Soil Health and Disease Suppression

N. Jhansirani[1], MSV Satyanarayana[2] and Kuruba Ajay Kumar[3]

[1]Assistant Professor, College of Horticulture, Dr. YSR Horticultural University, Parvathipuram, Manyam (Dist), Andhra Pradesh – 535 502.

[2]Assistant Professor, SKY College of Agricultural Sciences, Acharya N.G.Ranga Agricultural University, Srikakulam (Dist), Andhra Pradesh – 532 403.

[3]Department of Vocational Studies & Skill Development, School of Agricultural Sciences, Nagaland University, Medziphema Campus, Nagaland-797106

Corresponding Author: jhansinagaraju7@gmail.com

Abstract

The concept of soil health considers both biotic and abiotic components, along with their interplay. There has been particular attention given to the influence of soil microorganisms, plant endophytes, and the rhizosphere microbiome on the well-being and growth of plants. In terms of evaluating and measuring soil health, soil microorganisms are suggested as ideal indicators, both for long-term evaluation and as a tool to assist in determining management strategies. Disease-suppressive soils may be especially valuable in deducing indicators from their microbiomes because they have traits directly linked to plant and soil health. The diversity of soil microbes is associated with the prevalence of soil-borne diseases. Key words: Management, Microorganisms, Soil health, Suppressive soils

Introduction

Soil health has been defined in various ways over time, but it can generally be described as the ongoing ability of soil to function as a living system that supports biological productivity, preserves environmental quality, and fosters the health of plants, animals, and humans. This definition emerged from the soil quality concepts and discussions of the 1990s. While these ideas had existed for some time, there was a renewed push during this decade to emphasize the importance of soil health for a sustainable future. After years of focusing mainly on the fertility aspects of soil as a physical medium for plant growth, the degradation of agricultural soils was recognized as a significant barrier to long-term productivity and sustainability (Doran *et al.,* 1994; 1996).

The idea of soil health encompasses both living and non-living elements, as well as the interactions between them. There has been a specific focus on the impact of soil microbial communities, plant endophytes, and the rhizosphere microbiome on plant growth and health (Coban *et al.* 2022).

Suppressive soils

Higa and Parr (1994) and Singh (2007) have identified four categories of soil based on its microbial function: conducive soil, suppressive soil, zymogenic soil, and synthetic soil. Conducive soil serves as a breeding ground for pathogenic microbes such as Fusarium, which can make up a significant portion of the microflora.

Suppressive soil has been extensively studied for controlling numerous plant pathogens including *Gaeumannomyces graminis* var. *tritici*, *Fusarium oxysporum*, *Aphanomyces euteiches*, nematodes such as *Heterodera avenae* and *H. schachtii*, *Meloidogyne* spp., *Criconemella xenoplax*, *Thielaviopsis basicola*, *Phytophthora cinnamomi*, *Phytophthora infestans, Pythium splendens, Pythium ultimum, Rhizoctonia solani, Streptomyces scabies, Plasmodiophora brassicae*, and *Ralstonia solanacearum*.

Mechanism in suppressive soils

Antibiotics

These suppressive soils have long been studied for their antibiosis properties, which may directly suppress pathogens. One commonly discovered antibiotic is the antifungal polyketide 2,4-diacetylphloroglucinol, produced by *Pseudomonas* spp., that suppresses diseases such as take-all in wheat and black root rot in tobacco.

Agricultural methods, plant-associated microbial communities, and crop diseases

Suppressiveness can be categorized as general or specific, depending on whether a broad or specific group of microorganisms is responsible for the soil's antagonistic properties. For instance, the presence of *Pseudomonas* spp. in suppressive soils has been associated with protection against various plant diseases, such as apple replant disease, Fusarium wilt of tomato, and club root diseases of Chinese cabbage. Other functional groups, such as *Flavobacterium, Chryseobacteria, Burkholderia*, and non-pathogenic strains of Streptomyces, may also contribute to specific soil suppression.

Tillage

Tillage is a commonly utilized approach for weed control, as well as for the uniform distribution of fertilizers and aeration in the soil. Conventional tillage (CT) is known to cause harm to soil aggregates and significantly changes the chemical properties of the soil. This results in decreased diversity and abundance of soil microorganisms, which in turn impact interactions between plants and roots, as well as between plants and microbes.

Mulching

Among the various types of mulching, inorganic mulching, such as plastic film mulching (PFM), is particularly popular for its immediate economic advantages, such as increased crop yield, improved crop quality, reduced water usage, and lower inputs, especially in dry regions. PFM, also referred to as the soil solarization technique, encourages the formation of soil aggregates, resulting in improved soil water and temperature conditions, decreased evaporation, and enhanced nutrient availability. (Singh *et al.,* 2021).

