iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 Issue: III Month of publication: March 2016

DOI:

Volume 4 Issue III, March 2016
ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Plant Growth Hormones - The Key Players In The Process Of Seed Germination

Ameeta Sharma[1], Nikita Jain [2]
[1,2]Department of Biotechnology, The IIS University, Jaipur, Rajasthan, India.

Abstract: Plant growth hormones along with numeral factors are the key players in the process of seed germination and seedling growth. They are produced by both plants and soil bacteria. They are defined as organic compounds other than nutrients, that affects the physiological processes of growth and development in plants when applied in low concentrations. Plant hormones and plant gene interactions also affect seed germination. Hormones activity of plants is controlled by expression of genes at different levels as plant genes are activated in the presence of specific plant hormones. So, seed germination can be enhanced be adjusting gene expression at different levels. The process of seed germination and the establishment of the seedling, the role of soil bacteria are quite significant for the production of plant hormones. The chief important plant hormones which influence germination process are abscisic acid, ethylene, gibberellins, auxin and cytokinins. They are biochemical substances which reins numerous bio-chemical and physiological processes in the plant.
Key words: Plant growth hormones, Seed germination, Radicle, Plumule, Seedling growth

I. INTRODUCTION

Since the beginning of the nineteenth century, studies have demonstrated the role of “substances” produced in small quantities that move from one part of the plant to another and regulate plant’s growth process. These substances are tiny molecules, present in very stumpy concentrations and are derivative of various essential metabolic pathways. Generally these compounds act locally at the site of their synthesis, nearby or at far-flung sites. The pantheon of plant hormones includes but is not limited to indole-3-acetic acid or auxin, abscisic acid, brassinosteroids, cytokinins, ethylene, jasmonic acid, salicylic acid gibberellic acid. Different aspects of plant life, like initially from pattern formation during development to plants response to abiotic and biotic stresses are under the influence of growth hormones. The biosynthetic pathways for most of the hormones are either well characterized as in the case of ABA, BR and GA or emerging. What we are learning is that hormone levels are highly regulated and responsive to a changing environment. In the case of auxin, local and long-distance transport of the hormone has an essential role in many aspects of plant growth and development, whereas transport of volatile compounds such as ethylene and methyl jasmonate is important for plant defense. Plant growth regulators or phytohormones are organic substances produced naturally in higher plants, scheming growth or additional physiological functions at a position distant from its place of manufacture and becomes active in tiny quantity. Phytohormones include auxins, GA, cytokinins, growth retardants, growth inhibitors and ethylene. Auxins are the first discovered hormones in plants and then later on, gibberellins and cytokinins were discovered. Ethylene which is gaseous in nature exerts a physiological outcome just close to site where it is produced. Seed germination is controlled by numeral mechanisms and is quite necessary for the seed and plant growth as well as development of the embryo, eventually producing a new plant. Plant hormones possess the important function of controlling and coordinating cell division, growth and differentiation in plants. And many physiological and bio-chemical processes in the plant are controlled by plant hormones like abscisic acid (ABA), ethylene, gibberellins, auxin (IAA), cytokinins, and brassinosteroids, which are biochemical substances for controlling the different activities in plants. The set of genes is indicated by the whole-genome analyses, which are related to development, hormonal activity and environmental conditions in *Arabidopsis*. Interestingly, Bassel, *et al.*, (2011) indicated the distribution of genes in different regions of a seed related to the following processes like germination, dormancy, ripening, ABA and gibberellins activities, drought stress and others.

The interaction between diverse signals, decide the seed dormancy or germination such as, the those signals, which endorse seed germination by inhibiting signals, which results in seed dormancy. Bassel, *et al.*, (2011) indicated that interactions may affect seed which in turn may result in transfer of seed state from dormant to active. In accord to Liu, *et al.*, (2013) whenever a dormant seed germinates, as a consequence hormonal and signaling activities are likely to happen. The features, affinity and cytosolic Ca^{2+} affects the behavior of plant hormones for example, they can influence stomatal activities through affecting the K^{+}channel (Weyers and Paterson, 2001).

