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POTENTIAL OF PHYTOHORMONES AS A STRATEGY TO IMPROVE ALGAL PRODUCTIVITY FOR BIOTECHNOLOGY APPLICATION: A REVIEW

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ABSTRACT

Algae are very large and diverse group of autotrophic organism ranging from unicellular to multicellular forms. Algae are important producers of vitamins, minerals, fatty acids, and protein contents. They have tremendous applications include agriculture, dairy, food, pharmaceuticals and cosmetic industries. In all most algal species, all typically known phytohormones like auxin, cytokinin, gibberellic acid, Abscisic acid, ethylene, etc were found in concentration comparable to higher plants. The presence of these hormones regulates metabolism and physicological activities in various algae. A wide range of bioactive compounds such as, pigments, vitamins, carbohydrates, lipids, protein and many more can be produced with algae or microalgae. Therefore such biosynthesis of algae or microalgae with phytohormones, which can enhance the production of highly valuable products. This opinion review article reports the effects of auxins, cytokinin, gibberalic acid, abscisic acid, and ethylene and its effect on algal or microalgal growth and metabolites.

KEYWORDS: *Phytohormones, Algal Bioproducts, Biotechnological Application*

INTRODUCTION

Algae is adiverse group of photosynthetic eukaryotic organisms. Which include organisms such as unicellular microalgae, a *Chlorella* and the diatoms, to multicellular forms, such as the giant kelp, a large brown alga, Blue-green algae (cyanobacteria), red algae and green algae. Most of they are aquatic and autotrophic. Algae have chlorophyll as their primary photosynthetic pigment and lack a sterile covering of cells around their reproductive cells. Microalgae or microphytes are micro size(small) algae, typically found in freshwater and marine systems, living in both the water column and sediment. Microalgae species produce unique products like peptides, enzymes, carotenoides, polymers, antioxidants, fatty acids, sterols and toxins. algae has phytohormones naturally. Phytohormones are chemical substance or chemical signal molecules that are produced in very small quantity. They regulate variety of cellular processes. In algae and microalgae, phytohormones play vital role in the growth and development. They are considered as growth regulators. Phytohormones is versatile and enigmatic. The function of these chemicals remains fragmentary and depends on their concentrations (Pietro Bartocci *et al*., 2018). It also provides protective properties that provide protection to the cells during stress conditions by affecting on tolerance factors of biotic and abiotic stress. Phytohormones are also involve in the processes of biosynthesis of pigments and lipids. Auxins, cytokinin, ABA, gibberellins etc phytohormones play crucial role and improve metabolites in algae and microalage which are important in many commercial process (Czerpak and Bajguz, 1997). In some algae Auxin

stimulate rhizoid formations, cell divisions and cell enlargement (Galan,2010).Auxins also helps in thiol mediated detoxification process in many green alga. IAA Regulates growth processes, by showing the direct effect on Mitotic cycle (Went and Thimann 1937).Phytohormone cytokinin helps in activation of growth processes, and increased photosynthetic activity. In some algae, cytokinin enhance pigment content and soluble protein (Tarakhovskay *et al*., 2007), it also helpful in branched formation process i.e. morphogenesis. Phytohormone ABA has been found to increase biomass production, carotenogenesis and lipid biosynthesis harides, chlorophyll a and b and total carotenoides 0 in many unicellulargreen algae. In many microalgae phytohormone ethylene helps in photochemical break down of dissolved organic matter, strees toleranceand also participates in signaling pathways.

Algae and microalgae have wide range of applications in biotechnology, including production of food ingredients, natural food colorants, dyes, food fertilizers, bioplastic, chemical feed stock, pharmaceuticals (Mata *et al*., 2010) and algal fuel. Algal cells are rich in vitamins, proteins, carbohydrates, enzymes, pigments, micro nutrients, macro nutrients and other bio-active compounds (Cardozo *et al*., 2015).Algae and microalgae are easy to cultivate and they can grow easily on land and water. Algae has long been used to fertilized crops as they provide rich source of nutrients such as nitrogen(N), phosphorus(P), potassium(K), iodine(I), iron(Fe), calcium(Ca) and organic matter. Algae can be directly deposited on the land where it can be used in decomposition process. Algae extract can be sprayed on crops. Other application includes fish oil, the fish oil has become famous for its omega-3 fatty acid content, and fish don't actually produce omega-3s, instead accumulating their omega-3 reserves by consuming microalgae. These omega-3 fatty acids can be obtained in the human diet directly from the microalgae.Many algae used as a dietary supplements or protein-rich food additive.Algae have therapeutic importances, as they are significant resource for bioreactive metabolites, particularly cytotoxic agents with applications in cancer chemotherapy and other broad spectrum antibiotic substances. Marine microalgae are also use as a chasis of polyethylene terephthalate (PET) degradation and residual of degradation process can be use as sole carbon source for different purposes. As Phytohormones enhance the growth of algae and microalgae, we can used them as pesticides and for heavy metal bioremediation (Alicja Piotrowska-Niczyporuk *et al*., 2014) process and also serves as a minute source for wastewater treatment and biogas production. Algal pigments have antioxidant properties and therefore it is also used in manufacturing of cosmetics. We can extract gelling agents from algae which can use in many frozen desserts (e.g.icecream, jellies), in bacteriological media and other culture media. They scavenge green house gases and can be used for Co2 mitigation (Ackman R G and Tocher, 1966). In many algae, phytohormones stimulate antioxidant enzymes such as superoxide dismutase, catalase and ascorbate peroxidase enzyme activity in stress condition, by growing algal cell in abnormal condition we can increased the production of these enzymes for commercial benefits.

