And What Does Tillage Need to DO?

- **The Main Event ?**
  - **Restore soil physical condition for "normal" air and water exchange**
    - » **Take off the "straight-jacket" SOILS need to Breathe!!!**

©jrm

Modern agricultural tillage technology has been historically designed for purposes of making planting equipment work better and controlling weeds or other undesirable vegetation. Until the invention of planting machinery which did not require the use of primary tillage to place, germinate and emerge a crop, and the use of modern herbicides to control unwanted vegetation, it has been rare to see the evidence of the other purpose which tillage has generally achieved.

Until fields appear like this and are investigated to determine why the water is appearing in the harvesting machine wheeltracks, it has been a rare thought that perhaps tillage operations influence the ability of the soil to receive and transport water downward and as a direct result change soil air content.

The fact is that the reason the water appears in these wheeltracks is because the water is a uniform depth over the entire field and appears in the tracks because the soil surface is lower there.

February 13, 1983 at 3:00 PM

One meter of snow melt plus 80 mm. of rainfall--- OVERNIGHT

The event which I am going to describe has proven to be the watershed event that would eventually redefined tillage in my professional career of agronomic consulting.

It was the middle of winter in northern New York in the USA when my good friend Donald called me about water that was now standing on his alfalfa field for four days. Nearly 1 meter of snow had melted while receiving 80 mm of rainfall. Approximately 30% of his 15 hectare field had water standing on it up to 50 centimeters deep.

He had removed deep compaction (over 45 cm; 18 in.) before planting this crop just as I had asked him. So having done everything right, he was frustrated to see his alfalfa preparing to die. The crop was not two years old yet when this happened.

He suggested that the machine from New Zealand, which I had brought to the area a few months before could solve his water problem in this field. I told him I thought he was crazy.

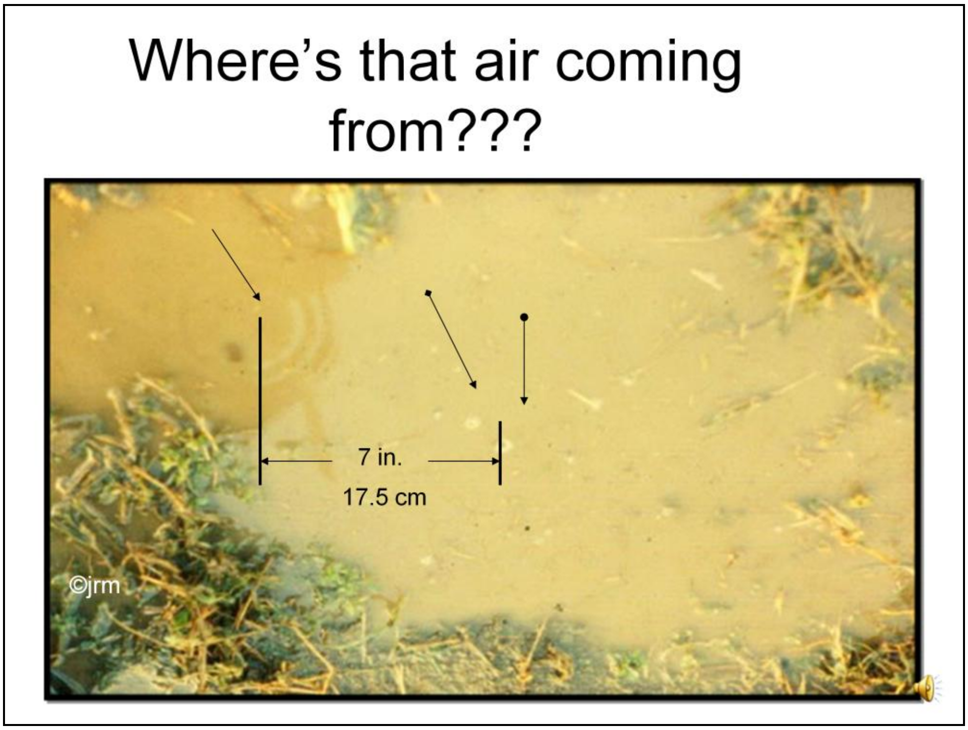
As you can see from the picture something was already happening by the time I was able to take the first picture. Only about 20 minutes had transpired from the time we began driving the tractor and machine through the water.

So now I'm going to tell you the rest of the story and let you see the results of creating fracture forces in this field only 15 cm. deep.

This Alfalfa is in Trouble…
5 days under water

There goes Donald now with a 15 foot (3.5m.) machine that had come from New Zealand. We began near the highway to the left of where Donald is now. When we first hit the water it rose up nearly over the front tires of the tractor. It then proceeded to bury the machine behind the tractor.

We went all the way to the end of the field, turned around and came back. There didn't appear to be anything happening to the water on the field. Then once we had gone up-and-down three times Donald stopped and told me I should look behind us at the water.



When I did I really only observed that the water had been turned brown by the soil that had been mixed with it. When I commented that all I could see was that we were stirring the water, he then insisted I look at the water again.

This time I saw what he was looking at. We had tilled about 15 meters (45 feet) of the total width of the small pond.

There on the surface of the water I observed bubbles of air. They were about the size of a US silver dollar or 5 cm in diameter. And they kept coming to the surface of the water everyplace we had run the machine.

Then because of where I was seated on the fender of the tractor, I was gazing at water that had not been undisturbed by the machine. Suddenly I realized as I focused on the surface of the water, the dust and dry plant materials that were stuck to the surface of the water were moving toward me and the machine.

It was then that I finally realized what the bubbles on the water surface were trying to tell me and you saw it in the first picture I took. The water was going into the soil just like Donald had predicted it would.

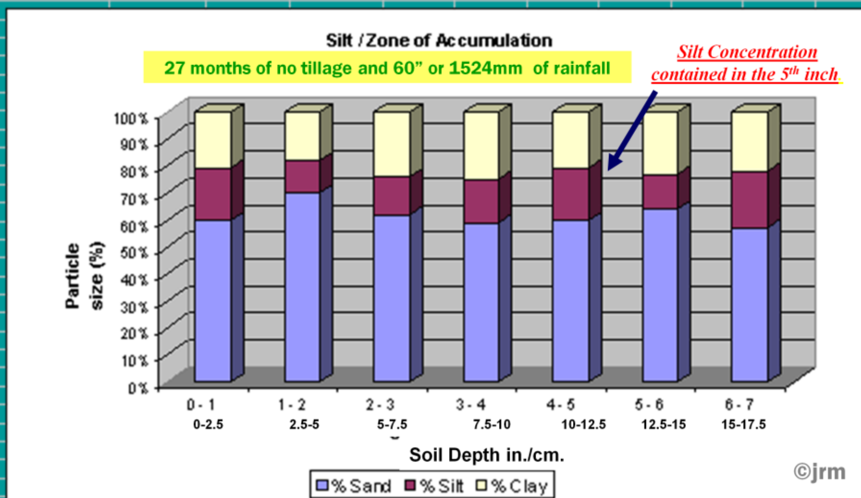
The consultant was in school again.

As you can see we didn't cause any damage to the alfalfa stand. The wheel tracks from the tractor even disappeared under the healthy plants that resulted from our operation. When I took this picture I pulled the small flag that I had placed several months before in the middle of the water.

Fortunately we had the forethought to **not run the machine on selected areas** of the field where there had been no standing water. This gave us an opportunity to do some comparisons of the soil condition resulting from the machine operation. In the next part of the story you will see data collected from both portions of this field.

Soil Depth (inches)	% Sand	% Silt	% Clay
0 - 1	60	19	21
1 - 2	70	12	18
2 - 3	62	14	24
3 - 4	59	16	25
4 - 5	60	19	21
5 - 6	64	13	23
6 - 7	57	21	22

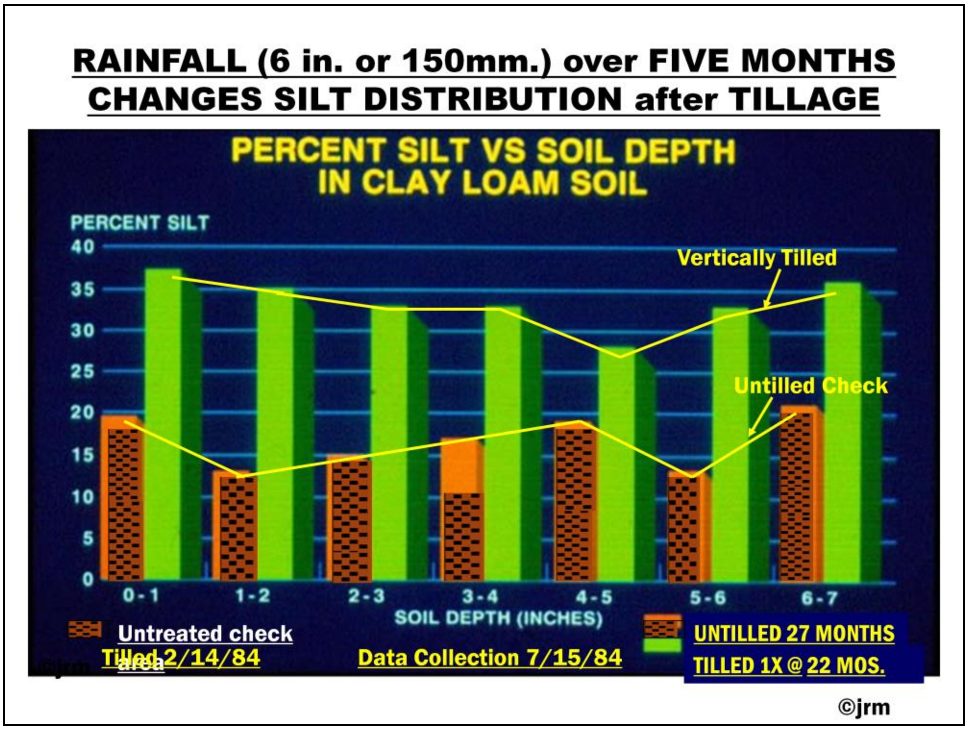
One Way of Looking at the Evidence of What Water Does to Silt Distribution Using Mechanical Assay



The testing procedure use to collect this data displayed here in the bar graph, is called a mechanical analysis. The procedure provides information concerning the relative amounts of sand, silt and clay in any soil specimen.