II. INDOLE- 3 ACETIC ACID (IAA)

The plant hormone IAA is commonly known as auxin, which helps in doing various functions like cell-cycle, plant growth and development, vascular tissues formation like xylem and phloem which in turn aids in transportation of essential products for plants (Davies, 1995) and pollen grains (Ni, *et al*., 2002), and maturity of other plant parts viz. stem, roots, seeds etc. (He, *et al.,* 2000). The development of different plant parts, including the embryo, leaf and root is controlled by auxin transport (Liu, *et al*., 1993). Synthetic auxins like 2,4- dichlorophenoxyacetic acid have their application as herbicides too, infact it has a role in every aspect of plant's growth and development, and defense mechanism. It has diverse functions in transport and signaling pathways. IAA is usually synthesized via at least two pathways from tryptophan which are the indole-3-pyruvic acid (IPA) pathways (Strader and Bartel., 2008) and tryptamine (TAM) and then in turn auxin is distributed throughout the plant by a highly well framed cell transport system (Vieten, *et al.,* 2007). The local auxin maxima (which is established by asymmetric localization of transport proteins in a cell) and gradients are created by efflux and influx system of auxins that directs the diverse growth and developmental processes for example, at the site of organ primordium formation, the local accumulation of auxin is responsible for initiation of leaves on the flank of the shoot apices. Hence the auxin transport direction and its cellular position which is usually in highly dynamic and quick to respond to both environmental and developmental signals are important aspects. Because of all the importance of above discussed processes in plant development, this is an exciting area of investigation. There is evidence for both genomic auxin responses and transcription regulated and effected by auxins (Badescu, and Napier, 2006). Auxin regulates the transcription process via two large families of transcription factors called the indole-3-acetic acid proteins and the Auxin Response factors (ARFs) which directly bind to DNA resulting in activating or inhibiting transcription.

The auxin regulated gene's activity is determined by the related proteins, their affinity and stability and the post transcriptional regulations. IAA helps in for the growth of young seedlings as well (Bialek, *et al.,* 1992). The collected IAA in the seed cotyledon is the chief resource of IAA for the seedlings. In legumes, the major source of IAA in mature seeds is amide products. Seed germination can be influenced by auxin reaction, when ABA is present (Brady, *et al.*, 2003). IAA has an effect on seed germination by changing the activity of enzymes, for example in germinating pea seeds, the activity of enzyme glyoxalase I was regulated by IAA, resulting in cell growth and development (Thornalley, 1990).

Notably, the auxins are short-lived and they degrade by ubiquitin-proteasome pathway (Mockaitis and Estelle, 2008). This is a sealed proteolytic pathway in which tagging with the tiny protein modifier ubiquitin occurs to proteins destined for degradation, which in turn are recognized by the proteasome and degraded.

III. ABSCISIC ACID (ABA)

Another important growth regulator is ABA which is an isoprenoid compound playing an important role in seed dormancy process, stress responses like drought and other growth and development processes. The ABA biosynthetic pathway was defined through genetic studies of mutants with seed dormancy defects, primarily in maize and *Arabidopsis* were the plant in which the ABA biosynthetic pathway was defined using genetics tools on seed mutants and almost all of the genes in the pathway now have been identified (Nambara and Marion, 2005). Fluctuations in environmental conditions also are important in regulating ABA levels in plants during seed maturation and in drought conditions. As In both processes, change occurs in biosynthesis and catabolism which in turn regulates ABA concentration. ABA not only influences the stomatal and plant activities but also affects seed dormancy under abiotic and biotic stress (Moore, 1989) in turn affecting the process of seed germination. In *Arabidopsis thaliana* plants, Seed germination can be repressed by 1–10 M concentration (Kucera, *et al*., 2005). Phosphatase regulators can also operate on ABA receptors (Ma, *et al.,* 2009).

There are diverse functions of ABA in the process of seed germination for example delaying the radicle growth and failing of endosperm, as well as the enhanced phrase of transcript factors, all them are inhibitory functions which may have adverse effect on the process of seed germination (Graeber, *et al.*, 2010). The G protein coupled receptor 2 also functions as one of the ABA receptor, arbitrating miscellaneous activities of ABA, including its unique effects on seed germination (Liu, *et al*., 2007b). Signal transduction pathways of ABA are intricate and in turn involves variety of proteins like two protein viz. phosphatase 2C proteins known as ABI1 and ABI2 and tiny molecules, variety of kinases, RNA-modifying enzymes and transcription factors functions in ABA signaling (Hirayama and Shinozaki, 2007; Finkelstein, *et al.,* 2008).

