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Ecology of Soil Microfauna in the Cropland of Siwan, Bihar

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Abstract

Microfauna that live in the rhizosphere of plants can also affect plant productivity and composition by feeding on plant roots and by altering the production of plant hormones and defenses. Soil microfauna are themselves a food source for other soil organisms, such as soil mesofauna, and once dead, saprophytic soil microbes. The population size and diversity of microfauna can thus be controlled top-down by other soil biota, bottom-up by the host plant and their mutualists, or through competitive interactions finally, soil microfauna, such as entomopathogenic nematodes, can contribute to insect pest suppression. These nematodes inject their endosymbiotic bacteria into insect larvae, where the bacteria kill and pre-digest the insect host which then serves as food for the nematodes.

Keywords: Microfauna, cropland, fungi, ecology.

Introduction

Soils provide an immense array of habitats that contain a vast and still largely unknown biodiversity, arranged in a highly-organized combination of a solid mineral phase, a network of water and air filled pores, and dead decomposing organic matters. Since the early days of the study of soil science, much has been done to describe and understand the progressive transformation of bedrocks into soils, including the distribution, nature and specific characteristics of mineral and organic components, and the opportunities and constraints that they represent for organisms.

Living and moving in this space is the first important constraint for soil organisms. Pore size is highly variable as is its connectivity, which may serve both as an opportunity or an obstacle to having an extended home. The available space theoretically accessible to a given organism may be further reduced by the amphibious nature of the system, partly filled with water and partly with air. Soil organisms should be adapted first to this very important double constraint. The second important constraint in soil is feeding on mainly low-quality food. The most abundant resources are leaf and woody litter deposited at the soil surface, root material, and soil organic matter, a very diverse set of materials with different particle sizes and chemical composition. The physically protected fraction is only accessible to soil organisms if aggregates are broken down; furthermore, a rather large energetic investment is required to use organic matter that only comprises a limited proportion (Ca. 5% in favorable cases) of the aggregates. The third is a chemically-protected pool generally equivalent to the amount of the physically protected pool comprising recalcitrant humic compounds with a very long turnover time (800-1200 years). Much soil ecology experimentation has actually been based on laboratory or small-scale field experiments (micro/mesocosms) since natural field observations and experimental designs, generally time consuming and costly, hardly provided conditions to test a single effect in isolation by an experimentation. These approaches provided a great deal of interesting results. Soil microbes contribute to many essential ecosystem functions, including decomposition, carbon and nutrient cycling, disease suppression, and regulation of plant growth and primary productivity. Bacteria and fungi play a major role in soil as the primary degraders of organic matter. Soil micro fauna comprise soil animals with body widths <100 µm, and the most abundant groups are Nematode, Protozoa, and Rotifera (Swift *et al*. 1979) [23]. Amongst these three groups, many thousands of species are known globally, but it is expected that these are still only a fraction of the number of species actually present on the globe. Soil micro fauna support several ecosystem functions. Their best known function is the promotion of nutrient cycling by feeding on various food sources and the release of nutrients via their excrements. The majority of micro fauna feed on bacteria, fungi, and (dead) plant material. In doing so, they can regulate the population size and activity of soil microbes and can promote the competitive ability and dispersal of beneficial rhizosphere micro biota by selective grazing on detrimental soil microorganisms. Microfauna that live in the rhizosphere of plants can also affect plant productivity and composition by feeding on plant roots and by altering the production of plant hormones and defenses. Soil microfauna are themselves a food source for other soil organisms, such as soil mesofauna, and once dead, saprophytic soil microbes. The population size and diversity

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of microfauna can thus be controlled top-down by other soil biota, bottom-up by the host plant and their mutualists, or through competitive interactions finally, soil microfauna, such as entomopathogenic nematodes, can contribute to insect pest suppression. These nematodes inject their endosymbiotic bacteria into insect larvae, where the bacteria kill and pre-digest the insect host which then serves as food for the nematodes.

