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RESEARCH ARTICLE

MICROBIAL BIOSURFACTANT: A NEW VERGE FOR SUSTAINABLE AGRICULTURE

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ABSTRACT

In some ongoing situations of changing climatic circumstances and the rising worldwide populace, there is a dire need to investigate novel, proficient efficient and normal items to assist humankind. Biosurfactants are one of the most recently investigated microbial orchestrated biomolecules utilized in various fields. The amphiphilic idea of biosurfactants has been demonstrated to be an incredible benefit, dispersing them into immiscible surface pressure and expanding the solvency of hydrophobic mixtures. Moreover, their eco-accommodating nature, sturdiness at higher temperatures, and capacity to endure a wide variety of pH vacillations make microbial surfactants the best compound for their synthetic partners. The biosurfactants blended with ecological disengages likewise play a promising part in farming. Numerous rhizosphere and plant-related organisms produce bio surfactants; their biomolecules assume an imperative part in motility, flagging, and biofilm development, showing that biosurfactants administer plant-microorganism communication.In cultivating biosurfactants can be used for plant microorganism removal and for extending the bioavailability of supplements for profitable plant-related organic entities. In the current audit, we summarize the most recent exploration of microbial blended biosurfactant creation, their application in further developing soil quality and plant illness the executives, and their utilization.

Key words: *Biosurfactants; Agriculture; Bioremediation; Hydrocarbon; Rhamnolipid.*

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INTRODUCTION

The increasing trends in urbanization, industrialization, and population growth have been linked to the emergence of a number of problems, including soil degradation, water scarcity, agricultural land shrinkage, pollution, and severe plant infections that lower crop productivity. The approaching years may witness acute food shortages and food poverty due to the direct correlation between agricultural productivity and biophysical pressures brought on by climatic adversity [1]. In addition to the quick development of novel cropping techniques, the majority of agricultural management approaches depend on the use of pesticides and synthetic agrochemicals. The widespread use of toxic chemicals harms all living forms' health and has detrimental consequences on the ecosystem [2]. A lot of effort is being made to replace synthetic products with natural ones in order to establish sustainable agriculture and the environment in light of these implications. Having outstanding interfacial and antibacterial capabilities, biosurfactants are one of the developing classes of biochemicals. They are among the most useful compounds for applications involving soil and agriculture because of their characteristics [3]. In technical terms, bio surfactants are organic compounds that are surface-active and formed during the growth of filamentous fungi, actinomycetes, bacteria, and yeast on hydrocarbon substrates [4].

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These molecules can concentrate at the interfaces to lower surface and interfacial tensions between the two immiscible systems because they have hydrophilic and hydrophobic ends [5]. In order to increase the mobility and bioavailability of hydrophobic compounds and micronutrients, they have a great propensity to increase their solubility in the aqueous medium [6]. Higher activity at lower Critical Micelle Concentrations (CMC), biodegradability, a wide range of chemical and structural variations, resilience to harsh environmental conditions, ease of production using agricultural and industrial waste, and the potential for use in a variety of industrial applications are just a few of the advantages they have over synthetic surfactants [7]. Nowadays, bio surfactants are used as natural detergents, foaming, wetting, dispersing, and emulsifying agents in the food, cosmetics, petroleum, and agricultural industries [8]. Their antimicrobial compounds are used in agriculture to control plant infections because of their varied qualities and sustainable nature. By creating a metal–surfactant combination, biosurfactants in agricultural soils increase the mobility and solubility of micronutrients, making them easier for plants to absorb [9]. Because of their distinct qualities and wide range of chemical compositions, biosurfactants are increasingly being used in agricultural formulations and are gaining traction in the agribusiness sector as emulsifiers, antibacterial agents, and solubility enhancers.

Properties of biosurfactant: When compared to synthetic surfactants, biosurfactants display an incredible range of better physical, chemical, and biological capabilities as well as an astounding diversity of chemical composition. Comprehending the self-assembly and micellization phenomenon of surfactants is regarded as crucial, as the

majority of their properties are influenced by the production of distinct micelles. Similar to conventional surfactants, biosurfactants are made up of hydrophilic and hydrophobic moieties. Biosurfactant molecules exhibit distinct phase behavior and characteristics in the aqueous system due to their dual polarity. The minimal surfactant concentration that corresponds to these surfactant aggregations is known as the critical micelle concentration (CMC). At concentrations below CMC, surfactant monomer exists alone in an aqueous solution and accumulates at air–water interfaces, changing from a free to an aggregation state. Higher concentrations of surfactant monomers have the tendency to self-assemble through non-covalent interactions that control the formation of a variety of strong supramolecular aggregates that are thermodynamically stable. Critical packing factors, temperature, counterions, and surfactant concentration all influence the shape of the surfactant micelles [10-12].

