Atomes BioSciences PHP
Plant Health Promoter

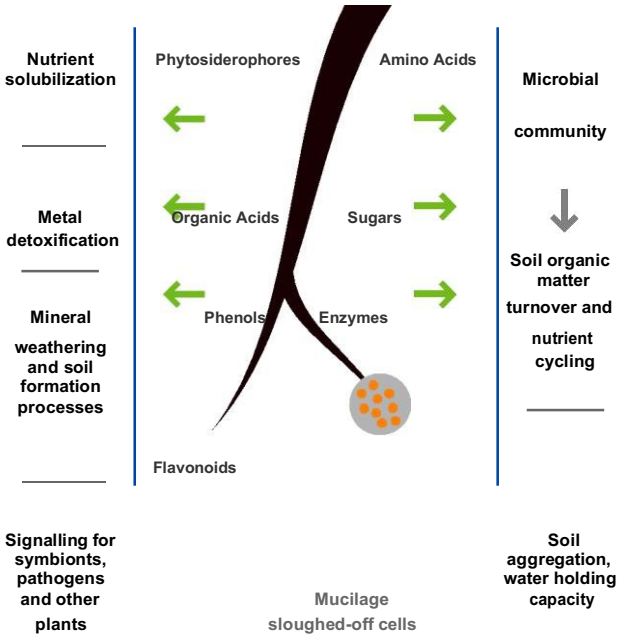
A highly concentrated liquid blend of bacterial spores to promote healthy plant growth

INTRODUCTION

Sustainable agricultural practices are widely accepted as an alternative to the use of chemical fertilizers, herbicides, fungicides, and insecticides. As the main agents for breaking down organic material and recycling nutrients, microorganisms interact with plants at the root level, and in turn, influence growth and nutrition of the entire plant. Plants are further affected by other variables such as temperature, moisture, and most importantly, pathogens. Pathogens cause serious diseases in plants resulting in yield loss. Fungal diseases that are soil borne are evolving and becoming more resistant to the fungicides currently being used, fueling the need for alternatives. A natural and environmentally friendly option is to apply a microbial supplement of scientifically selected microorganisms that will colonize the plant roots and displace the pathogens.

This paper explains the rigorous research and development that contributed to the creation of Atomes's Plant Health Promoter (PHP); which can be applied as a seed coating, in drip irrigation, via over-head watering, broadcast, or in-furrow.

Figure 1: Rhizosphere and Exuded Compounds



PRODUCT ATTRIBUTES

To begin, Atomes scientists ensured an understanding of the environment in which the bacteria will be utilized. Figure 1 shows a plant root and its exuded compounds. These compounds impact the soil around the roots, as indicated by the column descriptions,

allowing plants to recruit beneficial root colonizing bacteria. Knowing the compounds present in the rhizosphere, Atomes researchers isolated bacteria that utilize the root exudates as a food source, promoting bacterial cell growth and root colonization. The nutrients further allow the bacteria to produce metabolites that promote plant growth, as well as plant pathogen inhibitory compounds.

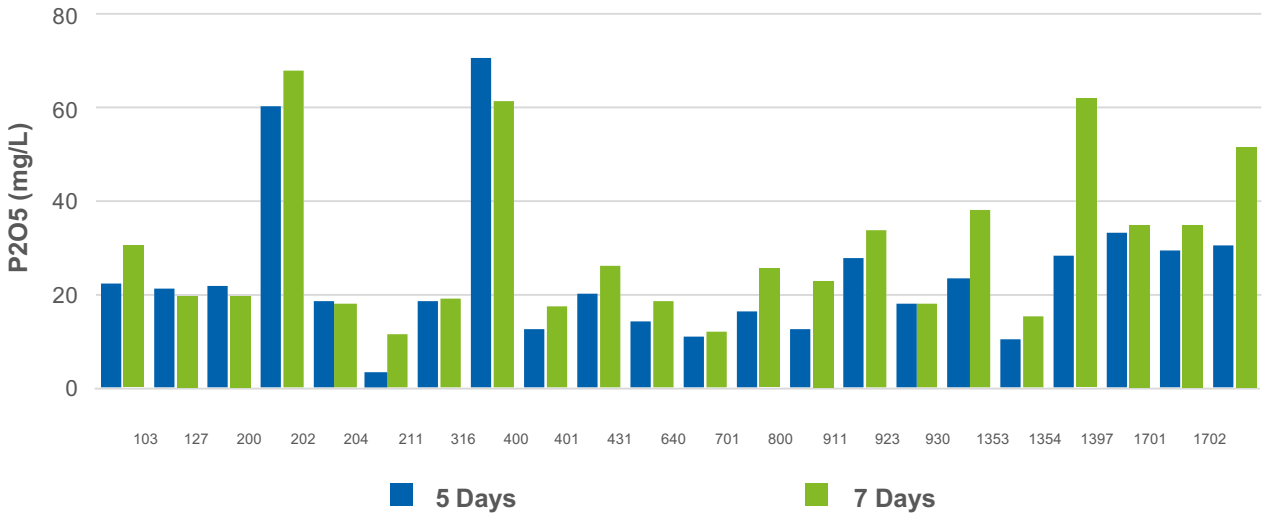
The beneficial microbes in PHP colonize the rhizosphere. As they grow, a biofilm is formed on the plant root that acts as a physical barrier to unwanted organisms. This close association between the plant and Atomes's bacteria ensures the plant will reap the additional benefits of the microorganisms in PHP.

