Evaluation of microbial Indole 3-Acetic Acid production for Sustainable Development of Natural Resources.

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Abstract: The worldwide increase in both environmental damage and human population has resulted in the unfortunate consequence of insufficient global food availability required to feed all of the world's people. It is imperative to significantly increase agricultural productivity to satisfy the world hunger. With such an intention, agricultural technologies are moving towards creating a more sustainable and environment friendly methods. This involves employing transgenic plants and plant growth aiding bacteria as a part of agricultural farming. In this article, we have discussed the plant growth facilitating microorganisms, which are the soil bacteria found to colonize plant roots, thereby facilitating nutrient uptake and availability. The benefit of such microbes for agriculture, their importance and more importantly their acceptance by agricultural community is reviewed with reference to future trend. The development of plant growth microorganism practice is expected to replace the usage of chemicals for agricultural purpose. A class of soil microorganism beneficial to plant growth, referred as plant growth promoting rhizobacteria (PGPR,) is also reviewed for their capacity of promoting plant growth and their potential for economic agricultural production.

Keyword: plant growth factors, microorganism, Indole acetic acid.

INTRODUCTION:

Plant bacterial interactions have received higher interest since ancient times as evident from the practice of organic farming and composting. The colonization of roots by microorganisms is beneficial to plant growth, development and productivity. Synthesis of plant hormone production has been demonstrated in microorganisms in form of auxins, gibberellins and cytokines (Tien et al., 1979; Ahmad et al., 2008). This phenomena has been documented for certain microorganisms inhabiting the rhizosphere and are also considered to be involved in major microbial and host plant interactions (Srinath et al., 2003; Yang et al., 2009).

Artificial chemicals employment in the world has enforced several challenges, thereby impacting the flora and fauna negatively through environmental pollution. For preserving healthy environment, progress in biotechnology achievements have inspired the use of natural materials in plant culturing as well as utilization of soil micro-organisms. Soil microorganisms are utilized in plant production since decades. Most of these operate by using microorganisms to produce nutrients that promote plant growth, through the assembly of growth augmenter. A variety of host-dependent and non-symbiotic microorganisms are currently being employed worldwide with the aim of enhancing plant productivity. Independent soils are being tested for application in plant growth and are typically grouped as plant growth promoting rhizobacteria. Rhizobacteria can support plant growth directly, for example by producing growth regulating substance. The growth regulating substances produced by the rhizobacteria include Indole 3-acetic acid (IAA), gibberellins, cytokines and ethylene.[29]

Indole 3-acetic acid is a natural auxin and a natural plant growth regulator. It is synthesized from several species of non-seed and seed producing plants, microorganism, fungi and algae. The synthesis of auxins in plants occurs because of an organic compound that is tryptophan. Therefore, screening of microorganisms for their in vitro potential of phytohormone production could provide a reliable basis to select and screen effective plant growth promoting microorganisms. IAA producing microorganisms form necessary constituents of biofertilizers and are extensively used to increase crop growth and yield.

IAA AS PLANT GROWTH FATOR:

IAA is known to affect plant cell division, extension, and differentiation, stimulate seed and tuber germination, increase rate of xylem and root development and control vegetative growth. Although Indole Acetic Acid synthesis by microorganisms is published throughout the literature, it is imperative to compare its production and effect with its natural route of plant pathways.

Generally, auxin regulates morphological features of plant body, direction and strength of organization and their mutual interaction (Patten and Glick, 2002). It also induces shoot epical dominance, encourages growth and initiation of flowering and development of reproductive organs and delay fruit senescence (Nemhauser et al., 2006). In rhizobacteria the IAA production is controlled genetically and also at cellular level. Study of spontaneous IAA nonproducing mutants is beneficial to map and characterize IAA genes. Conjugation, transformation or curing procedures are useful to determine the presence of IAA genes on plasmid. Further cloning, sequencing and expression studies can be elucidate IAA pathway.

EFFETS OF IAA CONCENTRATION ON PLANTS:

It is established for over 70 years that different IAA concentrations exhibit completely different effect on the physiology of plants in dramatically alternative ways. Plant responses to IAA vary from one kind of plant to another, however, some plants are more or less sensitive to IAA than other plants. According to the particular tissue involved, the optimal level of IAA for supporting plant growth differs in magnitude. It is found to be lower for roots than for shoots. It is also proportional to the function of developmental stage of the plant. However, the endogenous pool of plant IAA is also altered by the acquisition of IAA from external resources that has been secreted by soil bacterium.