Objectives of this review

1. Important of soil quality.
2. Bioremediation of contaminated agricultural soil.
3. Plant growth promotion by elimination of phytopathogens.
4. Application in pesticide industries.
5. Deciding the meaning of natural biosurfactants in plant development advancement and other rural purposes requires a point-by-point examination.
6. The current review examines biosurfactant and their creation by microscopic organisms, with an accentuation on their contribution to oil tidy-up.
7. To identify the notable biomolecules that potentially replaces harsh surfactants.
8. Emphasize the use of biosurfactants as eco-friendly and alternative surfactants.

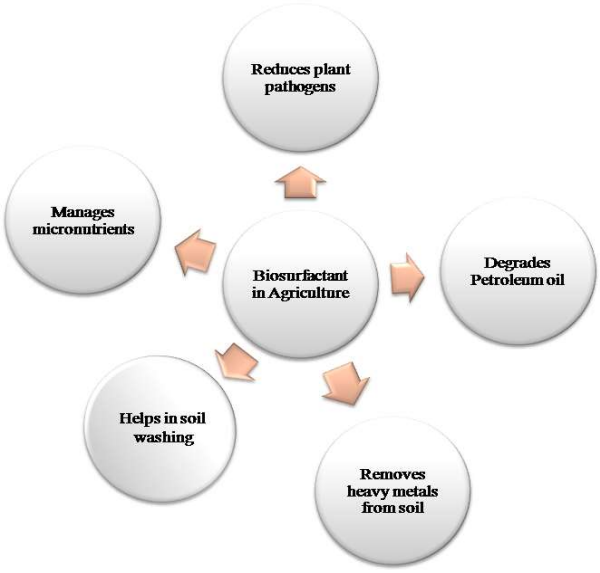

Figure 1. Biosurfactants in Agricultural Practices

Improvement of soil quality: Abiotic stress is imposed on cultivated crop plants by the presence of both organic and inorganic contaminants, which reduces the productivity of agricultural land. The method of bioremediation is necessary to improve the quality of such hydrocarbon- and heavy metal-contaminated soil. Hydrocarbons and heavy metals can be efficiently removed with the aid of microorganisms that produce biosurfactants [13]. Several technologies, including soil washing technology and clean up combination technology, use biosurfactants to effectively remove metal and hydrocarbons, respectively, because they are known to improve bioavailability and carry out the biodegradation of hydrophobic compounds [14]. Biosurfactants speed up a very significant process called the desorption of hydrophobic contaminants that are firmly attached to soil particles. This is essential to the process of bioremediation. Additionally, biosurfactants can speed up the breakdown of some chemical pesticides that have accumulated in agricultural soil [15]. Numerous findings indicate that biosurfactants play a part in soil remediation, which enhances the quality of agricultural soil. Research has been done on the biodegradation of pesticides aided by surfactin [11] and chlorinated hydrocarbons aided by glycolipids. The biodegradation accelerator property of Lactobacillus pentosus biosurfactant has been established by reducing octane hydrocarbon from soil from 58.6% to 62.8%. [12]. A range of pesticide contaminations may be bioremediated in soil contaminated with 182 types of oils. Numerous studies have found that when compared to synthetic surfactants, biosurfactants are more effective at removing organic insoluble pollutants from soil. Additional research in the literature indicates that Pseudomonas sp. needs iron to produce more biosurfactant and to further improve poly aromatic hydrocarbons. Pentachlorophenol and polycyclic aromatic hydrocarbons have been discovered to be removed from soil by rhamnolipids. Therefore, biosurfactants can be added to agricultural soil to improve its quality. The use of these green surfactants for bioremediation of soil contaminated by crude oil or petroleum is yet limited due to the high expense of producing biosurfactants (Table 1) [16].

