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A review on potential role of auxins in plants, current applications and future directions

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Abstract

Auxin is a plant hormone that significantly plays important role in plant growth cell division and differentiation, in fruit development, in the formation of roots from cuttings and in leaf fall. Auxin has many important functions for plant growth. The main function of auxin is to help the plants grow. Auxin stimulates plant cells to elongate, and the apical meristem of a plant is one of the main places that auxin is produced. It promotes the stem elongation, inhibit growth of lateral buds maintains apical dominance. Auxin is produced in different parts of plants such as the stem, buds, and root tips in the form of chemical compounds such as indole acetic acid that significantly increases the growth of plants. Auxin as a plant hormone produced in the stem tip that promotes cell elongation. Auxin moves to the darker side of the plant, causing the cells there to grow larger than corresponding cells on the lighter side of the plant. Auxin biosynthesis plays essential roles in many developmental processes including gametogenesis, embryogenesis, seedling growth, vascular patterning, and flower development. The aims of this review is the potential roles of auxins in plants such as roles in root development, functions in the growth of leaves structures and lastly the formation of flowers by increases auxins have been studied in this review. The functions of auxins in plants have not completely studied.

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Introduction

Use of compounds relevant to auxins source on top of the stigmas of tomato and numerous other species causes the ovary to mature into the natural or artificially induced production of fruit without fertilization of ovules (Mapelli *et al.*, 1978). The use of pollen extracts to the external part of the ovary indicated same results, which led to the theory that pollen grains comprise plant hormones similar to the plant growth substance auxin. After fertilization, the pollen may pass enough amount of these plant growth substances to the ovary to initiate growth of fruit (Wang *et al.*, 2018).

Now subsequently, gibberellic acid like plant growth substances were recognized in diverse flowering plants families, thus assuming that these plant growth substances are also involved in the programme of fruit development. It was recognized that concentrations of auxin in the flowers with a traditional bioassay were cut and put on agar blocks. Consequently, the content of auxin in these blocks was evaluated by the standard *Avena* geo-curvature test. No auxin was present at the stage of anthesis. On the other hand, concentration of auxin improved within twenty eight after gibberellic acid treatment, proposing that it is not auxin, but gibberellic acid that is passed on from the germinating pollen to the ovary. Consequently, the gibberellic acid may induce a rise of the content of auxin in the ovary to stages sufficient to activate growth of fruit (Jong *et al.*, 2009).

In spermatophytes, the principal body axes of plants are patterned both during all the life cycle and early in development of embryo. The embryonic development causes the axis of apical-basal, the radial axis, the embryonic leaf and the meristems of primary plumule and radicle. During period of development after embryogenesis, these meristems produce plant lateral organs along the primary growth and create the progress zone. By comparing with animals, plants are thus able to develop morphemes during the whole lifespan. These modular morphological elements can also differ in form in reaction to adaptable environmental signals. Phenotypic plasticity in plant growth influence consequently restrain evolution in a very diverse way from animals inasmuch as the ultimate shape of the entire plant is not so channeled. In flowering plants, all these chiefmodelling events involve the auxin containing plant growth substances. Furthermore, auxin facilitates growth of plant in reaction to environmental signals. Therefore, the evolution of auxin homeostasis and response systems is supposed to show a main part in the evolution of land plant structural design (Cooke *et al.*, 2004).

The aims of this review is the potential roles of auxins in plants such as roles in root development, functions in the growth of leaves structures, response of auxins in biotic stress in plants, role of auxins transcriptional level in plants, the formation of flowers by increases auxins have been discussed in this review. The functions of auxins in plants have not completely studied.

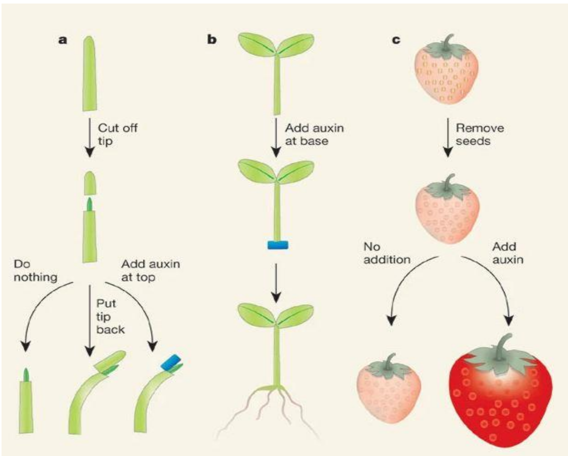

Fig. 1. Various functions of auxins for plant growth.

