Periodical Systems
SOIL MICROBIOME | TECHNICAL OVERVIEW

ECOLOGY | MECHANISM | FIELD VALIDATION

Soil Microbiome

Microbial ecology for agriculture

A technical guide to soil communities, plant-microbe mechanisms, the BioSystem nutrient-culture concept and controlled field validation.

PRIMARY TECHNICAL CONTEXT

Rhizosphere | soil function | crop programs

ECOLOGY | MECHANISMS | SOURCE CONTROL | PILOT

01 SOIL ECOLOGY

Soil as a living agronomic system

Soil function emerges from interactions among microorganisms, roots, minerals, organic matter, water and air. The microbiome changes with crop, soil and management.

10^8 to 10^10 **microbial cells per gram**

Range cited for soil in the plant-microbiome literature.

HOLOBIONT **plant plus microbiome**

A combined biological unit linking crop phenotype with microbial interactions.

LIVING SYSTEM **context controls function**

Soil chemistry, resident taxa and management shape the response.

Sources: Tkacz et al., 2020; Backer et al., 2018.

02 COMMUNITY STRUCTURE

Plant-microbe interaction zones

Microbial communities occupy distinct plant and soil compartments. The root recruits from soil, then filters the community at the root surface and inside tissue.

01 **Bulk soil**

Community beyond the immediate root influence.

02 **Rhizosphere**

Soil shaped by root exudates and root activity.

03 **Rhizoplane**

Microorganisms attached closely to the root surface.

04 **Root endosphere**

Microorganisms established inside root tissue.

STUDY RESULT Tkacz et al. found that roots strongly shaped bacterial profiles, while soil had the strongest influence on fungal profiles across the tested systems.

Source: Tkacz et al., 2020, mBio 11:e02785-19.

03 PLANT NUTRITION

Direct nutrient pathways

Beneficial soil microorganisms influence nutrient availability and root development through several distinct mechanisms, measured with route-specific endpoints.

MECHANISM	BIOLOGICAL FUNCTION	FIELD MEASUREMENT
Nitrogen fixation	Atmospheric nitrogen is converted into ammonia by compatible microorganisms.	Mineral N and plant tissue N
P and K solubilization	Organic acids and related processes release bound phosphorus and potassium.	Available P and K
Siderophores	Microbial iron-chelating compounds can influence iron acquisition.	Soil and tissue iron
Root architecture signals	Auxin, cytokinin and gibberellin pathways can change root growth.	Root length, mass and branching

Mechanism families summarized from Backer et al., 2018.

04 PLANT RESPONSE

Indirect defense and stress pathways

Microbial effects can also act through pathogen competition, defense signaling and stress regulation. These routes differ from direct nutrient supply.

01 **Biocontrol**
Competition, antibiosis and lytic enzymes can suppress some pathogens.

02 **Induced systemic resistance**
Microbial signals can prime plant defense responses.

03 **ACC deaminase**
Some bacteria lower stress ethylene under drought or salinity.

04 **Microbial volatiles**
Diffusible compounds can influence growth and defense signaling.

TERMINOLOGY

The literature commonly uses ISR for microbe-mediated priming. BioSystem also includes an oligo- and polysaccharide plant-response pathway.

Sources: Backer et al., 2018; BioSystem technical documents.

Plant response

05 RESEARCH EVIDENCE

What inoculant studies show

Meta-analyses support a positive average effect of microbial inoculation, while also showing that environment, duration and community context change the result.

LIVING-SOIL META-ANALYSIS

51 studies; plant-growth change relative to non-inoculated controls

META-ANALYSIS RESULT The literature reports average plant-growth changes of +29% for single strains and +48% for microbial consortia.

Sources: Liu, Mei and Falcao Salles, 2023; Azarbad and Junker, 2024.

CONTEXT FROM A SECOND META-ANALYSIS

71 articles

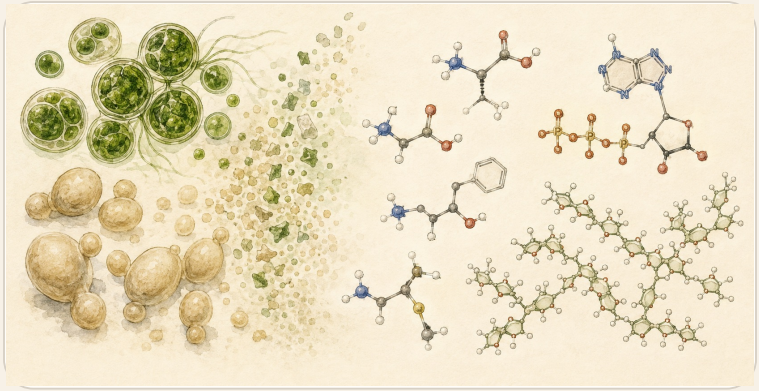
28 plant genera | 50 microbial genera | 8 traits

- Plant trait and microbial taxon changed the effect size.
- Sterilized and short studies produced larger effects than unsterilized and long studies.
- Effect size also differed by study duration and soil condition.

06 SOURCE FORMULATION

BioSystem nutrient-culture formulation

BioSystem is a soluble nutrient medium intended to support microorganisms already present in the crop environment.



NITROGEN-SIDE INPUTS

Amino acids and nucleotide breakdown products.

