Agri Articles
(e-Magazine for Agricultural Articles)
Volume: 05, Issue: 04 (JULY-AUG, 2025)
Available online at http://www.agriarticles.com

How Arthropods Boost Soil Fertility?

*A. Sivaraman[1], Dr. V. Sreedevi[2] and Patne Yashwant Babarao[3]
[1]Assistant Professor, Department of Entomology, Agricultural College & Research Institute, Tamilnadu Agricultural University, Vazhavachanur, Thiruvannamalai
[2]Assistant Professor, Department of Zoology, Govt. City College (A), Nayapul, Hyderabad, Telangana-500002, India
[3]Assistant Professor, Department of Zoology, Mahatma Basweshwar Mahavidyalaya, Latur S.R.T.M.U. Nanded, Maharashtra, India
*Corresponding Author's email: amirthasiva@gmail.com

Soil is the most precious but limited basic natural resource on which depends the security of food, nutrition, employment, livelihood, biodiversity and environment. The Green Revolution indeed brought significant advancements in agricultural productivity, but the long-term effects on soil health are now becoming evident. Issues like soil degradation, erosion, and loss of nutrients can threaten future food production and biodiversity. To address these challenges, sustainable agricultural practices are essential. Strategies such as crop rotation, organic farming, reduced chemical use, and conservation tillage can help restore soil health and ensure its productivity for future generations. Additionally, integrating agro ecological approaches can enhance biodiversity and resilience in farming systems. It's vital to recognize soil not just as a medium for crops, but as a living ecosystem that requires careful management and protection. The challenges facing Indian soils are significant and multifaceted. The low organic carbon content, coupled with widespread nutrient deficiencies-particularly nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and essential micronutrients-has serious implications for agricultural productivity and sustainability. Addressing these issues requires a comprehensive approach that combines improved agricultural practices, education for farmers, and investment in research to develop sustainable solutions tailored to local conditions. The growing population increases demand for food, while the declining land-to-man ratio and smaller farm sizes limit agricultural productivity. Additionally, declining soil health impacts crop yields, making it challenging to sustain agricultural output (Patra, 2021). From the beginning of agriculture in natural ecosystem due to active anthropogenic factor the soil environment subjected to many changes.

The soil flora and fauna population modified by human activities for agricultural purposes. The community and density of soil micro-fauna determined by comparing the intensity of the present population with the original ecosystem after the perturbation. The ability of the various organisms to adapt to these changes will determine the ultimate community present in soil ecosystem. Furthermore, this community can be changed because of agricultural practices which will suit human needs and changing agricultural paradigms. Agronomy practices *viz.*, crop rotation, crop diversification, organic matter application on top soil and minimum tillage, less soil disturbances play an important role (Hendrix *et al.*, 1995). However, soil correction and amendment techniques, such as the careless use of fertilizer, pesticides, and liming material, may have both beneficial and detrimental effects on soil biota. The use of pesticides, especially insecticides, nematicides, and herbicides, is generally thought to have detrimental impacts on the majority of species and is a significant input that determines soil fauna. These anthropogenic factors ultimately cause soil compaction, deterioration of soil physical characteristics, erosion, xenobiotic contamination, and soil ecosystem pollution. The arthropod fauna of the soil and overlying layer of organic debris normally includes a variety of mites, collembolans, pseudoscorpions, centipedes, millipedes, isopods, proturans, diplurans, symphylans, hymenopterans, coleopterans, and larval forms of many other orders. In most soil and litter worldwide, Acarina (mites) and Collembola (springtail) are the most diverse and abundant arthropods. In general, soil invertebrates are classified according to their size in microfauna, mesofauna, macro fauna and megafauna.

Microfauna: organisms whose body size is between 20 μm and 200 μm. Example:,protozoa, is found wholly within this category; among the others, small mites, nematodes, rotifers, tardigrades and copepod crustaceans all fall within the upper limit.

Mesofauna: organisms whose body size is between 200 μm and 2 mm. Microarthropods such as mites and springtails, are the main representatives of this group, which also includes nematodes, rotifers, tardigrades, small araneidae, pseudoscorpions, opiliones, enchytraeids, insect larvae, small isopods and myriapods.

Macrofauna: organisms whose size is between 2 mm and 20 mm. This category includes certain earthworms, gastropods, isopods, myriapods, some araneidae and the majority of insects.

Megafauna: organisms whose size exceeds 20 mm. The members of this category include large size invertebrates (earthworms, snails, myriapods) and vertebrates (insectivores, small rodents, reptiles and amphibians).

