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Review Article

Potential Regulators in Plants for Controlling Seed Germination, Development and Role in Seed Dormancy

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Abstract

Plant hormones are signaling molecules that needed for the growth of plants at optimum concentration to govern all the mechanisms of plants development and growth, embryogenesis, organ size regulation, defense from pathogens, tolerance to different stresses and also the reproductive development. The light-inhibition that aggravates the elongation of hypocotyl is controlled by red or far-red light receptor phytohormones that comprising the gibberellins, brassinosteroids, cytokinins, auxin, abscisic acid and ethylene. The level of cytokinin, auxin and GA increased at the fruit-set and constraint of their high level at fruit-set already been noted by their exogenous applications, and which causes the formation of parthenocarpic in tomato. In *Arabidopsis*, efficient induced germination of dormant seed needs cold-treatment and light activation of photo-chrome system. Germination of seed is plant first and adaptive choice in development and improvements in molecular physiology and genetics have revealed factors which controls the germination of seed. To improve photo-morphogenesis in the seedlings *of Arabidopsis*, PIF1 is regulated by light facilitated deprivation through the ubiquitin 26-S proteasome passageway. The germination of seed is important stage in the life cycle of plant and the decision made by an imbibing seed to initiate germination can be considered to be a critical regulatory step in plant development.

Keywords: Plant hormones, gene expression, Auxins, Gibberellins, Ethylene, Seed Germination.

INTRODUCTION

Phytohormones or plant hormones are signaling molecules, which are formed within the plants in very low concentration [1]. These hormones of plants govern all the mechanisms of plants development and growth, embryogenesis, organ size regulation, defense from pathogens, tolerance to different stresses and also the reproductive development [2-4]. In animals (For the production of hormones is limited to only specific glands) but in plants each cell has capability to produce hormones. Phytohormones are even present in algae, having the same functions as in the higher plants. Some of the phytohormones are also present in the microorganisms like unicellular fungi and in bacteria, there they play role as secondary metabolites instead of hormonal activity [5].

For proper growth plants need oxygen, light, minerals, water and many other nutrients for their development and growth. Apart from external requirements, plants also depend on certain organic compounds to signal, regulate and control the growth of plants. These are collectively called as Plant Growth Regulators or Plant Growth Hormones [6].

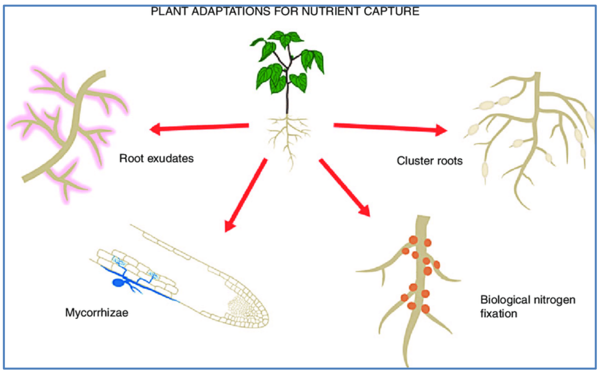

Fig-1: Shows different biological nutrients parameters and their interaction with plant hormones

Role of Different Plant Growth Regulators

Auxins are the most important hormones of plants. The naturally occurring main auxin is IAA (indole-3-acetic acid). The word auxin is derived from Greek meaning "to grow". Auxins are the important plant growth regulators and are produced on the points of roots and stems and are transported to other plant parts [6-8]. These hormones of plants includes both the synthetic and natural bases. Indole butyric acid and indole-3-acetic acid are formed by the plants and are not present synthetically, while 2, 4-dichlorophenoxyacetic acid and naphthalene acetic acid can be produced synthetically. ABA (abscisic acid) is the most important growth inhibitor of plants. ABA was researched and discovered under two names "abscicin II", and "dormin" afore its biochemical properties were completely identified. It was discovered that the two compounds are same, and was named as abscisic acid. The name abscisic acid was given because it was found that it is present in higher concentration in freshly abscised or newly dropped leaves [9-11].

The development and the growth of plants is controlled by instantaneously ascertaining and reacting to both of the internal and external signals. The one well known example is elongation of hypocotyl of the young saplings. The light-inhibition that aggravates the elongation of hypocotyl is controlled by red or far-red light receptor phytohormones and phytochromes, comprising gibberellins, brassinosteroids, cytokinins, auxin, abscisic acid and ethylene [12]. Phytohormones and phytochromes act together and control the growth. Many of the genetic investigations proposed that light directly affect cellular level of phytohormones and the signal-transduction of majority of phytohormones also distress photo-receptor signal-transduction. Signal-transduction includes the conversion and transmission of intra-cellular to extra-cellular signals in to cellular responses and where light play key role and can control the growth of plant. Phytochromes, the important sensors in the plant, belongs to photoreceptors gene family [13].

