



Algae Metabolites and Nutrient Uptake: TrueSolum® Enhances Phosphorus Availability and Uptake

1. Introduction

TrueAlgae is pioneering metabolite research to bring innovative solutions to agriculture. A critical area of focus is enhancing the availability and uptake of essential nutrients, particularly **phosphorus**, which is vital for plant health and productivity. Phosphorus supplies are dwindling globally. Using phosphorus that is already native to the soil, or using what is applied more efficiently, provides a solution to this growing concern.

TrueSolum, our metabolite-based solution, addresses this issue by stimulating natural plant and soil microbiome processes that improve the release and uptake of phosphorus, making it more accessible to plants. Through extensive research and field trials, we have discovered that TrueSolum signals and proliferates microbes that solubilize phosphorus. This innovative approach provides a powerful tool for improving nutrient availability and plant health across a wide range of soil and crop conditions.

2. Discovery of the Active Metabolites in TrueSolum

Metabolite analysis was conducted by Virginia Polytechnic Institute and State University (VPI), using both GC-MS and LC-MS. Homology searches for compounds with specific peaks were conducted to identify similar structures, probable molecular classes, and/or potential metabolites in various databases. A complex mixture of compounds in the following chemical groups was discovered: 9 small peptides, 4 eicosanoids, 6 octadecanoids, fatty acids, phenolic acids, and 2-3 coumarins. In addition, the metabolites that were discovered were consistent across multiple production batches and observed in a consistent ratio between each other. Many of these compounds are known chemical signalers which activate key microbes in the soil microbiome. The following research demonstrates these activities and the resulting improvement in phosphorus availability in the soil and uptake by crops.

3. Microbial Research

Phosphate solubilizing bacteria are capable of solubilizing inorganic phosphorus from insoluble compounds. P-solubilization ability of rhizosphere microorganisms is considered to be one of the most important traits associated with plant phosphate nutrition. It is well documented that many species of *Pseudomonas* sp. and *Bacillus* have the ability to solubilize phosphorus.

Early research conducted at AgMetrics in Dover, Florida, indicated an impact on soil microbial diversity. The soil treated with TrueSolum showed greater biological diversity and higher counts



Manufactured by GreenTech Ventures, Inc.

contact@truealgae.com

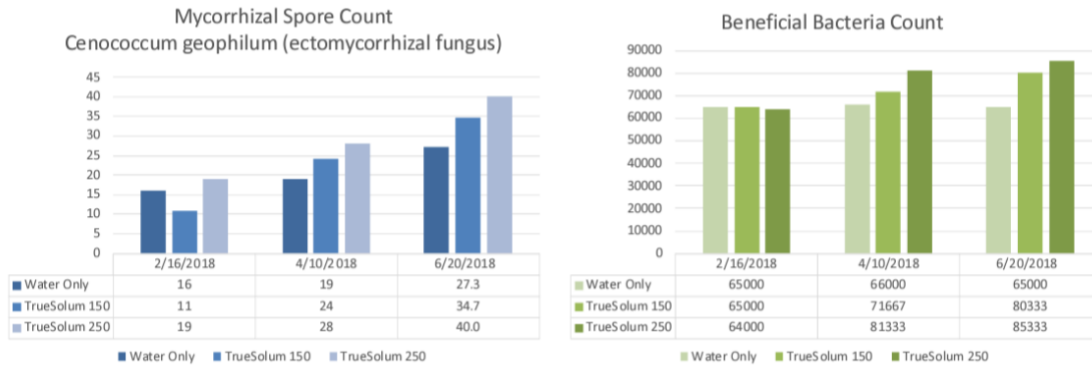
www.truealgae.com | www.truesolum.com



REVISION DATE: 11/07/2024



of beneficial microorganisms. Increases in mycorrhizal and other microbial populations in the soil are known to improve fertility and porosity, enhance seed germination and promote primary nutrients in the host plants. In this research trial, enhanced levels of key microbes resulted in a significant improvement in root vigor of the watermelons planted in the TrueSolum treated field.



Research conducted at the Mexican Research Center on Food and Development (CIDA) compared the presence and population of phytobenefic microorganisms per gram of soil treated with TrueSolum versus control. The analyses were conducted in two fields, one growing tomatoes and one growing table grapes. Soil samples were analyzed by means of dilution and subsequent plating on selective and semi-selective culture media for fungi and bacteria.

