"What Can Strip-Till Do For You" Series

Part III. *In Compacted Soils, Soil Biology Takes It on the Chin*

Mycorrhizal hyphae extending into soil

Leaf chewing insects start the breakdown

Earthworms pulling residues into burrows

For the most part anyone who considers the effects of compacted soils think first of the physical condition of soil: consolidation, then slowed water movement, thin layers of soil stacked upon layer, upon layer, increased horsepower requirements to till, soil crusting, and significant runoff during heavy rain events. Let us delve into the third issue; tiny living organisms that are impacted and the food they need to survive on – carbon.

Several issues stand out; **1)** the rolling over, tumbling and crushing of microbes, fungal hyphae, earthworms being sliced and crushed, **2)** soil pores that houses microbes, protozoa, amoeba, colembra, nematodes and other living creatures are broken down, **3)** the food supply is altered or buried away from the active microbes, microarthropods and other carbon converters, **4)** as soil dries out, exposed to air NO, CO_2 and other gases are lost into the atmosphere, and **5)** fungal hyphae development is very important in assisting plant roots, nutrient uptake, water uptake but compacted soils inhibit mycorrhizal spore attachment and infection of the roots.

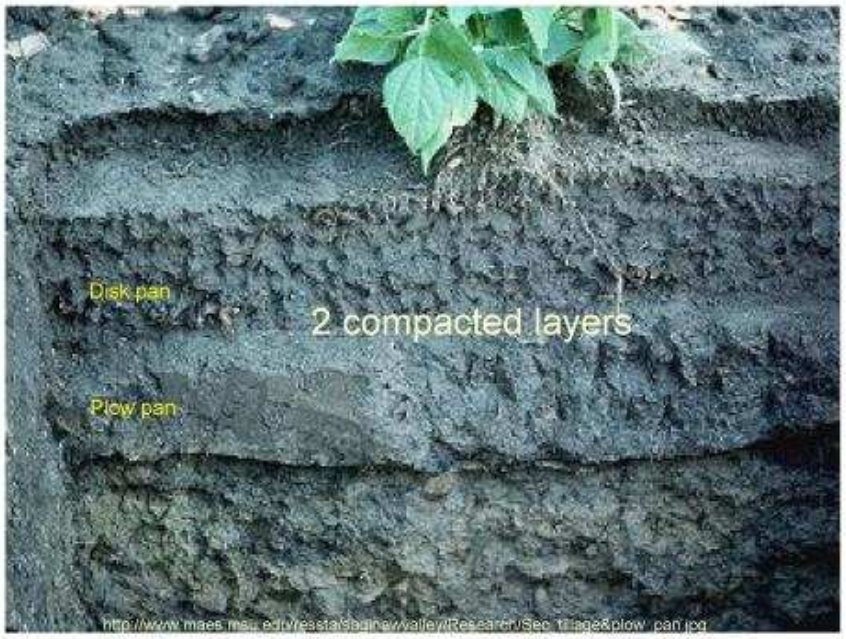
With strip-tillage residue is left alone between rows

Sounds like war has been declared on the soil ecosystem, sounds harsh, but conventional inversion tillage season after season has many detrimental effects.

Look at the first impact: The crushing, rolling and tumbling effects to soft bodied microbes, collembra (springtails) is like placing an 8 year old boy in a cement mixing truck with 250 pounds of rocks and starting the large drum to roll. The thought is a bit disturbing! Yes, soil will crush and can smother more than 75% of the creatures in the soil when turned with inversion tillage. Too, a cutting/sliding action of soil from the disc, blade, or plow lathe will cut off soil pores, earthworm burrows and root channels creating a thin layer of compacted soil. With inversion tillage the weight of the tractor, the forward and gripping action of the front and rear cleated tires clawing into the soils press soil particles together beginning compaction. The tiniest creatures are smeared, rolled and tumbled and yes we smell the aroma of rich earth – actinomycetes and nitrosomonas bacteria are broken and releasing nitrogen gases. We think we've started good things, hardly to millions of bacteria. Helpful fungi and yellow-green algae are damaged which have specific processes to convert carbon compounds and nutrients for root absorption. Earthworms are hearty creatures but in the cement mixer of discing or plowing they are sliced and diced, may die or go hide to rest and regenerate. In a weakened state the worm restricts his movement and eating activity. Worms are consumers of harmful nematodes and protozoa with their importance in the balance of the rhizosphere.

