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USE OF BENEFICIAL SOIL MICROORGANISMS IN INCREASING THE SOIL QUALITY AND HEALTH OF THE PLANTS. – A REVIEW

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ABSTRACT

Agriculture is the main source of our daily consumed food production. The increasing population is giving rise to various inventions to new agricultural technologies which in turn will increase the production of the crops by increasing the quality and quantity even in a limited available agricultural land. Healthy growth of the plants depends on the nutrition they get from their environment and also the quality of soil they grow in and also the quality of water which is used for their growth. So it is the primary responsibility of the farmer to check on the quality of the soil the crops are growing in so that the plants will grow with all the nutrients they are expected to be contained. If the quality of soil is not healthy then the plants grown in such conditions will have lots of pest infections and also diseases. A concept called Integrated management of the crops is a new approach for the production of the crops, which aims to increase the crop yield and also trying new techniques to minimize the negative impact of the changes in the environment and also by implementing various practices like rotation of the crops, proper selection of the crops suitable for the geographical environment and also carefully selecting the fertilizers and the pesticides.

The microbes which are present in the soil in which the plant is growing interact with the plants helping them by exhibiting the process of symbiosis where they provide required nutrients to the plants naturally also control pathogenic attacks on the plants and also helps in stimulating the growth of the plants in a positive manner. These all collective actions have a positive impact on the production of crops. Even when the beneficial impact of these micro-oganisms is known still their direct implementation in

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Subject: Life Science

agriculture is still limited. This shows that there need to be more research carried out in the field of soil microbiology so that we can increase and multiply these beneficial soil microbes so as to grow more nutritional crops without using chemical fertilizers and pesticides which has a harmful impact on human body. *Bacillus* genera is the most common microbe who has qualities to benefit the plant growth and also to control many plant diseases. In this review article more focus is on the beneficial role of *Bacillus* genus microbe, which is present in the soil in the healthy growth of the plants.

Keywords: Biofertilizers; biopesticides; sustainable agriculture; crop safety; *Bacillus* sp.; plant growth promoting

1. Introduction

Agriculture is the most prominent option, in order to meet the demand of the worlds increasing population for food. Now as we all know, that the rate at which the population is increasing, is on hike and it is going to speed more with the coming years, therefore it is the primary necessity to focus more on the new techniques, where we can improve the quality of crops, keeping in mind the time of production and also quantity[1]. But the main challenge, comes to save the plants from the pathogens, which inborn various diseases, which in turn gives rise to the loses of crops, along with economic crises. The soil which is a primary medium for the growth of the plant continuously loses its fertility, due to constant crops growing in it, which gives rise to the decline in the quality and quantity of the crops growing in it. So in order to keep the growth of these crops at its peak and also to save the plants from pest, various external factors like chemical fertilizers and also pesticides which are made, using chemicals, are forced to be used in the process of agriculture. But the long use of these external factors, have gave rise to various dreadful health diseases, in humans and animals and also have created a negative impact on our environment, including the degradation, on surrounding air quality and also lowering down the quality of underground water. In order to reduce the use of these chemical fertilizers and also pesticides, there was a need to search for some healthy options, who can substitute these chemical constituents at least to some extent. So the researchers have come up with a concept called biofertilizers and another is biopesticides, where bio denotes something that is alive, so these both are made up with something that is living. Next we also have now, a concept of biotechnology, which can be used to bring a positive boost in the field of

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Subject: Life Science

agriculture. So these alternatives can help us to increase the production of the crop through the limited agricultural land, and also can help us restore the fertility of the soil along with stimulating the growth of the plants and which indirectly will reduce the production cost and also will have a positive impact on the environment which we had faced due to the use of chemical fertilizers and also pesticides[2].

Soil which is a direct medium, in which we grow plants, has to be of great quality, which can provide the needed nutrition to the plants, so as for their proper growth. It is found that, the soil in which the plants grow, contains many microorganisms, such as various fungi along with bacteria, which are actually beneficial to the plants, as they provide required nutrition for their growth [3]. It is also seen that. they also stimulate the growth of the plants. by producing hormones. that are needed by the plants. for their healthy growth. It is also observed that, they help in controlling the plant disease causing pathogens and also improve the structure of the soil, and also in the bioremediation of the contaminated soil due to metals[4] . Beneficial soil microbes are seen to promote directly or indirectly the growth of the plants [5-8].

