations, the cells form an undifferentiated mass of tissue called a callus.

Cytokinins act as an antagonist to auxin in apical dominance. While auxin inhibits lateral bud growth, cytokinins transported from the roots signal the lateral buds to sprout, promoting branching and a bushier appearance. Cytokinins are known for their ability to delay senescence, the aging and death of plant tissues. They achieve this by promoting nutrient mobilization and maintaining the integrity of chloroplasts and chlorophyll.

The relationship between auxins and cytokinins is a beautiful example of a yin-yang dynamic in plant biology. They don't simply act in isolation; their effects are often a result of their relative concentrations and interactions. The most prominent antagonistic relationship is seen in the regulation of apical dominance and the balance between shoot and root growth.

Auxin promotes root development and inhibits lateral shoots, whereas cytokinin promotes lateral shoots and inhibits root elongation. This countercurrent flow and opposing function create a fine-tuned system for controlling plant architecture. Despite their opposing roles, they also work together. Both hormones are required for sustained cell division in tissue culture. Auxin initiates the differentiation of vascular tissues (xylem and phloem), and cytokinins are also involved in this process. Their combined action ensures coordinated development.

In essence, auxins and cytokinins form a central regulatory loop that governs fundamental aspects of a plant's life cycle. Their intricate balance and precise signaling allow plants to respond to internal developmental cues and external environmental signals, shaping the plant body from the ground up and the top down. Understanding this hormonal dance is crucial for advancements in agriculture, horticulture, and plant biotechnology

The interaction between auxins and cytokinins is particularly significant in Khejri's ability to cope with drought stress. A common plant response to water limitation is to increase its root-to-shoot ratio. This is achieved by promoting root growth to enhance water uptake while simultaneously reducing shoot growth to minimize water loss through transpiration.

In many plant species, including Khejri, this adaptive response is mediated by changes in hormone levels: drought stress often leads to an increase in endogenous auxin levels and a decrease in cytokinin levels. This hormonal shift facilitates the development of a more extensive root system and limits shoot growth, which are crucial survival strategies in arid conditions.

CONCLUSION

The Khejri tree's ability to thrive in harsh, dry environments is a testament to the finely tuned regulation of its internal hormonal systems. The dynamic balance and feedback loop between auxins and cytokinins allow it to prioritize root growth to secure water resources, while still maintaining a productive canopy. This hormonal interplay is a key reason why Khejri is a "wonder tree of the desert," capable of sustaining itself and the surrounding ecosystem where other plants cannot.

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