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Azospirillum- a potent Biofertilizer in Agriculture

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Abstract

Chemical fertilizers are affecting the yields of different agricultural crops by polluting the soil and water environment. This type of pollution increases algal blooms and affect the aquatic population also. *Azospirillum* as biofertilizer having biocontrol properties so as to increase the yield of various crops. This review highlights the importance of *Azospirillum* as a potent biofertilizer which emphasizes its effect to increase the crop yield through nutritional effects and regulating plant hormones for ultimate objective of improving soil environments.

Keywords: *Azospirillum*, Diazotrophs, Phytohormones

Introduction

Azospirillum belongs to the order of Rhodospirillales. It is a gram-negative bacterium and belongs to the genus of Alphaproteobacteria. This Bacteria is able to fix atmospheric nitrogen for which it is even called as Diazotrophs and the name Azo is derived from French word which means nitrogen while spirillum is based on the shape of bacteria. It competes with pathogens for trace nutrients like iron and protect the plants through induced systemic resistance. Role of bacteria are many in addition to role of fixation of nitrogen. It promotes branching of roots through production of phytohormones which also protect plants from stress conditions by producing antioxidants, phytoalexins, etc. Degradation of Xenobiotic compounds also occurs by inoculating *Azospirillum* spp. There are numerous species of Azospirillum like *A.brasilense, A.canadense, A.dobereinerae, A.fermentarium, A.griseum, A.oryzae*, etc. Media used for cultivation of *Azospirillum* is Nfb i.e.Nitrogen fixing bacteria medium.

Importance

Azospirillum is also called as PGPR i.e. plant growth promoting rhizobacteria. It is important due to the process of nitrogen fixation as it takes part in uptake of nitrogen and even through solubilisation of phosphorous. This bacterium competes with various pathogens that are present in roots for free space and also for nutrient like Fe and creating systematic resistance in plants. Certain crops like rice, maize, sorghum, and millets are known to be benefited after inoculation with *Azospirillum* species. These crops showed positive effect on the number of leaves, height as well as overall dry weight of plants.

Brief Review

Media used for the cultivation of *Azospirillum* is Nitrogen fixing bacteria medium. It forms pink, white, and yellow colonies when incubated at 32^{o}C. Commercialization of this species has gained importance in many countries like Argentina, Mexico, Italy, France, and India as reported by Diaz-Zorita and Fernandez-Canigia (2009) as well as Hartmann and Bashan (2009). Numerous studies have been carried out to see the effect of PGPR on growth and morphology of plants. A study reported by Dobbelaere et al., (1999) and Levanony and Bashan (1989) described the effect of PGPR on root morphology. The results obtained showed a good absorption of minerals which resulted in increased plant growth. This bacterium contributed by interacting with the host plant through the process of symbiosis.

Production of phytohormones

Tsavkelova et al., (2006) highlighted importance of PGPR in production of phytohormones. It has been observed that Gibberellins promoted increase of shoot length and induced parthenocarpy in grapes as well as increased size of fruits. A study conducted by Bottini et tal., (2004) gave importance of

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Gibberellins. Importance of phytohormones is not only altering the morphology but also promoted overall healthier conditions of plants. IAA is heterocyclic compound that belongs to the auxin phytohormone family that results in cell elongation, root initiation and has important role in plant physiology. Its importance was given by Spaepen et al., (2007). Ona et al., (2003, 2005) reported that the material that causes release of IAA is due to low carbon level and vitamin B especially pyridoxine and Nicotinic acid, and also responsible for gene expression in plants. Ethylene is plant hormone that leads to root elongation. However, while increase in its level resulted in inhibition of roots. Production of ethylene is due to the contribution of ACC (1-amino cyclo propane-1-carboxylic acid)-deaminase enzyme. A report made by Glick et al., (1999) found that PGPR played an important role in degradation of ACC and further gave evidence for growth promotion in plants due to decrease in level of ethylene. ACC is a non-protein amino acid acting as direct precursor of ethylene. Studies contributed by Giraud et al., (2007) reported the formation of nodulation factors when applied in combination with *Bradyrhizobium.* These are signalling molecules produced by soil bacteria known as rhizobia in response to flavonoid exudation from plants under nitrogen-limited conditions.