A separate core was collected for each 2.5 cm (one inch) layer of soil down to 17.5 cm (7"). Since we know the density of silt is only slightly greater than water, it was assumed the movement of water might be affecting the distribution of silt particles over time in an undisturbed soil. The purple bar segments represent the percentage of silt in each sample.

The effects of secondary tillage practices on the concentration of silt and clay is apparent in the top sample. Then as we move downward in our profile, we observe increasing concentrations of silt which peak in the 6 to 8.5 cm (4 to 5 inch) specimen.

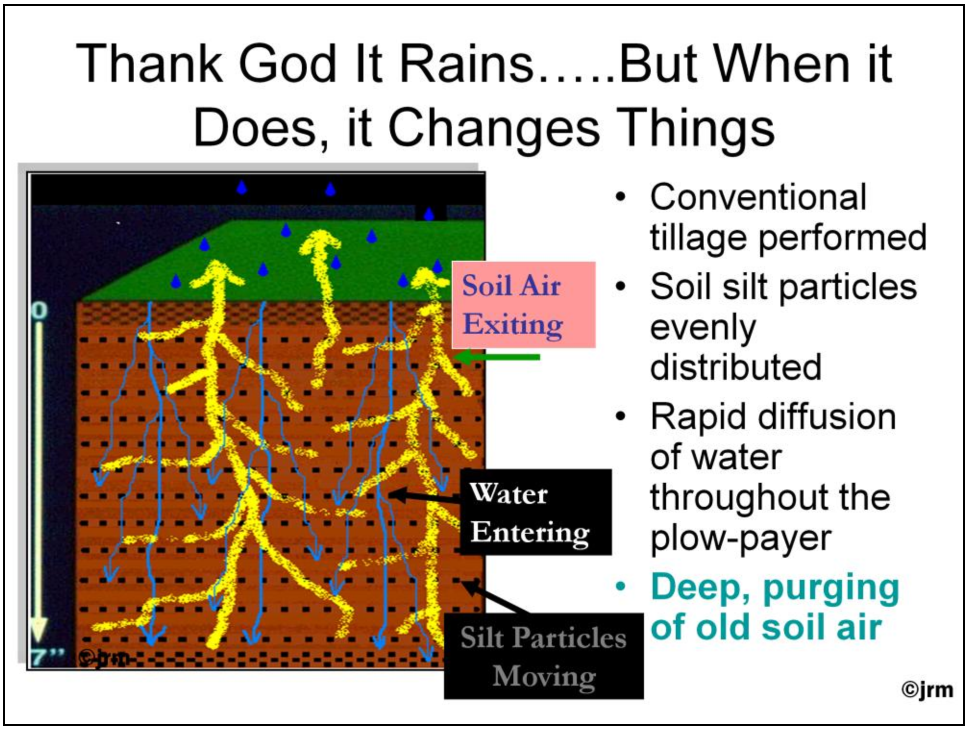


This chart displays only the silt concentration per 2.5 cm layer of soil. The brown-colored bars are taken from the data in the previous chart which was the average of 20 cores in the non-tilled area of the field 5 months following the treatment. The green bars are the silt concentrations found in the treatment area of the field or where the water was standing. The difference in percent silt resulted from the normal variation of silt concentration found in this particular soil type.

The soil penetration of the machine was 15 cm. and deep enough to perforate the zone of silt which had developed from water movement through the soil profile over the previous 22 months.

It is relatively safe to assume that smaller increments of soil depth in each sample taken would have resulted in more striking increases in the silt as a percent of the particle sizes found.

The effect is the same, air becomes trapped underneath the silt layer and cannot therefore be exchanged with the water which is trying to enter into the soil voids containing the air.



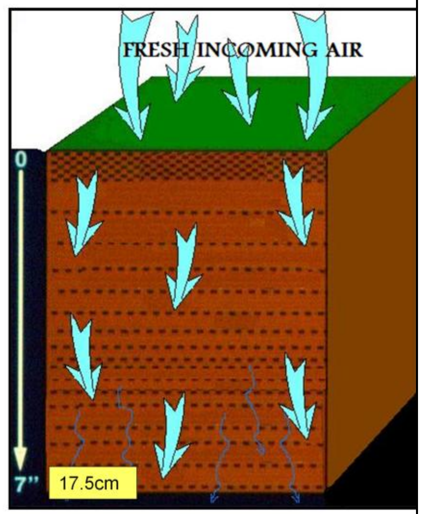
Traditional or conventional tillage practices serve to redistribute the silt concentration as long as they are performed deep enough to reach the silt concentration.

Subsequent, mechanical assays of a wide variety of soil types have shown a consistent trend of a discretely identifiable layer of silt. It has been seen to occur in more than one location in very sandy soils. For higher clay and silt soils the depth may vary considerably.

It has now been observed that various soil tillage and crop management practices can affect the depth of the silt layer over time. It has also been observed that soil with over 3% organic matter tends to re-establish the layer accumulation with about 600mm of precipitation equivalent.

When the Rain Stops….

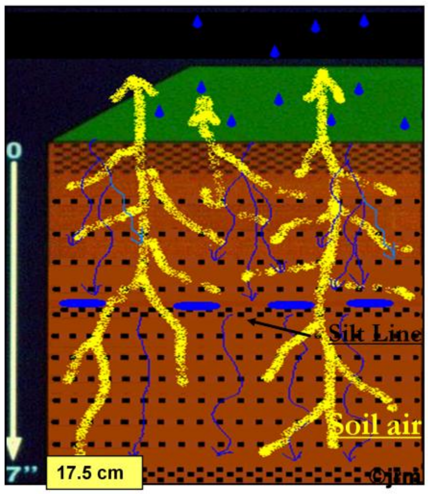
- Free water continues downward
- Leaves partial pressure behind
- Atmospheric pressure pushes “fresh air” into soil
- Brings a “Breath of Life” to all the good guys



In affect, water movement is crucial to healthy soil development because it is the efficient transport of water which purges the low oxygen and nitrogen air and induces a partial pressure which causes re-entry of high oxygen and nitrogen above ground atmosphere into the soil.

Beneficial mycorrhizal fungi and bacteria as well as other soil life forms such as beneficial nematodes and earthworms depend on aerobic soil conditions for growth and proper function.

And Then it Rains Some More- We Hope



- Silt particles travel with the free-water **DOWNWARD**
- Where water speed **drops** so does the **silt**
- **Water** percolation rate through silt is reduced
- **Air** purging from below the silt line is reduced
- This **Silt Concentration** is located anywhere from 5 to 15 cm. (2-5") under the soil surface in most soils

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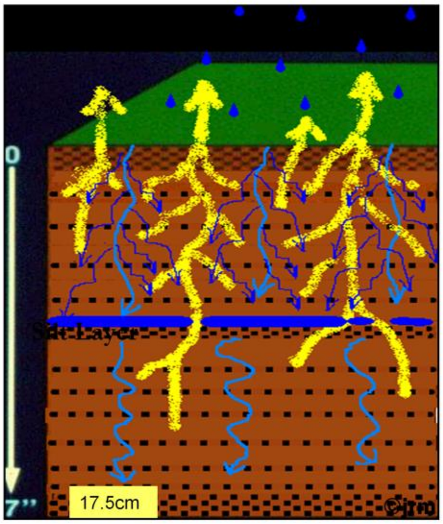
Looking at the progression of the silt layer development, we observe that initially water movement has no discernible ill-effects.

Then We Hope it Doesn’t Rain Too Much



- The free-water keeps on moving more silt to the same location
- The pore spaces are getting fewer and smaller
- Less field capacity; slower percolation
- Less soil air purged
- Less incoming fresh air and slower rate of air exchange

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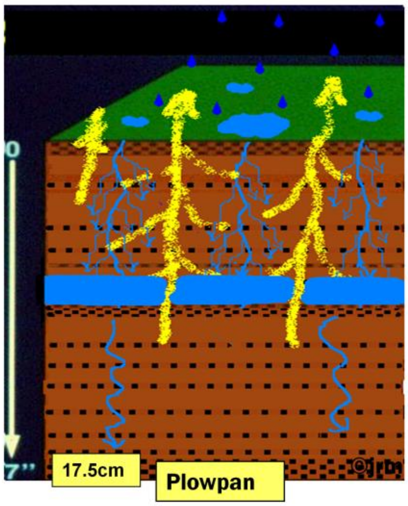
As the amount of water movement through the soil profile continues the effects become cumulative. Where the silt begins to accumulate becomes the location where additional silt will lodge as water attempts to traverse the plow-layer in search of the water table in the field.

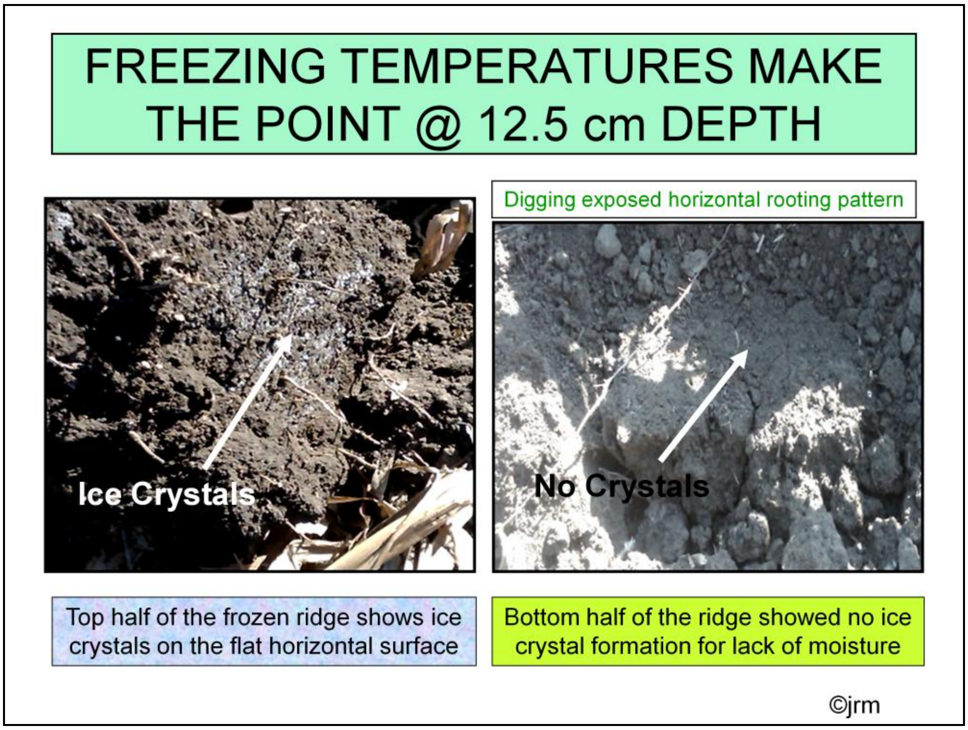
Now we start to See the Problem…



- Surface ponding appears
- Greatly restricted water percolation at silt line
- Little air exchange under silt line
- Soil spends more time anaerobic
- Field depressions become wet-holes
- The silt density layer is still only a fraction of an inch thick

Continued time and additional precipitation eventually produces a nearly impervious layer of silt. Water and air cannot pass each other so the soil becomes increasingly anaerobic.

