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A comprehensive study of soil fumigants over Soil born fungal infection in plants

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Abstract
Soil-borne fungal infections in plants are caused by fungi that live in the soil and infect plant roots, stems, or leaves. These infections can cause significant damage to crops and can result in reduced yield, stunted growth, or even plant death. Soil fumigants are pesticides that are used to control pests and pathogens in soil before planting crops. These chemicals are applied to the soil and then either evaporate or are absorbed into the soil. Once in the soil, the fate of soil fumigants depends on several factors, including their chemical properties, environmental conditions, and the management practices used after application.

Keywords: Soil-borne fungi, fungal infections, damping-off, soil fumigant

Introduction
Fungal species in the phyla ascomycota and basidiomycota are among the most common soil-borne pathogens of plants. In the absence of a host, these fungi can survive in soil as saprophytes on plant residues or in the form of spores or resting structures, such as sclerotia, for long periods of time, even under adverse conditions. Roots are often the primary site of infection, although developing epicotyls and hypocotyls of seedlings, stem bases, and crowns may also be the first target of fungal attack. Soil-borne plant pathogenic fungi cause a variety of diseases, such as root rot, stem rot, crown rot, damping-off, and vascular wilts, resulting in significant economic losses in the yield and quality of agricultural and horticultural crops worldwide. Of special interest are the emerging soil-borne fungal pathogens of plants detected in recent years.
Synthetic pesticides have long been used to effectively manage plant diseases. However, their prolonged and persistent use has resulted in many detrimental and unprecedented effects on the surrounding environment. Pesticide misuse has resulted in many phytopathogens becoming resistant. Pesticides’ bioaccumulation and toxicity to non-target organisms have also had negative environmental repercussions. Synthetic pesticides cause nearly two lakhs of deaths from poisoning each year, and 99% of them occur in developing countries [3]. Although synthetic pesticides are sometimes more convenient, biopesticides derived from natural resources are a superior option. This last decade has seen the various botanicals becoming increasingly prominent in the field of plant protection.

Types of soil-borne diseases
Soil-borne diseases in the garden include pre and post-emergence damping-off, like Fusarium, *Pythium* and *Rhizoctonia* species, root rot, including *Phytophthora*, vascular wilts caused by fungi including *Verticillium* and nematodes.

- Pre-emergence damping-off is where young seedlings decay in the soil before they appear above the soil surface. This occurs when conditions for seed germination are poor, such as cold, hot or very wet soil, poorly-drained soil, compacted soil or in the presence of undecayed organic matter.
- Post-emergence damping-off is where stems and roots of tender seedlings are attacked at the soil line and the seedlings fall over. High salt concentrations in the soil also cause damping-off.
- Root rots can affect plants beyond the seedling stage when the fungi invades internal root tissue, interfering with the supply of water and nutrients. Aboveground symptoms include loss of vigour, leaf yellowing, leaf drop, wilting starting at the growing tip, twig dieback, and sudden death.
- Vascular wilts are characterised by plant wilting and discolouration of the vascular

system at stems or trunks and branches.

- Nematodes are microscopic, unsegmented worms. They include pest nematodes like the root knot nematode which invades the roots and causes them to form gall-like lesions that restrict water and nutrient uptake which causes wilting.

The incidence and severity of soil-borne fungal diseases in cultivated systems depend on biotic and abiotic environmental conditions and on agronomic practices, as they influence the survival and dispersal of fungi, both in soil and air, and the interactions between the host and the fungal pathogen. Since fungal diseases are highly climate-driven, in the current context of climate change, changes in temperature, precipitation, and atmospheric CO_2 concentration will likely have a strong impact on fungal pathosystems, which has to be investigated.

Control of soil born fungal pathogens

The control of these pathogens is challenging, due to their ability to survive in soil and to current limitations in the use of synthetic pesticides. More research is needed on resistant cultivars, microbial antagonists, disease prediction models, the use of biotechnology and nanotechnology to obtain control products, etc., to design effective strategies for integrated disease management.