In this regard, the amount of IAA synthesized by the plant is very important in deciding whether or not IAA producing microorganism stimulates or suppresses the plant growth. In plant roots, endogenous IAA could also be affected by the amount supplied by soil bacterium. It might alter the IAA level to either optimum or supraoptimal range, leading to plant growth promotion or inhibition, severely.

Increased IAA produced by rhizobacteria or production of IAA in plant could lead to hypertrophy or hyperauxiny[20]. Hypertrophic growth is like cancerous cells where plants undergo uncontrolled cell division and growth. This leads to the formation of tumor like growth or malady disease of roots, leaves, stems or inflorescences. Hyperauxiny is also an indication of plant infection by pathogens. Phytopathogenic microorganisms are responsible for wilting, smut diseases of plants (21). The disease is exaggerated when IAA acts in conjunction with tumor inducing substances as produced by *Agrobacterium tumefacies*. The malady disease evoked by phytopathogenic *Agrobacterium* strains is classical example of hyperauxiny or hypertrophy.

IAA SYNTHESIS AND TYPES OF MICROBIAL IAA PRODUCERS:

Chemical synthesis of IAA is performed by reaction of indole with glycolic acid at 250ºC [15]. Biologically IAA is synthesized from tryptophan which is the precursor for IAA synthesis. Tryptophan is principle component of plant root exudates and rhizobacteria utilize this exuded tryptophan to synthesize IAA for the plant. The main pathways IAA biosynthesis pathways are indole-3-acetamide, indole-3-pyruvate, indole-3-acetonitrile, tryptamine pathway and tryptophan side chain pathway [15]. The pathways have derived their names as per the intermediate produced during IAA synthesis. IAA biosynthesis involves enzymatic catalyzation in form of deaminization, carboxylation, oxidation and decarboxylation.

The bacteria that are demonstrated to produce auxin include *Pseudomonas sp., Azospirillium sp., Azotobacter sp., Bacillus sp., Lactobacillus sp., Paenibacillus polymyxa, Enterobacter sp., Serratia marcescens, Klebsiella sp., Alcaligenes faecalis and Cyanobacteria* [18,28].

QUALITATIVE AND QUANTITATIVE ESTIMATION OF IAA:

The most common assay for detection of IAA production is colorimetric determination using Salkowski's reagent [Atiqur Rahman *et al* ,2010] . It is also detected by using blotting method with nitrocellulose or nylon membrane on agar plates using the Salkowski's reagent as color indicator. By using this technique, screening of huge kind of microorganism for IAA production has been possible. It also simplifies the assay by removing the requirement of refined extract or cell free supernatant for the analysis. Besides these assays, IAA can also be detected by Spectrophotometry, high performance liquid chromatography (HPLC) or gas chromatography (GC) are also used for estimation of IAA and its derivates [11].

Orthophosphoric acid indicated pink coloration in microorganisms producing IAA in cell free culture media, is employed for qualitative screening of IAA producers. The microorganisms which exhibited a pink to red colour with a little variation in intensity. Salkowski's reagent is used for quantitative estimation of IAA production by rhizospheric bacteria. The quantitative yields of IAA has been estimated from 36.4 to 52.5µg auxin/ml media [7]. Although the amounts of plant growth factors were less, they have profound effect on sprouting of seeds treated with such bacteria [7].

APPLICATION OF IAA:

IAA actively stimulates plant growth through its most vital function of breaking apical dominance and increase the growth of main stem. It plays potent role in many other important plant developmental growth processes such as cell division and cell initiation, gravitropic and phototropic responses, flowering, fruit ripening, leaf senescence and abscission of leaves and fruit. It also regulates cell permeability and is used to generate roots in explants cultures and seedlings. IAA is required in very small amounts to promote plant growth functions. In fact enhanced plant growth responses are indicators of healthy plant growth factor synthesis.

CONCLUSION:

Plant auxins have been crucial for optimal yield of desired crop in agriculture field. Limited amounts of such growth factors produced by plants suffice for individual plant. However for agricultural purpose, large batches of explants culture require rapid and consistent supply of plant growth promoters. Rhizospheric microflora has always been exhibiting symbiotic plant microbe interactions. Microbial Indole Acetic Acid has been well established as an alternative for plant growth promoters. This alternative technology for plant growth accelerators can be explored for potent types of agricultural enhancers. They also have a direct role in boosting agricultural biotechnology. Novel strains of plant growth promoter producers need to be explored and characterized for creating sustainable resources for future consumer generations.

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