EFFECTS OF MICROORGANISMS IN HUMIC SUBSTANCES ON SOIL AND PLANTS

A growing collection of research has been conducted on the interactions between humic substances and microorganisms. The importance of a healthy soil microbe population is well-known, but there are many factors that can impact the soil and plant bacterial community. Humic substances can play a positive role in this biological community in a variety of ways. It has been shown that many species of soil bacteria are still capable of growing when their only source of carbon is humic acid[1]. In that same experiment, the researchers discovered that humic acids stimulated the growth of bacteria when bacteria were only provided glucose as a growth medium[1]. A similar response has been shown regarding toxin-degrading organisms. When humic acid was applied to microbes degrading a toxic environmental contaminant, it increased the enzyme activity of the microbes, which resulted in accelerated microbial remediation[2].

Since we know that humic acid has a positive effect on microbial communities, it is not surprising that it also contains a large community of beneficial microorganisms on its own. If these microorganisms are provided the right conditions to survive and grow in a humic acid product, the biological effects could be multiplied. Our liquid humic acid and fulvic acid products contain large numbers of plant growth-promoting bacteria.

The species in our liquid humic products are mostly made up of the bacterial groups ***Bacillus***, ***Pseudomonas***, ***Paenibacillus,*** and ***Lysinibacillus***. ***Bacillus*** species have been proven to play roles in improving the biomass of plants under heat stress[3] and increase plant growth and seed nutrient contents under water stress, especially when paired with humic acid[4]. ***Bacillus*** has also been reported to alleviate the negative effects of salinity stress in plants[5] and contribute towards hydrocarbon degradation[6]. The benefits of ***Pseudomonas*** include phosphorus solubilization[7], production of siderophores, which help to limit plant disease[8], and hydrocarbon degradation in soils[6]. Species in the bacterial group ***Paenibacillus*** can degrade humics in cold environments[9], dissolve phosphorus, particularly in saline and alkaline soils[10], and when exposed to root-knot nematode eggs and juveniles, it has caused mortality to the plant pathogen[11]. ***Lysinibacillus*** species have exhibited insecticidal and larvicidal properties, with some species showing antimicrobial characteristics[12]. This can contribute towards biological disease control and bioremediation. Many of these studies found that two or more groups of these species often work together to produce these positive effects, so the combination of these organisms in our product is significant.

GHP Liquid Humic key species:

Species	Bacterial count (cfu/ml)
Bacillus	3.50 x 10^5
Pseudomonas	3.37 x 10^5
Paenibacillus	2.55 x 10^5
Lysinibacillus	2.70 x 10^5

Our liquid fulvic product contains a different set of species. The dominant bacterial groups in our liquid fulvic are ***Azoarcus***, ***Delftia***, and the species ***Derxia gummosa***. ***Azoarcus*** and ***Derxia gummosa*** are both important nitrogen-fixing bacteria for plants. This gives the organism – and the plants around it – an advantage for survival because they have the capability of transforming nitrogen gas in the atmosphere into nitrogen usable by plants[13, 14]. ***Azoarcus*** is also effective at solubilizing insoluble phosphate and producing indoleacetic acid, which is an important plant hormone responsible for regulating plant growth[15]. This group has an endophytic lifestyle[15], meaning that they live between living plant cells. They were found adhering internally to rice roots and did not cause plant pathogenic effects when applied to leaves[15]. In one study, looking at wheat, a mixture of nitrogen-fixing bacteria including ***Azoarcus*** was applied to the plants by foliar spraying while nitrogen applications were decreased over two years. The bacteria were discovered to be very effective at adhering to the surface of leaves and roots, and the researchers reported a reduction in nitrogen loss and an increase in the ability of plants to deal with environmental stress[16]. The group ***Delftia*** has shown unique hydrocarbon-degrading capabilities, specifically when humic acid is involved. One study found that the sorption of an environmental contaminant to humic acids caused a limitation to bioavailability that only a few groups of bacteria were able to break, including ***Delftia***[17].

Other bacterial groups present in our liquid fulvic play roles in the nitrogen cycle. This includes ***Rhodobacter***, which contains species capable of photosynthesis and nitrogen-fixation[18]. There are organisms affiliated with the rhizosphere as well, including ***Rhizobium*** and ***Mesorhizobium***. Species in ***Rhizobium*** are known to be siderophore-producing bacteria, they stimulate nitrogen fixation on root surfaces, and have provided resistance to fungal infection of plants[19]. ***Mesorhizobium*** has been linked to phosphate solubilization in acidic soils[20]. There are also ammonia-oxidizing bacteria present – ***Nitrosomonas*** and ***Nitrosospira*** – and their role in the nitrogen cycle involves turning ammonia oxide into nitrite[21]. ***Bacillus*** and ***Pseudomonas***, described previously as beneficial organisms for soil and plants, are also present in our liquid fulvic.

GHP Liquid Fulvic key species:

Species	Bacterial count (cfu/ml)
Azoarcus	5.18 x 10^6
Delftia	1.70 x 10^6
Derxia gummosa	1.56 x 10^6
Rhodobacter	9.56 x 10^5
Bacillus	5.45 x 10^5
Pseudomonas	2.83 x 10^5
Rhizobium	2.10 x 10^5
Nitrosomonas	1.79 x 10^5
Nitrosospira	1.35 x 10^5
Mesorhizobium	1.14 x 10^5

This assortment of microorganisms in our products can provide services including nitrogen fixation, ammonia oxidization, phosphorus solubilization, stress mitigation in plants, biological disease control, and hydrocarbon degradation. Our liquid humic contains nearly one million cfu/ml of these beneficial organisms, and our liquid fulvic contains over ten million cfu/ml of beneficial organisms. The microbial community in our products have occurred because the species present in the raw material have been given an environment that allows them to multiply through our liquid manufacturing process. There are no external species added, so we can be confident that the species present can live and function in equilibrium. These numbers are in line with many liquid microbial products currently on the market, but the addition of humic acid in our product also supports bacterial life in the soils and plants where it is being applied.

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