Is Strip-Till Worth – Part III

Significance of Earthworms – How These Amazing Creatures Affect Nutrition and Soil Water
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To explore a little more into the soil fauna involves looking at the tunnel experts – earthworms. There are 3500+ earthworm species worldwide, and approximately 100 species are living in North America (Gates 1976, 1982, Reynolds 1995). Some 45 exotic species have been introduced into North America. Approximately 70 species of earthworms in the U.S. have been studied in detail (Hendrix, 1995, 1996; James 1995).

In this article we will discuss issues of water movement and enhancements to soil nutrition brought about by increased worm activity associated with strip-till systems. For better association in the readers' minds: strip-till is a form of vertical tillage that shatters and disrupts soil in a zone approximately 6 to 12 inches deep and 7 to 10 inches in width on row center widths of 28 to 40 inches. Soils are not rolled or inverted in this strip/zone.

Earthworm Species and Activity Periods

Fig. 1 Nightcrawler on soil surface

Deep burrowing earthworms that move up and down in their tunnels (anecic and epianecic species) affect soil hydraulic properties in a positive manner. Shallow dwelling and tunneling worms (endogeic species) can affect water storage, gas exchange and carbon storage in the surface soils. All earthworms are negatively affected with plowing and other forms of inversion tillage systems. Worm numbers have been reduced by as much as 90% with deep inversion tillage (Anon. 1997) due to residues being buried, burrows being destroyed and worms being cut up or smothered. In the spring of the year worms are at their most active state when the soil temperature hovers below 52°F. (Bouché, 1972).

The worms move to the soil surface to capture litter, eat it and pull more litter/residue down into their burrows for midnight snacks so to speak. Much of their activity is determined by temperature, humidity and food source. The lower the C:N ratio of the surface residues, the more earthworms ingest and return to the soil. This is what really works best for the farmers soils.

During our strip-till studies, where we have conducted long term research in the Central High Plains of Eastern Colorado [2001- present] we have observed increasing earthworm population especially as we strip-till and disturb only 30% of the surface every year. This method allows worms to work in the standing corn stalks and residues. We have also observed since 2001 the increase in the number of earthworm burrows. The number of worms counted in April of each year has improved to 15 to 32 worms/ft^2 compared to 1 to 10 worms/ft^2 in the conventional tilled areas. Edwards and Lofty (1982) observed as much as 17.5 times more deep burrowing species (*Lumbricus terrestris* and *Allolobophora longa*) in their no-till studies.

Effects to water movement

Earthworm burrows do enhance water infiltration, gas exchange, and aeration. Fields with worm burrows have been observed to absorb water 4 to 10 times greater than (Edwards and Bohlen, 1996) fields lacking worm tunneling. Studies show that burrows of worms do reduce water runoff and help recharge deeper sections of the soil profile for drier spells during the growing season. This is what we want to see happen in healthy soils.

Fig. 2 *L. terristris* in burrow

Worm tunneling creates open channels (1 to 5mm diameter holes) that connect the soil surface to the subsurface and on into the subsoil. As rainfall or irrigation water flows into these little pipelines, the potential for soils to be wetted more quickly is significant. As the tunnels and larger pores fill with water, the remaining soil matrix pulls the moisture into the drier soil giving way for more water to flow downward. Barnes and Ellis (1979) show that with higher populations of earthworms in conservation tillage method/no-till compared to conventionally tilled small grains, macropores greater than 1.5mm in diameter were filled quicker at depths of 8 to 12 inches deep. The National Soil Tilth Laboratory found that soils with populations 100 /yd^2 of living nightcrawlers (*L. terrestris*) were able to absorb a 2 inch/hr rainfall event in 12 minutes. In the same soil without worms, the absorption rate of water was more than 12 hours.

In the studies at the Yuma Irrigation Research Foundation (IRF) between 2002 to 2005, near saturated flow infiltration rates in loam textured surface soils (soil hydraulic conductivity) was 3.1 to 8.0 times faster in strip-till (Petersen and Tichota unpublished) compared to conventional chisel-disk tillage. This is partially due to earthworm tunnels/macropores. Our observations based on the actual counting of pores, in the same IRF study, across a square decimeter (10cm x10cm – 4x4 in^2) at the depth of 2 to 6 inches showed earthworm tunnels to number 8 to 41, size 2 to 5 mm in diameter.

Effects to soil nutrient availability

Earthworms, when active, are voracious consumers of litter and residues when active. As they burrow, they consume nematodes, bacteria, protozoa along with the carbon based residues. As they eat bacteria, nitrogen-fixers have been found in the gut of earthworms and castings. These fecal pellets have a higher nitrogenase activity level, which means greater rates of N-fixation from the worm casts (Simek and Pizl, 1989). This process tends to accelerate nutrient cycling and availability to plant roots. It has been observed in another study in Georgia (Parmelee et.al, 1990) that with incorporation of ryegrass litter by earthworms there was a 25% increase in N-uptake. It has been said by numerous researchers that macronutrients and micronutrients are retained in a more stable (chelated) form after passing through an earthworms gut. Auxins (plant hormones) are produced in the worm castings. These products stimulate roots to grow and take up nutrients and

water. The castings can further stimulate microorganisms in the soil to release N-P-K to the soil for root absorbtion.

Earthworms also tend to neutralize pH of the soil material that passes through their guts, which has a positive effect in nutrient availability to plants. Soil mycologists have discovered that earthworms consume mycorrhizal spores, deposit them deeper in the soils. As roots extend deeper into the soil, root/spore contact is initiated and fungal hyphae growth is regenerated, this association helps roots to absorb water and nutrients similar to what happens in the soil surface layers. It is known that mycorrhizae hyphae absorb phosphorus, sulfur and zinc and feed its hosts in a symbiotic relationship. Corn, soybeans, small grains, sunflowers, dry edible beans all are very dependant upon mycorrhizae.

To summarize how earthworms affect Strip-Till systems

Our tunnel making friends, the earthworms were studied many years ago by Charles Darwin, who said "It may be doubted whether or not there are many other animals which have played so important a part in the history of the world as these lowly creatures." Definitely more than fish bait.

Worms tunnel, leaving large vertical pores that allow preferential flow of water deeper into the soils subsurface and subsoils rather than water moving only through soil pores and connected pores. At the IRF we observed infiltration rates from 2.4 in/hr to 5.3 in/hr in strip-till with the assistance of worm tunnels. This kind of infiltration reduces soil erosion, allows deeper water penetration and subsequent deeper root development, and in irrigated crops, potentially less applied water. The National Soil Tilth Lab determined that heavy rainfall events can be absorbed in No-till farmed soils with good populations of earthworms 60 times faster where soils had no worms. That is an incredible boost to soil quality and soil health!

Worms digest surface litter from crops and turn it into available nutrients which crop roots take-up. The filled-in tunnels have fillings of soil that has passed through the gut of the earthworm yielding more nitrogen plus stimulating bacteria to fix nitrogen and released auxins that promote root growth. Studies show that over the last 100 years that earthworms and their eggs are detrimentally damaged by plows, disks, and mulch-packers.

As growers use strip-till methods to prepare their seedbed and employ the no-till system in soils with textures finer than sandy loams, they will see a continued benefits to crop production and soil quality from the amazing positive affects of earthworms in their fields.

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