Mini Review

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Functional biodiversity and sustainable integration of microbiological bioproducts in agroecosystems

Abstract

The integration of bioproducts during the agroecological transition towards sustainable production should not be carried out as a single substitution of chemical inputs for biological ones. Bioproducts made up of microorganisms, whether for the nutrition, growth or health of crops, need the cultivation system to be an appropriate habitat for the functional interactions that determine their effectiveness. Innovations for the development of microbiological bioproducts must consider these characteristics in the utilization system.

Keywords: biodiversity, microbiological bioproducts, sustainability, agroecosystems

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Luis L Vázquez
Associate Researcher, Latin American Center for Agroecological Research (CELIA), Cuba

Correspondence: Luis L Vázquez, Associate Researcher from Cuba, Latin American Center for Agroecological Research (CELIA), Email llvazquezmoreno@yahoo.es

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Introduction

The agroecological transition process towards sustainable production has the purpose of facilitating the restoration of biodiversity and its functions in systems degraded by conventional agriculture.

Restoration ecology, which promotes the recovery of ecosystems after disturbance, acquires great relevance and functional ecology becomes a key tool for the restoration of communities and ecosystems,[1] so that strengthen the ecological functions of the agroecosystem.[2,3]

In this context, the synergistic integration of microbiological biopesticides, biofertilizers, biostimulants and mycorrhizal inoculants is in high demand and puts scientific pressure on the methodological innovations necessary to achieve their sustainable use, mainly to determine the compatibility between the microorganisms used to produce them and their interactions with the populations that cohabit in the rhizosphere and phyllosphere of cultivated plants, as well as developing appropriate technologies for their integration into crop technologies and transforming the design of the agroecosystem as a quality habitat for these microorganisms.[4]

Technological innovation in the development of microbiological products (MBP) must contribute to sustainability in their integration, mainly the facilitation of functional interactions of said products in agroecosystems, an aspect that is intended to draw attention in this article.

Biodiversity and functional interactions

Although the definition of biodiversity has been associated mainly with the number of species in a community, landscape or region, it currently recognizes the variety of roles that species play in communities and ecosystems and the ways in which they transform the environment with their activity, what is known as functional diversity.[5]

With functional biodiversity it is possible to initiate synergisms that contribute to favoring ecological processes in agroecosystems,[6,7] facilitated by the redesign of cropping systems, which contributes to interactions with the associated biota in the rhizosphere and the phyllosphere of productive agrobiodiversity and auxiliary vegetation;[8] considering that microorganisms live in associations and form stable natural consortia[9] of two or more microorganisms, which can be archaea, fungi, bacteria, viruses and algae.[10,11]

The complexity of plant-soil-microorganism-environment interactions are varied and a complete understanding of all the relationships involved is unlikely; however, the beneficial effects of biological interactions that stimulate crop yields and improve plant health can be evaluated and some general interaction strategies become evident,[12] as well as some cultural practices, such as mechanization, crop rotation, the use of irrigation, among others, modulate the interaction.[13]

The discoveries of the plant microbiome[14,15] and the application of "omics" techniques have allowed enormous progress in the development of biotechnologies for sustainable agriculture,[16] including the study of the interrelationships between species of microorganisms (synergistic, antagonistic, physical and biochemical competition), modulated by multiple and complex biotic and abiotic factors.[17]

The MBP used in agriculture, which can be obtained through industrial, semi-industrial or artisanal technologies, have the characteristics of being made up of one or more species of microorganisms, which facilitate nutritional functions, growth stimulators or antagonists of harmful organisms and require conditions appropriate in the cropping systems where they are used.

Sustainable integration of bioproducts

Several factors negatively influence the effectiveness of MBP in agroecosystems, which in turn are determinants in the sustainability of the use of these biotechnologies,[18] mainly the following:

a) Productive specialization, including monoculture
b) Simple cropping system designs (uniculture)
c) The integration of bioproducts and agrochemicals with application substitution criteria
d) Exposure of the bioproduct to direct solar radiation
e) Direct exposure of the bioproduct to surface air currents
f) Low relative humidity in the soil and microclimate
g) Poor quality of the bioproduct with respect to the concentration and viability of the microorganisms that comprise it
h) Poor quality of water used to prepare and apply suspensions
i) Prolonged exposure of the bioproduct to excess heat before its use (transportation and preparation).