Soil-borne fungal infections in plants are caused by fungal pathogens that live in the soil and infect plant roots, causing diseases such as root rot, damping-off, and wilt. These fungal pathogens can survive in the soil for many years, making them a persistent problem for plant growers. Some common soil-borne fungal pathogens that can cause plant infections include Fusarium, *Pythium*, *Rhizoctonia*, and *Phytophthora*. These fungi can infect a wide range of plant species and can cause significant damage to crops, leading to reduced yields and even crop loss.

Preventing soil-borne fungal infections in plants is essential and can be done through various management practices. Crop rotation, the use of disease-resistant plant varieties, and proper soil drainage and aeration are effective measures to reduce the risk of infection. Additionally, avoiding overwatering and maintaining proper sanitation practices can help prevent the spread of soil-borne fungal pathogens. Fungicides can also be used to control fungal infections, although their effectiveness can vary depending on the specific pathogen and the timing of application.

Some common soil-borne fungal infections include

1. **Fusarium wilt:** Caused by the fungus Fusarium oxysporum, this infection affects many crops, including tomatoes, cucumbers, and watermelons. It causes wilted leaves, stunted growth, and discoloration of the stem.
2. ***Verticillium* wilt:** Caused by the fungus *Verticillium* dahliae, this infection affects a wide range of plants, including strawberries, tomatoes, and potatoes. It causes yellowing and wilting of leaves, stunted growth, and discoloration of the stem.
3. ***Phytophthora* root rot**: caused by the fungus Phytophthora spp., this infection affects many crops, including peppers, tomatoes, and cucumbers. It causes brown or blackened roots, yellowing of leaves, and plant death.
4. ***Rhizoctonia* root rot:** caused by the fungus *Rhizoctonia* solani, this infection affects many crops, including beans, peas, and tomatoes. It causes stunted growth, yellowing of leaves, and brown or blackened roots.
5. **Anthracnose:** This is caused by the fungus Colletotrichum and affects many types of plants, including trees, vegetables, and fruits. It causes dark lesions on leaves and fruits, and can also cause the plant to wilt and die.

Preventing soil-borne fungal infections can be challenging, but there are several strategies that can help. These include practicing crop rotation, using disease-resistant varieties, maintaining good soil drainage, and avoiding overwatering. Additionally, using fungicides and other chemical treatments may also help prevent soil-borne fungal infections in plants.

Properties of Soil Fumigants and Their Fate in the Environment

Soil fumigants are chemical compounds that are used to control pests, pathogens, and weeds in soil. They are typically applied as a gas or a liquid that evaporates into a gas. The properties of soil fumigants and their fate in the environment depend on several factors, including the chemical composition of the fumigant, its application method, and the environmental conditions where it is applied.

Soil fumigants are pesticides used to control pests, pathogens, and weeds in soil. They are applied as gases, liquids, or solids, and their fate in the environment depends on several factors such as chemical properties, soil characteristics, weather conditions, and application method. Here are some common properties and fate of soil fumigants:

1. **Volatility:** Soil fumigants are highly volatile, which means they can evaporate and move through the air. This property allows them to penetrate soil pores and reach pests and pathogens in the soil. However, it also increases the risk of exposure to humans, animals, and non-target organisms.
2. **Chemical stability:** Soil fumigants are chemically stable and can persist in the environment for several weeks to months. They can also undergo slow degradation and transformation into other compounds, some of which may be more toxic or persistent than the parent compound.
3. **Solubility:** Soil fumigants vary in their solubility in water and soil. Some are highly soluble and can move with water and contaminate groundwater, while others are less soluble and remain in the soil.
4. **Toxicity:** Soil fumigants are highly toxic to pests, pathogens, and non-target organisms. They can cause acute and chronic health effects in humans and animals, such as respiratory irritation, headaches, nausea, and even death. Long-term exposure to low doses of soil fumigants has been linked to cancer, developmental disorders, and reproductive problems.
5. **Persistence:** Soil fumigants can persist in the soil and affect soil health and ecosystem services. They can reduce soil microbial activity, nutrient cycling, and organic matter content, and alter soil structure and water-holding capacity.
6. **Mobility:** Soil fumigants can be mobile in the soil, depending on their chemical properties and the soil

characteristics. They can move through the soil profile and potentially contaminate groundwater and surface water.

