7 Development of a microbially derived polymeric product for gel formation, microbial colonization and metals binding

Introduction

Exopolysaccharides are carbohydrate-rich polymeric material synthesized by the microorganisms mainly under limiting nitrogen conditions. These molecules constitute an important class of biological polymers having multifaceted utilization potential in variety of industries. Extensively cross-linked sugar moieties in an exopolysaccharide makes a highly branched, carbonaceous structure, with multiple surface ligands capable to react readily with different types of chemicals and elements. Highly branched structure enables these polymers holding high amount of water and other solvents, as well as capability to interact with different elements, and many other industrially important properties.

Water deficit is major concern currently to agricultural productivity worldwide. Currently available strategies in this regard predominantly include development of tolerant varieties, improved management practices, and fertigation techniques. Major limitations among the existing strategies include lack of a system to ensure sustained supply of moisture in rhizosphere region. Moisture being the key factor for plant growth, as well as for microbial colonization and optimal activity, its availability can be ensured through amendment of water holding agents in the rhizosphere. Water holding polymers have been shown best fit for this purpose, where they could gain moisture during surplus availability, and release the slowly during deficient conditions. Variety of polymers having synthetic / semi synthetic origin have been proposed for similar function, however demand of completely green, biologically originating material is frequent. Therefore microbial exopolysaccharide-polymers being completely green, carbonatious materials, have gained rapid importance for agricultural utility. The polymers are important in agriculture particularly due to high water holding capacity and improvement of soil health and quality; these molecules also serve as attachment factors for microbes, thus able to induce colonization of microbes through development of biofilms. Additionally role of exopolysaccharides in promoting soil aggregation and improving microbial colonization in rhizosphere is well known. Therefore present biopolymer based technology was developed to alleviate abiotic stresses in crop plants.

Technology details/salient features

Aforesaid biopolymer was developed by using *Rhizobium* strain originating from wild habitat. Detailed characterization of the biopolymer was performed which revealed presence of multiple functional ligands that could react with different chemical moieties. The product also exhibited high water holding capacity, and potential to induce microbial colonization. Thus applicability of the said biopolymer to facilitate microbial colonization, mitigation of drought stress was analyzed and validated under *in situ* conditions. The technology has applicability for alleviation of drought stress. Similarly it has wide applicability for enhancement of microbial colonization as well as soil microbial activity. Moreover biological origin of synthesis, and ability to facilitate the colonization by plant growth promoting microorganisms including phosphate solubilizers and nitrogen fixers

further extend applicability of the technology to promote sustainable farming, with reduced dependence on chemical fertilizers.

Some of the most prominent salient features of the biopolymer-based technology include :

- Excellent gelability
- High water holding capacity
- Eco-friendly product
- Enhance soil microbial activity, and soil health
- Interact with multiple elements including micronutrients
- Induce microbial colonization
- Can be utilized in crude form
- Economic production
- Easy-to-use
- Suitable for multiple crops
- Retain activity in diverse soil types

Biopolymers developed using *Rhizobium* strain

Performance results

The biopolymer was initially utilized for alleviation of drought stress in onion crop under field conditions. Foliar application of the product was performed and response was evaluated under a gradient of water deficit stress, generated using line source sprinkler system.

Evaluation of biopolymer for mitigation of drought stress in onion under field conditions.

Similarly the product was also evaluated in brinjal crop for mitigation was water deficit stress. In onion as well as brinjal crops, the product yielded promising outcomes under moderate water deficit conditions (IW: CPE 0.55).

Microbial colonization and nutritional-enhancement ability of the product under nutrient-limiting conditions was evaluated in turmeric crop. Various formulations including diluted crude form of the product, and beads imposed significant positive influence in turmeric crop. Colonization of the rhizosphere, rhizoplane, and roots by phosphate solubilizers, nitrogen fixers and exopolysaccharide producers was significantly enhanced under the influence of biopolymer.

Cost of technology

Medium designed for production of the biopolymer involves use of simple carbon and nitrogen sources having low cost. Moreover, utilization in crude form further reduces downstream costs. Thus estimated cost of the biopolymer remains around INR/- 30 L^{-1}.

Impact and beneficiaries

Technology and the package-of-practice developed using aforesaid biopolymer for mitigation of drought stress, as well as for improved microbial colonization has been rigorously analysed in different crop plants. The technology is currently under incubation; however massive impact is expected on arid, and semi-arid regions of the country, particularly to promote sustainable farming under water limiting conditions. Similarly significant impact is also expected on several cropping systems where improvements of microbe-plant interactions are required. Beneficiaries are estimated to save significant cost particularly with respect to water budgeting, and chemical fertilizers application. Direct ecological impact of the technology is estimated in terms of improved soil health, and microbial activity, which is directly linked to crop productivity.

Team Members

K.K. Meena, Ajay M. Sorty, Kishor K. Krishnani, P.S. Minas, G.C. Wakchaure and N.P. Singh

❑ ❑ ❑