Auxin is Essential for the Flowers Formation

Auxin has long been assumed as an important controller for development of flower, but the precise auxin role in development of flower was not well clear in recent times. A connection between auxin and development of flower was first recognized when the mutant of auxin transport pin1 was isolated and categorized (Gallavotti *et al.*, 2013).

Themutantpin1showed pleiotropic deficiencies during the course of practically all phases of development, however the most outstanding phenotype is that the inflorescence of pin1 regularly does not have any flowers proposing that auxin shows a vital part in originating flower primordia (Li *et al*., 2019).

Our understanding of how auxin biosynthesis and degradation are regulated in the root system under normal and different stress conditions is still very limited, but it is clear that auxin homeostasis has a major impact on root architecture. Many genes believed to be involved in auxin biosynthesis are strongly expressed in the root apical meristem, where there is a high rate of IAA biosynthesis. Furthermore, local auxin biosynthesis combined with polar auxin transport is involved in forming the auxin gradient within the root apex. Auxin signaling is key to many plant growth and developmental processes from embryogenesis to senescence. Most, if not all, of these processes are initiated and/or mediated through auxin-regulated gene expression. Pin1translates a protein of transmembrane that has recently been revealed to localize with polarity in cells and to contribute in auxin efflux (Cheng *et al*., 2007).

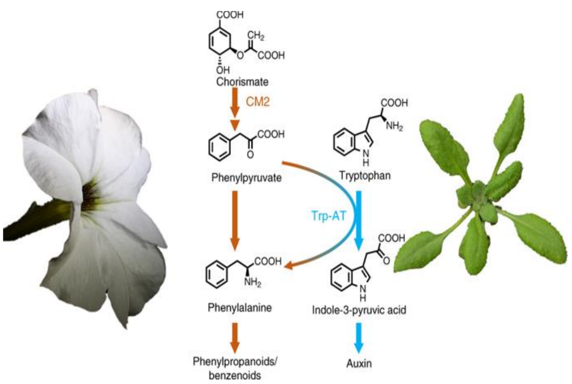

Fig. 2. Role of Auxins in the formation of flowers.

Role of Indole-3-acetic acid in Floral Organ Patterning

Indole-3-acetic acid not only regulates whether flower primordia are formed, it also shows a crucial part in identifying floral organs and is responsible for the developmental process within a floral organ. Numerous Arabidopsis mutants were initially isolated from mutagenesis screen for mutants with abnormal flowers, but later found to be involved in aspects of indole-3-acetic acid pathways (Pfluger *et al*., 2004). Wild-type of flowers of Arabidopsis generally have six stamens, four sepals, two fused carpels and four petals.

Alongside the orientation of apical/basal axis, wild-type female part of flower can be categorized into three sections with well-known structures: a basal ovary, a style and an apical stigma (Damodharan *et al*., 2016).

The allelic alterations affect the growth of all four kinds of floral organs, but the maximum intense deficiency is in female part of flower patterning. Alterations in the gene ETTIN intensely affect female part of flower with decrease in the size of ovary and improper position of style of flower and stigma (Van *et al*., 2012).

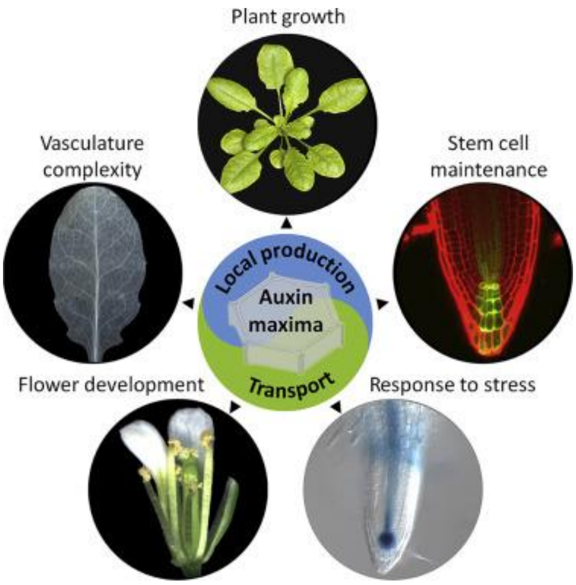

Fig. 3. Role of Auxins in the formation different parts of flower.