The invention of biopesticides along with biofertilizers, is a gateway towards the improvement of the better yield of the crops [9]. Biofertilizers have seen to be used in many crops like cucumber, sugarcane, various varieties of rice, oats, beet, tobacco, egg plant, coffee, potato, coconut, fan cypress, pepper, grass sudan, flax, tomato, soybeans, lettuce, beans, cotton, strawberries, black pepper, sorghum, sunflower, neem, alfalfa and many more[2]. Biopesticides also have shown an important role in the protection of the crops, to a big extend, though, it is still not successful in substituting chemical pesticides completely [10] . It is observed that, the pest or the phytopathogens, which are attacking the plants, are much in number and which in turn are causing us a huge economic losses. *Bacillus* genus is the most used microorganism as a biofertilizers and biopesticides. This can be used in corporation with different indirect or direct methods, which can benefit the plants growth. The direct method mostly include its property to supply nitrogen along with potassium and phosphorus including many minerals, to maintain the plant hormone levels, whereas the indirect mechanisms consists, if secreting antagonistic substances, which inhibit pathogens of the plants or to increase the capacity to resist the pathogens[4]. *Bacillus thuringiensis* is the most widely used biopesticides all over the world.

This research gains the importance of microorganisms, which are contributing to increase the yield of agriculture, especially the genus *Bacillus*, which is seen to be widely used micro-organism, as a

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June 2025
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Subject: Life Science

biofertilizer. Lots of research is going on, so that more insights can be revealed and this knowledge can be commercialize so that every farmer can benefit. Therefore in this review, main focus is on the *Bacillus* genus, present in the soil and also its benefit in increasing the plant health.

2. Relation between Soil and Plant Health

Before trying to develop biofertilizers or before making their formulation, it is important to understand the formation and contents of the soil, in which the plant grows. Soil is the main medium for the growing of the plants. The soil formation is basically from big rocks, it fundamentally consists of many elements such as clay particles, sand particles, silt, lots of organic matter, and some quantity of water. In the presence of carbon dioxide, the soil and water dissolves the particles of various minerals at a very slow rate and then release nutrients, which in turn is taken up by the plants for their healthy growth. The plants in corporation with the microorganisms, present in the soil, helps in the recycling of the nutrients of organic matter, which in turn are decomposed and nutrients are returned back to the nature, so as to be reutilized by the living forms, for various life processes. This results in the conclusion, that good health of the soil is the basic key for the successful healthy growth of the plants[11]. Our scientists refer the quality of the soil as the health of the soil, as it defines the quality of the soil in order to maintain the healthy growth of plants and animals [12].

So we can directly correlate that, to get the healthy crops, we need to concentrate on the health of the soil, as soil is the medium which we are using, for growing crops, and as plant roots depends on the soil for its nutritional needs, as it absorbs from it. Beneficial soil microorganisms, are seen active and are able to suppress the harmful microbes and boost the growth of the plants. Soil is said to be healthy, only if it contains enough nutrients which are needed by the plants and the soil is well drained and have a good capacity for aeration which in turn helps the roots to get well settled and go deep for better support. The soil should also be free of pests, which can interfere with the growth of the plants and make provoke diseases in the plants causing huge economic loses, if not taken care of [13]..

Maintaining soil health is not so easy, as it depends on various factors, such as loss of organic matter due to many uncontrollable factors, erosion of soil, acidification of the soil, imbalance of nutrients, contamination of the soil, water logging due to floods, salinization and loss of biodiversity of the soil.

Relation between soil problems and soil management practices with plant health is shown in figure 1.

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Figure 1:- Relation between soil problems and soil management practices with plant health

So if the soil is detected with any problem then soil quality is assumed to be affected. Lets take for example, in compact soil type, where there are hardly any internal space or pores, which stops any larger organism to move out or in. Then if we talk about soil who has hit with water logging, will surely result in soil denitrifying [13,14]

There are various factors responsible for degradation of soil health, one of them are various practices implemented in agriculture, like tillage[14]. Tillaging of the soil, may be responsible for loss of organic matter on large scale, speeding up erosion, may also break down soil aggregates. In other case, if the soil is very much compact, then it is not easy for water to get into it and the roots are not able to develop easily, this results in the erosion of soil as the roots not able to hold the soil and this results in poor production of the crops. The soil which faces salinity is again a cause for depletion of soil's health [15]. Water which is used for irrigation, mostly contains many mineral salts which in turn can affect the infiltration of water in the soil [16].