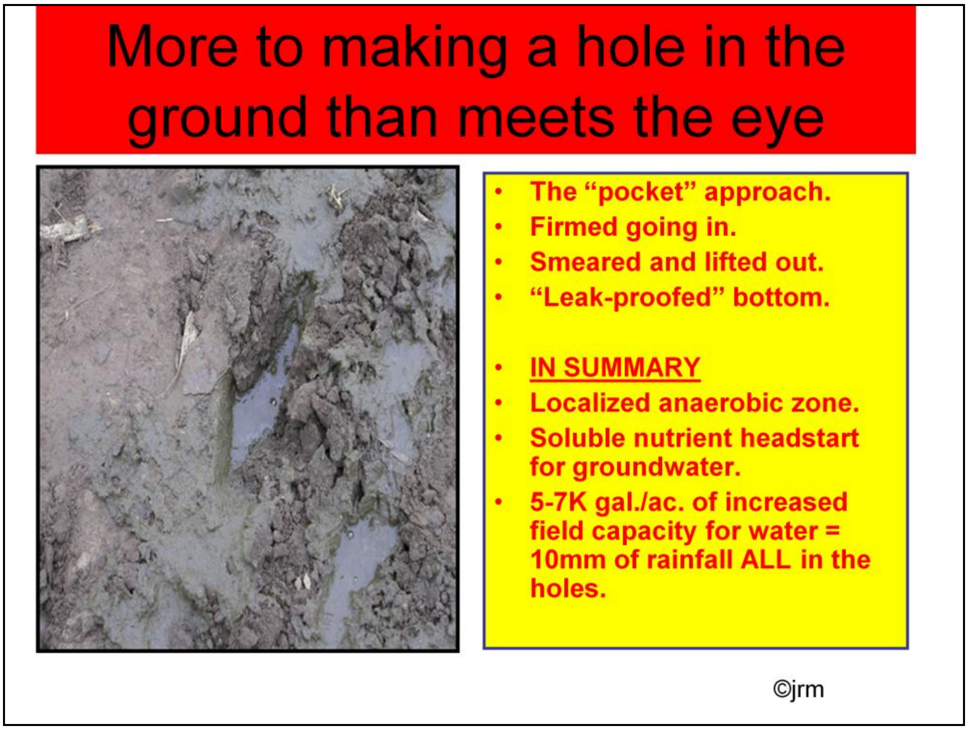
The amount of rainfall in a single event becomes less and less before the water starts to pond and run-off the field. In ridge-farming practice the water exits the end of the ridge to a greater degree and creates gully erosion patterns.



This process takes place inside ridges too. It is evidenced here in a rare sight with temperatures low enough to crystallize water. The water is only found in the upper portion of the interior of the ridge or above the silted layer. The integrity of the silt layer was so great that it forced this root to grow horizontally on top of the layer.

The soil below the density layer of silt was at the same temperature as that above but no ice crystals were formed since the water would not penetrate the lower level even by the force of gravity. The discontinuity of the pore space caused by the silt movement and resulting stratification or layering stops the downward and upward movement of free water and capillary water as well.

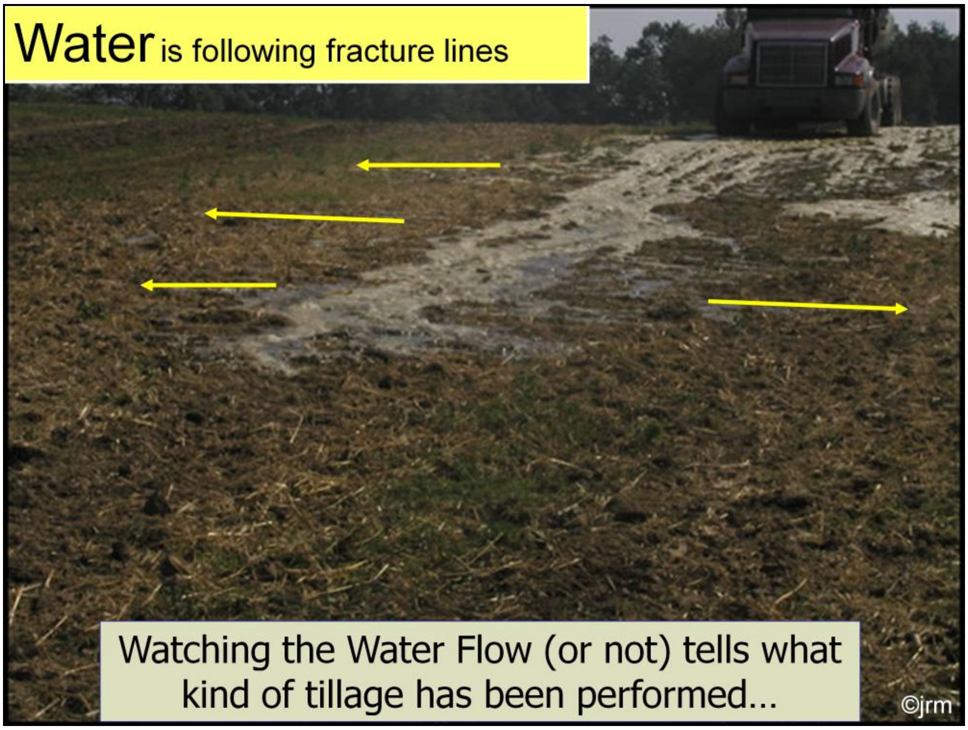
The typical rotovation tillage performed in the springtime in this ridge was too shallow to redistribute the silt layer which would have enabled normal water and air exchange within the ridge for at least some period of time.



At this point in the discussion it is necessary to point out the fallacy of thinking that just putting any old hole in the soil is all that is needed. Here is an example of a hole made by a Canadian product which claims to shatter soil and produce water and air exchange.

The proof is in watching what happens to water when it is applied to the soil surface. In this case liquid dairy cattle waste was applied in a band directly over the series of holes made by the machine. The 5% solids manure sat like this in this unchanged condition for over an hour.

When the liquid applied exceeds the capacity of the holes that have been created, erosion forces on the soil surface are at work as if the tillage operation had never been performed. When the liquid finally leaks out of the bottom of the hole in this case, it places groundwater in jeopardy of contamination from nitrogen containing animal wastes and pathogens.

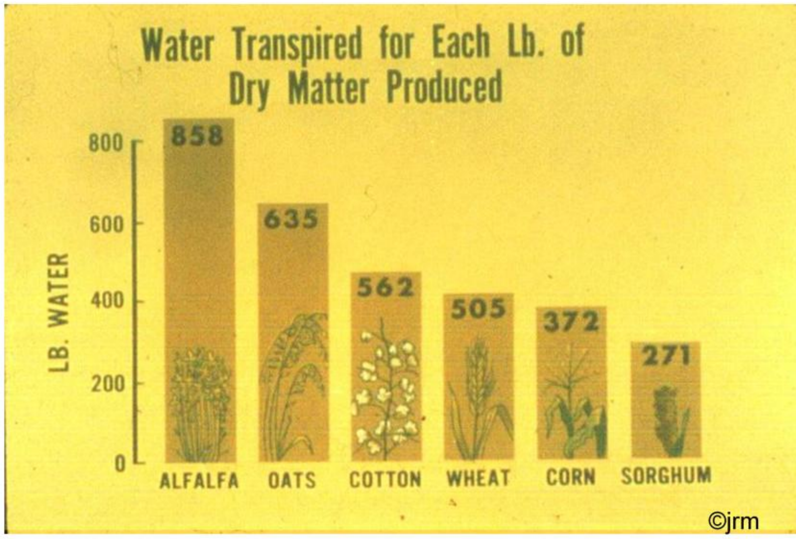


A properly built machine made the holes in this sloping field to demonstrate the impact of a design which truly fractures soil to induce water absorption from the soil surface and sub-surface diffusion.

The original intent of this demonstration was to create a potential disaster where liquid dairy waste could potentially escape from the field to pollute a small freshwater stream. The same demonstration the day before had required several machines to make dikes to contain the manure.

In this case the same volume had been pumped from two trucks at high rate and very little liquid emerged from the tilled strip across the face of the sloping hillside.

The white appearance on the surface of the soil is being created by the air which is escaping up through the liquid manure waste. The yellow arrows indicate the direction of the diffusion of the liquid across the face of the slope. Capillary action should always overpower gravity in a properly functioning soil as seen here.



Different Crop Plants Require Different Amounts of Water to Grow

Different crops require different amounts of water to produce any given weight of dry matter of plant material. That water requirement is largely met by precipitation which is often received during nonproductive periods of the year. Tillage which is properly applied and conceived should efficiently receive, transport and store these water resources.

We will see the relevance of moisture requirements of the various crops in this chart in a cropping strategy later in this presentation.

Also keep in mind that corn and sorghum species will take up to as much as 80 percent of their total water requirement from the air. This will be important information.

Root Development in No-Till and Minimum Tillage Systems

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This is a typical root growth pattern for a corn plant grown with shallow minimum horizontal tillage techniques. By measuring it was determined that the longer roots which are visible after breaking off during extraction from the soil, were formed in the locations where the vertical action of the tillage tines took place.

The minimum tillage tools used never ran deep enough in this clay-loam soil to redistribute the silt particles. The air and water exchange was occurring only in the vertically fractured zones.

The compacted layers were also serving to restrict root elongation except where the vertical tillage had been done one time.

