Agricultural Exploitation of the Trichoderma hamatum - Brassica Crops Interaction as a Biotechnological Tool for Nutraceutical and Defensive Improvement

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Background and Objectives

Beneficial fungus-plant partnerships can raise crop performance while supporting sustainable input reduction. Trichoderma hamatum is a root-associated fungus known for growth promotion, nutrient mobilization, and biocontrol. Brassica vegetables are valued for glucosinolate-derived bioactives and phenylpropanoid antioxidants that contribute to human health.

Objectives

- Summarize how T. hamatum colonization reshapes Brassica metabolism and defense.
- Highlight strain, timing, and environment factors that govern field performance.
- Identify methodological and regulatory gaps for nutraceutical claims and microbial inoculants.

Mechanistic Triggers

- Root colonization and rhizosphere competence enable persistent signaling to the host.
- Elicitation of JA/ET/SA-linked networks primes induced systemic resistance (ISR).
- Improved nutrient acquisition and stress buffering support biomass and quality.

Nutraceutical Modulation

- Upregulation of phenylpropanoid routes increases flavonoids and related antioxidants.
- Modulation of glucosinolate biosynthesis can raise health-promoting isothiocyanate precursors.
- Reported reductions in selected antinutritional factors depend on cultivar and dose.

Biocontrol and Defense

- Direct antagonism: competition, mycoparasitism, and inhibitory metabolites limit pathogen establishment.
- Host priming: faster oxidative burst control, strengthened cell walls, and defense gene activation.
- Outcome: lower incidence and severity for several Brassica diseases in greenhouse and field trials.

Conceptual Model: From Colonization to Quality and Resilience

T. hamatum input
Seed/soil delivery
Root colonization
Rhizosphere competence

→

Host signaling
JA/ET/SA priming
ISR activation
Nutrient/stress support

→

Crop outcomes
Pathogen suppression
Higher antioxidants
Enhanced glucosinolate profile

Key message: stable colonization links molecular priming to quality traits and lower disease burden.

Field Implementation

- Use well-characterized strains; confirm identity, viability, and colonization in planta.
- Optimize delivery: seed coating, nursery drench, or transplant dip; repeat under high disease pressure.
- Track timing: early establishment often yields stronger metabolic and defense responses.
- Record environment: soil type, temperature, and moisture strongly influence efficacy.

Current Limitations and Gaps

- Standardize metabolite assays (sampling stage, tissue, extraction, and analytics) for comparable nutraceutical datasets.
- Report dose-response and persistence metrics for reproducibility across sites.
- Clarify regulatory positioning: biofertilizer vs biopesticide vs biostimulant may differ by jurisdiction.

Conclusions and Future Directions

T. hamatum-based biotechnology offers a dual-benefit pathway for Brassica systems: stronger disease resilience with potential improvement of nutraceutical traits. Priority next steps include genome-informed strain selection, multi-location field validation, and harmonized protocols linking colonization to metabolite outcomes and consumer-relevant quality indices.

Keywords: beneficial fungus-plant interaction; Brassica crops; induced systemic resistance; glucosinolates; phenylpropanoids; microbial inoculant