Review of Literature

The term soil quality; soil degradation, soil health, and soil resilience are being used more frequently and with greater urgency in connection with strategies to protect our global environment. The needs to improve our quality of life and protect many scarce natural resources are forcing society to recognize the importance of their soil resource. Soil quality is frequently over-looked in a society that places more emphasis on water and air quality, likely because these resources have a more apparent connection to human health and existence.

However, soil quality and land management both have a direct influence on water and atmospheric quality and, by extension, to human and animal health. Soil is a vital resource for producing the food and fiber needed to support an increasing world population (Papendick & Parr, 1992) [16]. While seemingly a straight-forward concept, soil quality has been difficult to define and more difficult to quantify (Karlen *et al*., 1997) [18]. Many feel that soil quality cannot be defined for a complex system as diverse and dynamic as soils. "Quality" and "soil quality" are seen by some to have infinite meanings and basically are indefinable (Sajka & Upchurch, 1999). Others, however, have taken on the challenge of converting a subjective term such as "soil quality" into an objective characterizable term. The definition of soil quality (and some may argue soil) is controlled by a multitude of variables. Additionally, not all involved accept the same terminology. Soil quality and soil health are often considered to have the same meaning (Chen, 1999) [20]. The term soil health is often preferred to soil quality by farmers, while scientists relate the term "soil health" to the status of various biological properties in the soil. Soils serve as a medium for the global cycle of nutrients and energy. The soil plays an ecological role in the purification, detox Low microbial respiration could indicate the presences of pollutants such as fungicides or other pesticides. Soil microbes perform many beneficial functions as well as some detrimental impacts. The impact of soil biota is complex and difficult considering the same activity may be positive or negative depending on its location in the soil profile. Soil respiration and other microbial indicators need to be interpreted with respect to the specific function carried out by the soil microorganisms (Parkin, 1996) [21].

Decomposition of wastes and hazardous materials (Jazen *et al*., 1992) [22].

Siwan is a land locked district of Bihar State. It has Sadar block on its north side at one end while the other end is connected to the Gopalganj district. The three districts like Siwan, Gopalganj and Chapra lie in the same commissionary called Saran. It is one of the oldest commissionary in Bihar province and one played pivotal role in the several independence movements.

The Siwan areas are full of plains and fertile soil mostly prepared by holy river Ganga. Several million years ago still today, the geographical areas is dominated by sandy soils which have low water holding capacity but exhibits very fertile in productivity.

Materials and Methods

Three sites were selected in each location in Siwan and Pachrukhi block representing areas of dense crops of wheat and rice (with flood and drought disturbance); indicative of biological soil diversity because the areas are covered by grass and crops only and bare soils on the paths. The sampling sites in each area were inside an area of less than 100 square meters. Samplings in Siwan were done across 24 months (two cycle of January, March, April, May, June, September, October, November and December) At each sampling event and site, three cores were collected and pooled, resulting in a total of 24 soil samples for Siwan and Pachrukhi.. The collection of samples followed the protocol described by Davies, *et al*. (2003) [26]. In brief, a tube was introduced in the first 5 cm of soil and this core was packed into a plastic bag after removing roots and soil from the samples. Samples were brought to the lab for processing within 3d. One portion of the samples was used to determine the soil characteristics.

Physico-chemical soil characteristics were measured from one soil sample at each site. The pH of all samplings zones was determined with a litmus paper and electronic meter in a soluble extraction of the soil samples.

Separation of Soil Fungi

For the separation of soil fungi, plates were prepared by dispersing minute quantities (of around 0.05mg) of the different soil samples on the surface of a sterile Petri dish with a cultivation medium following the procedure described by Davies, 2003 [26]. The method is a variant of soil plates, and consists of spreading a minute quantity of soil in a water suspension on the surface of the agar medium. Each soil sample was cultivated in duplicate on three media: potato dextrose agar (PDA; Panreac,), malt extract agar (Davies, 2003) [26], and malt yeast peptone agar (MYP, Roth), all these amended with 0.5g l^{-1} tetracycline. The plates were incubated at 25°C for up to 25 d in an incubation chamber until colonies developed. This process involved the observation of cultures every day, making dilutions in water to separate spores, and re-cultivating until obtaining pure cultures. Re-cultivations were done on different media (PDA, MEA, MYP, and glucose yeast peptone liquid medium).

