Irrigation Research Foundation Agronomic Fact Sheet

Four Years of Strip-Till Improves Soil Quality to Benefit Soil Fauna

In 2000 farmers in the eastern tier counties of Colorado that are irrigated by the Ogallala Aquifer voiced their concerns to the leadership at the Irrigation Research Foundation (IRF) to have research/demonstrations look at Strip-Till effects. A team of scientists got into action and set up 600 foot long strip plots comparing three tillage systems. In those studies soil quality was a focal point.

As an outcome many improvements have and are being observed at the IRF and where growers have adopted the practice. Soil biology is a slow responder to any reduced tillage practice. Microbes, the microscopic sized creatures slowly repopulate the first three to eight inches of soil. In rich soils of the Iowa Corn Belt it is commonly known that in the surface acre six inches the soil will have a population of ½ to 100 million of living creatures in a teaspoon of soil. Their life's work is eating and converting plant remains, old roots, corn stalks, leaves and cobs into humus, the material we call organic matter. They are the first line workers of the process called "carbon sequestration". Here in eastern Colorado strip-till soils we can find high populations of microbes, protozoa, nematodes, microarthropods and then larger creatures such as worms, millipedes, centipedes, orbit beetles, springtails, spiders, and ants.

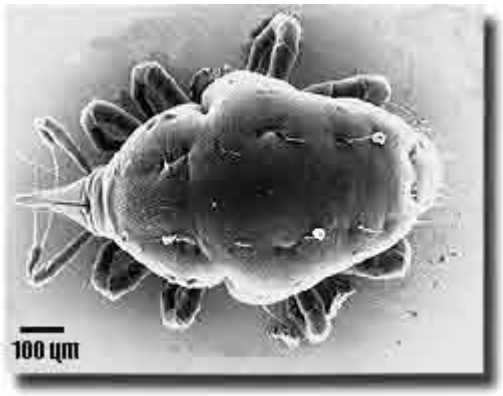

Figure 1. Microscopic mite (microarthropod) that is a decomposer.

At the IRF scientists, Mike Petersen with USDA-Natural Resources Conservation Service and Jeff Tichota with Monsanto have made spring time worm counts as a barometer of how well the "soil fauna" are fairing in the long term strip-till plots against the conventional till plots. Their observations have indicated that soil quality is improving as more residues are left on the surface year around, see below.

Table 1. Comparison chart of worm population in strip-till plots vs. conventionally tilled plots. Counts of live worms in spring of 2004.

Cultivation Type	Worms per sq. ft.	Pores per sq. decimeter	Pct O.M.
Strip-Till (after 4 yrs)	15-32	<1mm 320-345 1-2mm 25-32 2-5mm 5-12	1.78-1.91
Conventional Till (after 4 yrs)	1-10	<1mm 65-145 1-2mm 10-18 2-5mm 1-6	1.50 - 1.56

As the soil ecosystem becomes more diverse and healthy, thusly more productive, the amount of nutrients retained and available to plants increases. In the conventionally tilled area at the IRF depicts a significantly less population of worms. Worms feed off of microbial protozoa, microbes, and some fungi. This is an indication of a improving and healthier soil ecosystem where more food is available to the myriad of bacteria, nematodes,

millipedes, centipedes, mites, ants and so on.

Millipede

Figure 2. Larger burrowing and predator insects that occur in agricultural fields

The "bugs" we can see such as mites, millipedes, centipedes, ants, spiders, and springtails consume leaves, roots, old corn cobs, and stalks, then the materials they excrete and pass on is eaten by the bacteria and protozoa which are in a usable form by the plant root.
Thousands of bacteria live throughout the soil profile, but tend to amass adjacent to plant roots. Actinomycetes, a large family of bacteria assist in breaking down cellulose (which makes up the cell walls of plants) and chitin (cell walls of fungi). Actinomycetes are the creatures that give that distinctive scent of freshly exposed moist soil. Actinomycetes and Nitrosomonas bacteria both process organic nitrogen into the ammonium form (NH3). When these little microscopic creatures