Atomes's complimentary *Bacillus* strains strategically selected for PHP are all fierce competitors. These carefully selected strains out-compete native strains for nutrients, reducing the proliferation of unwanted microbes that do not benefit the plant. By introducing the strains in PHP that are hyper producers of different enzymes, pathogen attracting compounds naturally exuded by the plant are sequestered and utilized for growth of the PHP strains. The consumption of pathogen attracting compounds essentially makes the plant invisible to pathogens. PHP contains rapid growing strains that consume a vast variety of organic compounds, helping to ensure that beneficial microbial strains occupy the rhizosphere.

The scientists at Atomes have also screened our strains for the ability to release phosphorous, an expensive and valuable resource. Phosphorous is a major macronutrient needed for plant growth, but is not easily accessible to benefit the plant.
Phosphorous is reactive with iron, aluminum, and calcium resulting in the precipitation of phosphorous, making it unavailable to plants. The bacteria in PHP can convert phosphorous into a form easier for the plant to access, such as orthophosphate. Figure 2 shows the efficacy of multiple Atomes *Bacillus* strains to solubilize phosphorous over a seven-day period.

Potassium is another major macronutrient needed for plant growth. Atomes scientists conducted assays similar the phosphorous solubilization assay to select specific microbial strains for high potassium solubilizing capabilities. This ability of the microbes in Atomes's PHP to solubilize potassium makes the potassium more readily available for plants. Iron is another important but scarce nutrient in soil. The bacteria in PHP can produce compounds called siderophores. These siderophores acquire ferric iron in the soil so root cells can utilize the iron by active transport mechanisms.

Figure 2: Phosphorus Solubilization by Atomes's Bacterial Strains



Enzymes, like macronutrients, are also essential to the growth of a healthy plant. Enzymes are needed for the digestion of organic matter found in the soil and root exudates. The enzymes also serve to feed the plant. They are formed by chains of amino acids, which are made of carbon, and more importantly, nitrogen. PHP contains bacterial strains that produce high levels of enzymes and convert organic matter into amino acids to directly feed the plant.

Beyond helping the plant absorb nutrients, Atomes scientists recognized the importance of our strains to inhibit the growth of fungi. Atomes's research started by testing potential strains from our extensive culture collection for the ability to inhibit the growth of plant pathogenic fungi. This experiment was performed by adding a fungus to the center of a plate, followed by spotting bacteria in four areas around the fungus. After being incubated, scientists selected several strains that inhibited the progressive growth of the pathogen. This is well demonstrated by the Atomes cultures at the six and nine o'clock positions on the petri dish in Figure 3. Additional strains were selected with activity against *Fusarium*, *Pythium*, *Rhizoctonia*, *Phytophthora*, *Sclerotinia*, and *Sclerotium*.

Figure 3: Inhibition of Pathogenic Fungi by Atomes's Bacterial Strains

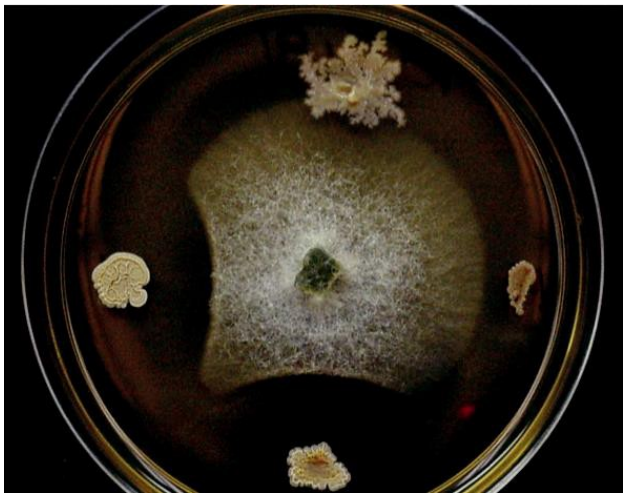
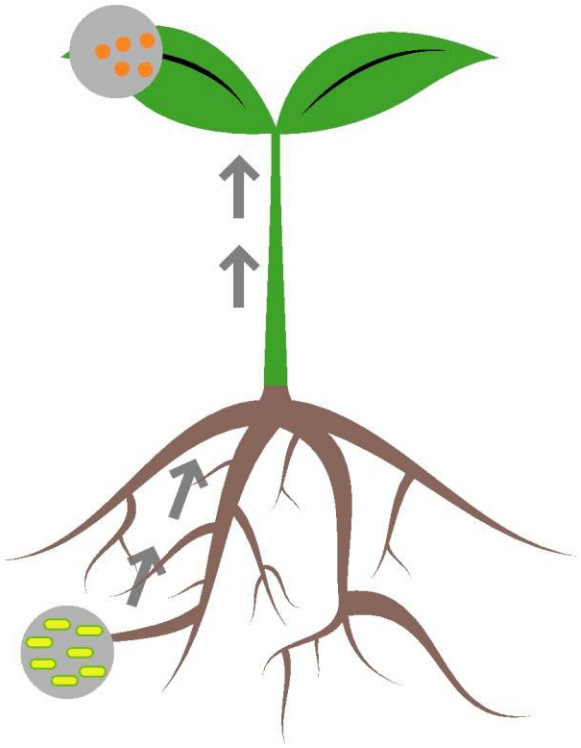


