# REVIEW OF SOIL AMENDMENT WITH SAWDUST AND TRICHODERMA VIRIDE FOR MANAGEMENT OF RHIZOME ROT OF GINGER (ZINGIBER OFFICINALE

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**Abstract**

Rhizome rot of ginger (Zingiber officinale) — caused by soil- and seed-borne pathogens (notably species of Pythium, Fusarium, etc) — is a major constraint in ginger production worldwide. Among non-chemical management strategies, use of soil amendments (such as sawdust) and biological control agents such as Trichoderma viride have been explored. This review synthesises available studies on: (a) the effect of sawdust or other organic soil amendments on rhizome rot incidence and yield of ginger, (b) the role of T. viride (and related antagonists) as a biocontrol agent, (c) any documented synergy of amendment + biocontrol, (d) mechanism of action, and (e) gaps and practical considerations. The evidence indicates that soil amendments (including sawdust or burnt sawdust) may reduce incidence of rhizome rot and increase yield under certain conditions, but the degree of efficacy varies widely. T. viride shows promise in suppressing pathogen activity and improving germination/yield in field trials. However, few rigorous studies have evaluated the combined use of sawdust amendment + T. viride, and further region-specific, mechanistic and cost-effective work is required. For practitioners, soil amendment with sawdust (or equivalent organic residues) together with seed or soil treatment with T. viride may represent an eco-friendly component of integrated rhizome rot management in ginger.

**Keywords:** ginger, rhizome rot, Znigiber officinale, soil amendment, sawdust, Trichoderma viride, biological control, organic amendment.

1. Introduction

Ginger (Zingiber officinale Roscoe) is an important spice, medicinal and flavour crop grown in many tropical and subtropical regions. However, the crop is frequently threatened by rhizome rot or soft rot diseases, which can lead to severe yield losses. The causal agents are often fungal or oomycete pathogens (for example, Pythium aphanidermatum, Pythium myriotylum, Fusarium oxysporum f. sp. zingiberi) and other associated fungi. These pathogens can survive in soil or planting material (rhizomes) and proliferate under warm, moist, poorly drained soils. Controlling rhizome rot poses significant challenges, especially under small-holder and low input systems.

Chemical fungicides have been widely researched but concerns about environmental impact, cost, resistance, and residue have led to interest in more sustainable, integrated approaches. Among these, organic soil amendments (e.g., oil-cakes, composts, sawdust, burnt residues) and microbial antagonists such as Trichoderma spp. have been the focus of several studies. Soil amendments may improve soil physical, chemical and biological properties, suppress pathogens via soil-microbiome shifts, or improve plant vigor; biological control agents attack or inhibit pathogens directly or via induced resistance.

This review focuses on the two components: sawdust soil amendment and Trichoderma viride (an antagonist fungus) in the context of ginger rhizome rot management, using publications up to 2014. The objective is to examine the state of knowledge, highlight mechanisms and practical findings, and identify knowledge gaps for future research.

## 2. Rhizome Rot of Ginger: Pathogens, Symptoms and Management Context

### 2.1 The disease and its causal agents

Rhizome rot of ginger is characterised by yellowing and wilting of leaves, water-soaking of the plant base, softening and rotting of rhizomes, often leading to collapse of plants and severe yield losses. The disease is soil- and seed-borne, with pathogens such as Pythium aphanidermatum, Pythium myriotylum, Fusarium oxysporum f. sp. zingiberi frequently implicated. For example, a study from Bangladesh reported rhizome rot caused by Pythium aphanidermatum.

2.2 Management challenges

Because the pathogens live in soil or infected rhizomes, management must include clean planting material, good drainage, crop rotation, soil health improvement and often chemical/biological treatments. Organic soil amendments and microbial antagonists are promising as part of integrated disease management (IDM).

3. Soil Amendment with Sawdust and Other Organic Materials

3.1 Rationale for organic amendments

Organic amendments such as sawdust, oil-cakes, poultry manure, composts etc. may improve soil aeration, reduce bulk density, enhance microbial diversity, increase beneficial organisms, reduce pathogen activity and improve plant resilience. They may also alter soil pH or suppress pathogens via nutrient competition or antibiosis.

3.2 Sawdust (and burnt sawdust) as amendment and its effect on rhizome rot in ginger

One key study in Bangladesh by Ayub et al. (2009) tested three organic amendments (poultry refuse, mustard oil-cake, and sawdust burning at 15 t/ha) together with antagonists and fungicides against rhizome rot of ginger (caused by Pythium aphanidermatum). The sawdust amendment (soil burning with sawdust) reduced plant infection percentage from ~35.4% in control to ~25% in sawdust treatment at one site (Domar upazila) and gave yield ~17.23 t/ha vs 12.74 t/ha in the control. The authors concluded that soil amendment with sawdust burning was “also found to be effective to control the disease and increase rhizome yield”.

Another older reference (Hasnat et al., 2014) noted that in Bangladesh, sawdust was one of the organic amendments studied and showed disease-severity reduction (though details of sawdust alone are limited).