In this review, we summarize and analyze the functions of phytohormones, especially their effects on the growth and biosynthesis of microalgae.

Although, the knowledge of physiological role in algae is still in infancy, the essential and bioactive forms of five classical phytohormone, auxin, cytokinin, Gibberellic acid, ethylene and abscisic acid have been detected in algal lineage is shown (Table 1).

Table 1: Importance of Phytohormones in Algae

Phytohormones	Function in Higher Plant	Physiological Importance in Plants	Importance in Algae	Referance
Auxin (IAA,IBA,NAA, PAA,IPA)	Cell proliferation and callus differentiation into Root	Cell elongation,apical dominance, parthenocarpy,Respiration, Callus formation,Vascular differentiation, Prevention of Abscission etc.	It increase the biomass and lipid production in Chlorella pyrenoidosa andScendesmusquadricauda. Indole 3 acetic acid shows inductive effect on carotenoid accumulation in Chlorella sp. BR2. IAA, 2,4-D and NAA improve the growth pattern of green algae Ankistrodesmusfalcatus.	Junging Liu et al., (2016) Faisal alsenani et al., (2018) Aravind K Vijay et al., (2020)
Gibberellins (GA3)	Stimulate the growth of main stem	Seed germination, root growth, dormancy of buds, elongation of internodes,De novo synthesis of enzyme α-amylase, bolting and flowering.	It affects growth,metal biosorption, and the content of essential metabolites in unicellular green algaeChlorella vulgaris. GA3 Increase the biomass production and some metabolites in marine micro algae Isochrysisgalbana.	Monika falkouska et al., (2011) Nasim sadatHosseniMadani et al., (2020)
Cytokinin (Kinetin, zeatin)	Cell proliferation and differentiation of callus into shoot	Cell division, delay in senescence, play crucial part in mobilization, promotes lateral bud development, increase cell expantion in dicots	It enhance the biomass and lipid productivity in Acutodesmus obliques under nitrogen strees. Cytokinin & auxin improves the production of eicosapentaenoicacid (EPA) In Monodopsissubterranea microalgae.	Nirmal renuka et al., (2017) Shaweta Arora & Girish mishra (2019)
Abscisic acid	Stimulate abscision	Act as growth inhibitor, it inhibits stimulatory effect of other hormones, induce dormancy, it controls geotropic responses of roots, causes closer of stomata.	It increases triacylglycerol (TAG) content in green microalgae Chlorella saccharophila. In unicellular green algae, Chlorella fusca&Ankistrodesmusbraunii, nitrate uptake in light was stimulated as in dark by appropriate concentration of ABA.	Patricia Yolanda et al., (2016) Wolframrullrich &Gunterkunz (1984)

Ethylene	Ripening of fruits	Prevent elongation of stem and roots, stimulates the formation of abscission zone in leaves, flowers, and fruits to shed prematurely, inhibit the growth of lateral buds, induction of flowers in some plants e.g. Mango and Pineapple.	It stimulate the growth & affects fatty acid content in Synechocystissp.PCC6803. It play key role in marine macroalgae Ulva intestinalis during strees condition.	Michael charton et al., (2017) Inaplettner et al., (2005)
Salicylic acid	Plant growth and development and response to stress condition	It increase the resistance of plants, involve in growth process, thermogenesis, uptake of ions, flower induction, in stomatal movement, enhance the level of chlorophyll and carotenoids pigments, increase the photosynthetic rate, reverses the effect of ABA on leaf abscission.	In marine diatom Phaeodactylumtricornutum, it cause accumulation of fatty acids during stationary growth phase. In marine microalgae, Arthrospiraplatensis, it is useful for elicitation of pharmaceutical alkaloids.	Jiahui xu et al., (2017) Mahnazhadizadeh et al., (2019)
Brassinosteroids	Essential in growth and development of plants	Cell division, cell wall elongation, cell expansion and elongation, under stress condition such as draught, salinity, extreme temperature, and heavy metal toxicity, it play key role in growth processes, improve yield of crops.	It influence the growth & provide protection against abiotic strees in algae. It enhance the level of ABA in Chlorella vulgaris subjected to heat strees (30-40).	Andrzej bajguz (2019) Andrzej bajguz. (2009)
Jasmonic acid (JA)	Plant resistance to abiotic stress	Activation of the antioxidant system, accumulation of amino acids, regulation of stomatal opening and closing	It promotes the production of lipid in Chlorella vulgaris. It induced lipid production in microalgae Monoraphidium sp. QLY-1,under nitrogen deficiency condition.	Mallinajusoh et al., (2015) Xueting Song et al., (2020)

CONCLUSIONS

Phytohormones play an important role in life of algae. In most cases, the observed biological activities of algal phytohormones corresponds to higher plant phytohormones. With so many advantages linked to algae, it can prove to be one of the most used sources for energy generation and for the production of other products like cosmetics, food additives, nutraceuticals, as a food product itself and many more. It has been found that phytohormones enable microalgae to accumulatemore biomass or high-valued bioproducts, which will facilitate the scale-up cultivation of microalgae, contributing especially to the industrialization of biodiesel from microalgal lipid. Nevertheless,the scalable and viable microalgal production still requires more investigations and studies.

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