Role in Seed Germination and Cell Signaling

Though light stimulate the production the photosynthate, it reduces the elongation of hypocotyl once the photoreceptors are stimulated, especially the red light and blue light capturing photoreceptors are called crys(cryptochromes) and phys(phytochromes), correspondingly. Many investigations have been led on the photoreceptors functioning revealing variable dimerization and phytochrome binding features and lately focused on phytochromes and phytochrome interacting factors (PIFs) that have been revealed to regulate the distinct photo-morphogenesis function, comprising germination of seed. For example, it was found that the PIF6 control the germination of seed, while the PIF3, PIF4 and PIF5 control the elongation of hypocotyl. The PIF1 can control the both elongation of hypocotyl and germination of seed. Likewise, adding the green-light to the blue-light partly subdued blue-light inhibition of elongation of hypocotyl. In the mutant plants called the PIFq mutant, which lacks the functions of PIF1, PIF3, PIF4, and PIF5, even when grownup in the full darkness, display phenocopy transcriptional and the morphological reactions of light grown plants [14-17].

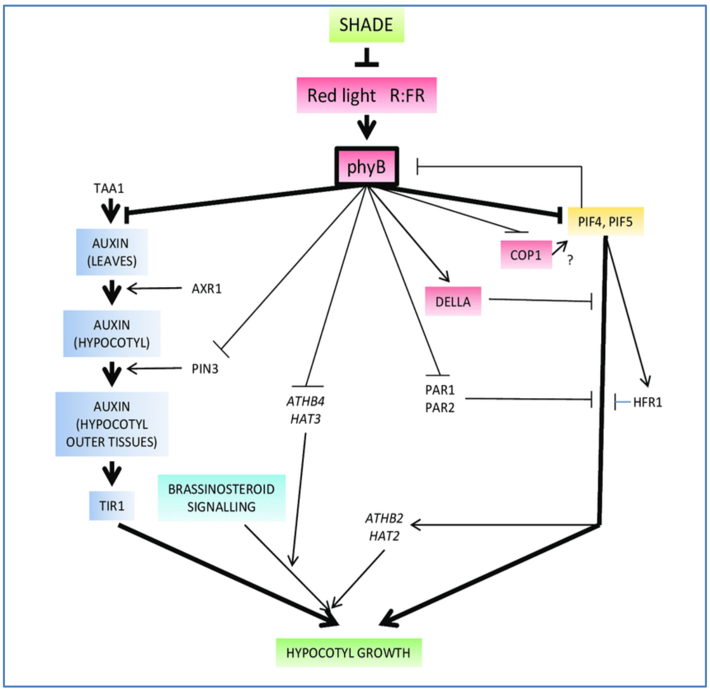

Fig-2: Shows the activation of different genes in plant under plant growth hormones

Germination of seed is plant 1st adaptive choice in development and improvements in molecular physiology and genetics have revealed factors which controls the germination of seed. In Arabidopsis, efficient induced germination of dormant seed needs cold-treatment and light activation of photo-chrome system. When act synergistically, cold temperatures and light endorse the seed germination, a reaction controlled by the SPATULA factor that is the light stable. Seed germination in light or dark is subdued by bHLH factor SPATULA and PIF1. To improve photo-morphogenesis in the seedlings of Arabidopsis, PIF1 is regulated by light facilitated deprivation through the ubiquitin 26-S proteasome passageway [18].

PIF3 and PIL5 have diverse effects on the genes of gibberellin. PIL5 inhibit the germination of seed in Arabidopsis thaliana. Moreover, PIF1 stimulates the abscisic acid biosynthetic genes but suppresses an abscisic acid catabolic gene and leads to increased abscisic acid level without binding to the gibberellin and abscisic acid metabolic gene promoters but connected direct to GAI (GA-INTENSIVE) and RGA (REPRESSOR OF GA) promoters. In the germination of seed, biosynthesis of gibberellin is linked with the nitrate level which is coped by the embryonic abscisic acid [19].

In an investigation associating ChIP-chip analyses and microarray of PIF1 during the germination of seed, PIF1 facilitated 166 genes by the direct adhering to promoters. In short, PIF1 inhibit the germination of seed by harmonizing the hormone signal and regulating the properties of cell wall in drunk seed and by the biosynthesis of both ABA and GA [20].

The results of higher resolution temporal investigation in the germination of seed, study involving the sucrose propose that photo-morphogenetic signals system can altered due to the availability of carbon. Sucrose extended the days and plants experienced fast elongation of hypocotyl causing notable increase in final seedlings height and change the time of daily growing limits and showing additional plastic diel growing dynamic[21].

Cytokinin and ethylene are showing response the receptors sharing the resemblance to bacterial 2-component controllers. In prokaryotes are common, but actually limited to plant and fungi in the eukaryotes, these integrated signals systems include a membranous receptor comprising an intra-cellular HK (histidine kinase) domain. Ligand connectivity triggers the kinase, and cause auto-phosphorylation and launch of a chain of phosphotransferase reactions which terminates with initiation of a regulator protein response which work as effector constituent of pathway. Signaling of cytokinin seems to mainly following this model. Response of ethylene, though, looks more complex [22-25].