SOIL ANALYSIS I: Tomato Farm – Sinaloa, Mexico

Soil Sample	Aerobic Bacteria	Anaerobic Bacteria	Bacillus sp	Pseudomonas Fluorescens	K-Solubilizing Bacteria	Diversity Index
TrueSolum	4,400,000	11,000,000	12,800,000	890,000	40,000	7.27
Control	3,118,000	21,733,000	6,400,000	121,000	6,666	5.94

SOIL ANALYSIS II: Table Grape Farm - Sinaloa, Mexico

Soil Sample	Aerobic Bacteria	Anaerobic Bacteria	Bacillus sp	Pseudomonas Fluorescens	K-Solubilizing Bacteria	Diversity Index
TrueSolum	8,200,000	220,000	3,633,333	560,000	1,533,333	2.24
Control	2,900,000	133,333	2,166,667	0	1,033,333	1.17

4. Pseudomonas sp. Discovery

Our continued investigation into TrueSolum’s effect on nutrient availability builds on earlier findings regarding microbes that solubilize phosphorus. We used advanced genetic sequencing techniques conducted in collaboration with Biome Makers to uncover how TrueSolum interacts with the soil microbiome, with a focus on specific bacteria that help in the release and uptake of phosphorus.



Manufactured by GreenTech Ventures, Inc.

contact@truealgae.com

www.truealgae.com | www.truesolum.com

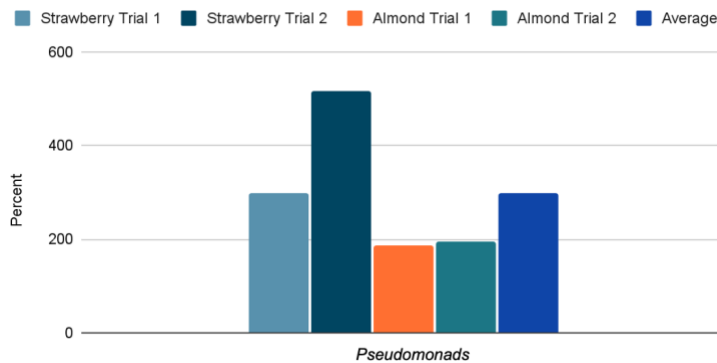


REVISION DATE: 11/07/2024



Research demonstrated that TrueSolum significantly increases the population of *Pseudomonas* sp., phosphorus solubilizing bacteria. Unlike other products that indiscriminately feed microbes, TrueSolum’s metabolites are targeted signalers, providing the specific dynamics in the soil to address the crop’s needs. Field trials across strawberries, almonds, and soybeans showed that within 30-35 days of TrueSolum application, there was an average 298% increase in these beneficial bacteria. This surge in microbial activity not only improves phosphorus availability but also enhances the uptake of phosphorus, leading to healthier plant growth and better overall crop outcomes.

In the chart below, we observe the comparative increase in *Pseudomonas* sp. populations in plants treated with TrueSolum versus those in the control group.



Percent increase in the relative abundance of *Pseudomonas* sp. in the TrueSolum treated soil vs control

By enhancing the soil’s microbial activity and boosting phosphorus availability, TrueSolum offers a natural and effective solution for enhancing phosphorus availability and uptake in a wide variety of crops.



5. Field Assays

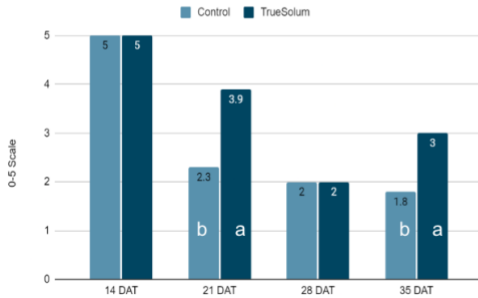
Four trials were conducted to assess the impact of TrueSolum on phosphorus deficiency in peppers and corn. The trials were conducted in two locations, Great Bend, KS by Performance Crop Research, and Mebane, NC by AgroSky Research. The trials consisted of 8 replicates in very small plots, with 5-6 plants per plot. It was designed to function more as an assay than a large field trial and did not extend to harvest.

