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USING EARTHWORMS TO IMPROVE SOIL HEALTH AND SUPPRESS DISEASES

INTRODUCTION

Ever since Charles Darwin conducted his classic studies with earthworms in the late 1800's, we have recognized their role as major processors of dead and decomposing organic matter. Darwin thought that all tillable land on the planet has been processed through the gut of earthworms. Earthworms improve soil bulk density, pore size, water infiltration rate, soil water content, and water-holding capacity. Many consider the number of earthworms to be directly proportional to the health of a soil.

Earthworm excrement or "castings" support a diverse microbial community, including beneficial fungi and bacteria. Research at The Connecticut Agricultural Experiment Station (CAES) has shown that earthworm activity suppresses some soilborne diseases. This may explain why vermicompost, an end-product of the breakdown of organic matter by earthworms, is also associated with disease suppression.

The deep burrows made by the earthworms, *Lumbricus terrestris* (Canadian nightcrawler) (Figures 1 and 2) can burrow over a meter deep and break up hardpans in poorly drained soils, promote aggregate structure, and facilitate percolation. Their role in suppressing root diseases of vegetables was not known until greenhouse and field studies were done at the Experiment Station.

Figure 1. Nightcrawlers ready to be applied to asparagus experimental plots.

EARTHWORM ECOLOGY

Earthworms fall into three ecological niches: epigeic ("upon the earth"), endogeic ("within the earth"), and anecic ("up from the earth"). Nightcrawlers fall into the anecic category while red wigglers, which are used in vermicomposting, are epigeic.

Earthworms that fall into the endogeic category are not as well studied in regard to their agricultural benefits. As follows are some results of studies conducted at CAES using Canadian nightcrawlers (Figure 2).

Figure 2. Canadian nightcrawler *(Lumbricus terrestris).*

EFFECTS ON ROOT DISEASE

Experiments were done in the greenhouse and field to determine if there are positive effects of augmenting soils with earthworms on plant diseases. Asparagus, eggplants, and tomatoes were individually grown in the greenhouse in soil infested with soilborne plant pathogens. Half of the 12 pots were augmented with four healthy adult Canadian nightcrawlers (*L. terrestris*) per pot. Soils planted with asparagus and tomatoes were infested with *Fusarium* pathogens and eggplants were grown in soil infested with *Verticillium dahliae.*

In each system, adding earthworms was associated with an increase in plant growth and a decrease in disease (Figures 3 and 4). Plant weights increased by 60 to 80% and estimates of disease were reduced 50 to 70% when soils were augmented with earthworms.

Figure 3. Asparagus on the right was grown in *Fusarium*-infested soil and augmented with earthworms. The asparagus on the left received no earthworms.

Figure 4. Tomatoes on the right were grown in *Fusarium*-infested soil with earthworms. Tomatoes on the left received no earthworms.

When the soil was assayed, beneficial microorganisms were found in higher densities in soils that were augmented with earthworms.

Disease suppression may have been mediated through microbiological activity.

These microbes may prevent disease by competitively excluding the pathogen from infection sites, antagonizing the pathogen with antibiotics, and/or by inducing resistance in the plant.

Studies were also conducted under field conditions. Experimental field plots of asparagus and eggplants were established in naturally infested soils. Earthworms (1-2/ ft^2) were added to the five replicate plots at planting.

Figure 5. Effect of earthworms on growth of asparagus.

Both asparagus and eggplants were bigger and showed less damage from disease when they were treated with earthworms (Figures 5 and 6). These published studies suggest that strategies to increase earthworm densities in soil may suppress soilborne diseases.