Though not exclusively sawdust, several studies on organic amendments in ginger indicate that adding organic matter (including wood derived residues) improved disease suppression: e.g., Thakore (1988) found wood sawdust + T. viride resulted in low incidence of rhizome rot (cited in Hasnat et al.)

3.3 Mechanisms by which sawdust amendment may help

Improvement of soil structure and drainage (reducing water-logging and thus pathogen proliferation).

Increase in beneficial microbial populations which can out-compete or antagonise pathogens

Possibly production of phenolic compounds or other inhibitory metabolites during decomposition of sawdust which suppress pathogenic fungi/oomycetes.

Enhanced plant vigor due to improved root environment, enabling better resistance.

Soil heating or burning of sawdust may reduce pathogen inoculum in soil surface layers (as in the burning treatment in Ayub et al.).

3.4 Practical outcomes, limitations and factors influencing effectiveness

The evidence suggests that sawdust (or burnt sawdust) can reduce rhizome rot incidence and improve yields, but with caveats:

The biology of the pathogen, soil-type, moisture regime, and local conditions matter greatly.

Sawdust alone may not suffice; integration with other practices (clean rhizome planting, drainage, antagonists) is often needed.

Decomposition of sawdust may temporarily immobilise nitrogen (depending on C:N ratio) unless balanced with N fertiliser.

Burning of sawdust may require labour/energy and may have environmental impacts.

Many studies are limited in replication, geographic locations, years and often grouped sawdust with other amendments; pure sawdust-only trials are fewer.

4. Use of Trichoderma viride in Management of Ginger Rhizome Rot

4.1 Background on Trichoderma viride

Trichoderma viride is a soil-borne filamentous fungus widely used as a biocontrol agent against soil-borne plant pathogens (for example Pythium, Fusarium, Rhizoctonia). It acts via mechanisms such as mycoparasitism, antibiosis (production of antibiotics, volatile compounds), competition for nutrients/space, induction of plant defence responses, and promoting beneficial microbial shifts. (General background from multiple sources)

4.2 Field/greenhouse trials in ginger up to 2014

A 2014 field-trial by Tripathi et al. in Bundelkhand region (Madhya Pradesh, India) tested seed treatment + soil drenching + soil application of T. viride and found good results: germination ~91% with T. viride, rhizome rot incidence ~6.4% (vs ~28.6% control), rhizome yield ~126 q/ha (control ~61 q/ha).

Another Bangladesh study (Ayub et al., 2009) included T. viride (60 g $m^{-2}$ soil amendment) but found moderate efficacy: infected plants ~30.21% in T. viride treatment vs ~35.42% in control; yield ~15.47 t/ha vs ~11.92 t/ha in control. Sawdust and fungicides performed better.

These findings indicate that T. viride is effective but its performance may depend on dose, timing, integration with other amendments, and local pathogen pressure.

4.3 Mechanisms of action in the ginger rhizome-rot context

T. viride colonises the rhizosphere and competes with soilborne pathogens, reducing their prevalence.

It may produce enzymes such as chitinases, β-1,3-glucanases, or secondary metabolites that inhibit pathogen growth or spore germination.

It can enhance root health or stimulate plant defence responses, making plants more tolerant topathogen attack.

When combined with healthy planting material and good soil environment (e.g., via amendments), its efficacy is enhanced.

4.4 Practical considerations and limitations

- Efficacy depends on inoculum formulation, viability, application method (seed-treatment vs soil drench vs soil incorporation), and environmental conditions (moisture, temperature, soil microbial community).
- Single application may not suffice; repeated applications or integration with soil amendments may be needed.
- It is best used as part of an integrated approach rather than a standalone 'silver bullet'.
- There is less information on long-term persistence, cost-benefit in smallholder contexts, and comparative trials of T. viride plus soil amendment vs each alone ( literature on combined application is quite limited).

5. Combined Use of Sawdust Amendment + Trichoderma viride

5.1 Evidence

While several studies have separately tested organic soil amendments (including sawdust) and T. viride, fewer have explicitly designed trials to test their combination. For example, the Hasnat et al. (2014) review (though slightly post-2014) mentions that wood sawdust + T. viride showed reduction of rhizome rot incidence (citing Dataram, 1988) but detailed field data are scarce. The Ayub et al. (2009) study included both amendments and antagonists in the same trial, but did not evaluate their interaction (they were separate treatments) so synergy cannot be conclusively determined.

5.2 Possible rationale for synergy

- Sawdust amendment improves soil physical/chemical/microbial environment (better drainage, oxygenation, beneficial microbes), thus creating conditions more favourable for establishment and efficacy of T. viride.
- The decomposition of sawdust may release compounds or shift microbial community that suppress pathogens, and T. viride may exploit those shifts to further suppress the pathogen.
- Together they might lower pathogen inoculum and increase plant vigour, leading to a double benefit: reduced disease pressure and improved crop tolerance.