Formation of Polyamines

Polyamines are low molecular weight organic compounds having more than two amino groups. Alkyl polyamines occur naturally, but some are synthetic. Certain compounds like polyamines play important role in plant when exogenously supplied as reported by Kuznetsov et al., (2006). Perrig et al., (2007) highlighted the importance of *A. brasilense* strain AZ39 in production of polyamines such as spermidine and spermine when inoculated in wheat and Maize which resulted in boosting beneficial effects. Marchal and Vanderleyden (2000) discussed the role of nitrogenase enzyme and presence of oxygen components that stopped its activity and resulted in inhibition of nitrogenase activity.

Removal of salinity and stress conditions

Due to heavy use of chemical fertilizers, there is problem of salinity. Inoculation with *Azospirillum* has proved to be a boon and challenge to this problem. Studies carried by Bashan and Holguin (1997) showed that *Azospirillum* inoculation in soil resulted in removing salinity problem. A comparative study was performed between *A. amazonense* and *A. halopraeferans*. Role *of A. amazonense* was found least effective in the removal of salinity. Studies performed by El-komy et al., (2003) found the role of nitrogenase activity in roots and shoot. As *Azospirillum* was inoculated in plants, it regulated turgor pressure and showed the effect on cell wall elasticity. Toxicity does not allow the proper growth of the plant. Cd toxicity was studied in the fields to overcome its toxic effect *A. brasilense* sp245 when inoculated in plants, resulted in overcoming the toxic effect and there was an increase in plant biomass as reported by Belimov, and Dietz (2000). *In vitro* test performed by Bacillo et al., (2004) reported that *Azospirillum brasilense* and *Azospirillum lipoferum* in presence of humic acid affected plant development to overcome this problem and used to mitigate such problems.

Phosphate solubilization

Phosphate plays a critical role in soil by solubilising inorganic phosphorous minerals and storing then in large amount in biomass. A report carried out by Seshadri et al., (2000) gave importance of two strains of bacteria that can fix phosphorous. *A.brasilense* and *A.lipoferum* were found to produce gluconic acid leading to solubilisation of insoluble phosphate. Puente et al.,(2004 and 2006) confirmed ability of bacteria to produce organic acid that can solubilise phosphorous.

Xenobiotics degradation

Compounds that are not degraded easily are called as xenobiotics. *Azospirillum* besides growth promotion activity plays an important role in degradation of compounds that are man-made. Some strains like *A. brasilense* and *A.lipoferum* served an important role in degradation of phenols and benzoate. This was reported by Barkovskii (1997). Young et al., (2016) reported *Azospirillum* isolation from hydrocarbon-contaminated soil. Major property included degradation of xenobiotic compounds and release of biosurfactants that was produced by bacteria and fungi taking part in absorption of hydrocarbons. It was also found that *Azospirillum* has dispersing and emulsifying properties. Wu et al., (2021) studied two strains RWYS-1-1T and ROY1-1-2 from Gansu, China. A similar comparative study was done for two strains of bacteria for degradation of hydrocarbons. It was found that RWY5-1-1T was sufficient for hydrocarbon degradation to an extent of 36.2%. This work highlighted importance of hormones secreted by bacteria that played an important role to reduce contamination in soil caused by Cd, Cu, etc.

Herbicides effect on *Azospirillum*

Herbicides are basically chemicals which are used to control weed vegetation. PGPR strain like *A.brasilense*, AZ39, and reference strain sp7 was used to evaluate the effect on commercial herbicides like glycophosphate and atrazine. Alori and Babalola (2018) emphasised the use of biological compounds that resulted in reducing the use of chemical fertilizers. There are certain strains of bacterial species that degrade herbicides. An assay was carried out to evaluate whether strain uses herbicides as nutritional source. It was found that *A. brasilene* AZ39 was not able to use atrazine as nitrogen source after giving 70h of incubation while this strain used glyphospate-based herbicides as sole source of carbon after 60h of incubation. Aguirreacdena et al., (2014) and Zabaloy et al., (2008) studied the effect of glyphosate 2,4 D and metasulfuron –methyl in microbial population in Pampas region soil in Argentina.

References

1. Aguirre Cadena J, Reyna Tellez S, Cuautle M, Aguirre Medina J. (2014). Sobrevivencia de *Azospirillum brasilense* despues de aplicar herbicidas en *Triticum aestivum* L.var. *altiplano* Rev Mex Cienc Agric.5:1549-1555.