Figure 4. Clostridium bacteria at 100X magnification

exchange with a plant root for it's carbon in the form of sugars and a home.
have rapidly converted nitrogen (N) they excrete excess NH4 into the soil matrix, now usable by plant roots. Other nitrogen fixing bacteria, cyanobacteria are able to fix N in wet soils. Azotobacter, Clostridium, and Azospirillium fix up to 30% of all the N2 in the world, these bacteria are called free living nitrogen fixers. Symbiotic N fixers such as Rhizobium fix nitrogen in

Earthworms and Their Activity

Earthworms were described by Aristotle as 'the intestines of the earth'. Soil scientists at many universities have studied these creatures in depth. Worms may deposit up to 10 to 15 tons of castings per acre on and in the near surface during a year. These casts leave behind high quantities of microbes, organic matter (OM), and plant nutrients. The N-P-K ratio of the castings is 0.5-0.5-0.3 and are 50% OM and 11 trace minerals. Castings acts much like time-released fertilizer.

Figure 3. Night crawler

Figure 4. Dung worm

Figure 5. Red wiggler

Lumbricus terrestris (common nightcrawler) is capable of digesting in a corn field 400 lbs/acre/year of corn residue (Bohlen et.al., 1999). Night crawlers are our most noticed earthworm in eastern Colorado. Earthworms in the Bohlen et al study determined that they were able to incorporate applied N via manure in a 10 week period faster than just soils growing rye. L. terrestris can burrow 10 to 16 inches in a 24 hour period in the spring months when the soil temperatures are cooler than 58-64° F.

In the worm counts done at the IRF, the scientists have seen L. terrestris, red worms (L. rubellus), and brown wigglers (Aporrectodea longa). The dominant benefits of earthworm populations improving are improved water infiltration, soil aeration, stirring and digesting organic matter, buffering of soil pH, increasing soil porosity, and limited nematode control. As seen in Table 1. the porosity in the strip-till soil sampled in the first six inches is 4.4 times greater than the conventional tilled area (335 pores/sq.dm in strip-till compared to 75 pores/sq/dm. in conventionally tilled).

The long term strip-till studies completed here on the IRF have included standard soil infiltration studies. Due to increased soil fauna (both micro and macro) we have concluded that their feeding and day to day living activities have helped improve soil organic matter, soil porosity, stable soil aggregates and infiltration/water movement. Since 2002 the two scientists that work here on the Strip-Till demonstration project have numbers to back up that claim. Water infiltration has improved 4.3X in strip-till plots over that of the conventionally tilled plots.

Table 2. Standard pre-saturated infiltration rates taken at Irrigation Research Foundation near Yuma, CO

Site Name		*2002* in/hr	*2003* in/hr	*2004* in/hr
ST-MT-CT	Strip-guess row	4.85	5.39	4.59
ST-MT-CT	Strip- semi-tracked row	1.49	2.65	2.42
ST-MT-CT	Strip-hard tracked row	1.14	1.24	0.85
ST-MT-CT	Conv.-guess row	0.72	0.69	1.81
ST-MT-CT	Conv.-semi-tracked row	0.50	0.49	0.38
ST-MT-CT	Conv.-hard tracked row	0.37	0.31	0.06

Note: Infiltration tests run with Cornell Infiltrometer (Dr. Harold van Es., Cornell University) 45-55 days after corn emergence. Soils sampled are Manter fine sandy loam, 0 to 2 percent slopes.

Summary:
In the long term multi-year strip-till study (2001-2004) here at the IRF in Yuma County, Colorado we have observed improved soil porosity, faster intake rates, increases in organic matter in the surface soil horizons, and improved populations of worms that indicate overall soil fauna populations. Strip-till farming clearly demonstrates that improved soil quality characteristics offer benefits to growers in Colorado, Kansas, and Nebraska. Those improvements are also being observed in yields at harvest time in more bushels in the bin.

References that may be of help:

1. www.soils.agri.umn.edu/academics/classes/soil2125/doc/s9chap1.htm
2. www.cias.wisc.edu/wicst/pubs/earthworm.htm
3. www.soils.agri.umn.edu/academics/classes/soil2125/doc/s9chap2.htm
4. http://soils.usda.gov
5. www.rain.org/~sals/ingham.html