In order to get good healthy crop yields, many steps have been taken especially in the management of the soil, then techniques are developed to suppress the pest attack and focus is kept on the research of beneficial soil microbes. In order to get more yield from limited land, chemical fertilizers and pesticides were used in agriculture after regular intervals. Fertilizers are basically synthetic elements of nutrition made in laboratory, which when added to the soil and plants help the plants by providing the nutrients

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June 2025
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Subject: Life Science

externally and pesticides are added to control the diseases causing germs and insects. So both these elements are important to get healthy crop yield [17] .

But at the same time, they also disturb our environment to a larger extend, and directly and indirectly, they also cause harm to human body and also disturb the balance of ecology of the microflora present in the soil and the surrounding environment and also degrade the quality of soil, which results in decrease of the beneficial microbial community. The continuous use of chemical fertilizers and pesticides have resulted in delays of the rains and shift in climate change to a larger extend[18,19], for example erosion of soil, loss of organic matter is observed in various agriculture areas, then also nutrients imbalance is been observed.

Continuous application of chemical fertilizers along with pesticides have resulted to adverse effects on the health of the soil and also has affected the productivity of the crops and have given rise to problems in regards to human health and other environmental issues.

3. Microorganisms as Biofertilizers

As a rise in the issues related to chemical fertilizers and pesticides, various alternatives has been fetched, which led us towards the progress of sustainable agriculture with new eco friendly techniques, which included use of biofertilizers and also biopesticides.

The best advantage of biofertilizers was that, it can be inoculated directly on the surface of the seeds as well as the roots of the plants [20].

Biofertilizer basically consists of beneficial microorganisms which are living, these are applied to crops in various ways like to the surface of the seeds, then also on surface of the plant or even on the soil, then in turn these microorganisms make the nutrients available to the plants in the simpler forms by their biological activities like secretion of enzymes, etc., which directly or indirectly helps in promoting the healthy growth of the plants [3].

It is found that these biofertilizers enrich the soil through various natural processes like fixing the atmospheric nitrogen, stimulating growth promoting hormones in the plants, and also in solubilizing of phosphorus [21,22].

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Subject: Life Science

Depending on their functions and nature, these can be classified in different groups. These biofertilizers are mostly eco friendly and also cheap when compared with chemical fertilizers [23].

There are many microorganisms which show properties which are beneficial to the healthy growth of the plants, like decomposing of the biodegrade substances and returning the nutrients back to the environment, then fixing of nitrogen, again in mobilizing of certain mineral in the form where the plants can directly absorb the nutrients which in turn increases the productivity of the crops [24].

There is a vast population of different types of beneficial soil microbes in the area of plant rhizosphere , this is the soil which is surrounding the plant roots. In this area the most microbes which are found abundant are different types of fungi and bacteria [25].

It is observed that the beneficial soil bacteria which are free living in the rhizosphere, by inoculation colonizes the roots of the plants and then makes the nutrients available for the healthy growth of the plant, and are called as plant growth promoting rhizobacteria, as they secrete and produce many chemicals in the roots of the plants which are seen to promote the growth of the plant[26,27].

These microbes which include different types of bacteria and fungi are used as biofertilizers as they promote the growth of the plants and also develops stress tolerance and also help in providing nutrition to the plants. These beneficial microbes have also shown properties to defend the pest attack on the plants therefore they can also be used as biopesticides. It is also observed that, these beneficial microorganisms are capable of degrading and also detoxifying harmful inorganic and organic compounds, which get collected in the soil and are also responsible for the degradation of the quality and fertility of the soil.

It is observed that these beneficial soil microbes show the bioremediation action which results in the benefit of the soil, the plant grows in and also promote the healthy growth of the plants [28].

Bacterial biofertilizers are basically a group of bacteria that are seen to help the plants making them available different nutrients which are required by the plants for healthy growth in the soil[29].

They are able to solubilize potassium along with phosphorus and also many more nutrients, also are able to fix nitrogen. It is also observed that they also secrete some organic compounds which are responsible to suppress pathogens who are stopping the healthy growth of the plants.

Airo International Journal
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Volume:2 Issue:3
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The most bacterial types used in biofertilizers are mostly Rhizobium , Azospirillum, *Bacillus* and Azotobacter as shown in the Figure 2[30,31].

Depending on the association of these beneficial microbes with the plants, it is observed that in Rhizobium, which is mostly used for legume crops as it resides in the root nodules of these types of plants and Azospirillum along with Azotobacter are used for crops which fall in non-legume family. As per the properties shown, Acetobacter is found to be more specifically associated with sugarcane [2].