*Corresponding Author: **Aradhana Dohroo**

2. Alori ET, Balalola O.O. (2018).Microbial inoculants for improving crop quality and human health in Africa. Front Microbiol.9: 2213.
3. Bacilio, M. ,Rodriguez , H., Moreno. M., Hernandez, J.-P and Bashan,Y. (2004). Mitigation of salt stress in wheat seedlings by a gfp-tagged *Azospirillum lipoferum*. Biol. Fertil. Soils 40, 188-193.
4. Bacillo, M., Rodriguez H., Moreno, M., Hernandez, J-P., Bashan, Y. (2004). Mitigation of salt stress in wheat seedlings by a gfp-tagged *Azospirillum lipoferum*. Biol. Fertil. Soils 40,188-193.
5. Barkovskii,A.L.; Korshunova,V.E; Pozdnyacova,L.I. (1995). Catabolism of phenol and benzoate by *Azospirillum* strains. Appl.Soil Ecol. 2,17-24.
6. Bashan, Y., and Holguin ,G. (1997). *Azospirillum* - plant relationship: Environmental and physiological advances. Can. J. Microbiol.43, 103-121.
7. Belimov, A., and Dietz, K . J. (2000). Effect of associative bacteria on element composition of barley seedlings grown in solution culture at toxic cadmium concentrations. Microbiol Res. 155,113-121.
8. Bottini, R., Cassan, F., and Piccoli , P. (2004) . Gibberellins production by bacteria and its involvement in plant growth promotion and yield increases. Appl. Microbiol . Biotechnol. 65, 497-503.
9. Chong, H.;Li,Q. (2017). Degradacion de fenantreno por microorganimos en la rizosfera del pastor aleman.Microb. Cell Fact.16,137.
10. Diaz-Zorita, M., and Fernandez-Canigia, M.V. (2009). Field performance of a liquid formulation of *Azospirillum brasilense* on dry land wheat productivity. Eur. J. Soil. Biol .45, 3-11.
11. Dobbelaere , S., Croonenborghs, A., Thys, A., Vande Broek, A., and Vanderleyden,J. (1999). Phytostimulatory effect of *Azospirillum brasilense* wild type and mutant strains altered in IAA production on wheat. Plant Soil 212, 155-164.
12. El-Komy, H.M., Hamdia , M.A., and El-Baki, G.K.A. (2003). Nitrate reductase in wheat plant grown under water stress and inoculated with *Azospirillum* spp. Biol. Plantarum 46, 281-287.
13. Giraud, E., et al. (2007). Legumes symbioses. Absence of genes in nod in photosynthetic bradyrhizobia. Science 316, 1307-1312.
14. Glick, B.R., Pattern, C.L., Holguin , G., and Penrose, D.M. (1999). Biochemical and genetic mechanism used by plant growth-promoting bacteria. Imperial College Press, London, UK.
15. Hartmann, A., and Bashan, Y. (2009). Ecology and application of *Azospirillum* and other plant growth promoting bacteria (PGPB)-special issue. Eur. J. Soil Biol. 45, 1-2.
16. Hartmann, A., Baldani, J. I. 2006. The Genus *Azospirillum*. The Prokaryotes. New York. USA, pp. 115-140.
17. Johnsen,A.R; Wick,L.Y; Harms, H. (2005). Principles of microbial PAH-degradation in soil. Environ.Pollut.133,71-84.
18. Kuznetsov, V., Radyukina, N. And Shevyakova, N. (2006). Polyamines and Stress: Biological role, metabolism, and regulation. Russ. J. Plant Physiol. 53, 583-604.
19. Lamattina, L., and Polacco, J. (2007). Nitric Oxide in plant growth, development, and stress physiology. Plant cell Monographs. Springer-Verlag, Berlin Heidelberg, Germany.
20. Levanony, H., and Bashan, Y. (1989). Enhancement of cell division in wheat root tips and growth of root elongation zone induced by *Azospirillum brasilense* .Can. J. Bot. 67, 2213-2216.
21. Marchal, K., and Vanderleyden, J. (2000). The "oxygen paradox" of dinitrogen-fixing bacteria. Biol. Fertil. Soils 30, 363-373.
22. Microbial producers of plant growth stimulators and their practical use: A review. Appl.Biochem . Microbiol. 42,117-126.
23. Ona, O., Smets, I., Gysegom, P., Bernaerts, K., Impe, J.V., Prinsen, E., and Vanderleyden, J. (2003). The effect of pH on indole-3-acetic acid (IAA) biosynthesis of *Azospirillum brasilense* sp. Symbiosis 35, 199-208.
24. Ona, O., van Impe, J., Prinsen, E., and Vanderleysp. 245den, J. 2005. Growth and indole-3-acetic acid biosynthesis of *Azospirillum brasilensis* environmentally controlled. FEMS Microbiol. Lett. 246, 125-132.
25. Perrig,D., Boiero , M.L., Masciarelli, O.A., Penna ,C., Ruiz,O.A., Cassan ,F. D., and Luna, M.V. (2007). Plant growth promoting compounds produced by two agronomically important strains of *Azospirillum brasilense*, and implications for inoculant formulation.Appl.Microbiol. Biotechnol.75,1143-1150.
26. Puente, M.E., Li, C.Y., and Bashan,Y. (2004). Microbial populations and activities in the rhizoplane of rock-weathering desert plant II.Growth promotion of cactus seedlings Plant Biol.6, 643-650.
27. Puente,M.E., Rodriguez -Jaramillo , M.C., Li,C.Y., and Bashan , Y. (2006). Images analysis for quantification of bacterial rock weathering. J. Microbiol. Methods 64, 275-286.
28. Sabidet,M.I., and Barneix,A.J. (1998). Growth stimulation and nitrogen supply to wheat plants inoculated with *Azospirillum brasilense*. J.Plant Nutr.21,2565-2577.
29. Sarig,S., Okon , Y., and Blum, A. (1992). Effect of *Azospirillum brasilense* inoculation on growth dynamics and hydraulic conductivity of Sorghum bicolor roots. J.Plant. Nutr.15, 805-819.