Functional roles of arthropods in maintaining soil fertility

The term "soil fertility" denotes the degree to which a soil is able to satisfy plant demands for nutrients (including water) and a physical matrix adequate for proper root development, which is significantly influenced by biological processes. Arthropods function on two of the three broad levels of organization of the soil food web. Litter transformers, of which the microarthropods comprise a large part, fragment, or comminute, and humidify ingested plant debris, improving its quality as a substrate for microbial decomposition and fostering the growth and dispersal of microbial populations. Ecosystem engineers are those organisms that physically modify the habitat, directly or indirectly regulating the availability of resources to other species. In the soil, this entails altering soil structure, mineral and organic matter composition, and hydrology. Ants and termites are the most important arthropod representatives of this guild, the latter group having received the greater share of research attention. Arthropods constitute about 20% of the soil fauna and through their continuous activities such as burrowing, ingesting of soil particles and the decomposition of soil organic matter, soil nutrient cycling continues to take place and leads to changes in soil physicochemical properties (Culliney 2013). Decaens *et al*. (2006) stated that soil fauna make up 85% of soil organisms with arthropods constituting 85% of the population. But only about 10% of soil arthropods are identified. Plant litter is a mixture of labile substrates (e.g., sugars, starch) easily digested by soil biota, and other components (cellulose, lignins, tannins) more resistant to breakdown. Decomposition of this material results from an interaction between physical and biological processes. Before being acceptable for additional deterioration by the soil microflora and fauna, litter must first be physically worn. The primary early colonizers of plant litter are fungi. Bacteria become more significant as the substrate becomes more disintegrated and soluble. Following this first microbiological stage, the breakdown process slows down and, if animal activity is not present, may stop completely. Saprophagous arthropods have an indirect impact on decomposition through converting litter into feces and reworking (re-ingesting) the fecal material, comminution of litter, mixing of litter with soil, and regulation of the microflora through feeding and the spread of microbial inoculum. They also have a direct impact through feeding on litter and adhering microflora, which transforms the energy contained therein into biomass production and respiration.

Ecology of Soil Collembola

The Collembola (springtail) are small apterygote insects and cosmopolitan in distribution. They are common, numerically dominant and species rich among the fauna of soils supporting temperate and tropical grassland, moorland, heathland and forests throughout the world. Most soil forms range in size from 0.5 to 3.0 mm and feed on decaying vegetation and/or microbes. Collembola have two life forms, i.e. epedaphic and euedaphic. The ededaphic Collembola are those which are present in ground and leaf litter and strikingly large as compared with euedaphic Collembola. Their body has richly pigmented pattern and often bears a dense covering of hairs of scales and possess a long, well-developed furca. Since the highest decomposition activity occurs in the upper soil layer, the highest population density of Collembola is typically found there. In the organic layer, or the 10–15 cm soil layer, the collembolan are abundantly represented in terms of both individual and species numbers in the majority of permanent grassland, moorland, and woodland sites.