a. Phosphorus Deficiency Visual Score

Peppers

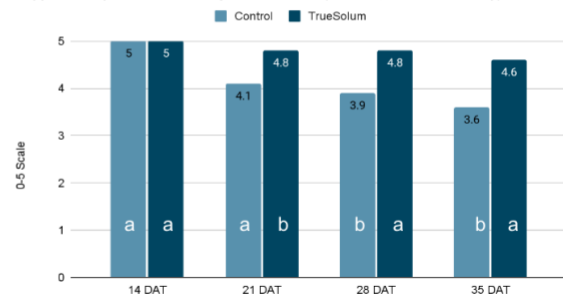
Performance Crop Research
Great Bend, KS

Pepper Phosphorus Deficiency Visual Score (0=dead, 5=no deficiency)



AgroSky Research
Mebane, NC

Pepper Phosphorus Deficiency Visual Score (0=dead, 5=no deficiency)

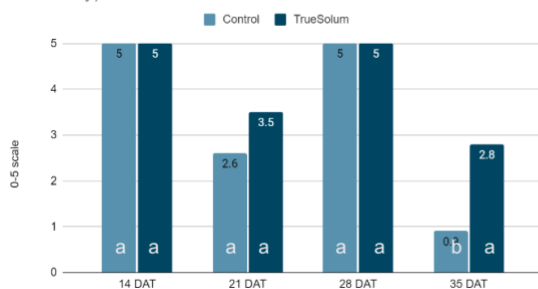


By 21 days after treatment, the TrueSolum treated plants showed significantly less phosphorus deficiency symptoms compared to the control. This was also present in the TrueSolum treated peppers at the final rating.

Corn

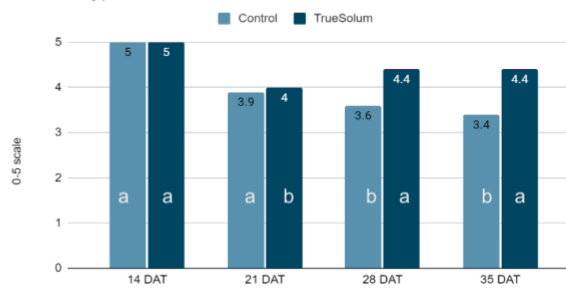
Performance Crop Research
Great Bend, KS

Corn Phosphorus Deficiency Visual Score (0=dead, 5=no deficiency)



AgroSky Research
Mebane, NC

Corn Phosphorus Deficiency Visual Score (0=dead, 5=no deficiency)



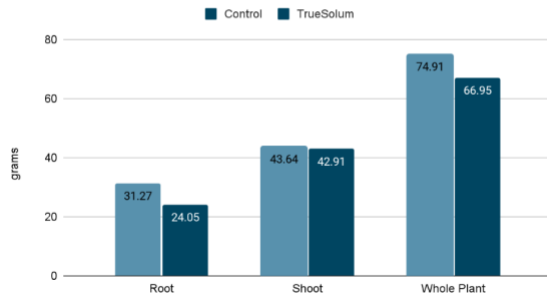
At 28 and 35 days after treatment, TrueSolum-treated corn in both studies showed significantly less phosphorus deficiency symptoms compared to the control.

b. Average Plant Weight

Peppers

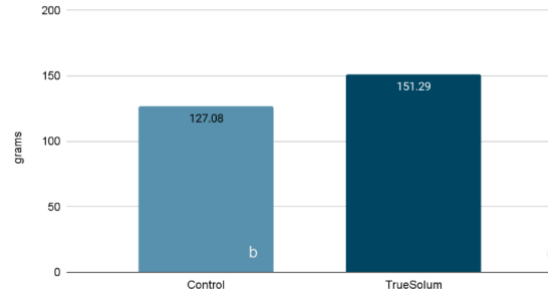
Performance Crop Research
Great Bend, KS

Average Weight Per Pepper Plant at Trial Termination (35 DAP)



AgroSky Research
Mebane, NC

Average Weight Per Pepper Plant at Trial Termination (35 DAP)

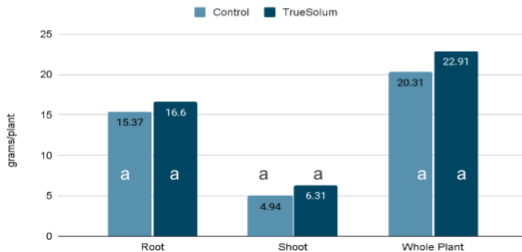


At trial termination, there were no significant differences in root, shoot, or whole plant weights for peppers treated with TrueSolum compared to the control in the KS location. However, in NC, the TrueSolum-treated peppers weighed significantly more than the untreated control.