Minimum Tillage Tool

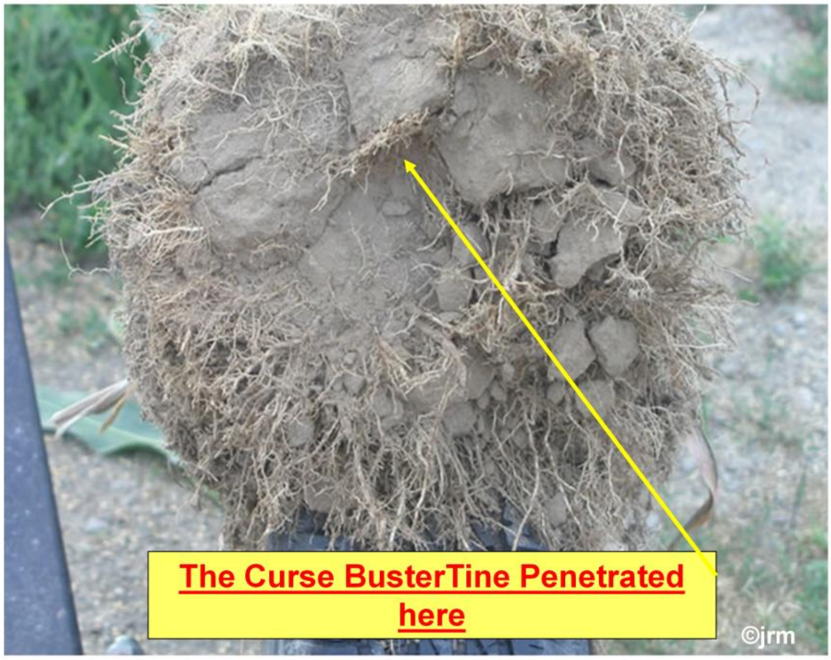
Popular sweep attachment for minimum tillage tools… would not compact if it could always stay razor sharp… but it CAN'T!

These tools produce a nicely lifted and mixed layer of soil. The leading edge as soon as it begins to wear into a rounded edge starts to pack the soil under the sweep device.

Only rarely do these attachments operate deeply enough to disturb the silt layer which is created in all soils.

This is an example of what happens when soils are routinely tilled plow-layer deep. Even though no salt based fertilizers or pesticides of any kind had been applied in over 10 years, this soil had lost it ability to resist compaction forces from tillage machines and other equipment.

This is a perfect example of multiple applications of the sweep technology being applied to the soil at different depths.

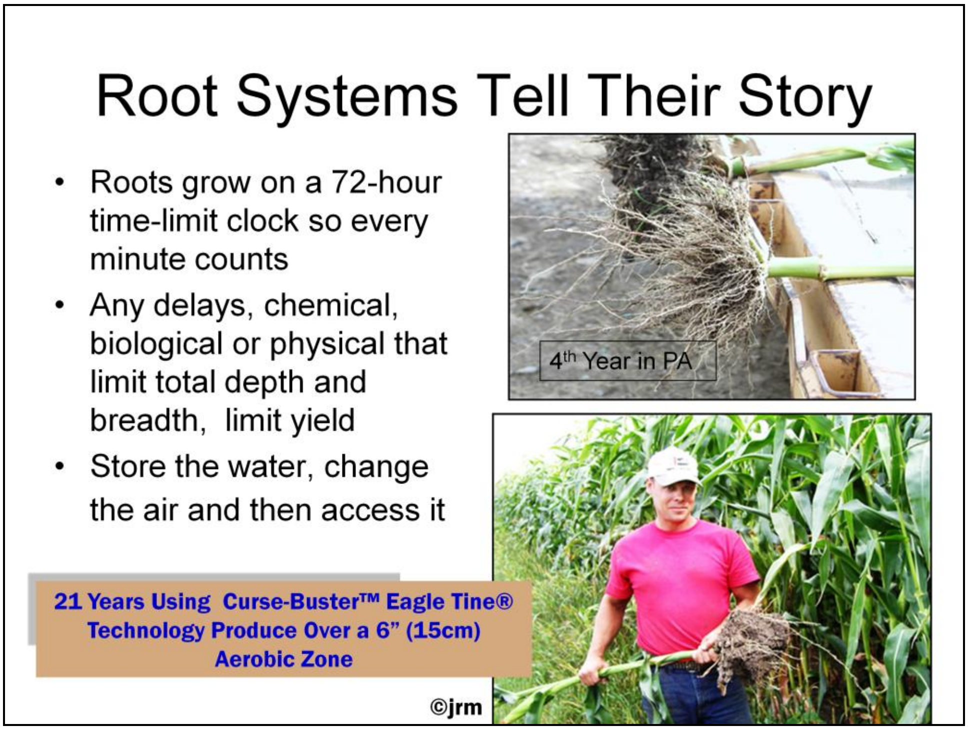


These organically managed soils received one pass of the vertical tillage technology, and the location of the time operation was clearly evident in the nature of the root growth pattern.

What we are seeing here in the unusual root growth patterns is the direct result of using large amounts of tillage to address soil structural problems which are already unstable from previous excess tillage.

Notice once again with a closer look, the impact of the vertical action of the tillage tine.

After 10 years of organic soil amendments, the soil had declined in organic matter by nearly 30%. Virtually all rooting activity was confined to the top 17cm. of the field. Massive amounts of primary and secondary tillage coupled with mechanical row-crop cultivation for weed control had oxidized organic matter into volatile humic acid to a massive degree.

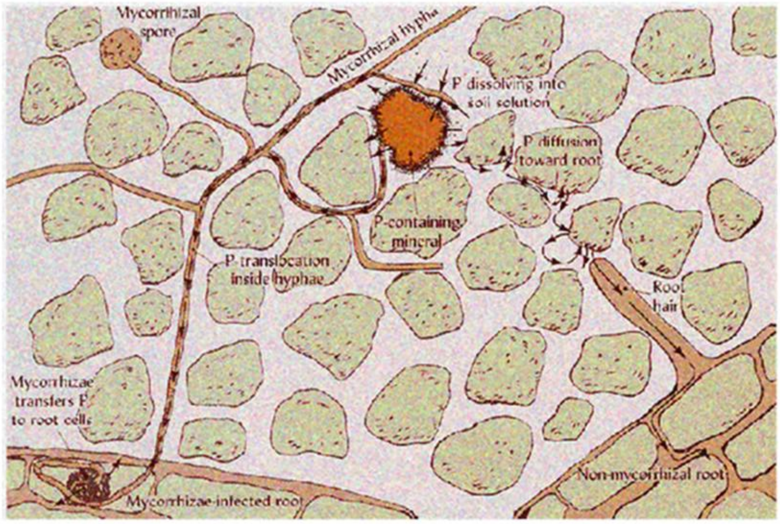


The operation of horizontal tillage machines have a profound impact on root system development because of the nature of root growth habit. After 3 days the growing tip of the root searching for new territory in which to lodge and serve as a source of energy for mycorrhizal fungi and bacteria, the growth ceases.

In grass family plants such as corn, all of this activity downward and outward boundary setting ceases at 40 days. At this time the ear embryo is formed and the number of rows of kernels is established. From that point on the plants grow roots within the boundaries set in the first 40 days.

The mycorrhizal colonization zone in the upper picture is nearly 15 cms. deep after just four years.

Mycorrhizal vs. Non-Mycorrhizal Root and Soil Systems



On the left is an illustration of a healthy soil and plant root relationship. There are literally thousands of meters of nutrient gathering and synthesizing microbial and fungal life forms that live in this soil. At the same time they live and function either inside or in close proximity to the plant root hair. They are dedicated to creating complete proteins and enzymes to nourish the plant and defend it from diseases.

The unhealthy soil on the right has few colonizing life forms so that the plant only finds mineral nutrition by experiencing nutrient transport in soil solution. This is very inefficient and requires very expensive additions of commercial fertilizer. When the soils become very dry the nutrition also disappears with the water.

Fortunately most of the plants we grow supply the necessary nutrition for these microbes to perform their very valuable service. That nutrition consists mostly of glucose as the energy source for them.

Unfortunately, these microbes are very fragile and excessive moisture for prolonged time periods or lack of oxygen and sudden additions of large quantities of oxygen and nitrogen altering the soil atmosphere composition, will destroy these very unique beneficial health and yield producing life forms.

Todd Mason, Cape Vincent, NY in August 2007 ©jrm

Been doing all tillage with the Eagle Tine® for 21 years

Here is an example of extensive rooting that can be achieve. The deposit of carbon from decaying roots which have no lignin in them is essential for a microbial food source to be coupled with air changes to promote mycorrhizal colonization to 23 cm or more on this farm.

Organic matter readings have increased through the full depth of 24 cms from 3% to consistently over 4.5% and much more in some areas.

In the summer of 1999 no precipitation was received from June 9^{th} until September 12^{th}. The harvest was normal for the farm (twice the county average) while neighbors who endured the same adversity yielded less than half the normal crop of corn and hay crop forages.

One of the most important aspects of this tillage technology is the tillage-created tendency for plants to root in new locations after each operation of the tillage tine. Research has shown that old root channels are prone to be droughty and a source of pathogen activity.

You will see a soil health report on these soils later this presentation.