IV. CYTOKININS

The Cytokinins are derived from side chain at N6 position from the adenine molecules, first discovered by Carlos Miller, in the 1950s which was based on their capability to develop plant cell cycling (Miller, *et al.,* 1955). Cytokinins help in wide range of plant activities along with seed germination. The behavior of meristemic cells in roots and shoots, and in process of leaf senescence, nodule formation throughout establishment of the N2-fixing symbiosis as well as other relations between plant and microbes are influenced and enhanced by cytokinins, in (Murray, *et al*., 2007). Stresses such as salinity, drought and heavy metals are well managed by cytokinins during seed germination (Khan and Ungar, 1997). The enzymes like cytokinin oxidase and dehydrogenase have an effect on the action of cytokinins by deactivating them by (Galuszka, *et al*., 2001) catalyzing cleaving reaction of their unsaturated bonds. Miscellaneous activities of cytokinins, just like their effects on parameters of seed germination, have been ascribed to the cytokinins in special cell types (Werner, *et al*., 2001). Plants like *Arabidopsis thaliana* has got three distinct histidine kinases that can ensue as receptors for cytokinins (Inoue, *et al*., 2001). Regulating and controlling seed and embryo size, endosperm development and seed coat growth, are amid the functions of cytokinins (Mansfield and Bowman, 1993). The obtainable carbon source for seed utilization is one of the chief factor with respect to the number of seeds (Riefler, *et al*., 2006)

V. GIBBERELLINS

The gibberellins are a huge family of diterpenoid and tetracyclic growth regulators which have a very interesting function in contemporary agriculture. It was isolated as a metabolite in year 1938 from the rice fungal pathogen *Gibberella fujikuroi* (Yamaguchi, 2008). Infection of rice crop when infected by this fungus resulted in extreme stem elongation, eventually causing the plant to become sensitive to lodging. Later in 1970s, introduction of new dwarf varieties were associated with the “Green revolution”. Gibberellins are responsible for. Like the other phytohormones, GA play a major role in regulating plant growth and growth processes like seed development, organ elongation and the control of flowering time(Yamaguchi, 2008). Gibberellins are synthesized from a multi-enzyme pathway having a multifaceted regulation. Further, other hormones like ethylene and auxins also influence GA levels. DELLA proteins are negative regulators of GA response and they are named so as they have conserved N-terminal DELLA domain and moreover contain a C- terminal GRAS domain (Schwechheimer, 2008)

Gibberellin induces variety of genes, which are essential for the protein production. This plant hormone is required for seed germination which is stimulated by the Signaling pathways of hormone during the end of coat dormancy. The interesting mechanism, which gearshift seed germination, is the restrain effects of excess of ABA on embryo development, which slow down the promoting effects of gibberellins on radicle enlargement, and thus it will not grow through the endosperm (Nonogaki, 2008).

VI. ETHYLENE

Ethylene has the simplest biochemical structure and wide range of plant activities are influenced by it (Arteca and Arteca, 2008). The two component protein that is a kinase receptor helps in perception of ethylene. On the membrane of endoplasmic reticulum the receptor of ethylene is present (Kendrick and Chang, 2008). Different plant behavior, tissue growth and development, and seed germination are embellished by ethylene, however it is not yet understood in what way the ethylene influences seed germination and development. Different researchers have diverse views regarding seed germination and growth. In accord to few researchers, ethylene is formed as a consequence of seed germination and in other’s view; ethylene is indispensable for the procedure of seed germination. Under stress conditions too, ethylene is capable of regulating plant responses for example ABA and ethylene together are able to influence plant response to salinity stress. Under augmented levels of salinity, decreases in plant growth and development were observed with increased ethylene production. A precondition for ethylene production is the presence of enzyme 1-aminocyclopropane-1 carboxylic acid (ACC), which is catalyzed by ACC oxidase. During the germination of many crop plant seeds like wheat, corn and rice it was observed that the rate of seed germination was highly influenced, as amount of ethylene increased (Pennazio and Roggero, 1991). An enhance in seed radicle emergence through the production of ethylene was observed in numerous experiments (Kucera, *et al*., 2005).

VII. SALICYCLIC ACID

Salicylic acid commonly known as SA is exceptionally known for its imperative function in plant defense mechanism (Durrant and Dong, 2004). Salicylic acid is manufactured from chorismate via isochorismate. As the plants get infected by a extensive range of pest or pathogens then it results in an increase in SA concentrations both at the site of infection and in tissues at distant. Some of the SA signaling details have been worked out and some have been not, including the mechanism of SA perception. Nevertheless, it’s quite apparent that SA response is dependent on a protein called Nonexpresser of Pr Genes (NPR1). In the situation when SA concentration increases, NPR1 is translocated inside the nucleus where it participates in the promotion of the transcription of a large family of pathogene.