Results and Discussion

Fungal Distribution

As far as the fungal distribution in the different layers of the crop land area is concerned i.e. upper layer, middle layer and the lower layer, the different fungal species percentage along with their total number is asserted. From the upland area of the Pachrukhi block, Siwan during 2017-18 (Site-I), the highest number of fungal SP was shared by *P. restrictum* with 142 CFU × 10^3 having upper, middle, and lower layer percentage distribution were 75%, 20% and 5% respectively. Several species were totally absent like A. *cylindrospora, R. pusillus.* etc. Again, of the percentage wise distribution of fungal species from the upland area of Pachrukhi block, Siwan during 2018-19 (Site-I) showed highest number of fungal species is P. verruculosum (98x10^3 cFu) whereas very less number of fungal species like *P. waksmanii* (2 × 10^3 CFU), F *oxysporum* (2x10^3 cFu) were found is less number in the crop land area of the soil. From the lowland area of Pachrukhi block, Siwan during 2017-18 (Site-I) *P.chrysogenum* showed highest percentage of fungal distribution sharing 62x10^3 cFu. Now, the P. brevicompactum showed very less amount fugal percentage distribution, It is about 2x10^3 cFu. With the 98% distribution at upper surface

and 2% distribution at lower surface of the crop soil. This species was totally absent in the lower surface of the soil. Again, *P. herquei* is also absent in the lower strata of the crop land area. The fungal species from lowland area of Pachrukhi Block, Siwan during 2018-19 (Site-I). Showed maximum percentage distribution of *A. flavus* ($66x10^3$ cFu) with upper, middle and lower layer of distribution of 70%, 20% and 10% respectively. Species *R. pusillus* is totally absent in upper, middle and lower strata of the soil crop area. The upland area of Pachrukhi block Siwan during 2017-18 (Site-2) showed maximum number of fungal population was Trichoderma species ($112x10^3$ cFu) with percentage distribution 87%, 10% and 03% respectively. R. pusillus is almost absent from three layers of the soil crop. Here, the percentage wise distribution of fungi species form upland area of Pachrukhi block Siwan during 2018-19 (Site-2) showed maximum number of *A. tamarii* with $142x10^3$ cFu and same number is also shown by *Trichoderma* SP; with 97%, 2% and 01% percentage wise distribution at upper, middle and lower layer of crop soil distribution. Some species are totally absent from R. pusillus species. This species was tatally absent from the three strata i.e. upper, middle and lower level of the soil crop. The species which are found in very minimum amount is C. globosum in $3x10^3$ cFu, C. elegans $3x10^3$ cFu and *C. echinulata* found in $4x10^3$ cFu. During the several year of cycle of fungal percentage distribution from upland area of Pachrukhi block Siwan during 2018-19 (Site-2) Showed P. ochraceum with $232x10^3$ cFu with 85% at upper layer, 10% distribution at middle layer and 05% lower layer distribution.

Next to this, *P. citrinum* with $223x10^3$ cFu with 98% at upper layer, 02% at middle layer and totally absent in the lower layer of the soil. No species are totally absent from the above maintained crop field like. Now, the percentage wise distribution of fungi species from lowland area of Siwan during 2017-19 (at site-1 and site-2) showed maximum number of fungal population distribution was shared by *P. ochraceum* with $213x10^3$ cFu counts with 80%, 10% and 10% distribution on the upper, middle and lower layer of the soil strata. This site showed maximum number of fungal density. No one species is absent from the entire sampling site. The whole sampling unit showed marked variation in the fungal species population from upper layer to the lower layer of crop land area.

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