The agroecological transition in the use of bioproducts begins with the replacement of chemical inputs with biological ones, continues with the diversification in the supply and use of different types of bioproducts, at the same time that these are integrated into the management of cultivation systems, contributing with various agronomic, economic and ecological functions; while, the greatest sustainability in its use is achieved when synergies between bioproducts are fostered.[4]

Unlike agrochemicals, which are composed of specific molecules and additives, MBP have reproductive structures of species or communities of microorganisms and the substrate where they are preserved, which when used interact with the biota of the agroecosystem, both to achieve greater effectiveness (nutrition, plant growth, health), to facilitate its persistence or establishment and continuity of its positive effects.

Generally, MBP are used, separately or in mixtures, for the treatment of reproductive material by dipping the seeds or roots and spraying the seedlings; sprinkling or in the irrigation system for cultivated plants and the soil surface or incorporated into the soil using different types of implements, where the microorganisms that compose them interact with the rhizosphere (Figure 1a), the soil (Figure 1b), the phyllosphere (Figure 1c) and the microbiota that inhabits these sites.

The functional interactions of MBP in the cropping system (phyllosphere and rhizosphere) are closely related to the design and management of the cropping system and the integration of auxiliary vegetation structures, due to their contribution to the regulation of the microclimate and pedoclimate (Figure 1). That is, the cultivation system is the new habitat where these microorganisms will function for the nutrition, growth and health of the crop, which is why it is important for its integration to be sustainable.

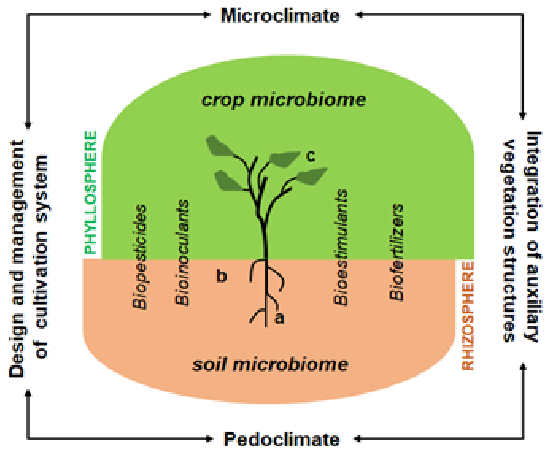

Figure 1 Interactions of MBP in the cropping system.

During the replacement of agrochemicals with bioproducts, the tendency is to use them under the same technical criteria, without considering that the agrochemicals are obtained through chemical synthesis; while MBP are the result of biological processes of massive multiplication of microorganism species. The effect of agrochemicals, whether biocidal, nutritional or others, is through the direct action of the molecules that make up said products; while, in the case of MBP, what happens are functional interactions of the microbiota that make it up.

The quality of the agroecosystem as a habitat facilitates the functions of the associated biodiversity and the synergies in the use of bioproducts, which is evident in its capacity for ecological self-regulation, because multiple cumulative effects occur that contribute to the regeneration and conservation of the biota in the soil, recovery and conservation of the associated biota (rhizospheric, epiphytic, natural enemies, pollinators) and higher quality of food, with less environmental impact, among others.[19]

Innovation for the adoption of agrobiotechnologies requires a holistic approach in its integration into agricultural production systems, so that synergies and functional interactions are facilitated that also contribute to the economic rationality of the transition towards sustainable systems. The strategy of decentralized biotechnologies for the transition towards sustainable agriculture and food means that the processes of obtaining and systems of use of these products are appropriate for the different socioeconomic and ecological-environmental contexts where they will be used.[20]

The synergistic integration of microbiological biopesticides, biofertilizers, biostimulants and mycorrhizal inoculants is in high demand and puts scientific pressure on the methodological innovations necessary to achieve their sustainable use, mainly to determine the compatibility between the microorganisms used to produce them and their interactions with populations. that cohabit in the rhizosphere and phyllosphere of cultivated plants, as well as develop appropriate technologies for their integration into crop technologies and transform the design of the agroecosystem as a quality habitat for these microorganisms.[4]

Conclusion

During the agroecological transition towards sustainable production, cropping systems (examples: polycultures, agroforestry) need to be redesigned to reestablish the functions of biodiversity in their interactions with the microorganisms that are part of the MBP.

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Conflicts of interest

Authors declare that there is no conflict of interest.

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