Integrating biofertilizers and precision agriculture

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Figure 1: Conceptual model on how biofertilizers can boost the integration of agroecology and precision agriculture techniques.

This article presents a comprehensive analysis of the integration of biofertilisers and precision agriculture, with the aim of creating a virtuous circle of agricultural growth and sustainability, by Cristina Cruz and Teresa Dias of the Faculdade de Ciências da Universidade de Lisboa

“What do plants feed on?” may seem a simple question, but our answer has changed over time, and there is still no consensus. From antiquity until the mid-18th century, we thought plants fed on organic compounds (i.e., the humus theory).

With the advances in chemistry and the discovery of chemical elements, we considered that plants feed on water and mineral salts. The industrialisation of the Haber-Bosch process allowed the production of large quantities of affordable fertilizers, allowing the green revolution of the mid-20th century and intensive agriculture.

However, advances in microbiology and the demonstration that legume improvement of soil nitrogen was, in fact, achieved by bacteria highlighted the contribution of soil biota (e.g., bacteria, fungi, nematodes, mites, worms) to supporting life on Earth, and crops in particular.

Advances in microbial ecology have shown that soil is a biodiversity hot spot (90% of which is still unknown), and that soil biota activity is key for ecosystems' functioning, food production, clean water and air, nutrient recycling, climate regulation, recreation, etc.

Today's challenges urge us to rethink the role of soil in agriculture, especially the relevance of soil biota to food production sustainability and quality. Since many soils worldwide are already degraded by intensive production practices and their biodiversity is already very low or unbalanced, we must restore their soil biota's diversity and functionality.

One of the ways to achieve this is by using biofertilizers.

Biofertilizers for sustainable agriculture and soil health

Biofertilizers contain living microorganisms such as bacteria, fungi, and algae, which enhance nutrient availability, soil fertility, and plant growth when applied to plants or soils. Biofertilizers are game changers in soil functionality and stimulate beneficial relationships between soil biota and plants while reducing the need for synthetic fertilizers.

They contribute to sustainable agriculture and improved soil health, mainly by reducing nutrient runoff, minimising environmental pollution, and promoting healthier soils. Their effectiveness varies depending on soil type, climate, and crop, so correct selection and application methods are essential to maximise their potential benefits. Despite their benefits, several reasons contribute to their limited adoption by farmers.

Expanding adoption of biofertilizers

Although biofertilizers are compatible with all types of farm management, some farmers (organic, agroecological, small-scale, subsistence, farmers in ecologically sensitive areas) have been more willing to embrace these products.

Expanding adoption requires government policies, research, extension services, raising awareness, providing technical training and support, addressing cost concerns, and demonstrating their effectiveness through successful case studies. The living labs focused on soil health promoted by the EU Soil Deal Mission may play a fundamental role in this transition by demonstrating the benefits of adoption.

Although using biofertilizers may seem more aligned with agroecology and similar farming practices, it is also compatible with precision agriculture or smart farming. Indeed, farmers using precision agriculture may be more open to new approaches and innovative techniques, such as using biofertilizers.

This is where two distinct views of agriculture meet and can merge to deploy a virtuous cycle of agricultural prosperity and sustainability; biofertilizers and precision agriculture can work together to enhance agricultural sustainability, productivity, and resource efficiency.

The advantages of merging biofertilizers and precision agriculture in precision agroecology were demonstrated within the SOILdarity project.

Precision agriculture

Since precision agriculture uses technology and data to apply inputs (including fertilizers, water, seeds, etc.) at variable rates (precisely where and when they are needed), biofertilizers can be applied strategically based on soil nutrient levels, crop needs, and other environmental factors. This targeted approach reduces waste, minimises the overuse of biofertilizers (and associated costs), and optimises their effectiveness.

Precision agriculture relies on detailed soil mapping and nutrient analysis, and biofertilizers can be used to address specific nutrient deficiencies identified through soil testing. For example, if a particular area of a field has low nitrogen, nitrogen-fixing biofertilizers can be applied only to that area.

Sensors, drones, and other real-time technologies to monitor crops and soil can also provide recommendations and decision support systems for biofertilizer application, ensuring that plants receive the proper nutrients when needed most (Figure 1).

Biofertilizers and precision agriculture

Combining biofertilizers and precision agriculture allows for a more efficient and targeted approach to nutrient management, reducing environmental impacts and optimising crop production. We are at the crossroads of transformation.

The modern resource-intensive farming techniques introduced during the green revolution are exhausted; however, there is growing awareness about food safety, nutrition, and the ecological impact of farming practices.

Corporations are now reimagining farming and actively participating in its growth. Thus, this is an opportune time to scale up sustainable agriculture practices that will further contribute towards this goal while improving yield, environment, and human health. Combining biofertilizers with precision agriculture can deploy a virtuous cycle of prosperity.

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cE3c – Centre for Ecology, Evolution and Environmental Changes

The Centre for Ecology, Evolution and Environmental Changes addresses science and societal challenges. Formerly named Centre of Environmental Biology, a R&D unit based at the Faculty of Sciences, University of Lisbon, the cE3c – Centre for Ecology, Evolution and Environmental Changes has evolved its vision and strategy in recent years, expanding its research to address science and societal […]