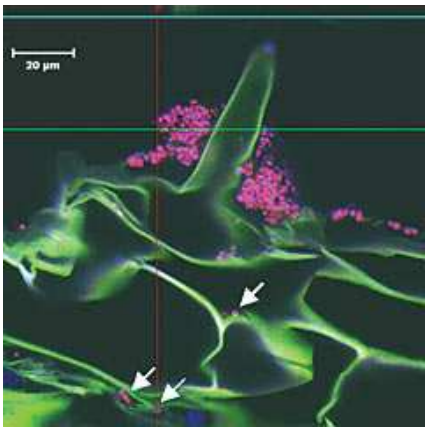
In compacted soils, I as a soil scientist have observed in the 38 years of digging pits for root studies since 1981-present, earthworm activity in conventionally tilled (broad acre tillage) populations slowed nearly zero.

Reduce the tillage to the minimum, as we promote with strip-till, earthworms repopulate and by the second and third year of strip-till system, worm numbers may reach 20-70 per cubic foot each spring. Fungal hyphae, symbiant hair-like growths from the host plant root may extend 1 to 8cm (0.4 to 3 inches) into the soil to absorb water, P, S, Zn and some organic N materials. They are very small in size, 3 to 10 microns in diameter and where they exist they leave narrow little tunnels. Bacteria will exist in these tunnels, but as inversion tillage and forces of compaction occurs, the tunnels are broken down, the aerobic bacteria are cut off from oxygen, they will suffocate and run out of food. It is important to note, most bacteria are most active during warmer periods of the soil and when living roots are thriving. Within the last 100 years of tillage and cultivation of soils for food, fiber and grazing – growers have over-used inversion tillage tools. With the advent of strip-tillage tools, a form of vertical tillage, we can offer growers a physical disruption of the soil compacted layers without the major tumbling and inversion action which will yes till, disperse microbes, scatter spores of arbuscular mycorrhizae (AM), mites and other critters without annihilation.



Soil compaction: Courtesy of Saginaw Research Farm, Michigan State U.

Second impact: Along with the meltdown of soil structure, pores, tunnels and crevices are all impacted during soil compaction broken into smaller units, closed off and separated into smaller cavities that run out of oxygen that cause death or hibernation of aerobic microbes. During inversion tillage, carbon dioxide (CO_2) is released into the atmosphere, soils dry out or wet and become like concrete entombing CO (carbon monoxide) which is disastrous for aerobes, nematodes, springtails (colembra), mites, pseudo-scorpions, leaf chewing beetles, ants, spiders, millipedes, dung beetles and so on. In wetter climates of the Central and Eastern Corn Belt, soils can remain wet much longer under the soil compacted zone and anaerobic bacteria will gain population, other harmful acids such as butyric acid, proprionic acid, acetic acid and alcohols – phenols are produced and cause havoc with roots and oxygen loving bacteria. The balance of the soil rhizosphere changes as the pH level drops and aluminum can become toxic – all potential problems for the soil-root interface.



Azospirillum bacteria(pink) alive near root hair scale in upper left 20 milli-microns

Third impact: Compacted soils, continuation of conventional inversion tillage methods will alter the carbon food supply for the microbes, worms, and all the other creatures mentioned in the above paragraphs. How? Fewer roots because of tight, compacted soils will leave less foodstuffs for microbes and other creatures to digest and live off of. Less water that can penetrate deeper into the soil profile and fewer roots, less biomass above ground is produced this will not return as much carbon to the soils which feeds the microbes, invertebrates, insects and all. With shallow inversion tillage (discing 3 to 5 inches in depth) residue is buried in a thin layer and as the soils raise in temperature to 100ºF+ (32ºC+) the residue can turn to ashy like material – close to worthless for microbial food. The residues that fall onto

the soil surface especially in the Western states will oxidize from UV light, heat, bright sunlight throughout the late fall and winter months when the soil life is either asleep or slowed due to cold soil temperatures. Shallow inversion tillage to "return the trash to the soil" only speeds up the transition from residue to CO_2 if done late in the summer or fall – the loss can be great. Further south the soils remain warmer longer into the months of September, October, November and even December and what bacteria and other creatures get to the organic materials it maybe oxidized on the soil surface when soils are compacted.