Ecology of Soil Acari

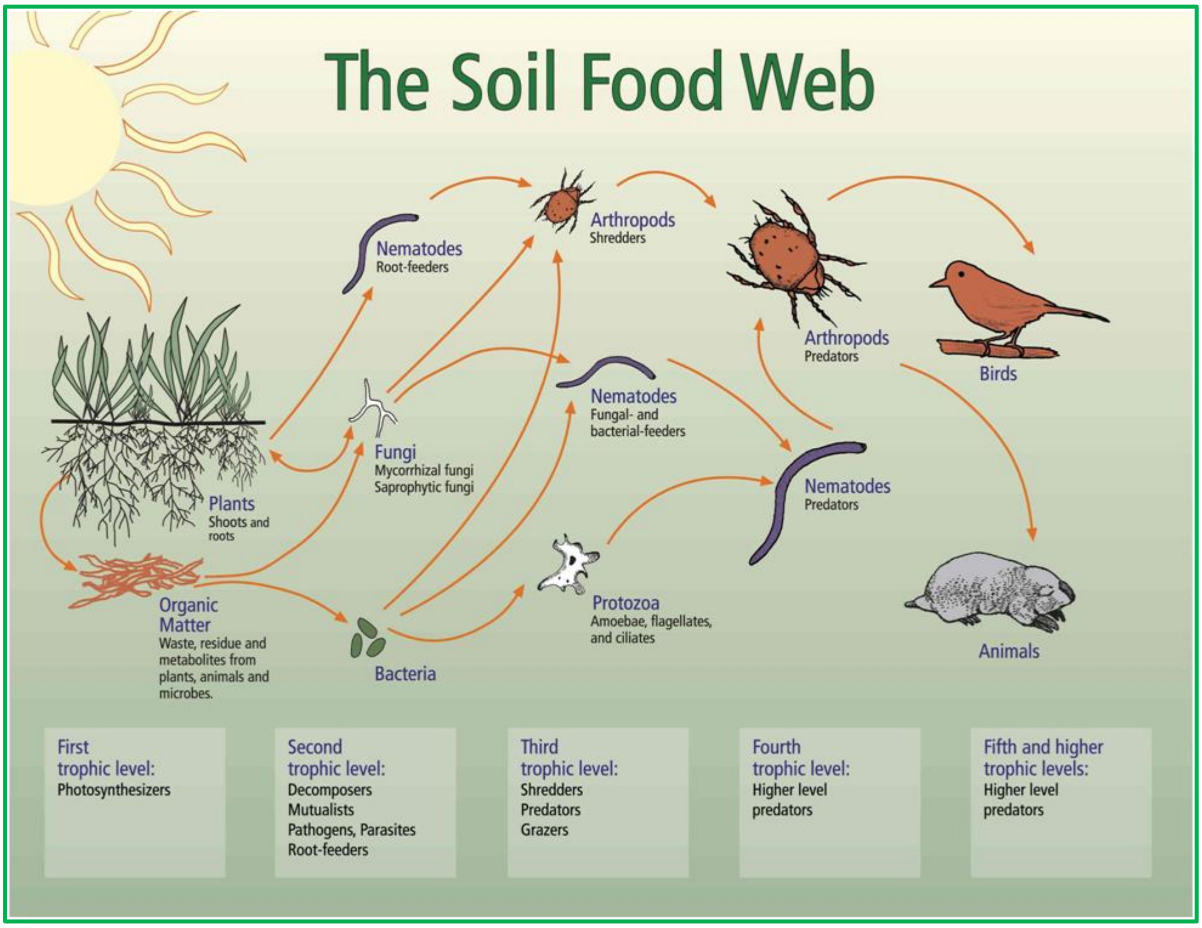
In trees and forest floors, the Acarina (mites) are frequently the most prevalent group of arthropods. Mites live in all types of soil, from severely acidic to alkaline, from nutrient-poor to nutrient-rich, and they have been discovered up to 10 meters deep in soil. They are the competitors of insects in the variety of life habits and niches occupied. Mites, like other arachnids, have six pairs of articulated appendages, including four pairs of legs and two pairs of mouthparts (chelicerae and pedipalps). There are only three pairs of legs on larvae. Parts of the pedipalps create a through or tube-like structure that houses the chelicerae. This unique component of the mite body, known as the "gnathosoma," is typical of the Acarina order.

