Earthworms: under-valued, under-rated and unloved

Introduction

The developement of an agriculture that is more ecological, and therefore more sustainable, requires a greater understanding of agricultural practices and their impact on soil life. Earthworms are bio-indicators of the soil's fertility. In temperate climates they are the third most important component of the soil's biomass, representing between 1-3 t/ha depending on whether they are agricultural or forest soils. It is therefore important to understand their ecology, especially in disturbed soils (i.e. farm land) to gain an understanding of their effect of soil fertility.

Three types

The 15 species of earthworms identified in Quebec are of european origin. In Ontario, Dr. Reynolds has identified 19 species, only one of which is of north American origin. Evidently, each species is not present in every field. Depending on the type of soil, cultural practices, etc. certain species thrive compared to others.

Earthworms have been classified according to their relationship with the environment: the EPIGES, the ENDOGES, and the ANECIQUES.

The EPIGES are small dark colored worms that live in plant residues or manure piles. They burrow into the soil only when subjected to a stressful environemnt (ie. drought or winter conditions).

The ENDOGES are medium sized worms that feed on organic matter dispersed among the mineral particles of the soil. They burrow in the first 20-30 cm of the soil, creating horizontal tunnels that do not lead to the soil surface.

The ANECIQUES are the largest worms. They feed on plant residues at the soil surface and create deep vertical tunnels, depositing their waste at the surface (called TURRICULES). Some species possess characteristics of more than one group.

Benneficial effects

Earthworm acitivty influences soil physical properties. By mixing organic matter (upon which they feed) with mineral soil particles as they burrow, they improve soil structure. The TURRICULES (a mix of soil and digested organic matter) that are deposited in the soil or at the surface are generally more stable than the adjacent soil aggregates.

Earthworm tunnels, which may make up 5% of the total soil volume, contribute to soil aeration. With a high population of earthworms, a

soil can drain water 4-10 times more quickly than a soil without any earthworms. Indirectly, earthworms improve plant growth by improving soil physical properties, thereby allowing better plant root growth. The tunnels enable roots to develop deeper in the soil thereby increasing their ability to extract nutrients from the soil.

Earthworm activity is particularly important in no-till systems where soil aeration is limited. Plant residues left on the surface are "incorporated" slowly by the worms' activities. In systems with no plowing, the number of earthworm tunnels increases significantly, with a consequent increase in water infiltration.

Organic matter and earthworms

Because earthworms feed for the most part on organic matter, they are active participants in the recycling process that occurs in the soil. Through feeding, the worms break up the organic matter thereby rendering it more susceptible to microbial breakdown and increasing nutrient release.

Because of its large size, Lumbricus terrestris is particularly important in this role. In Europe where winters are mild, it has been calculated that in apple orchards, earthworms can incorporate more than 90% of the fall litter during the season (about 1.2 t/ha of dry matter). The decompostion of the litter also breaks up the apple scab disease cycle.

Nitrogen mineralisation:

The dry weight of worms in the soil consists of 8-10% nitrogen. Dead earthworms decompose rapidly and therefore are a source of nitrogen that is readily available to soil organisms and plants. The TURRICLES are often higher in carbon and nitrogen than the adjacent soil and therefore are a favorable environment for microbial activity and root growth.

By acting as incorporaters and recyclers, earthworms act as soil reservoirs for nitrogen in the ecosystem. In systems with no plowing, researchers have estimated that the equivalent of 63 ???? N/ha/year passes through earthworms.

Effects of gricultural practices

Fertilization using synthetic fertilizers does not appear to harm earthworms if done in moderation. In effect, fertilizer does not depend solely on the amount used but also the type of chemical. For example, ammonium sulfate seems toxic because it acidifies the soil. However, in general, earthworms benefit indirectly through the increased amount of plant residues left on the soil. ???? As well, in soils with a pH less than 4.5-5, earthworms benefit from applications of lime. Above this pH, the different species seem tolerant enough of the pH.

Fertilization with manure is better for maintaining good populations of earthworms. ????This is all the more evident in cropped fields than in

fields planted to perennial forages where addition of residue is higher, more stable and where the soil is not disturbed.

Even though it contains less dry organic matter than solid manure, liquid manure can have a beneficial effect on the earthworm population. ???? However, at high doses, the effect may be negative, as is the case with liquid hog manure applied above 150 m3/ha (which is not a common practice in Quebec.)

Because of its low dry matter content, liquid manure does not appear to favor large sized earthworms such as Lumbricus terrestris in cultivated soils. This species requires solid organic matter at the soil surface. As well, liquid hog manure tends to reduce the diversity of earthworm species.

Pesticides

The least harmful products are herbicides which, when used post-emergent, furnish organic matter to the soil. ???? In contrast, some studies have demonstrated that atrazine, for example, could have a slight negative impact. ????

Most of the organochloride insecticides have negative effects on earthworms. Chlordane and heptachlor are persistant insecticides in the soil and are very toxic. One thing is certain, the organochloride insecticides reduce the reproduction potential of the population. As well, earthworms concentrate these substances in their bodies, which pose risks of contaminating the food chain, particularly of the birds that feed upon the worms.

Certain organophosphates are also toxic to earthworms. This is the case with parathion and PHORATE which can dramatically reduce L. terrestris populations. The carbamates have also been reported to kill earthworms. Such is the case with carbaryl, which is toxic even at low doses. Aldicarbe and carbofuran also reduce earthworm populations.

Fungicides, especially those containing copper, are also toxic. It is therefore not certain that the "organic" practice of using Bordeaux mixtures (containing copper sulfate) in orchards has no effect on earthworms. Fumigants such as methyl bromide, used to control soil nematodes and pathogens, also have a drastic effect on earthworms.

Soil Tillage

It is recognized that fields planted to perennial forages contain more earthworms and a more diversified soil fauna than cultivated fields. This phenomenon is attributed, among other things, to soil tillage (particularly plowing) which damage the worms' tunnels and exposes them to prey by birds. As well, tillage reduces soil cover which acts as a protection against fluctuations in temperature and humidity, two factors to which earthworms are sensitive.

Tillage also reduces organic matter in the soil over the long term, especially when only chemical fertilizers are used. As a result, the

earthworms' source of food becomes limited. Minimum and no-till systems are therefore favourable cultivation practices for earthworms.

Conlusion

Under eastern Canadian climatic conditions, soil cover in the fall better enables earthworms to survive the winter. Green manures are very useful for this purpose, absorbing nitrogen released by the earthworms during the fall, providing a source of food in the form of organic matter before the onset of winter and covering the soil once winter arrives, thereby retaining a better snow cover which acts as insulation.

In effect, the development of an ecological agriculture should favor earthworm populations and enable them to contribute fully to the soil's fertility. Of course, earthworms have also been identified as having some negative impacts on crop production, as is in the case of weed seed dispersal and the dissemination of plant pathogens such as Fusarium and Pythium.

However the beneficial effects far outweigh the negative ones that occur from time to time. Aristotle, more than 2,000 years ago, qualified the role of earthworms as "the intestines of the soil", thereby recording their vital role in soil fertility.