*Corresponding Author: **Aradhana Dohroo**

30. Seshadri, S., Muthukumuramasamy, R., Lakshiminarasami, C., and Ignacimuthu,S. (2000). Solubilization of inorganic phosphates by *Azospirillum halopraeferans*. Curr. Sci.79, 565-567.
31. Spaepen, S.,Vanderleyden, J.,and Remans, R. (2007). Indole -3-acetic acid in microbial and microorganism-plant signaling. FEMS Microbiol. Rev.31, 425-448.
32. Tsavkelova, E.A., Klimova, S.Y., Cherdyntseva,T.A., and Netrusov, A.I.(2006). Microbial producers of plant growth stimulators and their practical use: A review. Appl. Biochem. Microbiol. 42, 117-126.
33. Wood, C.C., Islam, N., Ritchie, R.J., and Kennedy, I.R. (2001). A Simplified model for assessing critical parameters during associative 15N2 fixation between *Azospirillum* and wheat. Aust. J. Plant Physiol. 28, 969-974.
34. Wood, C.C., Islam, N., Ritchie, R.J., and Keneedy, I.R. (2001). A simplified model for assessing critical parameter during associative 15N2 fixation between *Azospirillum* and wheat. Aust.J. Plant Physiol. 28, 969-974.
35. Wu, D.; Zhang, X.J.; Liu, H.C; Zhou,Y.G; Wu,X.L; Kang,Y.Q.; Cai,M.(2021). *Azospirillum oleiclasticum* sp.nov, a nitrogen-fixing and heavy oil-degrading bacterium isolated from an oil production mixture of Yumen oil field. Syst.Appl. Microbiol.44,126-171.
36. Xu, Q.; Pan, W.; Zhang, R.; Lu, Q.; Xue, W.; C.;Song,B.; Du,S.(2018). Inoculation with *Bacillus subtilis* and *Azospirillum brasilense* produces Abscisic acid that reduces Irt1-Mediated calcium uptake of roots. J.Agric Food Chem. 66,5229-5236.
37. Young,C.C; Lin,S.Y.; Hameed, A; Liu,Y.C; Hsu,Y.H.; Huang, Lai,W.A.(2016). *Azospirillum Agricola* sp.nov., a nitrogen-fixing species isolated from cultivated soil. Int.J.Syst.Evol.Microbiol. 66,1453-1458.
38. Zabaloy C, Garland L, Gomez M (2008). An integrated approach to evaluate the impact of the herbicides glyphosate, 2,4-D, and metsulfuron-methy on soil microbial communities in the Pampas region, Argentina. Appl Soil Ecol.40:1-12.

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