Over 86,000 plants/ha. in 50 cm rows; Manure and Bio-Stimulant w/ 6-24-6 (12 l./ha.) with the seed

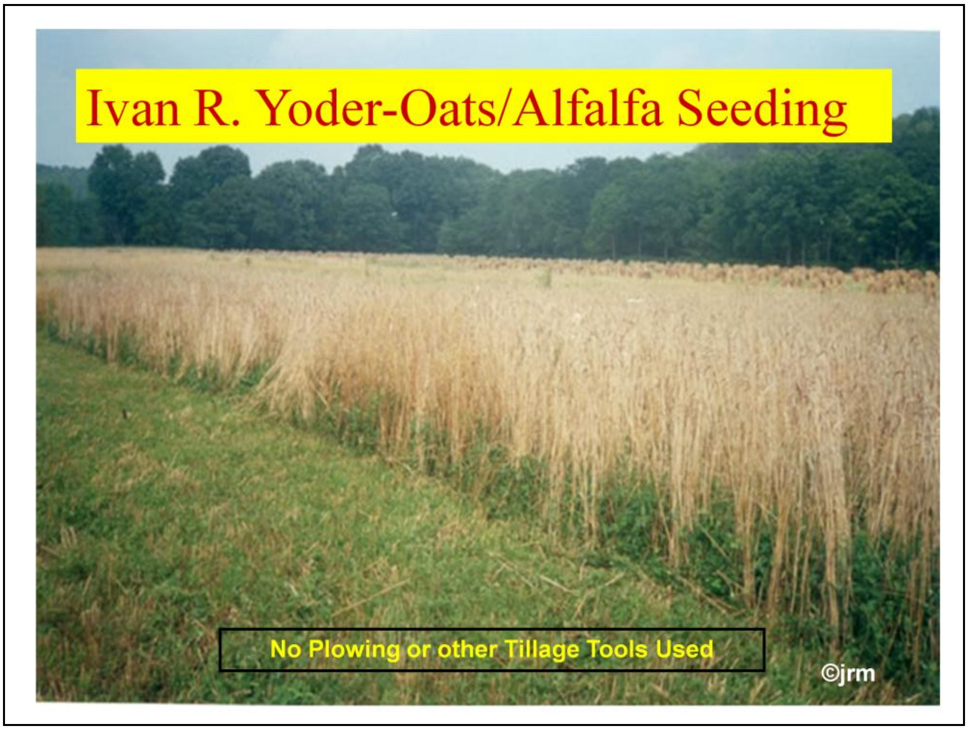
Over 35,000 plants/ac. in 20” rows; Manure and Bio-Stimulant w/ 6/24/6 at 3 gpa with the seed

This is an outstanding crop of corn with very minimal inputs. Consider the fact that just as much carbon has been placed into the soil as is present in the plant parts that we can see.

Because the tillage system will leave these root systems in the same place where they grew, this abundant crop has made a contribution at the same time in producing topsoil.

Corn has been characterized by some as a crop which robs much nutrition from soil. Quite the opposite can be true. We will see university tests that prove that this is not necessarily the case later in the presentation.

This is an example of a corn crop produced without chemicals and soil fertilizers. One mechanical cultivation was required for weed control. Otherwise the only tillage on this field was performed by the Free-Till combination vertical tillage tine and Rotary Harrow.

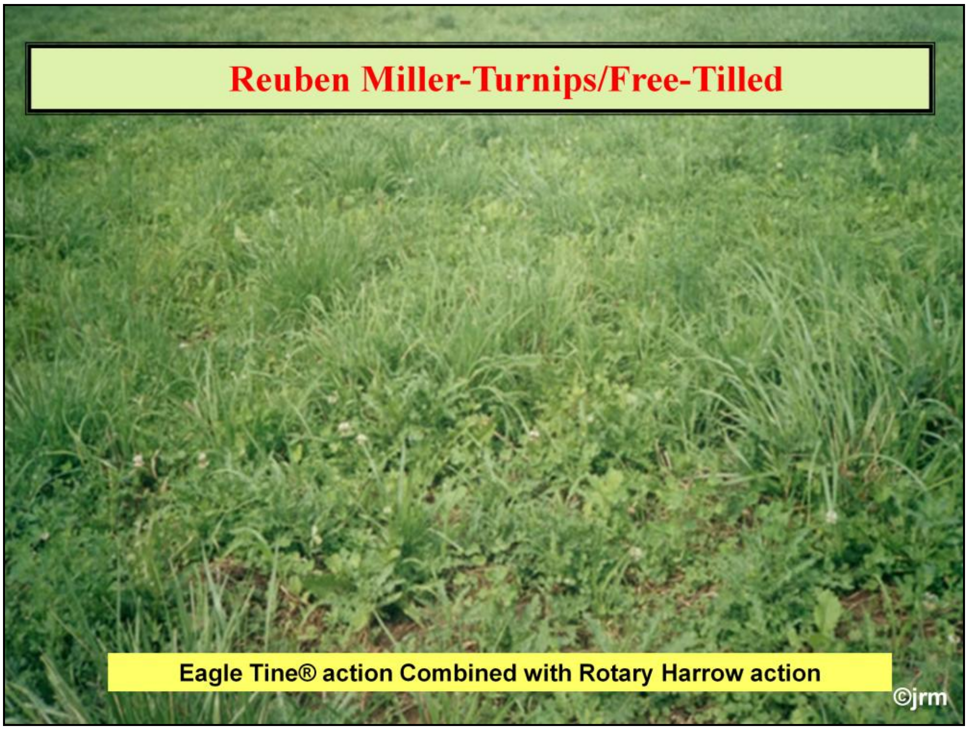


This is another example of an organic producer. He used the tillage machine to create the seedbed for small grains and broadcast the seed before the final pass.

Once this was completed the small seeds of the forages were broadcast on the surface and left.

One of the secrets to these successful experiences is being able to perform tillage without experiencing moisture loss. In addition crops which can be planted very early in the springtime, like this small grain. They do not have to be delayed because of wet soil conditions.

In the reverse situation where the seedbed is very dry, the use of the machine will cause soil moisture to rise by capillary action to germinate the crop where normally moisture would be considered insufficient.



This field is located on a grazing based dairy farm. In order to increase the length of the grazing season this farmer plants turnips and radishes late in the summer. He prepares the soil by running the Free-Till machine and broadcasting the seed before he does this tillage.

The tillage does not destroy the existing pasture grasses and legumes. I does destroys small weeds and incorporates the seed of the new inter-seeded crop all at the same time.

A common practice in cropping systems is to rotate crops using a legume and a grass. The legume supplies nitrogen to the grass plant which follows in the rotation. Under some circumstances this nitrogen source can replace all or most of the synthetic nitrogen fertilizer sources.

The difficulty in using this soil building technique has been the requirement to use extensive tillage or expensive and environmentally hazardous chemicals to destroy the legume in the system. The free till combination of tillage physics now makes it possible to loosen the soil and remove the legume vertically with out destructive horizontal tillage techniques or the use of chemicals.

The equivalent of one pass of the free till in late autumn in this Red Clover cover crop resulted in 80% mortality. One additional pass in advance of the planter in the springtime created a weed free, cover crop free seedbed.

The nitrogen contained in the legume nodules remain in the soil while the carbon containing root system itself was moved to the surface. The result is a soil system which experiences more available organic nitrogen for crop production. The nitrogen required for decomposition of the carbon containing root mass had been dramatically reduced.

These plants were on top of the field feeding beneficial insects and mulching the soil surface for cooler soil temperatures in the summer and shading to retard weed competition.

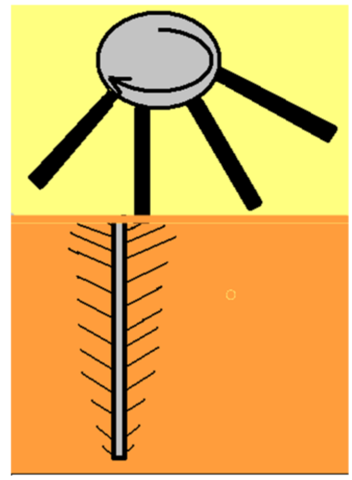
The tillage system called Free-Till is particularly well-suited to animal agriculture. The field we see here was a sacrifice field for winter feeding of the herd. It contained surviving grasses which were undesirable. Very early in the spring the combination tillage tool was used to loosen and remove the undesirable tall fescue variety.

After this first pass spring oats were broadcast and incorporated by the Free-Till machine. Each pass of the machine also served to remove cattle traffic compaction. In this particular situation the oats were able to be grazed two times before neighboring producers were able to graze once. The seed was out on the field so early that it received two snowfalls on it.

After the second grazing by the cattle, the farmer broadcast a warm season annual grass called sorghum-sudangrass hybrid. The plant provided summer grazing for the herd. When the cattle were taken off, the field was planted to the pasture forages for the next grazing season using the broadcaster and the Free-Till.

Zero Degree Offset of Curse-Buster™ Tine

- The Curse-Buster™ tine creates limited surface disruption.
- Normal setting for haycrop and pasture conditions.
- Great for thatching pasture grasses
- Distributing manure
- Removing shallow-rooted weed seedlings



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All of the combinations of various planting strategies for various kinds of crops are possible because of the relationship of the fracture forces created by the vertical tine action and the rotating motion of the Rotary Harrow which follows.

Since the Rotary Harrow adjustment is available in 5° increments, clockwise and counterclockwise from the perpendicular of the machine direction, the harrow can be used very gently to tamp the soil or very aggressively to extract root systems from the soil profile.

Rotary Harrow Set to Tamp

The Rotary Harrow is set here to simply tamp the soil surface. This is very useful when working with very shallow rooted vegetation. The offset angle is at or near zero from perpendicular to the travel direction.

This also shows the Rotary Harrow in the locked up 45° position with the entire module raised so that it does not touch the soil at all.

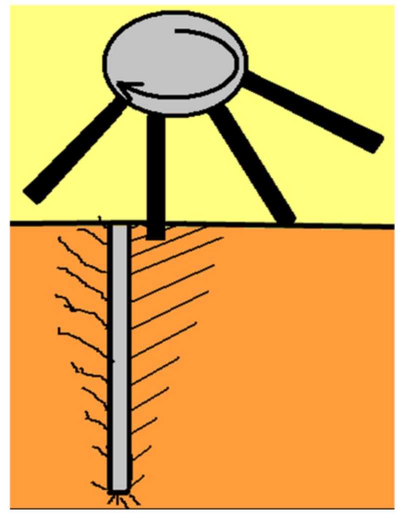
In case you are surprised to see this machine working in the snow, don’t be. Often times some of the best soil conditions for this operation exist under a few centimeters of snow cover. Often times soils are too wet to perform the operation before snowfall begins. Wait. Let them dry under the snow. Wait. Let them freeze on the top up to 5 cm.

What is being effected by the tillage is rarely visible to the eye.

Short Movie clip

2.5 Degree Eagle Tine® Offset

- Increasing aggressiveness of the harrow tines
- Improved penetration at lesser offset angle
- Permits greater harrow speed for superior self-cleaning



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The fracture force lines shown on both sides of the tine mark indicate that this hole has been created by a tandem design machine. In other words the front set of tines are creating the fracture forces on one side of the hole and the rear set of tines is creating fracture forces on the opposite side.

Since the amount of total fracture force which this configuration creates is so extensive, the Free-Till machine has been created with infinite adjustability in the offset of the vertical tine assemblies. This allows superior adjustment for varying soil moisture conditions and plant root system sensitivities.

