



## Management of Subterranean Pests: Strategies and Innovations

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Insects that feed on roots, like termites, wireworms, and white grubs, as well as plant-parasitic nematodes, pose a serious danger to global agricultural productivity. These insects disrupt root systems, which results in reduced uptake of nutrients and water, stunted development, and a significant loss of output. Since they are difficult to find and manage due to their covert position, integrated pest management (IPM) techniques are necessary for the long-term viability of crop output and soil health.

Precision farming, biotechnology, and ecological intensification are the main topics of recent advancements. Monitoring techniques include soil sensors, molecular diagnostics, and remote sensing provide early detection and targeted actions. Environmentally friendly substitutes for chemical controls include microbial biopesticides, helpful nematodes, and entomopathogenic fungi. Transgenic resistance and RNA interference (RNAi)-based pest suppression present novel, less expensive methods of managing pests.

Chemical control methods have also evolved, such as seed treatments, systemic insecticides, and formulations based on nanocarriers that lessen resistance and non-target effects. Crop rotation, biofumigation, and organic soil additives are examples of regenerative farming techniques that increase soil resistance to insect incursions. To lessen the damage caused by underground pests, future studies should focus on incorporating these techniques into evidence-based management approaches.

This paper looks at innovative subterranean pest management technologies that offer environmentally friendly substitutes that work with the present-day intensive agriculture. These days, farmers can use computer technology, biotechnology, and natural ecosystem-based strategies to manage these elusive pests while boosting long-term crop and soil health.

### Subterranean Pest Challenges in Agriculture

Subterranean insects are some of the most devastating but least perceptible agricultural threats worldwide. Their effects are frequently underestimated because symptoms take a long time to appear, manifesting as wilting of plants, stunted growth, and losses in yield. Subterranean insects attack root systems mostly, compromising plant structures and predisposing crops to drought stress and secondary infections.

Key pests include white grubs (Scarabaeidae larvae), wireworms (Elateridae larvae), and Termites, which cause direct damage to roots, wireworms (Elateridae larvae), and white grubs (Scarabaeidae larvae) are important pests. In addition, underground crop damage is exacerbated by plant-parasitic nematodes such as lesion nematodes (*Pratylenchus* spp.), cyst nematodes (*Heterodera* and *Globodera* spp.), and root-knot nematodes (*Meloidogyne* spp.). These pests harm valuable horticultural crops in addition to infesting major food crops like potatoes, wheat, and maize.

Early discovery is problematic due to their burrowing habitat. Infestation is often undetected by farmers until significant crop loss has occurred, making effective treatment

challenging. Because of this, modern agricultural systems must integrate sustainable control mechanisms and sophisticated detecting techniques.

### **Innovations in Subterranean Pest Detection**

**Soil Monitoring Technologies:** The advancement of soil monitoring methods has improved the ability to identify subterranean pests before damaging signs become apparent. Finding early signs of plant stress that indicate root damage is made easier by remote sensing, hyperspectral analysis, and multispectral aerial photography using drone technology. Sensors that measure electrical conductivity and soil moisture help identify irregularities in root zone activity.

**Molecular Diagnostics and Predictive Analytics:** Nowadays, molecular techniques such as polymerase chain reaction (PCR) and loop-mediated isothermal amplification (LAMP) are used to quickly identify soilborne diseases and plant-parasitic nematodes. Early intervention is made possible by the prediction of pest outbreaks using artificial intelligence (AI) models that track field data.

**Baiting and Trap Systems:** Pheromone traps, pitfall traps, and light traps are used to track adult insect populations. This aids in forecasting when larval infestations may emerge. whether or not to implement control measures to guarantee optimal efficacy, these monitoring tools are essential.

### **Integrated Pest Management Strategies for Subterranean Pests**

#### **Cultural and Agronomic Practices**

**Crop Rotation:** Disrupts pest life cycles by alternating non-host crops with susceptible crops.

**Soil Tillage:** Exposes soil-dwelling pests to predation and environmental stress.

**Organic Amendments:** Enhances soil microbial activity, promoting natural pest suppression.

#### **Biological Control Approaches**

**Entomopathogenic Nematodes:** Beneficial nematodes such as *Steinernema* and *Heterorhabditis* are effective against soil-dwelling insect larvae.

**Microbial Biopesticides:** *Beauveria bassiana*, *Metarhizium anisopliae*, and *Bacillus thuringiensis* are used to suppress pest populations.

**Predatory Mites and Fungi:** Naturally occurring biological agents help control root-feeding nematodes and insect pests.

#### **Chemical and Biotechnological Strategies**

**Seed Treatments:** Systemic insecticides and nematicides provide early protection for seedlings.

**Precision Chemical Application:** Granular formulations and biodegradable nano-carriers reduce environmental impact.

**RNA Interference (RNAi):** Targeted gene silencing technology is emerging as a novel approach for pest suppression.

**Transgenic Resistance:** Genetically engineered crops with pest-resistant traits reduce reliance on chemical treatments.

### **Soil Health and Pest Management Synergy**

An important component of subsurface pest control is soil health. Beneficial microorganisms that promote plant resistance and prevent pest growth are fostered by healthy soil. Composting, cover crops, and conservation tillage are sustainable soil management techniques that improve soil fertility and prevent pests.

According to studies, nematode populations can be naturally decreased by include biofumigant crops like mustard and radish in crop rotations. Similarly, by changing the soil microbiota, soil solarization—which traps heat using transparent plastic mulch—effectively lowers soilborne pest problems.

## Conclusion

Because of their destructive impact on root systems and covert lifestyle, underground insects continue to be a problem in modern agriculture. A comprehensive approach that incorporates biological control, targeted chemical use, and advanced monitoring techniques is necessary for sustainable control. Predictive analytics, microbial biopesticides, and new developments in RNA interference technology offer potential ways to decrease pests with little harm to the environment.

Future research should focus on using precision agriculture, biotechnology, and soil health recovery techniques to optimize integrated pest management systems. Farmers can lessen damage from subsurface pests while preserving long-term agricultural yield by adopting data-based, environmentally friendly pest control methods.