Monoculture and polyculture

The monocultural farming system, as discussed in this analysis, involves the ongoing cultivation of a single crop over consecutive growing seasons within the same field. In contrast, polyculture systems, such as intercropping and crop rotation, involve the simultaneous or successive cultivation of two or more types of crops within the same field. The intensive and continual use of monoculture poses a significant challenge in field farming systems, horticulture, and agroforestry. With the global population on the rise, farmers have increasingly turned to monocultures of high-value cash crops in favor of intercropping and crop rotation, seeking greater yields, profits, and lower management costs.

Soil amendments

Fertilizer application

Traditional soil cultivation and monoculture practices have been found to exhaust soil nutrients, resulting in nutrient-poor soils with reduced levels of soil organic carbon and microbial diversity. As a result, the use of fertilizers becomes necessary in agricultural fields to replenish nitrogen and phosphorus levels and enhance crop yields. However, the continuous use of chemical fertilizers has well-known disadvantages, including the degradation of soil health, risks to animal and human health, and the release of greenhouse gases and nutrients into water sources, leading to ecological imbalances in aquatic systems.

Bio control agents

Despite its high cost, the use of agrochemicals is one of the most widely utilized methods in agriculture, prompting the industry to seek efficient and durable approaches to control plant infections (Ijaz *et al.* 2019). For bacterial and fungal-based bio formulations, peat is the preferred carrier, although other substrates such as charcoal, lignite, and composts are also added. Furthermore, an encapsulation technique has been developed as a means of transport that utilizes biodegradable and eco-friendly products to reduce the use of pesticides and enhance the delivery systems of BCAs (Balla *et al.* 2022).

Conclusion

Certain types of soils have been observed to have the ability to inhibit the growth of diseases in crops. These soils contain a high concentration of microbes that are believed to aid in the suppression of pathogens by enhancing plant health, stimulating natural plant defenses, producing antibiotics, outcompeting pathogens, or parasitizing the pathogen. Soil that exhibits this ability due to its unique microbial composition is referred to as disease-suppressive soil. This characteristic makes suppressive soil an appealing form of biocontrol, as it has the potential to be sustainable over multiple growing seasons under favorable circumstances. Research has demonstrated that these microorganisms assist plants through actions such as phosphate solubilization, nitrogen fixation, nutrient absorption, and the production of plant hormones and growth regulators.

References

Balla, A., Silini, A., Cherif-Silini, H., ChenariBouket, A., Alenezi F. N., Belbahri, L., 2022. Recent advances in encapsulation techniques of plant growth-promoting microorganisms and their prospects in the sustainable agriculture. *Appl Sci* 12:9020.

Coban, O., de Deyn, G. B., van der Ploeg, M., 2022. Soil microbiota as game-changers in restoration of degraded lands. *Science* 375: eabe0725.

Doran, J.W., Parkin, T.B., 1994. Defining and assessing soil quality. In Defining Soil Quality for a Sustainable Environment, ed. JW Doran, DC Coleman, DF Bezdicek, BA Stewart, Madison, WI: *Soil Sci. Soc*. Am. pp. 3-21.

Doran, J.W., Sarrantonio, M., Leibig, M., 1996. Soil health and sustainability. In Advances in Agronomy, ed. DL Sparks, pp. 1-54. San Diego, CA: Academic.

Higa, T., Parr, J.F., 1994. Beneficial and effective microorganisms for a sustainable agriculture and environment. International Nature Farming Research Center Atami, Japan.

Ijaz, M., Ali, Q., Ashraf, S., Kamran, M., Rehman, A., 2019. Development of future bioformulations for sustainable agriculture. In: Kumar V, Prasad R, Kumar M, Choudhary D (eds) Microbiome in plant health and disease. Springer, Singapore, pp. 421–446.

Singh, A., 2007. Effective Microorganisms. The Canadian Organic Grower. Summer. pp.35-36.

Singh, B.K., Trivedi, P., 2017, Microbiome and the future for food and nutrient security. *Microb. Biotechnol*, 10, 50–53.

Singh, U., Choudhary, A. K., Sharma, S., 2021. Agricultural practices modulate the bacterial communities, and nitrogen cycling bacterial guild in rhizosphere: Field experiment with soybean. *J. Sci. Food Agric.*, 101, 2687–2695.

* * * * * * * * *