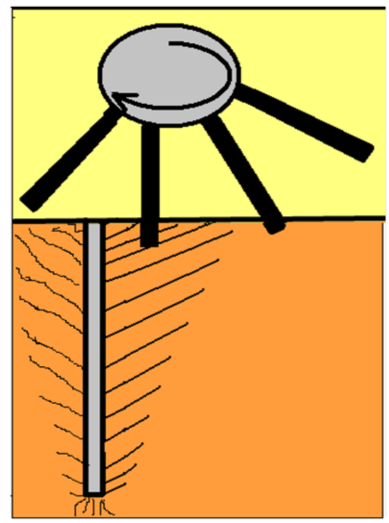
The video clip which follows demonstrates how the rear tine set conforms to the front roller tine holes. This is a patent pending design arrangement. It is exclusive to Free-Till. It is important because it assures the operator of optimal depth of penetration into the soil for disrupting the density layers in the top 24 centimeters all the time. Even if front tines which are forming the hole are badly worn, the rear tines will maintain nearly full length.

When tine replacement is performed on the unit, the rear roller sets are relocated diagonally to the front of the machine and the new replacement tines are installed on the front rollers which are now located diagonally on the rear of the machine. The effect of this design is to guarantee maximum effectiveness throughout the service life of the tines and to cut the cost of maintenance to less than half compared to other similar technology which uses one rank of tines.

Short Movie clip

5 Degree Eagle Tine® Offset

- More fracture force produces deeper penetration of the rotary harrow
- Serious soil disturbance capabilities
- Incorporation of small seeds- inter-seeding
- Eliminate winter annuals
- Eliminate a herbicide in the fall, maybe even in spring


©jrm

A moderate setting such as this is capable of removing most small weeds and providing a sufficient seedbed for planter operation.

The action of the Rotary Harrow which is gently centrifuging lifts and distributes crop residues uniformly on top of the soil. This unique ability provides maximum advantage for beneficial insect habitat including shelter and food.

Disk openers on planters may experience difficulty in cutting these residues. Coulters are designed to cut on a firm surface. The tine action does not present that condition. The soil will be soft, generally too soft to provide the proper hardness for cutting residue with a coulter or disc blade.

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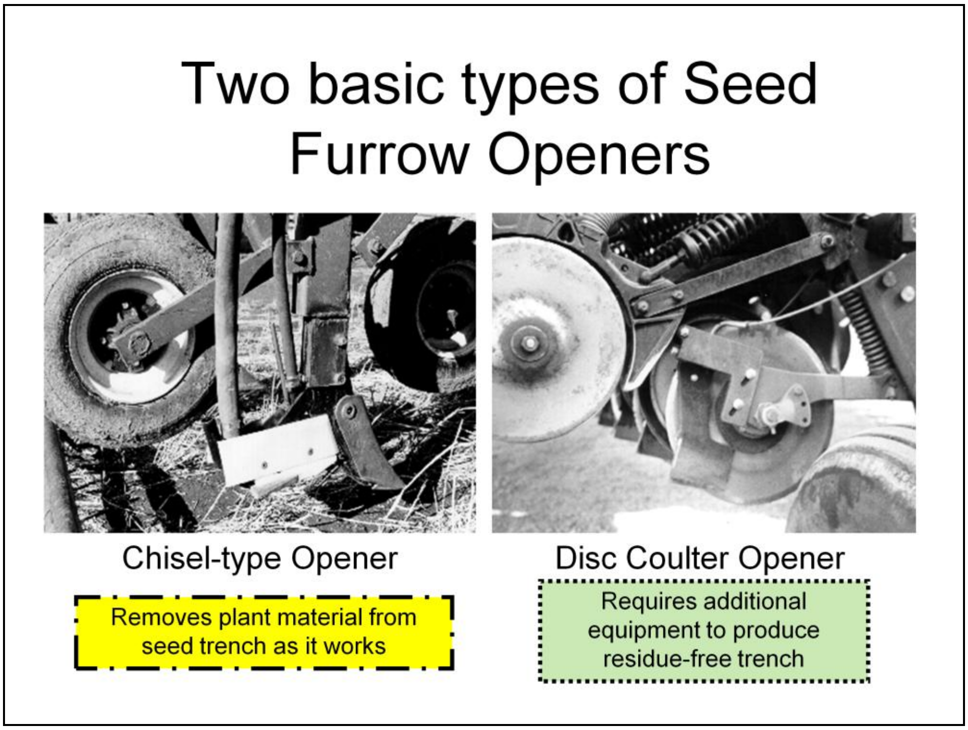


Another excellent choice is the use of a chisel point type of soil opener. If the point style opener is properly designed and maintained, it produces the most ideal seed furrow available. Of course, it can have problems in soils which have rocks in them.

The increasingly popular, and predominant furrow forming system in the world, is the disk coulter. These blades must be replaced in a timely fashion or they to will fail to produce good results especially in moist soil conditions.

Obviously, the way these two seed furrow opening systems deal with plant material located on the soil surface is very different.

Row-Cleaner Assembly

©jrm

Here is a typical row cleaner attachment which is required in most coulter systems when crop residues are left on the field surface. There are many variations to the basic design. Some systems even consist of a single rotating wheel.

Most of these systems now are made to float on or close to the soil surface. The goal includes leaving soil in place.

The addition of residue management wheels or row cleaners is often the best solution. Instead of trying to cut the residue, simply move the residue out of the path of the seed opener disc.

With either furrow forming system, the emerging plant should find itself in a relatively residue free, bare soil zone. This can provide for higher temperatures in the germination zone.

Residue-Free Seeding Area

In all situations the goal that is to be achieved is to move the residue and not the soil underneath the residue.

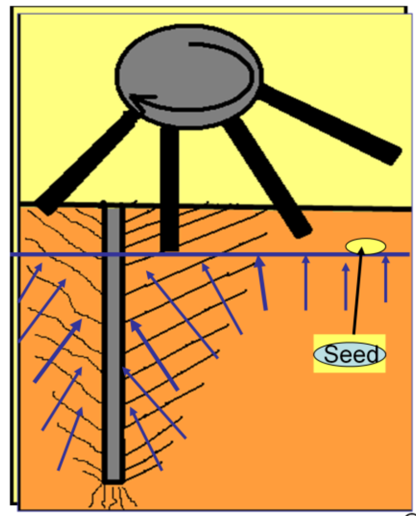
This residue free zone near the emerging seedling tends to dry on the surface more quickly after a rain event. This serves as a barrier to certain insect species that may attack the young plant such as slugs.

If the soil is breathing properly, the solar energy which is translated into heat energy in the surface of this bare soil can translate into improved soil temperatures where the young plant is starting its life.

The advantages of the chisel point opener include the elimination of the row cleaner attachment, the creation of vertical stress openings under the germinating seed for superior early root development and virtual elimination of seed furrow sidewall compaction.

7 Degree Eagle Tine® Offset

- Tines of rotary harrow can penetrate up to 5 cm (2 in.) or more
- Eliminate winter annuals and bi-annual seedlings in the fall
- Bring capillary water upward to the bottom of the seed placement zone



©jrm

The operation of the tine in conjunction with the Rotary Harrow has a profound effect on capillary water movement in the soil profile. Operations of the vertical tine by itself have clearly demonstrated an ability to promote vertical movement of capillary water to the field surface.

When attempting to plant especially using coulter systems, this can prove to be a problem as we have discussed. Higher soil moisture always has the potential to result in greater compaction forces in soil. Compaction in the seed zone will often restrict early root development. We will see why this is so important later. This situation is especially true for disc opener systems. Mid-season drought conditions can render the crop a failure under these circumstances.

Operation of the Rotary Harrow breaks the capillary water movement at the base of the harrow tine movement through the soil profile. By adjusting the tine fracture forces in conjunction with the Rotary Harrow angle offset, it is possible and practical to stop the vertical movement of capillary water where the operator wants it. Using the machine adjustments to determine the operating depth of the rotary harrow, the height of capillary water movement can be set precisely at the depth of the seed furrow bottom. This produces unmatched uniformity in seedling emergence because all of the seeds receive a uniform amount of moisture to hydrate the seeds at the same rate.

The slight reduction of moisture content where the rotary harrow has disturbed the soil will create ideal planting conditions with minimal compaction forces from coulters or depth gage wheels on the planting unit. Typical down-pressure devices which are needed in no-till planting approaches are not required. If these devices are used they only aggravate seed furrow area compaction and root system restrictions.

Here is an example of how gentle the combination of tillage technologies can be. Winter wheat planted only three weeks infested by chickweed and henbit is successfully cultivated without removing or covering fragile wheat plants.

Since this farmer was desiring to use no herbicides on this field and was unsure of the safety to the wheat plants from the mechanical cultivation, he performed the mechanical procedure on only a small portion of the field.

When he was contacted several months later in the springtime concerning the outcome of the trial, he said he now wished he had done the whole field. The weeds were gone where the tillage had been done. The wheat was thick and growing well. The weeds were so bad where he did nothing that he destroyed the entire planting with a moldboard plow.

After one pass with Curse-Buster™
Following first cutting of Alfalfa removal

Here is an example of using the Free-Till combination technology to establish a corn crop without destroying the existing crop. In this case it was alfalfa that had been growing for four years before the farmer decided to plant corn on the field. The first growth of hay was cut and removed. Then the field was tilled. Then liquid cattle manure was applied to the surface of the field.

Following the application of dairy waste the field was allowed to dry for about one hour. The free till machine was run once again before the field was planted to corn. The alfalfa plants were all still firmly rooted while all of the weeds were removed.

June 16th Weed control pass at zero offset with Curse-Buster™

Approximately 3 weeks later this is what the field looked like after one more pass of the Free-Till machine through the corn and alfalfa. The corn was about 10 cm tall. When the population of the corn crop was counted, it was determined there had been no stand reduction.

The weed seeds from the manure application and other weed seeds present in the soil by this time had germinated and some had emerged. By adjusting the machine properly the corn and alfalfa were left intact while all of the small weeds were removed.

Turbo Farms- Rick Noback,

Eaton Rapids, MI

As one can see, only two plants are growing together in this field, corn and alfalfa. Careful examination of the corn rows revealed some stand reductions were present. When measurements were taken, it was determined the problem was related to the large tires on the manure tanker operating directly where corn was to be planted.

