REVIEW OF RESEARCH
IMPACT FACTOR : 5.7631(UIF) UGC APPROVED JOURNAL NO. 48514 ISSN: 2249-894X

VOLUME - 8 | ISSUE - 4 | JANUARY - 2019

CYANOBACTERIA AND SALT- AFFECTED SOILS

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ABSTRACT :

Salinity is one of the leading factors affecting the agricultural systems. Nearly 7% of total global area of land is salt affected which negatively mitigates the growth of plants. Cyanobacteria have the capability to survive in adverse conditions like high temperature, salinity and pH. These have the capacity to modulate the salt stress effect and improve the growth of plants by reducing electrical conductivity of saline soils, increasing their organic matter content and solubilising the nutrients and thus can be used for the reclamation of salt affected soils

KEYWORDS : *Salinity, Cyanobacteria, Reclamation, Compatible solutes, EPS.*

INTRODUCTION

Soil salinity is one of the major detrimental factors responsible for the reduction in cultivated land area (Shahbaz and Ashraf, 2013) and for the major crop losses every year (Singh et al, 2009). Salt stress suppresses the growth and development of plants (Paul, 2012). Tavakkoli et al (2011) reported the dysfunctioning of photosystem II due to salt injury and resulting in inhibition of photosynthesis, stomatal closure and reduced biomass synthesis.

Salt affected soils may either be saline or alkaline. Saline soils have a high concentration of chlorides and sulphates of sodium, calcium and magnesium with sodium chloride as predominating one. Their electrical conductivity is more than 4dS/m (Pandey et al, 1992) and pH less than 8.5. Alkaline soils have carbonates and bicarbonates of sodium and their pH is more than 8.5 and electrical conductivity less than 4dS/m. Saline soils are not fit for crop production although they are having a high agricultural potential (Hashem et al, 2001). In India, nearly 7 million hectares of land is salt affected (Patel et al, 2011). Shrivastava and Kumar (2015) have reported an increase of salinized area at global level with a rate of 10% annually and more than 50% of agricultural land area will get salinized by the year 2050.

For the reclamation of saline soils one of the approach is the use of gypsum ($CaSO_4.2H_2O$) and pyrite ($FeSO_4$), followed by intensive irrigation (Dhar and Mukherji, 1936) to allow the leaching of excessive salts, but it is not cost effective and environment friendly. Another method for the bioamelioration of saline soils is by the application of cyanobacteria (Kaushik and Rajarao, 1990; Apte and Thomas, 1997) which can proliferate in saline soils where other plants find difficult to survive. Natural occurrence of heterocystous cyanobacteria in arid saline soils shows tolerance of cyanobacteria to such stress conditions (Singh, 1961, Sikander and Sander, 1972 and Arif, 1992). Cyanobacteria have the tendency to scavenge the sodium ions from the soils and to improve the characteristics of such soils (Rai, 2015).

Jaiswal et al (2010) and Murtaza et al (2011) also supported the use of cyanobacteria in bio-reclamation of saline-alkaline soils.

CYANOBACTERIA

Cyanobacteria also called blue green algae, are the ubiquitous (Kulasooriya, 2011), prokaryotic oxygenic photosynthetic organisms, capable of surviving in diverse habitats ranging from rocks, deserts to water bodies like rivers, lakes and oceans. These can thrive in extreme environmental conditions like high light intensity, temperature, high salinity and pH conditions (Lopez et al, 2004; Whitton, 2007). Heterocystous forms have the potential to fix atmospheric nitrogen (Pawar et al., 2013) and convert it to usable form and hence improve the nitrogen status of soil and contribute to the plant growth by enhancing soil fertility (Jangir et al, 2015).

SALT TOLERANCE MECHANISMS IN CYANOBACTERIA

Cyanobacteria adopt various strategies to cope up with the stress conditions although with a reduced growth rate. In earlier studies, it has been reported that *Anabaena sphaerica* a native isolate of salt affected soils of Haryana, had developed biochemical adaptations by accumulating total sugars and lipids although the overall growth in terms of biomass and proteins decreased with increasing salinity levels (Manchanda, 2015). Cyanobacteria generally use "salt- out strategy" to adjust with the changing salinity stress (Pade and Hageman, 2015). In this method, internal inorganic ion concentration is kept low by accumulating the organic molecules called compatible solutes. Compatibles solutes help to maintain internal osmoticum without interfering with the cellular metabolic machinery of the cell. Major forms of compatible solutes are sugars, polyols, glycine betaine and proline, lipids and proteins (Galinski and Truper,1994; Poolman and Glaasker,1998).

Other mechanisms are curtailment of sodium ions into the cyanobacterial cell by Na^+/H^+ antiporter (Apte et al, 1987; Malam et al, 2007), synthesis of salt stress responsive proteins, presence of combined nitrogen which prevents sodium accumulation & enhances salt tolerance in blue green algae (Reddy et al, 1989). Salinity induces the activation of stress responsive genes and a slight change in salinity affects the pattern of protein synthesis (Apte et al, 1998).

RECLAMATION OF SALINE SOILS BY CYANOBACTERIA

Use of cyanobacteria for reclamation of soils has been reported by Singh (1961). Addition of cyanobacteria help to maintain the carbon, nitrogen and phosphorus levels of the soil (Hashem, 2001). Cyanobacteria add to the organic matter of the soils (Apte and Thomas, 1997) and help in improving the physico chemical properties of soils by binding of soil particles, increasing soil permeability and aeration, lowering pH, electrical conductivity & by increasing hydraulic conductivity (Kaushik and Subhashini,1985; Prabhu and Udaysoorian, 2007). Cyanobacteria also act as heavy metal scavangers (Jangir et al, 2015) and are a good source of various bioactive compounds like vitamins, amino acids, pigments, enzymes and growth hormones etc (Higa, 1991).

Cyanobacteria produce extracellular polysaccharides (EPS), present around the cells or filaments. EPS produced are of diverse types and contain 12 different types of monosaccharide units. EPS help in aggregation of soil particles due to its gluing nature (Nisha et al, 2007) and prevent soil erosion (Mazor et al, 1996; Kumar et al, 2018). Cyanobacterial extracellular polysaccharides have certain active functional groups which help in binding the heavy metals. EPS chelate Na^+ ions and immobilize them from the saline media temporarily. The amount of EPS increases with increasing salinity as reported in earlier studies (Arora et al, 2010). Exopolysaccharides ameliorate heavy metal toxicity by biosorption (DePhilippis et al, 2003).

CONCLUSION

Cyanobacteria have various mechanisms to adapt under salt stress conditions and can also fix atmospheric carbon and nitrogen into usable form and help in improving nitrogen status and organic matter content of soil. These help in chelation of sodium ions and also produce extracellular polysaccharides which improve physico- chemical properties of such soils. Thus, cyanobacteria or blue-green algae have the potential to be used effectively for the reclamation of salt affected soils.

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