Implementing these bacteria in the formulation of biofertilizers, for speeding up the healthy growth of the plants and increase the crop yield, also improving the quality and fertility of the soil the plants growing in and also an alternative as a biocontrolling phytopathogens for pesticides, indirectly helps in sustainable agriculture by providing eco friendly alternatives to pesticides and chemical fertilizers.

It is observed, a symbiotic association of some fungal biofertilizers within the roots of some plants , this type of relationships are mostly referred to as mycorrhiza, which is seen to release nutrients, specially phosphorus. As some nutrients are unable to easily diffuse in the soil and therefore the roots deplete of the nutrients, which are absorbed from the surrounding.

*Arbuscular mycorrhiz*a are also a beneficial soil microbe which is observed to form a symbiotic association with plants and other crops. This association is mainly through the roots of vascular area of the plants[32].

It is observed that these fungi, tent to extend in the depletion zone, which indirectly increases the absorption area of the respective plants, so as to improve the availability of the nutrients to the plants [33].

The symbiosis association of arbuscular mycorrhiza fungi is observed to improve the microenvironment in the rhizosphere of the plant which indirectly increases the speed of absorption of mineral elements by the respective plant, it also improves the ability of disease and stress resistance capacity of the plant , and also promotes healthy growth in that plant [34].

It is observed that, using biofertilizers in agriculture has its own advantages, as we have seen above, for example, its easy to use for the farmers and again it is cost effective as compared to chemical fertilizers and it also is beneficial and effective for increasing the fertility of the soil and also the plants. But still its not easy for biofertilizers to spread its uniqueness as it has some hurdles which do not allow them to be

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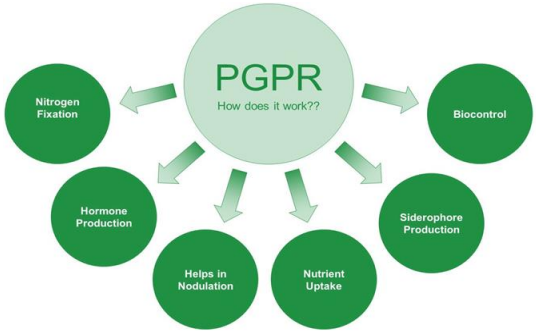
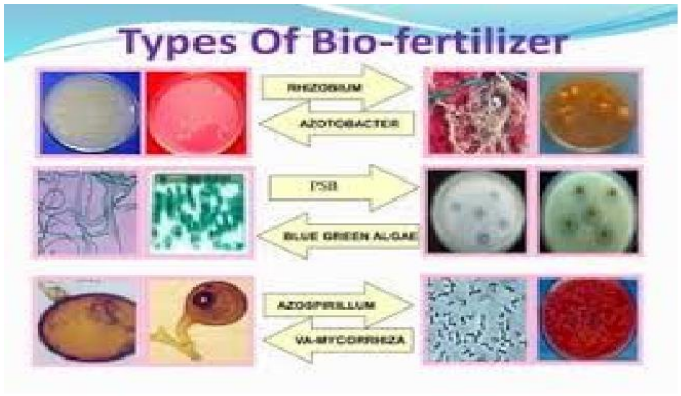
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

the favorite option of farmers still. Some hurdles include these biofertilizers still need a deep laboratory observations with many more tests so as to find out the best and strong strain of that particular beneficial soil microbe.

More on these issues, again manufacturing of these biofertilizers and also the quality control of biofertilizers involve highly sensitive technology and also required qualified and well trained employees, again there is lack of financial help in this industry and also transporting this product in a good quality is an issue. Then comes its storage, it needs a highly sterile storage area which is not always easy to find, so overall scenario suggest this process very much complex.

So these issues should be considered seriously which also include the poor quality of these products and also use of strains which are not suitable for its formulations should be avoided, then again as we all know these strains have a very short shelf life so that has to be taken care of and also there is lack of technical well qualified employees and also there is lack of awareness among most farmers, and then comes the environmental limitations like unsuitable temperature and many more, etc[35].





A comparison of microbes which are utilized in the formulation of biofertilizers and biopesticides are enlisted in Table 1.