This is another example of this same technique. Again when the corn was 12 cm tall the soil was again tilled with the Free-Till machine. The rainfall pattern was completely normal. The first cutting of alfalfa hay yielding nearly 6 metric tons per hectare had already been removed.

Now anyone with any experience with these two crops competing with each other knows instinctively that there should not be enough water to go around for everybody. These people are absolutely correct in their assertion.

This is indeed what we would expect to see if we tried to plant a corn crop into an existing mature alfalfa crop. This side of the same field also contains a dense population of broadleaf weeds including dandelion, shepherd’s purse and plantain.

The corn root systems were significantly smaller and at the finish the plants had small stalks and were badly lodged by a wind which contained rain.

Not only did tillage impact the weeds that were present and the root masses that were found in the corn but it also impacted the soil biology. When rainfall occurred during the winter and spring months it entered rapidly into the reservoir on the portion of this field which had received tillage in the fall. The air changes which this soil enjoyed also invigorated natural nitrogen fixers in the soil.

Last but not least the improved vigor of the corn plants where the tillage was performed, resulted in much greater leaf area in the corn crop. That under- leaf area contains stomata which remain open continually during the growing season. Research has now shown that these powerful, little understood features of the corn leaf are able to extract up to 80% of the total water requirement necessary for corn production.

The alfalfa crop is busily transpiring underneath the corn canopy. The rate of transpiration of the alfalfa is over two times the water requirement of the corn crop. This successful story without any use of chemicals to control the alfalfa plants was the second such success story.

The picture of the corn and alfalfa crop on the left was the first time we had seen a mature alfalfa field existing in the understory to a successful above average corn crop. The picture was taken one year before measurements of the stover weight were taken In this case, the grower who had been managing his alfalfa with the use of the Free-Till technology, had been unsuccessful in using glyphosate chemistry in killing the alfalfa. So in final frustration, the two crops were allowed to progress together.

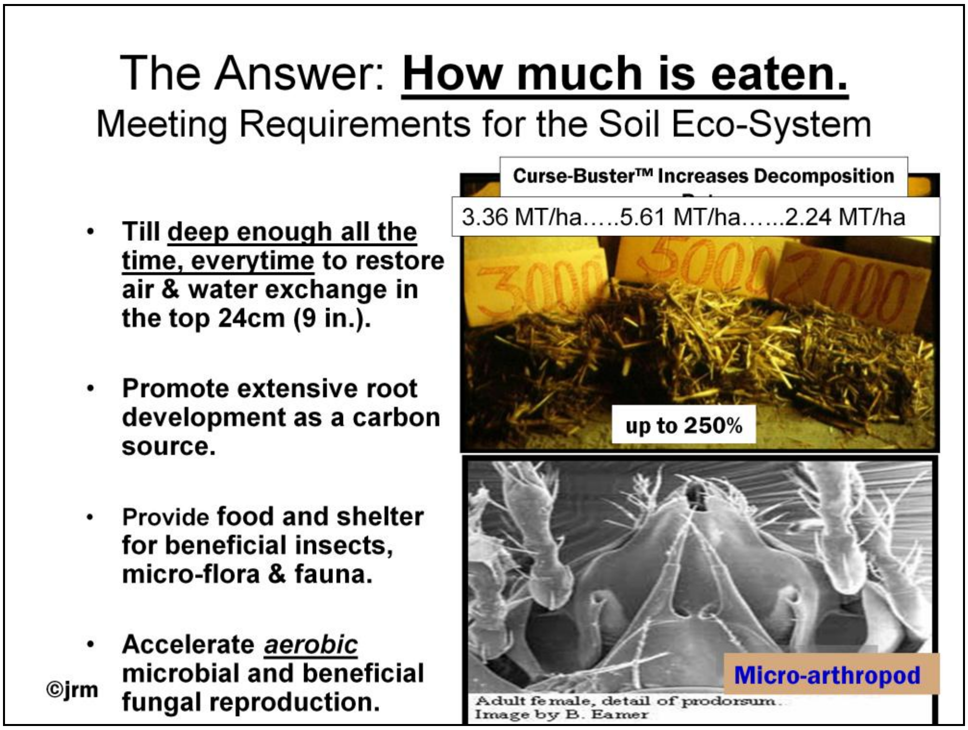
This is what it looked like when the combine entered the field for harvest. During the growing season, the field was a veritable beehive of activity. There had been four separate blooming events that had taken place during the growing season of the alfalfa. All of the plant materials remained in the field following harvest. By using standard values for alfalfa yields historically achieved on this field of close to 12 metric tons per hectare and the stover to grain ratio typical for corn it was estimated that nearly 25 metric tons per hectare of total plant material was deposited on the field surface during the growing season and following harvest. Try to make a note of that number. It will be very significant before we are done with this discussion.

The picture to the right is from the same farm. This picture was taken the same day the stover weight measurements were taken. This field was clean-tilled when it was rotated from a forage crop including alfalfa and grasses to corn. The stalks visible on the soil surface have been there for one year.

The lower picture is representative of a third field where the grass was chemically controlled before the corn was planted. This was done the same year that the alfalfa grew in the midst of corn crop.

One year after these pictures were taken, crop residue materials were collected from these three fields to determine the rate of disappearance of the corn stover over the previous 12 months.

The non-irrigated grain harvest on all three of these fields was virtually the same, slightly over 12,000 kg per hectare or 10,700 #/Ac.



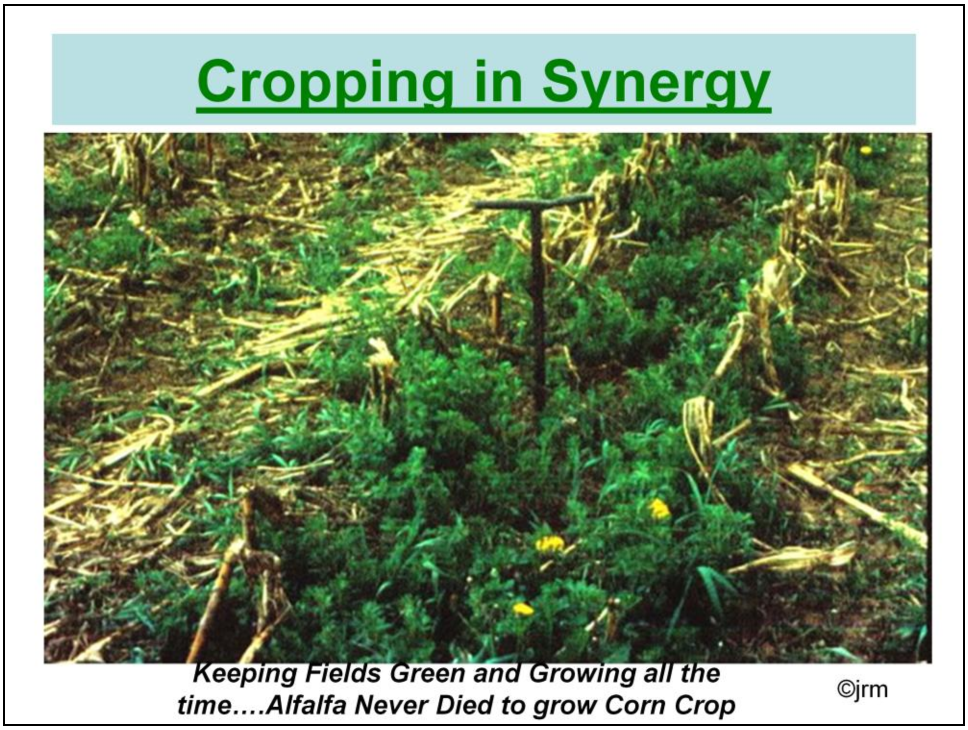
So here we have the figures from the plant residue collection procedure. Normally when with a live audience you are asked to tell which field the samples pictured here came from. There won't be a test this time.

Starting in the center, the field with the largest amount of cornstalk residue remaining on the soil surface after 12 months with only vertical tine tillage and no other mechanical processing, also showing the longest segments of stalks by far than either of the other two samples is the field which was **conventionally tilled** 24 months before.

We'll skip to the field sample with the least amount of residue next. With 2.24 metric tons collected and appearing like it has been mechanically processed, is the field which had around 12 metric tons per hectare of alfalfa plus another approximately 13 tonnes of corn stover left on the surface following harvest.

Lastly, the field with 3.36 metric tons of corn stover. It came from the field that was chemically killed grass and managed with the free till machine as the tillage for the corn crop and the preceding haycrop forage.

If you were thinking that these were the correct answers you are the one out of ten who have taken the test. With twice as much plant material present on the soil surface very few think that this field could be the one with the least amount of corn stalks left.



This is the same field that have the lowest amount of corn stover left on the surface after 12 months. This picture was taken in the spring approximately 6 months after harvest. The original alfalfa plants are actively growing and the four growths that were there at harvest time are already gone.

This story became even more interesting when we looked at the presence of predatory insect activity against European Corn Borers. The field that had been clean-tilled was directly adjacent to this field. It was in second-year corn production when this field was in its first-year. The second year of corn featured first and second generation corn borers in the clean tilled field.

This field which featured alfalfa in the understory and a host of continuous honeybee activity had no evidence at all of corn borer activity.