CARBON-SIDE INPUTS

Soluble oligo- and polysaccharides, including mannan, chitin and glucan in one Chinese sheet.

FORMULATION ATTRIBUTES

A Chinese variant adds green-algae and seaweed polysaccharides. Product documents describe natural, GMO-free, non-hormonal and organic-compatible positioning.

ANALYTICAL PROFILE August 2017 sample analysis: 18 hydrolyzed amino acids and 8.18% water-soluble polysaccharide.

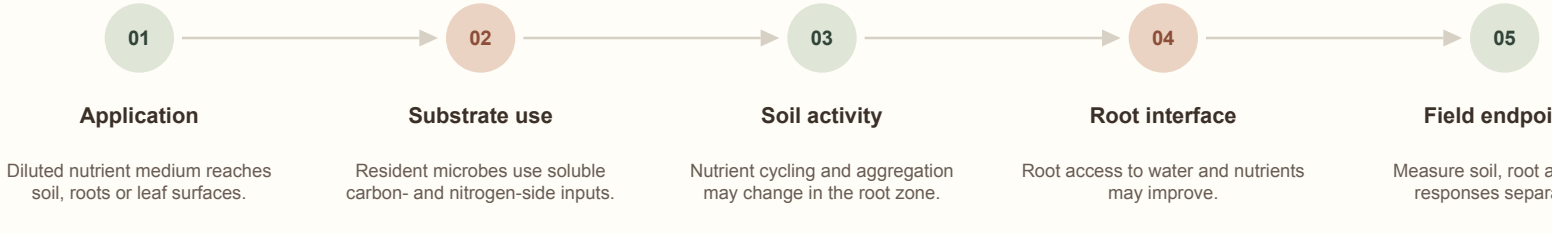
Sources: English culture guide, Chinese formulation documents and August 2017 analysis.

Source formulation

07 SOIL MECHANISM

Soil-improvement pathway

The product logic connects soluble substrates with resident microbial activity, then with soil and root functions that can be tested in a controlled field program.



MECHANISM SUMMARY Soluble substrates support resident microbial activity, which links to nutrient cycling, aggregation and root-zone response.

Sources: BioSystem technical documents and Backer et al., 2018.

08 APPLICATION GUIDANCE

Application records and source control

The technical documents contain dilution schedules for different concentrates and crop programs. Each schedule remains paired with its source.

DOCUMENT	SEED SOAK	FOLIAR	ROOT / CROP ROUTE
Green-algae variant	1:100; 5-8 h for vegetables and flowers	1:600-700 early; 1:300-500 at flowering	1:300-500 root drench
0.8% total-N example	1:500; crop-dependent soak time	1:1,000-1,500 early; 1:500-800 vigorous	1:500-1,000 root drench
2026 plant TDS	No general seed protocol stated	Crop-specific: field 1:4,000; orchard 1:500; vegetables 1:2,000	Use current crop protocol

SOURCE CONTROL Product identity, concentrate strength, crop and application route define the applicable dilution range.

Sources: three crop application documents.

Application guidance

09 FIELD VALIDATION

Controlled pilot for soil performance

The pilot separates baseline conditions, biological response, root development and harvest outcomes.

01 **Baseline**

Map blocks; record pH, EC, organic matter and available nutrients.

02 **Treatment**

Use treated and untreated blocks with the same crop and agronomy.

03 **Mid-season**

Track soil respiration or biomass, nutrient status, roots and disease.

04 **Harvest**

Compare yield and quality, then interpret them with the soil results.

MINIMUM DESIGN

Use replicated blocks where practical. Keep cultivar, irrigation, fertilizer and protection programs consistent. Record weather and sampling dates so treatment effects can be separated from field variability.

Sources: soil research presentation and meta-analysis design criteria.

10 SOURCE MATERIAL

Evidence sources and references

The references include peer-reviewed mechanism studies, product documents and historical application records.

1 **Peer-reviewed science**

Describes microbiome mechanisms and reported effects of microbial inoculants.

2 **Product documents**

Define ingredients, handling, application schedules and functional pathways.

3 **Controlled pilot**

Measures soil, root and crop endpoints under the target field conditions.

PRIMARY REFERENCES

01 Tkacz A. et al. (2020). mBio 11:e02785-19. doi:10.1128/mBio.02785-19.

02 Backer R. et al. (2018). Frontiers in Plant Science 9:1473. doi:10.3389/fpls.2018.01473.

03 Liu X., Mei S., Falcao Salles J. (2023). Applied Soil Ecology 190:105011. doi:10.1016/j.apsoil.2023.105011.

04 Azarbad H., Junker R.R. (2024). ISME Communications 4:ycae122. doi:10.1093/ismeco/ycae122.

05 Periodical Systems: soil research series, Culture Solution guide, plant TDS, Chinese formulation and application documents.

PRODUCT FUNCTION BioSystem supplies a non-microbial nutrient medium for resident soil biology. Field programs measure soil, root and crop responses under local conditions.

END OF TECHNICAL OVERVIEW

Thank you for your time.

For the current specification, research details or a controlled pilot discussion, contact the Periodical Systems technical team.

TECHNICAL FOLLOW-UP

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Technical documents, source files and current application guides are available on request.