Corn

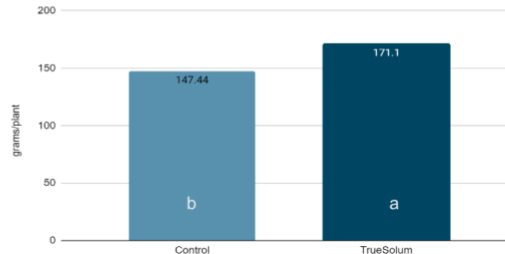
Performance Crop Research
Great Bend, KS

Corn Weight Per Plant at Trial Termination (35 DAP)



AgroSky Research
Mebane, NC

Weight Per Plant at Trial Termination (35 DAP)



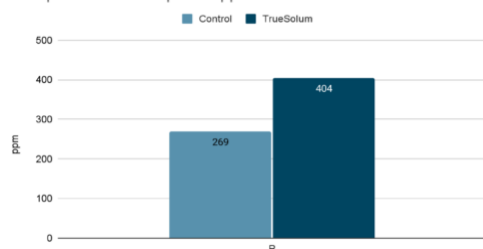
At trial termination, the TrueSolum treated corn weighed 2.6 more grams per plant compared to the control in the KS trial. This was an 11% improvement in whole plant weight. The TrueSolum treated corn in the NC trial weighed 24 more grams per plant compared to the control. This is a 14% improvement in plant weight.

c. Sap Analysis of Leaves | Phosphorus

Pepper

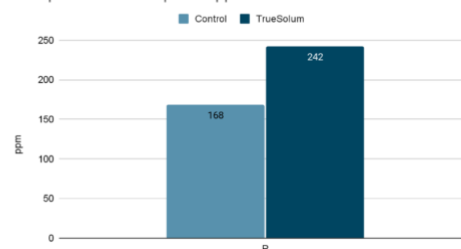
Performance Crop Research
Great Bend, KS

Phosphorus in the Sap of Peppers at Trial Termination



AgroSky Research
Mebane, NC

Phosphorus in the Sap of Peppers at Trial Termination

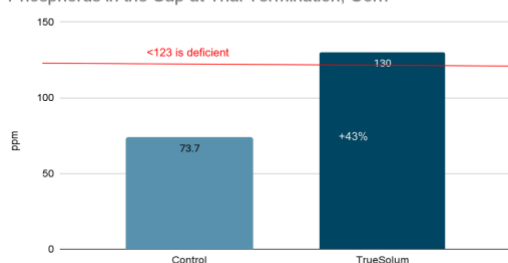


At trial termination, the TrueSolum treated pepper plants in both studies had >30% more phosphorus in the sap compared to the control. This was despite both treatments having “adequate” levels of phosphorus.

Corn

Performance Crop Research
Great Bend, KS

Phosphorus in the Sap at Trial Termination, Corn



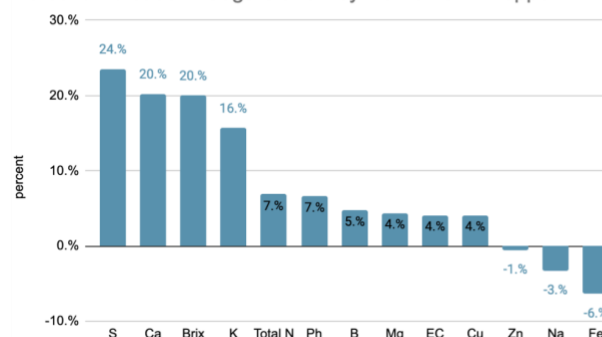
At trial termination, the TrueSolum treated corn plants in the KS trial had 43% more phosphorus in the sap compared to the control. Note that this brought the TrueSolum treated corn up to within the adequate range while the control was deficient. Sap results for the NC trial are not shown because there was no difference between treated and control.

