CONSERVATION OF MICROBIAL BIODIVERSITY TO SUSTAIN SOIL HEALTH

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Biodiversity is usually defined as the variety and variability of living organisms and the ecosystems in which they occur. Soil biodiversity encompasses all organisms that live in the soil, whether they are single-cell organisms or multi-cell animals or plants, which can be classified using traditional taxonomic techniques or genetically via unique DNA or RNA. It also embraces an immense ecological diversity manifested through behaviour patterns and feeding or habitat preferences. The combination of all these aspects is expressed in the functional diversity of soil organisms. The number of species (taxonomic diversity) clearly encompasses an important part of an ecosystem's diversity and this is controlled by the genetic diversity, which can be greater than the number of recognised species. Several species may have the same functions, resulting in what might appear to be functional redundancy. Equally, some species may interact to perform functions not possible by any single species. Biodiversity is therefore the interaction of all these elements. The diversity of soil organisms is more extensive than any other environment in the world when all living forms are considered.

SOIL IS RICH IN BIODIVERSITY

The soil biota contains representatives of all groups of micro-organisms, fungi, bacteria, algae and viruses, as well as the microfauna such as protozoa and nematodes. Soil algae and protozoa, like higher plants and animals, can be identified by their morphology. Fungi and bacteria, however, require more extensive biochemical and genetic analysis to enable identification. It has been estimated that only between 1 and 5% of all micro-organisms on Earth have been named and classified.

The new molecular techniques have shown that there is considerable genetic diversity among the microorganisms that are found in soil. It is estimated that a pasture soil sample contained about 3,500–8,800 genome equivalents. This could result in approximately 10,000 different species of equivalent abundance.

SOIL BIODIVERSITY AND ECOSYSTEM FUNCTIONING

Soil micro-organisms are clearly vital to sustaining the biosphere and functioning of ecosystems and, as a consequence, can be used for monitoring and predicting environmental change and pollutant impacts. Ecosystem functions provided by microbes are the transformation of inorganic carbon into biomass by primary producers, nutrient regeneration and cycling, conversion of organic matter including humus that would otherwise be lost from the food web into living biomass, regulation of biogeochemical cycles and consequently climate.

SOIL BIODIVERSITY AND SOIL HEALTH

Soil health can be defined as the continued capacity of soil to function as a vital living system, within ecosystem and land-use boundaries, to sustain biological productivity and maintain water quality as well as plant, animal and human health. The concept of soil health includes the ecological attributes. These attributes are chiefly those associated with the soil biota: its diversity, food web structure, activity and the range of functions it performs. Of primary importance is the contribution of soil organisms to a wide range of essential services and to ecosystem functioning by acting as the primary driving agents of nutrient cycling, enhancing the amount and efficiency of nutrient acquisition by the vegetation and enhancing plant health, through maintaining the hydrological regime and soil physical structure, through regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emission, as well as pedogenesis, the continuous building and restoration of the soil.

SOIL BIODIVERSITY AGAINST BIOTIC STRESS AND DISTURBANCE

Many soil organisms are detrimental to plant production and thereby reduce optimum resource utilization. Every year agricultural production suffers by million of rupees due to moles, rodents, snails, slugs, termites, ants, beetles and nematodes. Several species of bacteria and actinomycetes can cause plant diseases, but most damage is caused by fungi, which account for most soil-borne crop diseases, such as wilts, root rot, clubroot, and blight. Therefore, resistance against outbreaks or stress of pests and diseases and resilience from disturbance is of particular importance in agriculture.

IMPACT OF LAND-USE CHANGES ON SOIL BIODIVERSITY

Changes in the soil environment may have a large influence on the overall soil diversity and community structure. Some of the environmental factors that are known to influence community composition are organic contaminants, heavy metals, pesticides, etc. Physical parameters of the soil, such as particle density, permeability, porosity, moisture content, mineral composition and vegetation cover, are all factors that can influence microbial composition. There are now well-documented cases to show that conversion of natural vegetation to other land-uses, including agriculture, results in change in the diversity of the soil community.

MANAGING SOIL BIODIVERSITY

Soil animal and microbial diversity is part of the biological resources of agroecosystems, and must be considered in the management decisions. The main management options comprise tillage, crop rotation (and sequence) and organic matter management. The available literature indicates that high-input agriculture, particularly tilled agroecosystems with narrow crop rotation/short fallow management, leads to a decrease in species richness and dominance of some species. In contrast, management characterized by rotations, no-tillage, organic amendments and maintenance of non-productive ("natural") elements leads to an increase in species richness and overall density.

Since the management of agricultural soils has an impact upon the overall `health' of these communities, some of the potential management approaches are described below:

AGRICULTURAL MANAGEMENT PRACTICES

The soil biota may be manipulated by both direct and indirect means. Direct management is usually by inoculation with species of soil biota including N2-fixing bacteria, mycorrhizal fungi, control agents for pest and diseases and beneficial macrofauna such as earthworms. Indirect management is achieved through appropriate design and management of cropping system, including the genetic manipulation of the plant component, management of organic inputs and other soil amendments and soil tillage. Indirect approaches have the greater potential and relevance to the circumstances of most farmers. All management practices that maintain soil cover and return organic matter to the soil as well as ensuring that nutrient inputs and outputs are kept in balance. Such practices include: a) Integrated Soil Fertility Management (ISFM) ie the use of both organic and inorganic sources of nutrients rather than either alone; b) The use of legume cover crops and green manures by fallow rotation or inter- cropping; c) Agroforestry practices that provide for deep nutrient cycling and/or return of nutrient to the soil through biomass transfer, fallowing etc; d) The use of conservation tillage rather than continuous deep ploughing; e) Returns of farmyard manures and household wastes, with or without composting; f) Choice of crops and associated plants which have high nutrient use efficiency.

CULTURE COLLECTIONS

Maintaining cultures of micro-organisms of importance in agriculture is important but in many cases these are under threat due to lack of resources for their maintenance. The most common collections are those of micro-organisms such as Rhizobia or mycorrhizal fungi, but earthworm collections for vermi-composting are also available in many places in India. Legislation should address the maintenance of culture collections as well as in situ conservation and management.

PROMOTION OF SUSTAINABLE SOIL MANAGEMENT

Some approaches are mentioned specifically as sustainable management practices e. g: minimum tillage and organic agriculture. In the long run, greater use of animal and compost manures need to be promoted as a supplement to mineral fertilizers. Integrated pest management strategy should be given high priority. To reduce pollutants reaching water bodies, the run-off water should be filtered through the soil as an integral part of soil conservation structures. Greater attention needs to be given to drought resistant indigenous food plants.

CONCLUSIONS

Soil biodiversity is central to the sustainability of both managed and natural terrestrial ecosystems. Soil biodiversity should be considered as part of biodiversity action plans at a local scale and gradually upscale to regional and country level. Habitat conservation needs to be given full consideration and research priority, as well. There will be benefits to optimising soil biodiversity in all agricultural areas for supporting crop production, environmental protection, and other ecosystem services. The development of appropriate sampling or monitoring schemes requires standardised methods for sampling and characterisation of soil biodiversity. There is a need of benchmarks or ranges as standards for soil biodiversity in a given soil, under a particular land use, at a particular time and in response to environmental stresses, to interpret and predict the significance of any changes in soil biodiversity. Greater recognition to be given on the intimate relationships between soil biodiversity and the above-ground environment since they are key drivers in maintaining multiple soil functions.

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