VIII. FUTURE PERSPECTIVES

Sustainable agriculture is one of the most promising ways to ensure enhanced crop productivity. The two major and important processes affecting crop production are seed germination and dormancy which are influenced by a wide range of factors out of which plant hormones are of primary importance. Since the last decade, our improved understanding on the molecular mechanisms involved in phytohormone biosynthesis, their perception and response has contributed in this field and has lead to new prospects to engineer levels of hormone and thus regulate plant growth. Different plant hormones, including ABA, IAA, cytokinins, ethylene, gibberellins and brassinosteroids, are able to influence seed germination either favourably or unfavorably, by interacting with each other and plants. Already worked out molecular pathways and recognized by proteomic and molecular biology analyses, may elucidate more details related to the effects of plant hormones on seed germination and dormancy. There are different interactions between plant genes and plant hormones in which some plant gene, are activated by plant hormones and then there are other plant genes which are necessary for the activity of plant hormones itself. Future research prospects hubs on apt agricultural and biological strategies that can bid suitable methods for the better germination of seeds under a variety of circumstances.

IX. ACKNOWLEDGEMENT

We thank IIS University for providing financial grant and necessary facilities to carry out this work.

REFERENCES

[1] Arteca R. and Arteca, J. (2008). "Effects of brassinosteroid, auxin, and cytokinin on ethylene production in Arabidopsis thaliana plants", J Exp Bot. 59: pp3019–3026.
[2] Badescu, G.O. and Napier, R.M. (2006). "Receptors for auxin: will it all end in TIRs". Trends Plant Sci. 11: pp 217–223.
[3] Bassel, G.W., Lan, H., Glaab, E., Gibbs, D.J., Gerjets, T., Krasnogor, N., Bonner, A.J., Holdsworth, M.J. and Provart, N.J. (2011). "Genome-wide network model capturing seed germination reveals coordinated regulation of plant cellular phase transitions", Proc. Natl. Acad. Sci. U.S.A. 108: pp 9709–9714.
[4] Bialek, K., Michalczuk, L and Cohen, J.D. (1992). "Auxin biosynthesis during Seed germination in Phaseolus vulgaris." Plant Physiol 100: pp 509–517.
[5] Brady, S.M., Sarkar, S.F., Bonetta, D and McCourt, P. (2003). "The ABSCISIC ACIDINSENSITIVE 3 (ABI3) gene is modulated by farnesylation and is involved in auxin signaling and lateral root development in Arabidopsis" Plant Journal, 34: pp 67–75.
[6] Davies, P.J. (1995). "Plant Hormones" Dordrecht. Kluwer Academic Publishers, The Netherlands
[7] Durrant, W.E. and Dong, X. (2004). "Systemic acquired resistance." Annu. Rev. Phytopathol. 42: pp185–209.
[8] Finkelstein, R., Reeves, W., Ariizumi, T and Steber, C. (2008). "Molecular aspects of seed dormancy" Ann Rev Plant Biol. 59: pp 387–415.
[9] Galuszka, P., Frebort, I., Sebela, M., Sauer, P and Jacobsen, S. (2001). "Cytokinin oxidase or dehydrogenase. Mechanism of cytokinin degradation in cereals". EuropJ Biochem. 268: pp 450–461.
[10] Graeber, K., Linkies, A., Muller, K., Wunchova, A., Rott, A and Leubner-Metzger, G., (2010). "Cross-species approaches to seed dormancy and germination: conservation and biodiversity of ABA-regulated mechanisms and the Brassicaceae DOG1 genes."Plant Mol Biol. 73:pp 67–87.
[11] He, Y.K., Xue, W.X., Sun, Y.D., Yu, X.H., Liu and P.L., (2000)." Leafy head formation of theprogenies of transgenic plants of Chinese cabbage with exogenous auxin genes".Cell Res. 10:pp151–602.
[12] Hirayama, T. and Shinozaki, K. (2007). "Perception and transduction of abscisic acid signals keys to the function of the versatile plant hormone ABA." Trends Plant Sci. 12:pp 343–351
[13] Inoue, T., Higuchi, M., Hashimoto, Y., Seki, M., Kobayashi, M., Kato, T., Tabata, S.,Shinozaki, K and Kakimoto, T., (2001). "Identification of CRE 1 as a cytokinin receptorfrom Arabidopsis". Nature. 409:pp1060–1063.
[14] Kendrick, M.D and Chang, C., (2008). "Ethylene signaling: new levels of complexity and regulation. Curr Opin Plant Biol. 11:pp 479–485.