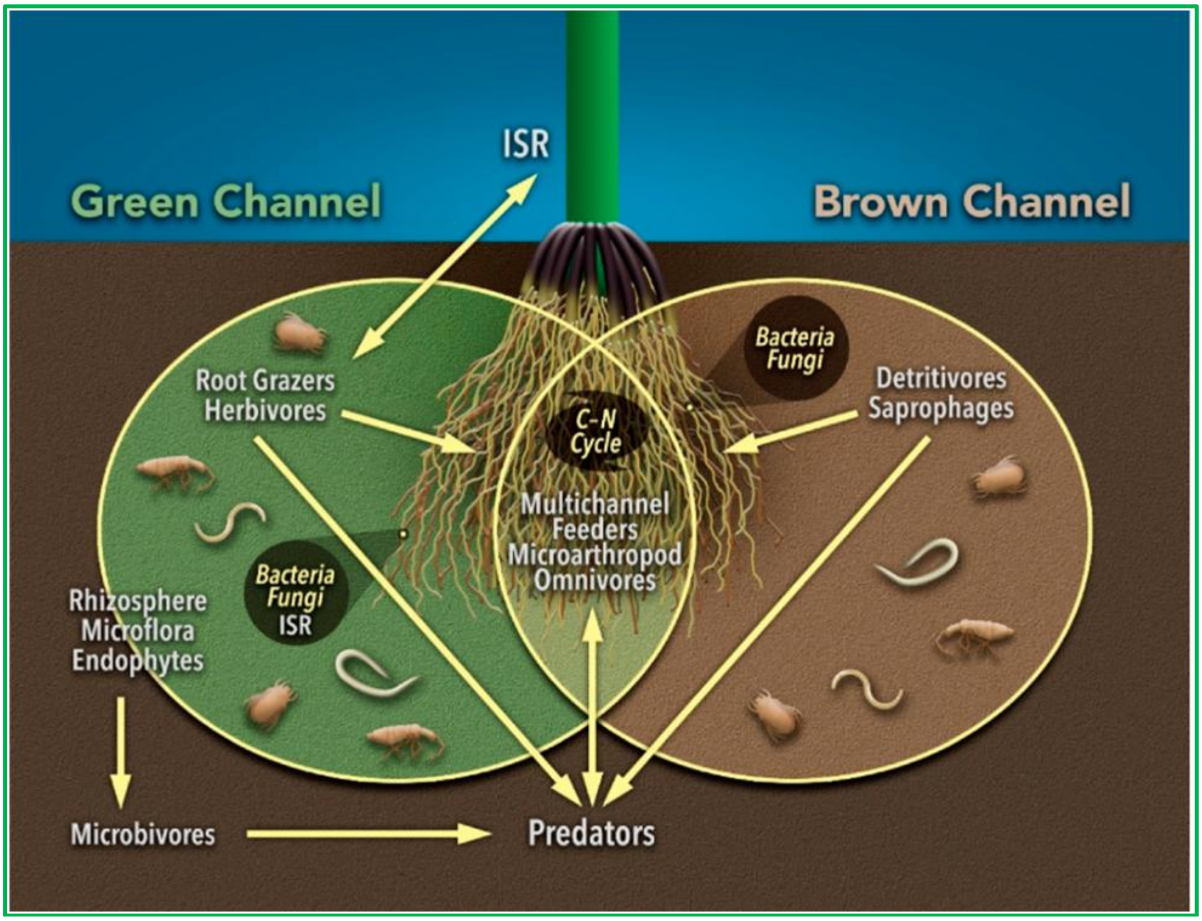
Conclusion

Soil is a living, dynamic ecosystem. Healthy soil is packed with microscopic and larger organisms that perform many vital functions including converting dead and decaying matter as well as minerals to plant nutrients. Different soil organisms feed on different organic substrates. Their biological activity depends on the organic matter supply. Nutrient exchanges between organic matter, water and soil are essential to soil fertility and need to be maintained for sustainable production purposes. The soil arthropods includes a variety of mites, collembolans, pseudoscorpions, centipedes, millipedes, symphylans, diplurans, proturans, hymenopterans, coleopterans etc. they play an important role in releasing nutrients and improve productivity within the forest ecosystem (less disturbed ecosystem) by decomposition process.

References

1. Patra, A. K., & Coumar, M. V. (2021). Sustainable soil resource management for food and nutritional security under changing climate scenario. *Indian J Agron*, *68*, S78-S97.
2. Hendrix, M. S., Brassell, S. C., Carroll, A. R., & Graham, S. A. (1995). Sedimentology, organic geochemistry, and petroleum potential of Jurassic coal measures: Tarim, Junggar, and Turpan basins, northwest China. *AAPG bulletin*, *79*(7), 929-958.
3. Culliney TW (2013) Role of arthropods in maintaining soil fertility. Agriculture 3:629–659.
4. Decaëns, T., Jiménez, J. J., Gioia, C., Measey, G. J., & Lavelle, P. (2006). The values of soil animals for conservation biology. *European Journal of Soil Biology*, *42*, S23-S38.


The Soil Food Web
Nematodes
Root-feeders
Arthropods
Shredders
Arthropods
Predators
Birds
Fungi
Mycorrhizal fungi
Saprophytic fungi
Nematodes
Fungal- and bacterial-feeders
Plants
Shoots and roots
Nematodes
Predators
Organic Matter
Waste, residue and metabolites from plants, animals and microbes.
Bacteria
Protozoa
Amoebae, flagellates, and ciliates
Animals
First trophic level:
Photosynthesizers
Second trophic level:
Decomposers
Mutualists
Pathogens, Parasites
Root-feeders
Third trophic level:
Shredders
Predators
Grazers
Fourth trophic level:
Higher level predators
Fifth and higher trophic levels:
Higher level predators


ISR
Green Channel
Brown Channel
Root Grazers
Herbivores
Bacteria
Fungi
Detritivores
Saprophages
C-N
Cycle
Multichannel
Feeders
Microarthropod
Omnivores
Rhizosphere
Microflora
Endophytes
Bacteria
Fungi
ISR
Microbivores
Predators