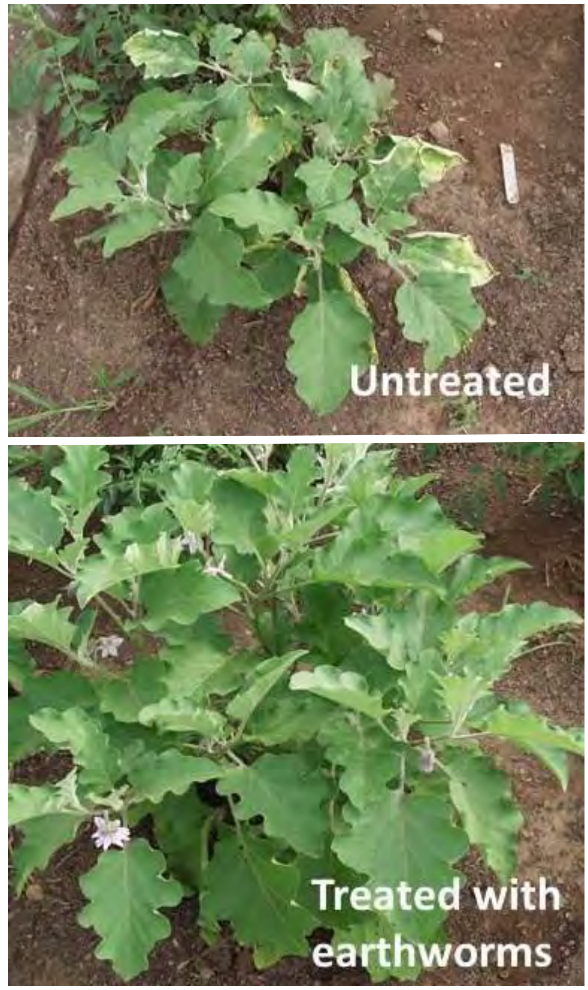

Figure 6. Effect of earthworms on growth of eggplant and Verticillium wilt.

WAYS TO INCREASE EARTHWORMS

Many have posed the question: Is it worthwhile to add earthworms to soils? Canadian nightcrawlers are very difficult to rear under controlled conditions, so distributors who sell earthworms for fishing bait obtain their earthworms from collectors who manually harvest the species from open lawns and golf courses. Therefore, the cost associated with purchasing these worms would make it prohibitive, especially for large areas. Extracting and collecting earthworms from nearby pastures might serve as an alternative.

Earthworms can be extracted from soil using a 10% mustard powder (Figure 7). Mix 13 ounces of mustard powder with a gallon of water, let stand for 2-30 min to solubilize the active oils, then pour over the surface of previously irrigated soil. Within a few minutes, earthworms will emerge, where they can be collected, immediately rinsed in clear water, and then added to soils.

Figure 7. Using 10% mustard powder to extract earthworms from soil.

Gardeners and growers transitioning from conventional to organic farming can also consider following practices that can promote resident populations of earthworms (Table 1).

Earthworms require calcium, which is a component of the mucilaginous coating that surrounds the excreted castings. Since acid soils are usually lacking in calcium, they often support very low densities of earthworms. Earthworms also require a continuous source of food. Food reserves that are preferred most by earthworms are plant residues (grass clippings, leaf mold, compost, and organic mulch) and manure. Plowing under green manure crops such as clovers and grasses can stimulate early production of earthworms, but care should be taken to provide additional plant residues such as mulch or manure during the growing season.

Table 1. Practices that favor earthworms.

Treatment	**Reason**
Liming	Acid soils harm earthworms
Cover crops	Increase food reserves
Mulching	Increases food reserves
Manuring	Increases food reserves
No tillage	Plowing destroys burrows

There are also practices that are harmful to earthworms and should be avoided (Table 2). Soil pH should be checked to keep soil from becoming too acidic. Leaving soil bare also deprives earthworms of food supplies. Earthworms breathe through their skin and require a thin film of moisture. Although they can survive in saturated soils for brief periods of time, constant flooding can reduce earthworms.

Chemical residues from rock salt, fertilizers, or pesticides can slow the buildup of earthworm densities. If chemical fertilizers need to be used, they should be used early in the growing season. Manure can be applied later in the season to nourish the earthworms and increase soil fertility. In addition, efforts to avoid soil compaction either by machinery or foot travel will prevent damage to burrows. Establishing walkways or travel lanes in the field or garden will minimize compaction. Tillage or excessive hoeing can also destroy burrows; therefore, mulching with compost can minimize the need for tillage and provide food substrates for the earthworms.

Table 2. Practices that harm earthworms.

Treatment	Reason
Acid soils	Soil pH <5.0 is harmful
Bare ground	Starves earthworms
Flooding	Depletes O_2
Salts and fertilizers	Injurious and/or lethal to earthworms
Pesticides	Injurious and/or lethal to earthworms
Compaction	Compaction destroys burrows

SUMMARY

Earthworms are singularly considered to be the best indicator of soil health. Low densities can reflect numerous problems with a soil, such as low pH, low organic matter, low calcium, toxic residues, and compacted or flooded soils. High earthworm densities are associated with well-drained, aerated, fertile soils.

Earthworms can also reduce damage from soilborne diseases. Although earthworms probably do not directly reduce pathogen densities, they may suppress disease by increasing beneficial organisms and improving soil properties. Growers and gardeners can increase earthworm activity by making their soils more hospitable to earthworms to help increase resident populations.

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