Plant and biosurfactant producing bacteria interaction at rhizosphere: To satisfy the requirements of the world's developing populace there ought to be more farming results. To guarantee the drawn-out reasonability green innovation is being utilized. It can possibly expand the stock of supplements for valuable microorganisms related with plants. As indicated by different investigations, soil wellbeing might be worked on by the utilization of Biosurfactants. For contemporary farming, biosurfactants are essential parts. It is explored, larger part recognizing molecule, for instance, Acyl-Homoserine Lactone (AHL)are expected to the mix of against infectious combinations by rhizobacteria. Focuses furthermore exhibit that the assembly of these iotas is high in the rhizosphere when appeared differently in relation to that in mass soil suggesting occupation of AHL and AHL - like particles in rhizosphere ability. These AHL are additionally answered to add to the guideline of biofilm developmenthave as of late detailed that the biosurfactants (rhamnolipid) delivered by *pseudomonas sp* manage the course of majority detecting (cell to cell correspondence) it is likewise revealed that biosurfactants influence the motility of microorganism take part in flagging and separation along with in biofilm development [18-20]. Biosurfactant from pseudomonas cepacian debase hydrophobic herbicide 2,4,5-trichlorophenoxyacetic corrosive. *Pseudomonas aeuroginosa* has a biosurfactant that can possibly separate gigantic measures of surfactants created from pseudomonas species and has been displayed to further develop methyl parathion and endosulfan solubilisation. Nonetheless, while developing harvests, biosurfactants might be utilized to expand the accessibility of micronutrients that are many times present normally or in waste to plants. Moreover, it has been shown that rhamnolipids and lipopeptides improve plant resilience to phytopathogens by supporting plant resistant frameworks also rhamnolipids use biopesticides fungicides and against zoospore specialists have been researched in late many years. Biosurfactants created by soil organisms give wettability to soil and support the legitimate conveyance of substance manures in the dirt hence helping plant development advancement. Checking on the elements of biosurfactants shows the fundamental job of these green mixtures in manageable agriculture.

Elimination of plant pathogen by biosurfactants plant defence mechanism stimulated by biosurfactants: Biosurfactants are demonstrated as the green surfactants. Which are amphiphilic surface dynamic particles, having a hydrophobic tail and furthermore a hydrophilic head [21]. These biomolecules are utilized to eliminate phytopathogens as safeguard different plant species. All plants are regularly self-safeguarded due to having the advanced organization of protection instruments; contribute the most opposition against the phytopathogens. After section of organisms to plant, first flagging ways goes to set up including 'receptive oxygen species collection', 'particle transitions' and phosphorylation pathways [22, 23].

Table 1. Application of various biosurfactants for removal of heavy metals and hydrocarbons from soil [17]

Biosurfactant		Microorganisms	Applications in Environmental Biotechnology
Group	Class		
Glycolipids	Rhamnolipids	*Pseudomonas aeruginosa, Pseudomonas sp.*	Enhancement of the degradation and dispersion of different classes of hydrocarbons ; emulsification of hydrocarbons and vegetable oils ; removal of metals from soil.
	Trehalolipids	*Mycobacterium tuberculosis, Rhodococcuserythropolis, Arthrobacter sp. Nocardia sp. Corynebacterium sp.*	Enhancement of the bioavailability of hydrocarbons .
	Sophorolipids	*Torulopsisbombicola, Torulopsispetrophilum, Torulopsisapicola*	Recovery of hydrocarbons from dregs and muds; removal of heavy metals from sediments ; enhancement of oil recovery
Fatty acids, Phospholipids and neutral Lipids	Corynomycolic acid	*Corynebacterium lepus*	Enhancement of bitumen recovery
	Spiculisporic Acid	*Penicillium spiculisporum*	Removal of metal ions from aqueous solution; dispersion action for hydrophilic pigments ; preparation of new emulsion – type organogels, superfine microcapsules (vesicle or liposomes) heavy metal sequestrants.
	Phosphatidyl-ethanolamine	*Acinetobacter sp., Rhodococcuserythropolis*	Increasing the tolerance of bacteria to heavy metals
Lipopeptides	Surfactin	*Bacillus subtilus*	Enhancement of the biodegradation of hydrocarbons and chlorinated pesticides ; removal of heavy metals from a contaminated soil, sediment and water ; increasing the effectiveness of phytoextraction .
	Lichenysin	*Bacillus licheniformis*	Enhancement of oil recovery
Polymeric Biosurfactant	Emulsan	*Acinetobacter calcoaceticus RAG-1*	Stabilization of the hydrocarbons in water emulsion
	Alasan	*Acinetobacter radioresistens KA-53*	
	Biodispersan	*Acinetobacter calcoaceticus A2*	Dispersion of the limestone in water
	Liposan	*Candida lipolytica*	Stabilization of hydrocarbons in water emulsions
	Mannoprotein	*Saccharomyces cerevisiae*	

These kinds of enactment of the multifaceted motioning of plant chemicals like jasmonic acids and furthermore salicylic acids are controlling the late guard opposition reactions in plants [24]. Which are including in creating the antimicrobial metabolites and steadiness of cell walls. Whereas, this guard opposition generally takes a ton of invulnerability and as a rule repeal different microorganisms' assault to plant [25]. Plant microbes permit an extraordinary decrease in world rural creation during previously or after gather conditions that make a greatest danger for the developing worldwide populace to significant food preservation. thus, it has been determined that up to 30% of the all-out creation is harmed in agribusiness, in view of various plant microbes assault followed by plant illness might be during pre-or post-collect capacity conditions [26]. Thus, to control this unfriendly condition, different microbial biosurfactants orchestrated by Microbial biocontrol specialists like microorganisms, parasites and yeast have been frequently applied for plant illness the board [27].