The ethylene is professed by the family of 5 receptors. ERS1 and ETR1 hold a consensus HK-domain, on the other hand, the HK-domains of ERS2, ETR2 and the EIN4 are perverted and lack the elements which are essential for the catalytic activity. This point, and together with investigations of "kinase dead" mutant of ETR1, proposes that the activity of HK is not obligatory for response of ethylene. Mutations which eliminate binding of ethylene in any of the 5 receptors genes confer the insensitivity of ethylene, representing that function of receptors as negative controllers of ethylene pathway [26].

Fruit setting is the first step of the development of fruit. In angiosperms, fruit sets by the completion of proper pollination and double fertilization process where one pollen nuclei fuses with egg cell and the other fertilized with the two polar nuclei (n) in central cell. All these processes then developed seed which finally regulate the division of cell and growth of fruit in harmonized manners. Present indication supports that the mutual action of the three hormones, cytokinin, auxin and the gibberellins play a vital role in regulation of the fruit setting. Independently, any of the hormones can only start development of fruit in a certain level; but, the combined activity of these hormones induces the normal growth of fruit even in absence of fertilization in both fleshy and dry fruits. Significantly, the level of cytokinin, auxin and GA increased at the fruit-set and constraint of their high level at fruit-set already been noted by their exogenous applications, and which causes the formation of parthenocarpic in tomato. Indications suggest that the GAs and the auxin act in same way during the fruit setting in the dry fruits. A fertilization prompted auxins signal is used in elevation of gibberellin biosynthesis in ovule that in turn triggers gibberellin signaling in the ovules and manages growth of silique in Arabidopsis thaliana. Moreover, it is noticed that collaboration between the gibberellin (GA) and auxin signaling pathways is necessary for upgradation of fruit-set in the chubby fruit [27-30].

Development of fruit and seed are closely related and coordinated procedures. But the present studies revealed that seeds are the enriched with the hormones, mainly cytokinin, gibberellin, and auxins, that are involved in the growth stimulation of neighboring tissues and also determine the size of fruit. It has been noted that the cytokinin and auxin level increases in seed during development, concomitant with fruit growth stages where cell division is followed by a cell-expansion phase of seed. Seed elimination has been found to cause the reduction of gibberellin biosynthesis in pea pericarp. The planned study reveals that the two hormones regulate the conversion of the GA_{19} in to GA_{20} in pericarp of pea partially by controlling the transcription level of GA oxidase gene [31].

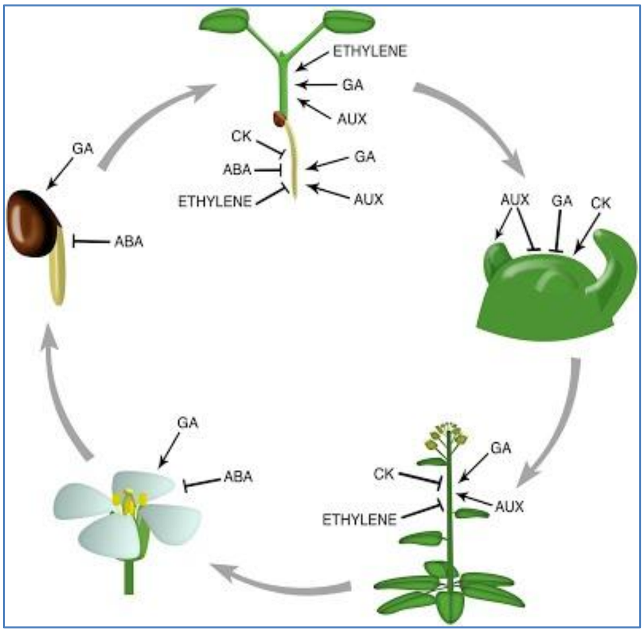

Fig-3: Shows the role of different plant hormones their influence on plant growth

Sexual promulgation includes the combination of pollens from male flower part with egg of female ovary to form grain. Seed can be recalcitrant, inter mediator orthodox seed. The orthodox seed durability is increased under varied environment circumstances by decreasing the storage temperature and water content of seed without damaging the metabolism of seed. The seeds of orthodox are, hence, considered as dryness tolerant seeds. Recalcitrant grains, conversely, reduction in viability when the content of water reduced under a comparatively higher value. The grain/seed is composed of three main parts: outer covering the seed coat that guards the seed; the inner endosperm that is food reserve; and embryo, that is young plant itself [32].

CONCLUSION

Different genes are involved in controlling the different patterns of expression at cellular and molecular level. A mature seed when placed in favorable environment, it begins to germinate. The germination of seed is important stage in the life cycle of plant and the decision made by an imbibing seed to initiate germination can be considered to be a critical regulatory step in plant development.

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