The chief driver of body plan multiformity is signified by the activity and formation leaf primordia of axillary buds, processes that as defined above are extremely linked to biology of auxin. Biosynthesis, signaling and transport of auxin are all essential for initiation of axillary meristem, as established by diverse defective mutants in these pathways in numerous species, i.e. *mp, yuc* and *pin1* in *Arabidopsis*, and *bif2, spi1* in *Zea mays*, which fail to form new tissues (Den Herder *et al*., 2010).

While leaf primordia of axillary buds outgrowth has greater consideration in the previous few years with the findings of the complex interaction among cytokinins, auxin and strigolactones quiet relatively little is well-known about how auxin stimulates the formation of new leaf primordia of axillary buds, although the huge number of categorized mutants that are affected in their initiation (Tsunoda and van Dam, 2017). Leaf primordia of axillary buds initiation can thus work as a model example to study how pathways of auxin interrelated among themselves and with other pathway of developmental process (Waite *et al.*, 2020).

Role of auxin-responsive genes in responding to biotic stress

At molecular level to recognize the potential role of auxin in plant defense responses, the auxin-responsive genes expression was examined under numerous biotic stress circumstances in *Oryza sativa* . Patterns of differential auxin accumulation within a field of cells determine spatial and temporal patterns of auxin-dependent developmental reprogramming. Nonetheless, in the end, the decision on the type of developmental output lies in the interpretation of these auxin accumulations at the level of the individual cell. Despite the diversity of cellular responses evoked by auxin, most of the effects of auxin come down to one relatively simple pathway that directly impinges on transcriptional regulation. In essence, it is the interplay between two classes of transcriptional regulators that represents the core of auxin signaling (Xu *et al.*, 2018).

The DNA microarray data for *Oryza sativa* seedlings infected with *Magnaporthegrisea*, a sac fungi, and *Strigahermonthica*, an obligate root hemiparasite, available at gene expression data and hybridization arrays, chips, microarrays database under series variety numbers GSE10373 and GSE7256, individually, was used for this examination. Under GSE7256 series based on microarray data for two-week old seedlings of *Oryza sativa* variety Nipponbare cultivar treated with haemacytometer of *Magnaporthegrisea* genes for pathogenicity and virulence starin FR13 in gelatin alone and contains 8 hybridizations signifying two biologically distinct samples of infected and mock samples for two time phases (3 and 4 dpi) (Emenecker *et al.*, 2020).

The series GSE10373 based on microarray data of root tissues from three-week old seedlings of two *Oryza sativa* varieties IAC165 (susceptible) and Nipponbare cultivar (resistant) treated with *Striga hermonthica* and contains of twenty-four hybridizations representing two biologically distinct samples of infected and mock samples for three time phases (Meng *et al.*, 2019).

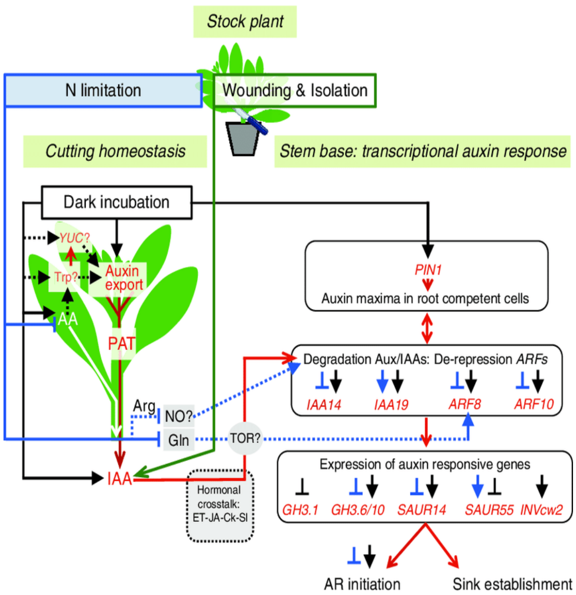

Fig. 4. Transcriptional Roles of auxins in plants.

Roles of auxins in different biotic interactions affecting the root systems

Plant–microorganism associations have gotten increasingly more consideration because of the advantages they present to edit efficiency by improving supplement take-up, expanding plant development and giving biotic and abiotic stress.

Recognizing correspondence frameworks and signs that decide the valuable or impeding results of plant–microorganism collaborations is a key to improve guard reactions without diminishing gainful (e.g., harmonious) affiliations (Du and Scheres *et al.*, 2018).

