# Earthworms in the Farm

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## The forgotten and lowly earthworm

While the "farming" of earthworms in vermicompost systems has been popularized over the past few years, the important and central role that earthworms play in the farm or in the garden has been largely under-recognized by mainstream agriculture. For instance classic Entomology textbooks such as "Destructive and useful Insects" by Metcalf in the 1960s and "Fundamentals of applied entomology" authored by Pfadt in the 1980s mentioned earthworms only once or twice, in passing. Similarly, a classical textbook on Vegetable Production authored by Nonnecke in the late 1980s didn't mention earthworms.

*With their burrowing, earthworms help to improve soil aeration and water infiltration.*

In Hawaii only a handful of refereed publications have been written about local earthworms, mostly by out-of-state researchers. In CTAHR, other than recent fact-sheets on vermicomposts, no graduate theses, research or extension publications have been published dealing with the activity of earthworms on the farm.

Earthworms are increasingly being recognized as key "ecological engineers," important drivers of soil tilth and fertility on the farm. Because of their key role in improving soil fertility, earthworms are also recognized as key indicators of sustainability and soil health on the farm.

Species of earthworms that have been identified in Hawaii include *Aporrectodea turgida* (Lumbricidae), and *Pontoscolex corethrurus* (Glossoscolicidae), two large, surface-feeding (anecic) species; as well as *Amynthas gracilis* and *A. corticis* (Megascolicidae), which create deep vertical furrows, coming to the surface only to feed. *Aporrectodea spp.* are known to produce surface casts (Whalen et al., 2004).

Some contributions to soil health provided by earthworms include:

- As "ecological engineers" and primary decomposers, earthworms have an effect on soil biological, chemical, and physical activities in the soil.
- Improve soil fertility and structure, by burrowing and casting.
- Create stable soil aggregates through cast formation. The organic matter in casts can maintain its stability over a period of years (Zhang et al., 2003).
- Soil burrowing increases soil aeration, water

*Earthworms ingest a large amount of soil and organic residues, and transform them into more stable forms of organic matter.*

infiltration, microbial activity, and nitrogen availability to plants.
- Water absorption or infiltration can be 4-10 times greater in fields with earthworm burrows compared to fields with no earthworms. This may reduce water runoff and soil erosion (Chan, 2004).
- Earthworms ingest organic residues of different C:N ratios and convert it to lower C:N ratio residues.
- Excretion of nutrient (N) rich materials.
- Improved plant growth, and translocation of nutrients within the plant
- Contribute toward soil and nutrient turnover by shifting organic matter into deeper soil layers.
- Improved nutrient cycling by fragmenting plant residues and by stimulating microbial activity (Langmark et al., 1999).

*Organic mulches moderate soil temperatures, conserve moisture and provide plant residues, providing an ideal environment for earthworm reproduction.*

- Increased phosphorus availability to plants in fields treated with low-soluble P fertilizers such as rock phosphate (Ouédraogo et al., 2005).
- Earthworms may help to preserve or conserve nutrients in the soil, making them available as long-term or slow-release fertilizers. Nutrients embedded in casts may slow nutrient mineralization by several months (Zhang et al., 2003).
- Considered to be important indicators of soil health, and key bioindicators, providing information about the stability of the agroecosystem.
- Earthworms may help to increase beneficial VAM mycorrizal populations. Mycorrhizal fungal associations in the soil help to improve nutrient availability to plants (Gormsen et al., 2004).
- Earthworms represent an important food source for a number of vertebrate and invertebrate organisms, contributing towards a rich food-web in the soil.
- Earthworms were found to improve the dynamics of the soil food-web, by stimulating the population of soil microarthropods (Loranger et al., 1998).
- Improved crop growth and yields, especially in degraded soils (Zund et al, 1997; Marashi and Scullion, 2003; Gormsen et al., 2004).
- Earthworms may help to restore degraded soils, such as from mining or plantation agriculture, after they have been introduced to soils with no recent earthworm activity (Zou and Bashkin, 1998; Marashi and Scullion, 2003).
- Earthworms may be able to ameliorate the effects of soil compaction, by decreasing bulk density (Zund et al, 1997; Langmaack et al., 1999; Jongmans et al., 2003).
- Contribute to carbon sequestration (Jongmans et al., 2003; Whalen et al., 2004).

(also see: Altieri, 1999; Cheng and Wong 2002; Heyer et al., 2003; Jongmans et al., 2003; Pan et al., 2010).

*Earthworms reproduce readily, as observed in this organic garden in Manoa. How many can you count?*

## Population densities in Hawaii

Earthworm population buildup 10-years after the closure of sugarcane plantations in the Hamakua coast found population densities of 400 earthworms per square meter. Greater populations were found in weedy grass/legume mixtures (Zou and Bashkin, 1998).

*Increased plant growth when earthworms are present is attributed to increased nutrient uptake, and to a better developed root system.*

## Some population statistics

Earthworms contribute toward biological diversity in the farm. One hectare of high-quality soil contains an average of (Pimentel et al., 1997):

- 1300 kg earthworms
- 1000 kg arthropods
- 3000 kg bacteria
- 4000 kg fungi
- 260 kg protozoa

A square meter of soil in temperate areas may contain (Altieri, 1999)

- 10 million nematodes
- 100,000 micro-arthropods
- 10,000 other invertebrate groups

## Soil and Nutrient Turnover

- Earthworms bring between 10-500 t/ha/yr of soil to the surface (Pimentel et al., 1997).
- Earthworms may injest up to 500 t/ha/yr of soil, contributing toward soil turnover. This turnover distributes nutrients, carbon, and improves aeration (Pimentel et al., 1997).
- Earthworms produce between 1 to 26 kg of surface casts per square meter per year in temperate regions (Whalen et al., 2004).
- Surface cast production in the tropics may reach up to 200 tons/Ha/yr, while total cast production may reach up to 1250 tons/Ha/year (Blanchard et al., 2004).
- One gram of earthworms may produce 5.6 mg of mucus (dry weight) in 24 hours (Pan et al., 2010).
- Earthworm casts contain 5x more nitrogen, 7x more phosphorus, 11x more potassium, and 2x more calcium and magnesium than untreated soil (IFOAM).
- In Laos earthworm casts had greater N and C contents compared to levels found in the surrounding soil (Zhang et al., 2003).

## Management practices that affect Earthworm activity

- Greater numbers found in organic farms than in conventional farms (Hansen et al., 2001; Vazquez et al., 2003; Riley et al., 2008; Carey et al., 2009).
- Greater numbers found in no-till fields (Denton and Tyler, 2002).
- Alley cropping may increase earthworms numbers in the field (Kang, 1997).
- Vegetative field margins (windbreaks, shelterbeds, or hedgerows), may serve as refuges to maintain high earthworm numbers in nearby fields (Lagerlo et al., 2002; Smith et al., 2008).
- Cover crops, especially legume, or legume-grass rotations may increase earthworm populations (Riley et al., 2008)..

- Intercropping systems, especially legume-based intercrops may increase EW populations (Schmidt et al. 2003).
- Compost applications have been found to increase EW numbers.
- Rotations may help to restore earthworm numbers after production of root crops that require deep field cultivation (Nelson et al., 2009).

## Products that are harmful to earthworms

- Fungicides containing copper and zinc
- Carbamate fungicides
- Carbamate insecticides such as Furadan, Sevin, and Temik
- Organophosphate insecticides
- Triazine herbicides such as Atrazine
- Anhydrous ammonia fertilizer
- Ammonium-based fertilizers
- Imidacloprid (Confidor, Admire) insecticides (Capowiez et al., 2005).

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