d. Sap Analysis of Leaves | Other Key Nutrients

Pepper

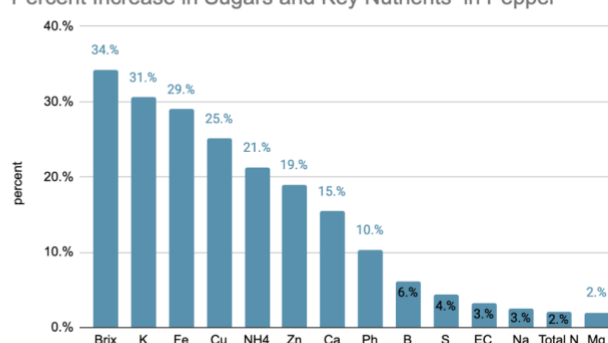
Performance Crop Research
Great Bend, KS

Percent Increase in Sugars and Key Nutrients in Pepper



AgroSky Research
Mebane, NC

Percent Increase in Sugars and Key Nutrients in Pepper

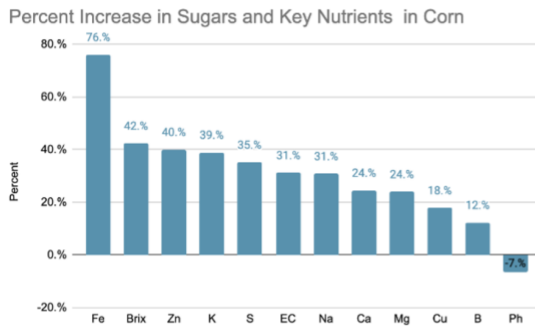




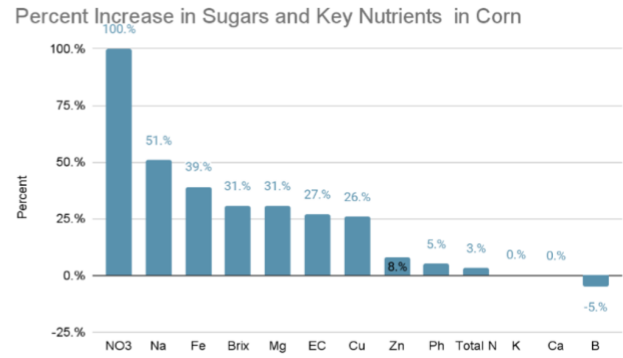
At trial termination, TrueSolum-treated pepper plants in both trials showed higher levels of nutrients beyond phosphorus - including S, Ca, K, N, B, Mg, and Cu - along with increased sugars, pH, and EC.

Corn

Performance Crop Research
Great Bend, KS



AgroSky Research
Mebane, NC



At trial termination, TrueSolum-treated corn plants had **higher levels of several nutrients** (Fe, Zn, Mg, Cu) and **increased sugars and EC** in both trials compared to the control, indicating improvements in general plant health and yield potential.

6. Conclusion

In the above four trials, TrueSolum treatments led to consistent improvements in plant phosphorus uptake and overall nutrient levels, reducing deficiency symptoms and enhancing plant growth in both corn and peppers. Prior sap analysis across several crops in 15 pair matched samples showed similar results in phosphorus and other nutrient uptake, further proving that TrueSolum is effective in supporting nutrient availability and uptake.

Treatment	P	Fe	Zn	Mn	Mg	Ca
Control	231.29	1.65	2.03	9.87	465.96	668.13
TrueSolum	316.09	2.10	2.46	11.81	622.74	878.24
% Diff.	26.83%	21.50%	17.65%	16.44%	25.18%	23.92%

In addition, the PLFA results align with prior research demonstrating increases in *Mycorrhizae* and *Actinomycetes* with TrueSolum treatments. Note that gram-bacteria (22 to 27% increase) are often associated with phosphorus solubilization and siderophore production (*Pseudomonas* sp.).

From microbial research, genomic sequencing, and field research assays, TrueSolum consistently causes beneficial changes in the soil microbiome that influence the solubility of phosphorus. It provides a natural way of working with the existing ecosystem to make phosphorus present in the soil more available to the crop by signaling *Pseudomonas* sp. These findings support TrueSolum's role in improving plant health through soil and microbial interactions, making it a valuable tool for managing phosphorus deficiencies in a variety of environments.



Manufactured by GreenTech Ventures, Inc.

contact@truealgae.com

www.truealgae.com | www.truesolum.com



REVISION DATE: 11/07/2024