Airo International Journal
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Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
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Microbial Biofertilizers and Biopesticides		
Sr. No	**Advantages**	**Disadvantages**
1	Improved Soil Fertility	Limited Shelf Life
2	Eco-Friendly and Sustainable	Slow Nutrient Release
3	Cost-Effective	Environmental Dependency
4	Enhanced Plant Growth	Requirement of Specific Conditions
5	Improved Soil Structure	Competition with Native Microorganisms
6	Reduction in Chemical Dependency	Lower Immediate Yield
7	Enhanced Crop Yield and Quality	Complex Application Process
8	Sustainability in Organic Farming	Lack of Awareness and Expertise

4. *Bacillus* spp. Beneficial for Plants

The most commonly and popularly used microbial species are *Bacillus* and their healthy strains in the formation of biopesticides, biofertilizers, and many other biotechnological tools. These bacteria are found to promote the growth of the plants and also seen to suppress the growth of pathogens infecting the plants using direct or indirect methodology. Their ability to obtain nutrients such as potassium, nitrogen, along with phosphorus, and also minerals to some extent and also regulate the levels of hormones in the plants.

The indirect mechanisms mostly include the secretion of many antagonistic elements which inhibit the growth of plant pathogens or increases the resistance of the plants towards the respective pathogens [36]. So it can be concluded that strains of Bacillus are found effective in the list of bio-control agents when induced to the plants as it prevents the colonization of the respective pathogens by anti-biosis approach towards the pathogens and also by the induction process of systemic resistance in the respective plant in which it is induced.

Many species of *Bacillus* are identified to fix nitrogen from the atmosphere and make it available to the plants by mixing it in the surrounding soil, this is possible only due to the presence of *nif*H gene else through the lab activity on nitrogenase activity [37]

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Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

As we all know that phosphorus is a macro nutrients required by the plants for its healthy growth but this nutrient is found in a complex manner which plants are not able to absorb so these *Bacillus* solubilizes this phosphorus and makes it available to the plants in the simple manner where the plants can easily absorb it and utilize it for their healthy growth [38]. It is also observed that some species of Bacillus are seen to secrete siderophores which is responsible to bind zinc and iron, which results in increasing the availability of some metals which are in their soluble forms and they help plants in the acquisition of zinc and iron [39].

In addition to all this, it is also proved that many species of *Bacillus* secrete phytohormones, like abscisic acid, cytokinins, gibberellins and auxins which complete many roles like enlargement in plant cell and also in cell division and enlargement in the roots overall size[40].

It is also identified that many genes of different species of *Bacillus* are participating in IAA biosynthetic pathways which results in the growth of the roots of compatible crops for examples potato[41,42].

Many strains of Bacillus are also found to produce gibberellins and Cytokinins and therefore are directly or indirectly involved in promoting the growth of the plants[40].

Several species of *Bacillus* are seen to secrete Abscisic acid which is responsible for the capacity of tolerance of stresses caused for example salinity, chilling, drought, heat, ,etc. and also in the process of dormancy[40].

It is also observed that different Bacillus species secrete many phytohormones, which are seen involved in the defense response to biotic stresses which the plant has to go through, for example ethylene and jasmonic acid, Mostly inhibiting the pests and necrotrophic pathogens , salicylic acid, mainly against biotrophic pathogens[43].

These phytohormones are seen to react with the tissues of the roots and are capable of inducing the defense system in plants which they might face in the future by various pests through a process called induced systemic resistance[43]. Bacillus can help the healthy growth of many crops through these phytohormones as shown in Figure 3.

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Multidisciplinary

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Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