7. **Degradation:** Soil fumigants can degrade in the environment through chemical and biological processes. These processes can break down the fumigant into less toxic compounds or compounds that are more easily absorbed by soil microorganisms.
8. **Mobility:** Soil fumigants can move through the soil and enter groundwater, which can lead to contamination of drinking water sources.
9. **Reactivity:** Some soil fumigants can react with other chemicals in the environment to form new compounds, some of which may be more toxic or persistent than the original fumigant.
10. **Breakdown:** Soil fumigants can break down into less toxic compounds over time, but the rate of breakdown depends on environmental conditions such as temperature, moisture, and soil type.
11. **Adsorption:** Soil fumigants can be adsorbed onto soil particles and other organic matter in the soil. This can reduce their availability to plants and other organisms, but may also result in accumulation over time.
12. **Leaching:** Soil fumigants can also move through the soil and potentially contaminate groundwater or surface water sources. The risk of leaching depends on the specific chemical properties of the fumigant, as well as the soil type, slope, and other factors.

The fate of soil fumigants in the environment depends on several factors, including

1. **Soil type and texture:** Soil fumigants can bind to soil particles and move with water through soil pores. The extent of binding and movement depends on soil type and texture.
2. **Weather conditions**: Soil fumigants can be affected by temperature, humidity, wind, and rainfall. Higher temperatures and humidity can increase the rate of fumigant volatilization and degradation, while rainfall can increase fumigant leaching and runoff.
3. **Application method:** The way soil fumigants are applied can affect their distribution and fate in the soil. For example, fumigants applied by shank injection or drip irrigation can have different rates of movement and volatilization than those applied by broadcast or surface spray.
4. **Soil management practices:** Soil fumigants can interact with other pesticides, fertilizers, and organic amendments in the soil. Soil management practices such as crop rotation, cover cropping, and reduced tillage can affect soil fumigant persistence and movement.
5. **Atmospheric Transport:** Soil fumigants can evaporate and move through the air, leading to off-site transport and exposure to non-target organisms.
6. **Degradation:** Soil fumigants can degrade in the environment through a variety of processes, including hydrolysis, oxidation, and microbial degradation.
7. **Sorption:** Soil fumigants can sorb to soil particles, reducing their mobility and increasing their persistence in the environment.
8. **Leaching:** Soil fumigants can leach through soil and contaminate groundwater, potentially leading to long-term contamination.
9. **Chemical degradation**: Some soil fumigants can undergo chemical reactions, such as hydrolysis, oxidation, or reduction, when exposed to environmental conditions such as heat, moisture, or sunlight. For example, methyl bromide can be degraded by sunlight and reaction with soil moisture.
10. **Biological degradation:** Soil microorganisms can also degrade some soil fumigants, such as chloropicrin and methyl isothiocyanate (MITC). The degradation rate depends on the microbial population, soil moisture, temperature, and other environmental conditions.
11. **Volatilization:** Soil fumigants are highly volatile and can evaporate from the soil surface into the air. The rate of volatilization depends on the fumigant's vapor pressure, soil moisture, temperature, and wind speed.
12. **Adsorption and leaching:** Soil fumigants can also be adsorbed onto soil particles, which reduces their mobility and availability to pests. However, some fumigants can also leach into groundwater, contaminating drinking water sources.

Conclusion

Soil fumigants are pesticides used to control soil-borne pests and pathogens in agriculture. They are highly volatile and can move through the soil, air, and water. As a result, soil fumigants can have significant environmental impacts, including contamination of air, water, and soil. The fate of soil fumigants in the environment depends on several factors, including the type of fumigant, application rate, soil type, weather conditions, and management practices. Generally, soil fumigants are transformed or degraded by various chemical, physical, and biological processes in the environment. Overall, soil fumigants are highly effective at controlling soil pests and pathogens, but their use comes with environmental and health risks. Proper application and management practices can reduce these risks and minimize the impact of soil fumigants on the environment.

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