**////Title: Healthy Soils, Healthy Planet, Healthy Humans!**

**////Standfirst:**

The earth beneath our feet is far more than just dirt. Soil is a living ecosystem filled with microbes, worms and insects, and vast networks of underground fungi filaments. Healthy soils are critical to healthy ecosystems and productive agricultural systems. Dr Joji Muramoto and researchers from the University of California have created a framework for Integrated Soil Health Management that could help suppress plant diseases without the use of harmful chemicals.

**////Main text:**

Soil with all its living organisms represents one of the most diverse ecosystems on the planet. These organisms interact with each other, their environment, and plant roots. Healthy soil is critical for growing healthy crops for food and fibre, improving water quality and supply, ensuring a stable atmosphere, and regulating the climate. Healthy soil is also fundamental for suppressing pests and diseases – helping to ensure our future food security.

Scientists and farmers across the globe are beginning to recognise the benefits of working in harmony with soil ecosystems to ensure healthy crops with good yields. To do this, accurate soil health assessment methods and better soil health management practices are necessary.

Conventionally, lab-based methods use several soil health indicators, such as soil pH, nutrient and mineral content, physical characteristics, and microbe presence. However, these methods don’t fully recognise soil-borne diseases – which have the potential to devastate crop production. Assessing other soil health indicators without considering soil-borne diseases can provide a misleading evaluation of overall soil health and plant disease risk.

That’s why Dr Joji Muramoto and his colleagues from the University of California have suggested that soil-borne disease assessments and management must be included in an integrated soil health approach. In their recent research, they examined the progress of soil-borne disease management, by using case studies from strawberry crops in California and advances in sustainable methods of managing agricultural insect pests.

Through their work, Dr Muramoto’s team has created a framework for developing and implementing a comprehensive Integrated Soil Health Management approach, which includes location and crop-specific factors, and soil-borne disease assessment and management.

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California produces around 90% of the strawberries grown in the USA. Over one million tonnes of strawberries are produced in the state each year, in an agricultural industry worth over two billion dollars. Conventional disease-control has involved preventative fumigation of soils with several chemicals. Many of these fumigation chemicals are toxic – being harmful to human health, soil ecosystems, and the wider environment.

As recognition of the harmful nature of fumigant chemicals grew, and stricter regulations came into force, other techniques for disease suppression were explored. These included rotating crops grown each year to include disease-suppressing crops, development of disease-resistance in crop plants through selective breeding or genetic technologies, and creating anaerobic fermentation processes to kill pathogens before planting. Despite many investigated techniques, the success of non-fumigant approaches to disease suppression in strawberries has been limited.

Each crop is susceptive to a unique set of soil-borne pathogens. For example, common soil-borne diseases of strawberries are usually caused by different pathogens to those of common soil-borne diseases of wheat.

Effective soil health management should therefore be crop-specific, while also being tailored to the agricultural ecosystem and location. This concept is called Integrated Soil Health Management, which incorporates all the factors affecting soil health, facilitates the development of more sustainable agricultural practices, and could help to ensure soil conservation and regeneration in agricultural systems. However, previous research into Integrated Soil Health Management has given limited consideration to soil-borne diseases.

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Dr Muramoto and his colleagues identified the history of agricultural insect pest control as a useful parallel to examine the development and uptake of integrated approaches in farming. Between the 1940s and 1960s, highly toxic chemicals that had lethal effects on a wide number of insect species were used as pesticides on most crops. However, by the late 1960s and early 1970s, many insect pests had returned with force, having developed pesticide-resistance – leaving farmers frustrated and defenceless.

Recognising that there are both detrimental and beneficial insects was a key step towards the development of an Integrated Pest Management approach. Increasingly, farmers across the globe are adopting the techniques used in this approach, such as cropping systems that boost beneficial insect communities. Such beneficial insects can prey on pests, reducing damage to crops.

However, changing the perception of farmers to new techniques can present challenges. In Integrated Pest Management methods that use predatory or parasitic insects to control pests, learning passed between farmers was critical to uptake of the approach.

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Unique challenges are present in the efforts to transition to Integrated Soil Health Management. In contrast to insect pests, disease-causing microbes in soil require advanced techniques to seek and identify their presence. Post-infection treatments for soil-borne diseases are limited. The complexity of soil ecosystems and soil microbe communities have slowed the development of non-fumigant approaches.

Recent advancements in rapid and accurate molecular techniques offer a feasible approach for identifying disease-causing microbes in soils. For instance, scientists have developed molecular techniques to identify and quantify several species of soil microbes that are lethal to strawberries.

Importantly, in addition to beneficial insects, we are now beginning to recognise the value of beneficial microbes for resilient plant growth. Establishing healthy soils through Integrated Soil Health Management approaches could help to foster beneficial plant-microbe relationships that improve the plants’ natural defences to disease-causing microbes.

Dr Muramoto and his research team suggest a framework for the development of bespoke Integrated Soil Health Management plans. The first component of the framework suggests molecular techniques should be used in conjunction with conventional measurements. This will aid development of a comprehensive soil health diagnostic system for the specific agricultural ecosystem and location. The development of cost-effective diagnostic tools is critical for the widespread roll-out of the approach.

A bespoke soil-health management plan incorporating techniques from a suite of practices that improve overall soil health should be devised. More intensive soil-borne disease management techniques can be included as needed, based on the results of the soil health diagnostic measurements.

The third key component within the framework is supporting farmers through the decision-making process, with assistance interpreting complex datasets and devising location-based strategies. The knowledge and experience of farmers is integral to the process. Widespread transitioning to the approach will be underpinned by collaboration between scientists and farmers.

Although Dr Muramoto and his research team have outlined a framework for developing Integrated Soil Health Management, they suggest that more research into soil-borne disease management is still required. The relationships between soil microbe communities, plant health, and disease suppression are not yet fully understood and are fundamental to the advancement of better soil health strategies.

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This SciPod is a summary of the paper ‘Integrated Soil Health Management for Plant Health and One Health: Lessons From Histories of Soil-borne Disease Management in California Strawberries and Arthropod Pest Management’, in Frontiers in Sustainable Food Systems. [doi.org/10.3389/fsufs.2022.839648](https://doi.org/10.3389/fsufs.2022.839648)

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