With fewer contiguous conduits, tunnels, old root channels in compacted soils the microbial population will be less and in a general statement fewer macronutrients [N,P,K] are released for root uptake to feed the plant. It all becomes a process of diminishing returns – so if growers are unaware of the damages from compaction we see more growers pour on the commercial fertilizer to think they can improve the playing field and it is either a temporary fix or an action with poor results. I think Dr. Albert Einstein said it very well, "*No problem will be solved with the same level of thinking that created it in the first place*."

Fourth Impact: As the compacted soils dry out, turning hard and dense; there are losses of gases such as nitrous oxide, carbon dioxide, carbon monoxide, sulfur dioxide, and oxygen in the surface. The compacted zone which is commonly found from 5 inches to 12 is where this occurs. Some of the gases may be trapped and may never be released or available as a resource to the plants which should be avoidable. So conventional wisdom has thought we need to turn the soil to mix in oxygen. Inversion tillage continues the cycle and we gain nothing.

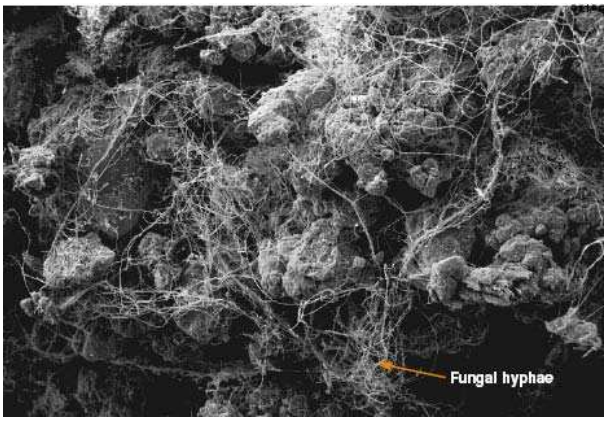


Image of soil held together with filaments of fungal hyphae

Fifth Impact: Friendly fungal development and hyphae growth in a healthy soil that is well aggregated can make up 40% of the dry weight of roots in the surface 8 inches. These hyphae are very important to nearly all higher living plants that we grow in the U.S. In the 1980's a soil scientist Sarah Wright with USDA-Agricultural Research Service in Maryland was able to isolate the sticky, glue like substance release from the mycorrhizae hyphae that hold small particles of the sand-silt-clay complex together. It has been aptly named "glomalin". This process of holding soil particles together into small lumps or peds is soil aggregation. The accumulation of aggregates creates macropores and mesopores which will have a positive effect to improve water infiltration. These complex carbohydrates given off from the hyphae bind the soil particles together and are a source for food of the bacteria in the soil – all very good things for the soil rhizosphere. Soils that are compacted due to heavy traffic, hooves, high intensity rain events in sandy soils, and inversion tillage passes will breakdown pores even the smaller than those 10 micron size to slow or stop hyphae extension.

Soils when fallowed and kept barren will lose the beneficial effects of hyphal growth on actively growing roots, especially in the semi-arid Western States in crop production. With no living roots from intended crop growth, grasses or weeds, mycorrhizal fungi which binds soil aggregates together diminish and do not complete their life-cycle to the spore state for later root infection. Result, soils can turn into mush or worse – concrete.

Mycorrhizal fungi and nitrogen-fixing bacteria are responsible for 5–20% (grassland and savannah) to 80% (temperate and boreal forests) of all nitrogen, and up to 75% of phosphorus, that is acquired by plants annually. As the hyphae in high numbers will have a greater surface area. As they come adjacent and grow around clay particles, into humus materials and in contact with soil bacteria; hyphae absorbs mainly P, then Zn, S and organic forms of N returning all back to the host root in trade for sugars to keep the hyphae growing and the cell structure alive. It is important to all stewards of the soil to maintain this good and beneficial relationship with mycorrhizae.

Where does that lead us?