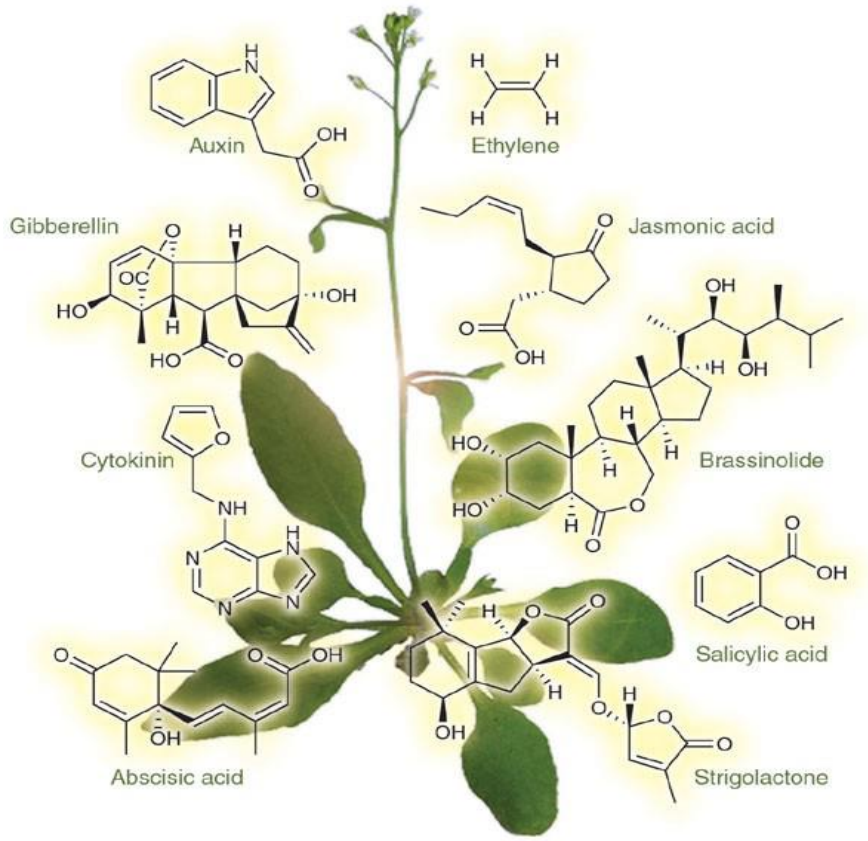

Figure 3. effect of Phytohormones on the growth of the plants.

Table 2. Commercial Bacillus-based biopesticides currently in use.

Microorganism	**Producer**	**Action**	**Brand Name**
B. subtilis	Green Biotech, Korea Agri Life	Fungicide	Biotilis
B. thuringiensis var. *tenebrionis*	Valent BioSciences	Insecticide	Lepinox plu Novodor
B. thuringiensis var. *aizawai*	Certis Green Biotech, Korea	Insecticide	Agree Turex
B. thuringiensis var. *israelensis*	Valent BioSciences Becker Microbial Biotech Int'l	Insecticide	VectoMax Aquabac Bacticide

Airo International Journal
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Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

	Clarke Mos. Cont.		BTI granules
B. amyloliquefaciens	BASF Ag products Syngenta Group pH Douglass Plant Health Bayer CropScience LP Certis Valent BioSciences	Fungicide	Serifel Integral Taegro Companion Maxxx Serenade Amylo-X
B. pumilus	Bayer CropScience LP	Fungicide	Sonata AS YieldShield
B. sphaericus	Valent BioSciences	Insecticide	VectoLex Kodiak

Now we all are aware that the health of the soil plays an important role in making the plants grow healthy and also are now aware the role of various microorganisms, like *Bacillus* which is a type of biofertilizers as we saw in the above text, but there are many more problems in relation to the healthy growth of the plants.

There is a wide range of insects and also different types of fungi which play a key role in destroying the crops. It is observed by the scientist that the *Bacillus* sp. shows many more properties which inhibit the growth of pest on the plants by secreting many secondary metabolites, like lytic enzymes, which are toxins against many pathogens of the plants which are responsible for causing various diseases in the plants[3].

There is a big future in the world of agricultural biotechnology as a role of biopesticides in which these *Bacillus* sp. has shown lots of positive approach towards various fungal diseases. Lots of research is already going on and many are converted in to commercialized products which are giving positive results, some of them are listed in the Table 2.

Lipopeptide surfactants, such as surfactin, fengycin, and iturin families are seen to be secreted by the metabolites shown by *Bacillus* sp. It is observed that Bacillus secrete various Antagonistic metabolites which include fengycin, surfactin and iturin families which are nothing but lipopeptide surfactants and

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Volume:2 Issue:3
June 2025
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they are seen to be potent biofungicide and also is seen to be implemented on various crops so as to inhibit various fungi which show pathogenic properties in plants, for examples *Magnaporthe, Botrytis cinerea, Fusarium graminearum, Magnaporthe, Oryzae, Fusarium oxysporum* and many more[44]. It is also observed that many species of *Bacillus* secrete several enzymes(lytic) like -1,3-glucanases, chitinases, lipases, glucosidase and proteases, as they have the ability to degrade the cell wall of fungus (proteins , glucans and chitin. But the antagonistic behavior of these enzymes may depend on quorum quenching, which is seen to interfere with molecules which can sense quorum which are used by many of these pathogens. Same is the case of enzymes containing lactonase, which are found in many Bacillus and are also seen interfering with N-acyl-L-homoserine lactones, which are known quorum-sensing molecules. It is also observed that strains of *Bacillus* contains many chemical compounds having antibacterial and antifungal properties against many plant pathogens, some of them are bacteriocins and macrolactins.