Figure 4: Induced Systemic Resistance



Although Atomes's microorganisms are added to the rhizosphere, benefits can be seen throughout the entire plant. This is due to induced systemic resistance - the addition of beneficial bacteria to the root zone to aid in the prevention of disease. As shown in the illustration in Figure 4, when microbes are added to the root zone of the plant, the bacteria elicit a plant-mediated defense response which is then translocated throughout the entire plant. This well documented phenomena results in reduced foliar diseases due to the addition of microbes to the soil.

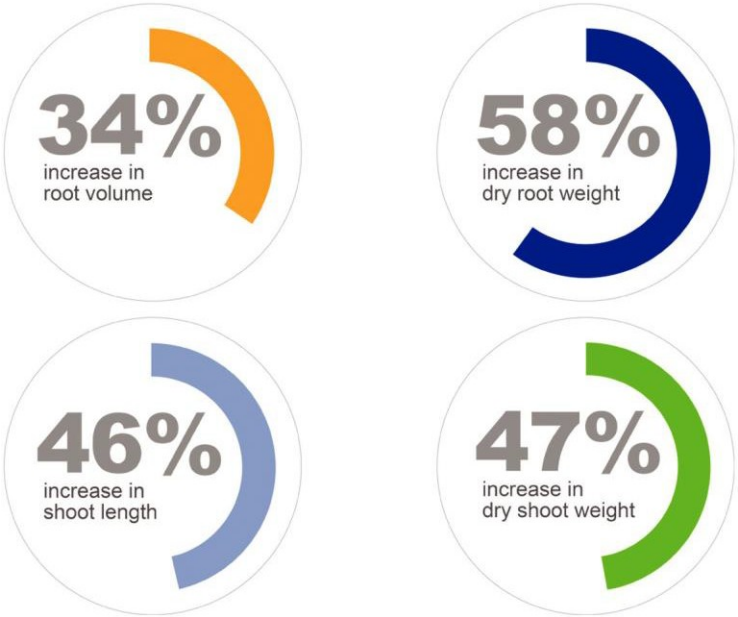
Testing hundreds of microorganisms for the attributes described in the aforementioned research has led to a multi-strain product. We combined complimentary strains to create a blend that helps the plant in multiple ways. This approach provides the best strain in each category, creating a well-balanced team of microorganisms that, when combined, elicit the most benefits possible.

PHP has been found to improve multiple aspects of plant growth. Studies were performed by Atomes in growth chambers using corn as a test plant in a nutrient poor soil. After three weeks of growth, the plants were harvested and a variety of parameters were measured. The results of this growth chamber assay can be seen in Figure 5. We observed 34 percent increase in root volume, 58 percent increase in dry root weight, 46 percent increase in shoot length, and 47 percent increase in dry root weight.

SUMMARY

Years of research and development yielded our proprietary formulation for Atomes's Plant Health Promoter. PHP microbes cycle the nutrients found in the soil and solubilize minerals, making them more available for the plant. The microbes colonize the plant, suppress pathogens, and feed the plant, all while promoting its growth. By incorporating multiple strains with complimentary activities, Atomes has built all of these attributes into a single product formulated for Plant Health Promotion.

Figure 5: Growth Chamber Results



Plant Health Promoter Specifications

Guaranteed Minimum Bacterial Concentration:

4.0 x exp.8 cfu's per ml (400,000,000 cfu's per ml)

APPLICATIONS

Lawns and other grasses
Bedding plants
Vegetables
Row crops

PRODUCT PROFILE

Multiple Bacterial and Fungal Species

- Naturally occurring, non-engineered
- Aerobes and facultative anaerobes
- Positive chemotaxis
- 100% stabilized bacterial spores

Appearance

Liquid product

Effective pH Range

5.0 - 10.0

Effective Temperature Range

12° - 40°C (54° - 104°F)

Shelf Life

Two years at 21°C (70°F)

STANDARD PACKAGING

20L Pails

STORAGE AND HANDLING

Store in a cool, dry location.

APPLICATION RATES

Broadcast	***Grams/Acre***
High Rate	86
Low Rate	30

Drip and In-Furrow	***Grams/1000' Row***
High Rate	5
Low Rate	1.75

Seed Coat	***Grams/3000 Seeds***
6.75 E5/Seed	0.04

Consult your Atomes technical representative for alternative formulations and additional applications.

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