It is quite evident that consistent inversion tillage, heavy loads and frequent trips over the soil surface will cause soil compaction, this has adverse affects to the soil biological life of the soil. Do not make a quick jump into a misdirected direction that if we stop all tillage and go to "Direct Seeding" we have the answer to dealing with soil compaction. First one must do something about the compacted soil. Direct Seeding has many benefits in both close-sown crops and row crops, we agree on that. But since soil compaction is a mechanical derived problem, the grower can have a great deal of control on how to alleviate and manage compaction. The issue is never completely erased but with several techniques, soils can be re-phased to a better condition. Numerous Ag colleges and Extension Service bulletins have addressed the physical function of breaking up compaction and we suggest checking those out. Freeze and thaw action is helpful in breaking compaction but studies with ARS have noted it takes numerous freeze-thaw cycles to rupture a zone of compaction. Since most compacted layers exist below 7 to 10 inches, soils freeze once and thaw once at those depths. In the Southern tier states of the U.S., freeze-thaw does not occur. To properly deal with soil compaction, the soil will need a lift and shatter tillage operation pulled through the soil. Not all shanks are created equal on subsoiling implements, be sure you have a tool that does not lift, heave, create boulder-sized chunks, and roll the soil similar to an inversion tillage pass.

Why is a strip-till manufacturer writing about this use of subsoiling and management of compacted soils in regards to the living organisms in the soil? We promote the use of the right tool, developing a sound strategy to maintain soil health, aggregate stability, better water infiltration function, and maintain organic matter between the narrow till zones - these will improve a growers' lot in life, our customers. We realize in many crop rotations that traffic on the soil surface is necessary; sugar cane harvest, tomato harvest, potato and sugar beet digging, rice harvesting, large farming operations that unload the 12 row corn combine on the go into 1000 bushel grain carts, and corn silage chopping with tandem axled trucks – many of these activities are accomplished when the soils are moist to sometimes near field capacity. Since that is all a reality, depending upon the depth of the created soil compaction in row crops, strip-tillage does have a proper place and has for over 15 years offered growers a way to manage compaction. As we have seen, soil health improves which we at Orthman Manufacturing have observed in specific field research in California, Colorado, Nebraska, North Dakota, Ohio, and Texas over the past 9 years. We are using tried and true scientific methods to measure soil aggregate stability, bulk density (measure of soil porosity and density), near saturated hydraulic conductivity, dry infiltration, levels of organic matter, pH, and soil penetrometer measurements that offer resistance to soil fracture and penetration of root tips. These methods give us empirical, real values of how the tilth and/or health of your soil is presently and then the with use of conservation tillage practices such as Strip-Tillage or Direct Seeding often called No-Till, we can improve soil quality.

Tilled strips, results after pulling a 1tRIPr through a field

It is important to note in all three of these articles we have written, we want to address issues that come with soil compaction; the message of the impacts is very pertinent to growers, consultants, conservationists, students, and other agriculturists. We see the impacts in crop production are so much of the time negative unless we are building a road base for a highway, we want to start the steps that offer a glimmer of hope of reduced yields, frustration and reduced soil quality of compacted soils. To grow a crop such as corn or soybeans, the roots have just so much "push" power to penetrate soils. Getting plant growth and roots to extend deeper into the soil for water and nutrition does take a change in soil management. Soil should teem with microbial life, if we treat it like 'dirt' and soil microbes are abused we must institute a different line of thinking. With poor soil condition soils require a different touch to get it back in shape, strip-till soils we have observed will respond positively over time. We at Orthman have accomplished that with strip-till in our numerous plots in three years at the

Orthman Research Farm – Central Nebraska. It is amazing. In Eastern Colorado we observed dramatic improvement in the second year and beyond in a long term study that lasted seven years.

The soil biological life of the upper portions of the soil profile is abundant and complex. Many scientists across the U.S. are directly involved in studying the components of soil biology and microbiology. The internet is an excellent resource to use. Soil Foodweb Inc., Carbon for Life, WSU Center for Sustaining Agriculture and Natural Resources based in Wenatchee, WA; Dr. Jill Clapperton**,** Rhizosphere Ecology Research Group, Agriculture and Agri-Food Canada, Lethbridge Research Centre, the Soil Health Knowledge bank in Australia, and the Rodale Institute are just a few resources to check out.

We welcome comments, thoughts as to what this series has provided you or stimulated some questions. Get hold of us on this website of www.precisiontillage.com under the Contact Us tab.

Strip-Till right after triticale was cut for haylage in Idaho

Springtime strip-till in Western Nebraska – continuous corn