[15] Khan, M.A and Ungar, I.A., (1997). "Alleviation of seed dormancy in the desert forb Zygo-phyllum simplex" L. from Pakistan. Ann Bot. 80:pp 395–400.
[16] Kucera, B., Cohn, M.A and Leubner-Metzger, G. (2005). "Plant hormone interactions during seed dormancy release and germination". Seed Sci Res. 15: pp 281–307.
[17] Kucera, B., Cohn, M.A and Leubner-Metzger, G. (2005). "Plant hormone interactions during seed dormancy release and germination". Seed Sci Res. 15: pp 281–307.
[18] Liu, A., Gao, F., Kanno, Y., Jordan, M., Kamiya, Y., Seo, M and Ayele, B. (2013). "Regulation of wheat seed dormancy by after-ripening is mediated by specific transcriptional switches that induce changes in seed hormone metabolism and signaling." P LoS One 8: pp 1–18.
[19] Liu, Chun-ming, Xu Zhi-hong, Chua and Nam-hai. (1993). "Auxin polar transport is essential for the establishment of bilateral symmetry during early plant embryogenesis." Plant Cell. 5: pp 621–630.
[20] Liu, P.P., Montgomery, T.A., Fahlgren, N., Kasschau, K.D., Nonogaki, H and Carrington, J.C. (2007). "Repression of AUXIN RESPONSE FACTOR10 by microRNA160 is critical for seed germination and post-germination stages." Plant J. 52: pp 133–146.
[21] Ma, Y., Szostkiewicz, I., Korte, A., Moes, D., Yang, Y., Christmann, A and Grill, E. (2009). "Regulators of PP2C phosphatase activity function as abscisic acid sensors." Science. 324: pp1064–1068.
[22] Mansfield, S.G and Bowman, J. (1993). "Embryogenesis. In Arabidopsis."In: Bowman,J. (Ed.), An Atlas of Morphology and Development. Berl., Springer-Verlag : pp 349–362.
[23] Miller, C., Skoog, F., Saltza, M.V and Strong, M. (1955). "Kinetic, a cell division factor from deoxyribonucleic acid." J Am Chem Soc. 77: pp 1392–1393.
[24] Mockaitis, K. and Estelle, M. (2008). "Auxin receptors and plant development: a new signaling paradigm". Annu. Rev. Cell Dev. Biol. 24: pp 55–80.
[25] Moore, T.C., (1989). "Biochemistry and Physiology of Plant Hormones," 2nd edn.Springer-Verlag, New York U.S.A.
[26] Murray, J., Karas, B., Sato, S., Tabata, S., Amyot, L and Szczyglowski, K. (2007). "A cytokinin perception mutant colonized by Rhizobium in the absence of nodule organogenesis." Science 315: pp 101–104.
[27] Nambara, E. and Marion-Poll, A. (2005). "Abscisic acid biosynthesis and catabolism". Annu. Rev. Plant Biol. 56: pp165–185.
[28] Ni Di-an, Yu Xiao-hong, Wang Ling-jian and Xu Zhi-hong. (2002). "Aberrant development of pollen in transgenic tobacco expressing bacterial IAA M gene driven by pollen-and tape tum-specific promoters." Acta Exp Sinica. 35: pp 1–6.
[29] Nonogaki, H. (2008). "Repression of transcription factors by microRNA during seed germination and post germinaiton." Another level of molecular repression in seeds. Plant Sig Behav. 1: pp 65–67.
[30] Pennazi, S. and Roggero, P. (1991). "Effects of exogenous salicylate on basal and stress-induced ethylene formation in soybean." Biol Plant. 33: pp 58–65.
[31] Riefler, M., Novak, O., Strnad, M and Schmulling, T. (2006). "Arabidopsis cytokinin receptor mutants reveal functions in shoot growth, leaf senescence, seed Size, germination, root development, and cytokinin metabolism". Plant Cell 18: pp 40–54.
[32] Schwechheimer, C. (2008). "Understanding gibberellic acid signaling–are we there yet?" Curr. Opin. Plant Biol. 11: pp 9–15
[33] Strader, L.C. and Bartel, B. (2008). "A new path to auxin." Nat. Chem. Biol. 4;pp 337–339
[34] Thornalley, P.J. (1990). "The glyoxalase system: new developments towards functional characterization of a metabolic pathway fundamental to biological

life." BiochemJ. 269: pp 1–11.

[35] Vieten, A., Sauer, M., Brewer, P.B. and Friml, J. (2007). "Molecular and cellular aspects of auxin transport-mediated development". Trends Plant Sci. 12: pp 160–168

[36] Werner, T., Motyka, V., Strnad, M and Schmulling, T. (2001). "Regulation of plant growth by cytokinin". Proc Nat Acad Sci U.S.A. 98: pp 10487–10492.

[37] Weyers, J.D.B and Paterson, N.W.(2001). "Plant hormones and the control of physiological processes." New Phytol. 152: pp 375–407.

[38] Yamaguchi, S.(2008). "Gibberellin metabolism and its regulation." Ann Rev Plant Biol.59:pp 225–251.