***Lipopeptides as an inducer of plant resistant framework*:** Various scientists have advised the contribution of Bacillus cyclic lipopeptides in plant immuno-framework collaborate on different path systems. Cyclic lipopeptides surfactin and fengycin possibly actuate the plant immuno obstruction, that was first displayed on Tomato and bean culture at whatever point surfactin and lower expand fengycin applied as unadulterated particles in micromolarfocus that have prompted huge sickness restraint in tomato and bean with parasite *B. cineria* [28]. Zymoseptoriatritici is a type of filamentous growth, this microorganism found in wheat plant causing septoria leaf smear. Unadulterated surfactin utilized at specific focus going from 1 to 100 miniatures M upon foliar application incite obstruction against zymoseptoriatritici [29]. Phytophthora infestans is an oomycete or water form, growth like microorganism microbe found in tomato and potato plants causes a basic sickness called late curse or potato scourge. Different CLPs are Delivered by *pseudomonas sp.* furthermore, uncover reliable incited fundamental obstruction (ISR) setting off capabilities. It was first demonstrated that massetolide A (CLP) integrated by *pseudomonas* fluorescens strain SS101 holds ISR - inspiring movement towards the control of *phytophthora infestans* [30].

Other strain CMR12a of *pseudomonas sp.* having incredible obstruction towards *R. solani* (*Rhizoctonia solani* organism) for initiating plant insusceptibilityand furthermore safeguards*Brassica chinensis* versus *R. solani* [31-33]. The *pseudomonas* CLPs like WLIP, lokisin, entolysin and orfamide additionally favourably animate the obstruction in monocots like rice plant against *C. miyabeanus* and *M. oryzae* [34-36]. CLPs of iturin bunch likewise having obstruction for enlistment of strawberry plant resistance. Iturin A has comparative action compare with surfactin in strawberry leaf against *Colletotrichum gloeosporioides* contagious microbe and furthermore safeguard the cotton plants by prompting plant guard quality articulation against *Verticilliumdahliae* (parasitic plant microorganism) attack [37, 38]. Mycosubtilin (iturin family) is a more huge lipopeptide, which enact defencing natural resistant reaction of salicylic corrosive and jasmonic corrosive flagging pathway in grapevine plant against necrotrophic organism *Botrytis cinerea* [39]. Antifungal bacillomycin D orchestrated by *B. velegensis* SQR9, which is a most sufficiency than surfactin to repress microorganism movement of P. syringae and B. cinerea in Arabidopsis plant through actuated fundamental obstruction (ISR) [40]. Cleaned surfactin can prompt defencing pathway towards the ' cucurbit fine buildup ' contagious sickness in melon plants [41].

Rhamnolipids against plant pathogen: Rhamnolipids (RLs) are one kind of glycolipid go about as biosurfactants incorporated by a few microbes animal categories including not many *pseudomonas sp.*furthermore, *Burkholderia sp.*and furthermore as of late known that rhamnolipid may prompt natural resistant framework in plants [42,43]. It was tentatively resolved that rhamnolipid initiated nearby resistant reaction against *P. syringaepv*. tomato, *Botrytis cinerea* and *Hyaloperonosporaarabidopsidis* having different safe flagging pathway that in view of specific microorganisms and furthermore set off a resistant reaction, which is associated with *B. napus*neighborhood opposition with any physiological problem counter to the hemibiotrophic growth *Leptosphaeria maculans* and *B. Cinerea* [44-46]. On these different plant species a specific extensive variety of rhamnolipid fixation as from 0.005 to 1 mg/ml are utilizing to make a protection reaction flagging [47, 48]. Antimicrobial

exercises are essentially expected to protection of post-gathering seeds and organic products from post-collecting plant microorganisms for overall expanding worldwide populaces. However, scientists can't well show the way that guard security could likewise be reason for plant insusceptible safeguard reactions [49]. However, when we use independently, rhamnolipids are driving antioxidative responses, causes playing a significant restraint movement of parasitic sickness in cherry tomato natural product and when applied in coupling with the biocontrol yeast specialist like Rhodotorulaglutinis in cherry tomato organic product, a huge decrease impact follow up on Alternaria alternata contamination thinking about a proficient security [50]. This kind of security is corresponded with a significant enlistment of protection-related chemicals and an appreciation the antimicrobial metabolites [51]. As of late exhibited that the rhamnolipids are situated towards the phospholipid bilayer phosphate bunch in plants. At the point when it (RLs) cooperate with the lipid bilayer and don'thave any tremendous impact on lipid elements, by the by the capability of phytosterols can change the glycolipids action and prompt destabilization of plant plasma layer, subsequently, this subtle effect of the lipid dynamic nature safeguard the plant microorganisms followed by plant protection acceptance [52].