5.3 Gaps and research needs

- Systematic trials that compare: (a) control, (b) sawdust alone, (c) T. viride alone, (d) sawdust + T. viride, under identical conditions (soil type, variety, pathogen pressure) are lacking in the literature .
- Dose/ratios for sawdust, timing of amendment relative to planting, decomposition period, possible nitrogen immobilisation effects need exploration.
- Formulation, survival and colonisation of T. viride in sawdust-amended soils need mechanistic study (e.g., microbial community shifts, root colonisation).
- Field trials across diverse agro-ecological zones, cost-benefit analysis for smallholder systems, and long-term effects (soil health, subsequent crops) are under-represented.
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6. Synthesis: Key Findings, Opportunities and Limitations

6.1 Key findings

- Soil amendment with sawdust (particularly when burnt/incorporated) in field trials (e.g., Ayub et al.) reduced ginger rhizome-rot incidence and increased yield relative to control.
- Trichoderma viride demonstrated ability to significantly reduce rhizome-rot incidence and increase yield in certain trials (e.g., Tripathi et al.).
- Organic amendments plus antagonists are promising parts of an integrated rhizome-rot management strategy for ginger.
- Mechanistic rationale exists for both approaches: improved soil health/physical conditions (sawdust) and direct pathogen suppression/biological activity (T. viride).

6.2 Opportunities

- Combining sawdust amendment + T. viride may yield additive or synergistic disease suppression and yield benefit.

- Use of locally available organic residues (sawdust) may be cost-effective for smallholder ginger growers, especially in women-led enterprises in circular economy contexts (reusing agro-residues).
- Integration with other best practices (clean rhizomes, crop rotation, drainage, seed treatment) can create robust management systems.
- Research exploring dose-response, formulation development and adaptation to local agroecologies is needed.

6.3 Limitations

- The variability in results across sites, limited number of replicated field trials , and limited long-term data means that generalizability is constrained.
- Some organic amendments (e.g., sawdust) may have unintended effects such as nitrogen immobilisation, slower decomposition, or initial drop in fertility if not managed.
- T. viride efficacy depends on many factors; inconsistent performance may occur when soil conditions (e.g., low organic matter, low moisture) are poor.
- Cost, labour, availability of amendment material and proper formulation/application of T. viride can be barriers in some contexts.
- The majority of studies up to 2014 focused on individual components rather than full integrated systems.

7. Practical Recommendations for Ginger Growers and Researchers

7.1 For practitioners

- Before planting ginger, consider incorporating a sawdust amendment (or equivalent organic residue) into the soil. For example, the Bangladesh trial used ~15 t/ha burning/incorporation of sawdust.
- Ensure that the sawdust is incorporated sufficiently before planting (allowing some decomposition) and monitor fertility (especially nitrogen) so that plant vigour is maintained.
- Use Trichoderma viride as seed/rhizome treatment and/or soil drench/soil application: seed/rhizome treatment may enhance germination and reduce initial disease pressure.

- Integrate these with other good practices: clean, disease-free rhizomes; well-drained raised beds; crop rotation; sanitation; minimal water-logging.
- Monitor disease incidence and yield: compare to previous seasons to assess benefit of the amendment/biocontrol investment.
- In small-holder or women-led circular economy enterprises: sawdust may be sourced from local wood/residue centres; using this residue helps recycling and adds value.

7.2 For researchers

- Design factorial trials that test sawdust amendment (various rates/timings) × T. viride (various application methods/doses) × control treatment, over at least two seasons and multiple sites.
- Investigate the decomposition dynamics of sawdust in ginger soils (C:N ratios, microbial changes, nitrogen immobilisation), and how that affects plant vigour and disease suppression.
- Study root and rhizosphere colonisation by T. viride in amended vs non-amended soils; track microbial community shifts, pathogen inoculum dynamics, and soil health indicators (organic matter, enzymatic activity).
- Conduct cost-benefit analyses that evaluate labour/costs of amendment + biocontrol vs yield gain and disease reduction, especially for smallholder contexts.
- Explore how sawdust+T. viride performs under real-world constraints (warm/humid tropical soils, varying pathogen pressure, resource-limited farmers).
- Investigate long-term soil health and rotational effects: e.g., impact on subsequent crops, residue accumulation, possible build-up of other pests/diseases.

8. Conclusion

The literature provides encouraging evidence that soil amendment with sawdust and biological control using Trichoderma viride can contribute to managing rhizome rot in ginger (Zingiber officinale). While neither is a standalone solution, their inclusion in integrated disease management offers a more sustainable approach. For best effect, attention must be paid to correct rates, timing, soil conditions, and integration with other agronomic practices. Yet, there remain important research gaps: trials combining both amendments, understanding decomposition and microbial mechanisms, economic assessments, and adaptation to small-holder systems. Moving forward, these components hold promise for resilient ginger production systems especially in resource-limited and women-led enterprises that emphasise reuse of agro-residues (e.g., sawdust) as part of a circular economy.

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