Auxin influx carriers stabilize phyllotactic patterning

One of the most prominent characteristics of architecture of plant is the symmetrical alignment of leaves and flowers around the stem. Peaks in concentration of the indole-3-acetic acid, created by the polar localization of the efflux of PIN1 auxin carrier, gives an instructive signal for initiation of primordium. This tool makes the spacing among adjacent primordia, that results in symmetrical alignment of leaves and flowers around the stem (Lee *et al*., 2015).

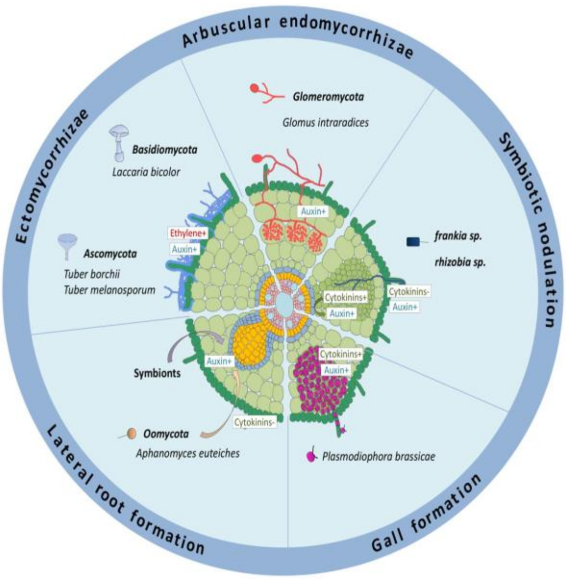

Fig. 5. Roles of auxins in different biotic interactions affecting the root systems.

Analysis of the role of indole-3-acetic acid transport in phyllo tactic arrangement have focused on efflux of PIN1 auxin carrier. Current computer models specify an additional role for indole-3-acetic acid transport uptake. Alterations in the influx of AUX1 auxin carrier have not, on the other hand, been described to cause an aerial phenotype. At this time, we studied the role of AUX1 and its gene copies LAX1, LAX2, and LAX3. Study of the four mutant tells asymmetrical deviation angles among succeeding primordia. An extremely rare feature of the phenotype is the existence of groups of primordia, in violation of traditional theory (Bainbridge *et al*., 2008).

At the molecular level, the well-defined sharp peaks in level of auxin and corresponding PIN polarization are lost. In adding, the augmented penetrance of the phenotype under short-day circumstances recommends that the AUX LAX transporters act to buffer the PIN-mediated model mechanism in contrast to environmental or developmental influences (Julien *et al*., 2019).

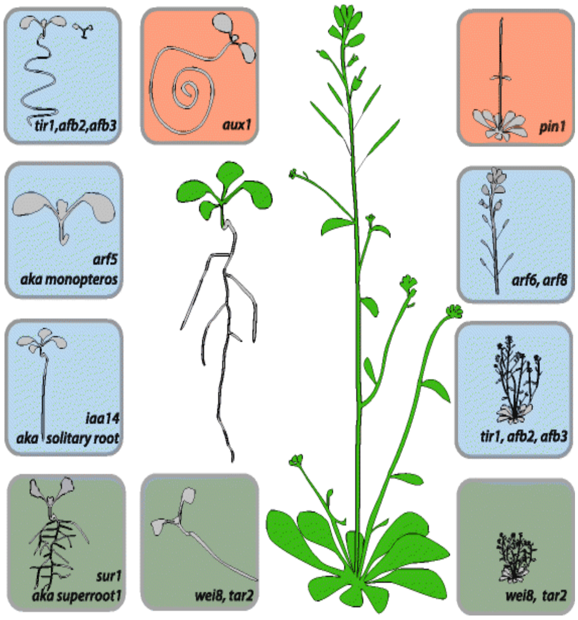

Fig. 6. Roles of auxins influx carriers stabilize phyllotactic patterning.

Conclusion

Several key auxin biosynthetic genes and their roles in plant development have been discovered. It is clear that auxin biosynthesis takes place locally in response to both environmental and developmental signals. *De novo* auxin biosynthesis plays an essential role in many developmental processes. The power of auxin in plants is clearly wide and deep. To understand it, we need to find the missing component parts of the auxin machinery. During the last ten years, our understanding of auxin metabolism and its role during plant growth and development has greatly improved. The great challenge will be to integrate knowledge about auxin metabolism into the regulatory networks that act on different developmental processes operating in plants, and to understand how these processes work in different plant species under normal and stress conditions.

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