Plant pathogen elimination: Many biosurfactants derived from bacteria are thought to be promising biocontrol molecules for attaining sustainable agriculture since they have antimicrobial activity against plant infections. Biosurfactants made by rhizobacteria are recognized to exhibit antagonistic qualities [53]. The biocontrol mechanism of plant growth-promoting bacteria, such as parasitism, antibiosis, competition, induced systemic resistance, and hypovirulence, is facilitated by the application of chemical and biosurfactants in agriculture. Surfactants are employed in large quantities in agriculture to amplify the hostile properties of microorganisms and microbial products. The significance of surfactants in enhancing the insecticidal effects of other systems has been shown in a number of in vitro and in situ investigations [54].Furthermore, these surfactants are employed in conjunction with a fungus called *Myrothecium verrucaria* to eliminate weed species that have a negative impact on biodiversity and land production. Hence, both synthetic and biological surfactants contribute differently to the direct or indirect eradication of plant pathogens at various stages of agricultural processes. A few instances of how biosurfactants are crucial for inhibiting phytopathogens are given in the section that follows. *Pseudomonas* and *Bacillus* rhizospheric isolates that produce biosurfactants have demonstrated biocontrol of *Dickeya spp*. and *Pectobacterium*, which cause soft rot. Researchershave shown that rhamnolipids can stimulate plant immunity, which is thought to be an alternate method of reducing plant pathogen infection [55]. They have also demonstrated that rhamnolipids can inhibit zoospore-forming plant pathogens that have developed resistance to commercial chemical pesticides. Rhamnolipid has also been proven to be an insecticidal substance by recent research.

The oomycete pathogen *Phytophthora capsici*zoospores can be lysed by the biosurfactants produced by the plant growth-promoting Pseudomonas putida, which is also the culprit behind cucumber damping off. *Aspergillus sp.*, *Biopolarissorokiniana*, and *Fusarium* species are only a few of the phytopathogenic fungi that are inhibited in their growth by the lipopeptide biosurfactant that *Bacillus* strains create. A biocontrol agent can be made of this kind of biosurfactant [56]. The lipopeptides biosurfactant surfactin isoform, which is produced by the *Brevibacillusbrevis* strain HOB1, has strong antibacterial and antifungal properties that can be used to control phytopathogens. It is commonly known that fluorescent *pseudomonas* with the capacity to produce biosurfactant have antifungal properties. These include the ability to prevent the growth of fungal pathogens such as *Pythiumultimum*, which is responsible for damping off and root rot in plants, *Fusariumoxysporum*, which causes wilting in crop plants, and *Phytophthora cryptogea*, which rots fruits and flowers. *Pseudomonas sp.*has been identified as biocontrol agents against *Verticillium microsclerotia*, which is primarily responsible for potato wilt. *Pseudomonas sp.* strains stop *Rhizoctonia solani*, a harmful fungus, from growing.

CONCLUSION

Surfactants have a few applications in farming and agrochemical enterprises. Be that as it may, there is interesting utilization of biosurfactants which are more natural agreeable. Precise job of surfactant in working with different frameworks as biocontrol specialists is yet not much gotten it and warrants examinations. Like examinations may assist in supplanting unforgiving compound surfactants with green ones. The utilization of horticulture squander for overproduction of biosurfactants likewise requires a more serious idea. The substance syntheses of biosurfactants detailed strong biocontrol specialists can be adjusted by changing the creation conspire. This approach might prompt biosynthesis of exceptionally target indicate green surfactants For the most part sorts of Pseudomonas and Bacillus appear recorded as a hard copy as creators of biosurfactants showing that vitally limited genera have been focused on till date. A state-of-the-art approach, for instance, reasonable metagenomics is the best conceivable degree of major which will attempt to provoke disclosure of novel green surfactants. Unprecedented work on green surfactants is critical to thwart the unpleasant effects of designed surfactants generally used in various business regions including agrochemical adventures. Consequently, it will in general be construed that a joined commitment by researchers from various fields, for instance, sub-nuclear science, normal science, microbial science, computational science, environmental science is basic.

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