In recent studies, it is observed that *B. amyloliquefaciens L-1* has shown excellent qualities of a biocontrol agent suppressing pear ring rot[45]. It is also observed that *Bacillus* species are capable to produce.

Many metabolites, and compounds containing various chemical which are seen to induce systemic resistance, which indirectly is connected to the immune in all plant organs[46].

In melons , *B. subtilis* strain (UMAF6614) when induced , various responses in relation to defense were induced like SA secretion and JA , which in turn made the plant resistant against powdery mildew[47].

As specified earlier, the genus Bacillus has the ability to produce many chemical compounds which benefit the overall health of many crops. But there are still few factors, which are affecting the overall production of the secondary metabolites, which are needed to understand the actual effect of various compounds on the crops.

Other factors (Abiotic), such as availability of oxygen, temperature and pH are also taken into consideration, as they influence directly or indirectly the secretion of many metabolites which plants are in association with various microbes[45]. At the same time, we cannot ignore the importance of Biotic factors, for examples root exudates are required for the establishment of rhizosphere, as they provide nutrition for the bacteria which are associated with the respective plants. Also in the complexity of the rhizosphere ecosystem, where there are many more microbes present, Bacillus also has to compete over

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these microorganisms, by secreting metabolites so as to defend these bacterial as well as fungal competitors[44].

We also need to focus on the factor that at times Bacillus may show an association with other microorganism which are beneficial for the healthy growth of the plants, as they also help in fighting again the phytopathogens.

It is important to put focus on the extended use of some beneficial microorganisms(*B. thuringiensis*) which are used as biopesticide. It is observed that, Cry proteins, which is a type of insecticidal protein , is secreted by *B. thuringiensis* along with spores, which are proved to be toxic against many insects, which cause heavy damage to crops resulting in financial losses.

Delta-endotoxins, which are insecticides, are applied on the leaves of the plants, or many times mixed with the soil in which the plants are to be grown as they have shown toxicity against *dipteran coleopteran, or lepidopteran* insects and also nematodes, depends on the type of Cry toxin, which is secreted by subspecies.

Once these beneficial microbes ingest , then the toxins are dissolved by the alkaline media which is present in the midgut of the insect and then are converted into a toxic fragments, which later on binds to the receptors present at the membranes of apical microvillus at the epithelial of the midgut cells[48].

Later on these toxins gets inserted in the cell membrane forming pores, leading to an imbalance in its osmotic, as a result the cell ruptures, leading to the loss of the integrity of the midgut at epithelium, which later on lead to the death of that particular insect which is caused by the tissue colonization and bacteremia[48].

Due to this effect now we can see this *B. thuringiensis* bioinsecticides product is commercially available in stores[49]. *B. thuringiensis* bioinsecticides which is used widely as a bioinsecticides also has many challenges to face, as it has limitation. The main issue with this species is that they can only be sprayed on leaves but cant be used on the complete plant[50]. Due to this issue, transgenic crops based with *B. thuringiensis* are used. This is again a topic of debate , which can be at high risk to the health of humans who consume this food[51].

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June 2025
Impact Factor:11.9
Subject: Life Science

Due to the use of these biopesticides in long term, made some species of these pathogenic insect resistance to these toxins. Therefore, new strains of *B. thuringiensis* who can secrete new type of proteins are on the high demand research for several years. Developing genetically modified crops and protein engineering was possible only due to the tools available in genetic molecules, which directly or indirectly produces toxins. This has created a new subject regarding the foods that are genetically modified, as there is no scientific evidence related to human health risks. There is a lot of positive evidence related to the safety of crops grown using *B. thuringiensis* and also safe for consumption by humans[52].

5. Implementing in practical life

It is in the rhizosphere zone, where the defense is given by the beneficial microorganisms againt the diseases causing microbes present in the soil, either by antagonism or competition. Induced systemic resistance and systemic acquired resistance are the two main types of resistance which are induced against the response to signals which comes from microorganisms.

Induced systemic resistance is the result of plant roots getting exposed to the rhizobacteria present in the in the soil. Due to intensive research in the soil microbes, now there are many beneficial soil microbes known, which helps in promoting the growth of the plants, for example, fungi, bacteria etc., which can help the plants to overcome issues like plants under stress, like the soil which has very less organic matter, or the soils which may be dry, due to some environmental issues, like drought.

The major drawback with these biofertilizers is that they are tested mostly in greenhouse conditions or in the laboratory , where they perform very well but when they are applied in the fields, they do not give the same results, this might be possible due to change in the environmental conditions like the rains, or the different type of the soil on any geographic zone, and also can be the diversity of the crops. This can be a reason why farmers do not use these biofertilizers as they dnt get much results[26].

There is a scope of research in the area of what are the factors that affect the process of production of these secondary metabolites and what is its actual role in stopping some of the phytopathogens and what is their role in increasing the immunity of the crops. The next important factor is the shelf life of the beneficial microbes used in the making of this biofertilizer, as they have a very short shelf life. Care need to be taken while storing these biofertilizers and also lots of care is needed when in transportation, and also the increase in the production cost is a concern.

Airo International Journal
Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

The other major factor of concern is the issues with regulatory in the registration of this product, which makes this process more complex and also complicated[53].

The ability of the species of *Bacillus* , to show the activities of being a biofertilizer and to inhibit the phytopathogens has been known widely, which has lead the economical importance of the products containing Bacillus. It is also proved that the species of *Bacillus* have the capacity to secrete many secondary metabolites, which play many roles in the protection of the crops and also promoting the overall growth of the plants. Researchers need to take a note that the isolation of these metabolites from these microorganisms are at a low yield, which results in difficulties in studying the biological activities of these microbes in vivo and also in vitro. Therefore it is important to invent some latest technologies which can solve these problems[54].

As compared with the traditional strategies , it is observed that the tools which are Genome-based, are more advantageous in the investigation of Bacillus thuringiensis, which also includes the identification of the genome sequencing (PacBio or Illumina ,MiSeq) bacterial strain (16S rRNAbased approach), genome annotation, SwissProt , analysis assembly (HGAP), GeneMarkS, and bioinformatics, etc[55].

This may give rise to many new compounds with controlling application of holographic microscopy, bioinformatics, deepCNN and genetic engineering[56].

For the need of new strains, there can be isolation of new compounds, and later on these new compounds can be applied in the agriculture, in the form of antifungal or even positive hormones, or even can help in the healthy growth of the plants.

These new products which are basically microbial based, needs a lot of deep research, so as to get the best results, which may be more surprising than what is known now, and also the trust of the farmers is to be gained, as they will be the primary users of these products in their fields.

Airo International Journal
Peer-Reviewed
Multidisciplinary

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

6. Conclusions

Soils health is the key to increase the good health of the crops grown in the soil. From ancient times, farmers have focus on increasing the health of their fields soil, by adding pesticides and chemical fertilizers . But as we all know that these chemical fertilizers have a bad impact on our environment including the ground water and causes lots of environmental pollution and direct or indirectly effects the health of the surrounding humans.

The awareness of healthy lifestyle and the consumption of healthy food has forced the farmer to grow the food without the use of chemical fertilizers and pesticides, instead grow food organically, so now the farmer is more interested in biopesticides and biofertilizers

Now the objective of the soil management system is to make the underground habitat healthy, so as to give a healthy structure to the soil and also to make a happy and safe place for all the beneficial soil microbes , so that the plants get all the required nutrients for their healthy growth, which in turn will give us a high yield of the desired crops, which will also be eco friendly as they will not cause any pollution in the environment.

All the optimal conditions required for the healthy growth and protection against pests are provided to the plants. These can be further grouped into strategies like growing healthy plants with increasing their immunity, knock down the phytopathogens, and try to enhance the beneficial soil organisms. With this reference, we can say that there are lots of microorganisms which can be beneficial to the plants and can improve the yield and quality of the crops

It is observed that these beneficial microorganisms has been playing an important role in maintaining healthy agricultural practices, as they directly or indirectly help in the healthy growth of the plants and the most important thing is that they are also eco friendly , as they do not cause any kind of pollution in the environment.

It is observed that the most commonly used genus is Bacillus, as it shows metabolites which act as biopesticide and even as biofertilizer. In this review, the main focus is on the microorganisms that are beneficial in the agriculture, and the main microorganism which is considered is the genus Bacillus,

ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

which has also got an economic importance due to its high metabolitic activities which are beneficial in the agricultural processes.

I would like to bring in focus to my follow researchers that there are millions of soil microbes which we need to study so that we can use them in the mankind and find a rigid solution so as to completely substitute the use of chemical fertilizers and also pesticides and move towards a healthy and safe life.

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Airo International Journal
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ISSN: 2320-3714
Volume:2 Issue:3
June 2025
Impact Factor:11.9
Subject: Life Science

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