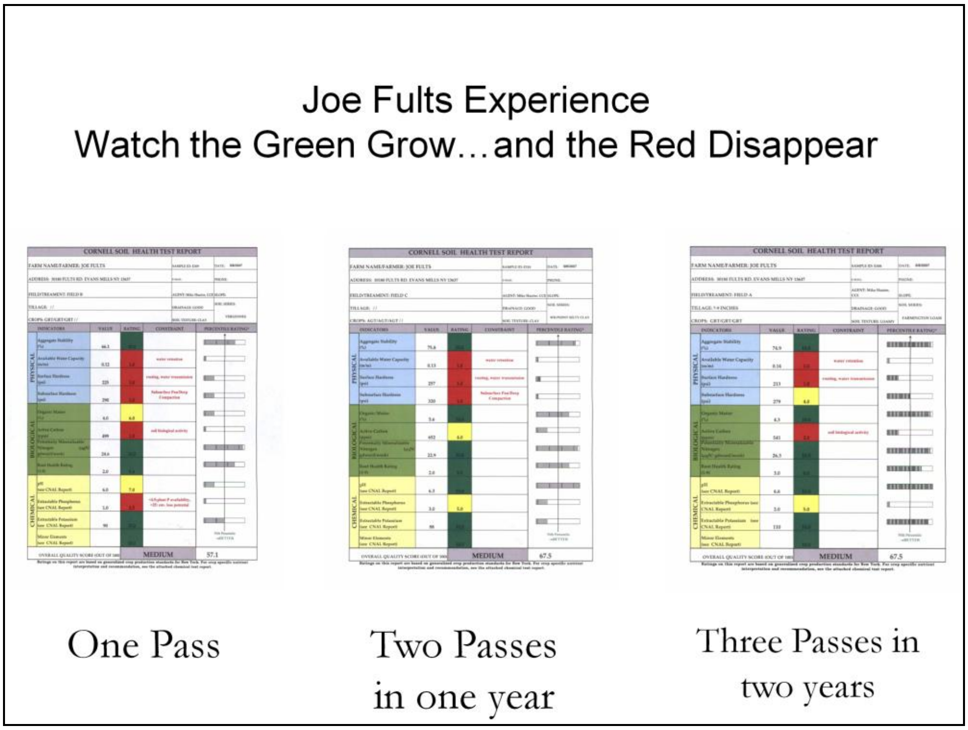
The neighboring farmer had first year corn approximately 200 meters away from the non-infested field. It was severely attacked with first and second-generation corn borers.

This alfalfa corn combination presented no insect problems in its second year despite plenty of opportunity to have corn borer activity. In addition actual soil tests for nitrogen showed enough nitrogen present following the harvest to support another 12,000 kg per hectare yield the next year. Certainly the alfalfa had a great deal to do with that.

Here is another example of crop synergy or complementarity. This field was covered with winter wheat seed in the fall following corn harvest. It grew normally and the usual effort was made to kill this ground cover using chemicals in the spring prior to planting corn. The wheat refused to die. Instead it recovered and went on to produce a seed crop in the under story of the corn crop.

It matured normally and fell to the ground just prior to corn harvest. The seeds scattered on the soil and sprouted and a new cover crop sprung forth from the old one before the corn harvest was commenced.

In this particular field no chemical weed control was applied during this particular growing season. The active ingredient, pendamethylin, had been applied the year previous in the corn crop. Because the soils were not inverted or mixed in any way and the chemical is very resistant to leaching, it still provided a full spectrum of weed control in this field the second year.



Some of you viewing this presentation may be aware of the groundbreaking efforts of soil scientists at Cornell University in Ithaca, New York, USA. They have developed a battery of tests which are designed to portray relatively intangible aspects of soil health.

Although these tests shown are too small to read you can easily see the relative amounts of the various colors that are representative of the various categories of soil health. As you study from left to right you see the relative amounts of red decrease and the relative amount of green increase. This is the type of display which indicates soil that is getting healthier.

We are looking here at a procedure which indicates measurable differences in just two years with no crop rotation. These fields were all planted to forages consisting of alfalfa, clover and grasses.

Cornell Soil Health Test -2007

Following 21 years of Plow-Layer Deep Curse-Buster™ operation

CORNELL SOIL HEALTH TEST REPORT

FARM NAME/FARMER: TODD MASON	SAMPLE ID: E269	DATE: 6/1/2007
ADDRESS: 35632 NYS RT. 12E CAPE VINCENT NY 13618	E-MAIL:	PHONE: 315-654-3608
FIELD/TREAMENT:	AGENT: Bob Schindelbeck, Cornell University	SLOPE: 0-2%
TILLAGE: 7-9 INCHES //	DRAINAGE: GOOD	SOIL SERIES:
CROPS: CRN/CRN/ALF //	SOIL TEXTURE: CLAY	

	INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	55.4	8.0		
	Available Water Capacity (m/m)	0.17	1.0	water retention	
	Surface Hardness (psi)	144	7.0		
	Subsurface Hardness (psi)	219	8.0		
BIOLOGICAL	Organic Matter (%)	3.7	5.0		
	Active Carbon (ppm)	812	8.0		
	Potentially Mineralizable Nitrogen (µgN/gdwsoil/week)	18.0	10.0		
	Root Health Rating (1-9)	3.5	8.0		
CHEMICAL	pH (see CNAL Report)	6.7	10.0		
	Extractable Phosphorus (see CNAL Report)	15.0	10.0		
	Extractable Potassium (see CNAL Report)	133	10.0		
	Minor Elements (see CNAL Report)		10.0		50th Percentile →BETTER
	OVERALL QUALITY SCORE (OUT OF 100)		HIGH		79.2

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient interpretation and recommendation, see the attached chemical test report.

- Vertical tillage "only" since 1985
- No inversion/mixing
- Alfalfa/Corn rotation
- 5 yrs. Alfalfa/
- 2 yrs. Corn- tested
- Sampled May -1st wk.
- Manure surface applied

This report from Cornell and the one which follows are from the same farm and same soil types. This farm changed its tillage in 1985. It has been consistently the same since that time to the present. The difference between these two reports is that this field had just finished two years of corn production in succession following five years of growing alfalfa. The report which follows is the same soil type and same management strategy except that the sample was drawn at the conclusion of five years of alfalfa.

Time does not allow us the luxury of discussing the intricacies of each of the testing categories contained on these reports. A visit on the Internet to the College of Agriculture and Life Sciences Agronomy Department website will take you to the information in detail. http://soilhealth.cals.cornell.edu/

Again it is necessary to say just study the colors. The soils which are tested here are heavy Clay-Loan soils consisting of 45% Clay, 45% silt and >5% sand. The organic matter readings on this farm have increased over 35% measured to a depth of 24 cm since 1985. No supplemental phosphate or potassium fertilizers have been applied during that time. Careful attention is given to the need for additional calcium and sulfur.

I'm sure you've noticed the one red category. That category is available water capacity. The note says water retention and of course the score is as low as possible, one on a scale of 1 to 10. How can this be in a Clay soil? I had the same question.

Different soil types use different database to determine the rankings of the various samples will receive from testing. This Clay loam soil does not act like a normal Clay loan soil when it comes to retaining water. Drought prone however, these soils are not. They are not wet either following rainfall events like most clay loam soils. This and the report which follows are from the farm which had no precipitation for the growing season in 1999.

For the record, all fertilizing practices are according to soil test results, use of herbicides to control weeds has been unchanged, crop rotations have not been altered and virtually everything has gone on with regard to crop production on this farm just as it was prior to 1985 except for one thing. They started fracturing the plowing layer vertically and that was all.

Second Field Sampled- May 07

CORNELL SOIL HEALTH TEST REPORT

FARM NAME/FARMER: TODD MASON	SAMPLE ID: E268	DATE:
ADDRESS: 35632 NYS RT. 12E CAPE VINCENT NY 13618	E-MAIL:	PHONE: 315-654-3608
FIELD/TREAMENT:	AGENT: Bob Schindelbeck, Cornell University	SLOPE: 0-2%
TILLAGE: 7-9 INCHES //	DRAINAGE: GOOD	SOIL SERIES: RHINEBECK/HUDSON
CROPS: ALF/ALF/CRN //	SOIL TEXTURE: CLAY	

	INDICATORS	VALUE	RATING	CONSTRAINT	PERCENTILE RATING*
PHYSICAL	Aggregate Stability (%)	66.8	10.0		
	Available Water Capacity (m/m)	0.13	1.0	water retention	
	Surface Hardness (psi)	134	8.0		
	Subsurface Hardness (psi)	214	9.0		
BIOLOGICAL	Organic Matter (%)	4.1	6.0		
	Active Carbon (ppm)	633	3.0		
	Potentially Mineralizable Nitrogen (µgN/gdwsoil/week)	10.5	6.0		
	Root Health Rating (1-9)	2.5	9.0		
CHEMICAL	pH (see CNAL Report)	6.2	9.0		
	Extractable Phosphorus (see CNAL Report)	4.0	5.0		
	Extractable Potassium (see CNAL Report)	138	10.0		
	Minor Elements (see CNAL Report)		10.0		50th Percentile →BETTER
	OVERALL QUALITY SCORE (OUT OF 100)		HIGH		71.7

Ratings on this report are based on generalized crop production standards for New York. For crop specific nutrient interpretation and recommendation, see the attached chemical test report.

- Sampled after 5 years of alfalfa/grass
- Less extractable P
- Less mineralizable N
- Less active Carbon
- Water retention?
- Good – Not Perfect!

This is the soil health audit on the soil we've been discussing following five years of alfalfa production. Of particular note is the lower levels of extractable phosphorus, less active carbon and less potentially mineralizeable nitrogen. So much for the theory that corn production robs from soil. It is actually in better condition biologically to produce corn the third time than it was following five years of a legume which was doing an above average job of supplying nitrogen to the corn.

One of the secrets here is the addition of large amounts of new roots into the soil. These roots represent a carbon source for soil microbial reproduction. The second key to the success of this tillage and cropping system is the non-incorporation of lignified or above ground plant parts into the soil.

Soil microbes and fungi are not equipped to digest lignin. Foraging insects are as we have seen in the corn/alfalfa production system.

	1979	80	81	82	83	84	85	86		
K- APPLIED 9 7 9	200	200	200	180	0	90	220	220/220	1530	soil test diff.
K-REMOVAL	100	125	240	240	360	360	360	360/200	2345	
BALANCE									-815	
# FOUND	200	400	488	361	377	296	521	790/542		PLUS 448#/ACRE
Net from Parent Material			1263#		1489 kg/ ha.					

Better Biology Releases Nutrients from Soil Parent Material ©jrm

There is a school of thought that commercial fertilizers and other nutrient sources must be applied to agricultural soils on the basis of what the crop being grown has removed. There are charts available designed for commercial fertilizer companies to sell fertilizers based on the crop being grown and its yield.

The summary of soil test and crop production yield data shown here clearly demonstrates through a simple potassium accounting procedure that removal charts are virtually never correct. After only 4 years of doing vertical Free-Till tine type tillage as the only change in the crop production system resulted in an increase of available potassium as determined by a standard soil test procedure.

A strong acid extraction performed on these soils through a procedure called total cations revealed in excess of 40,000 kg./hectare of potash in the soil parent material. We asked ourselves the obvious question, why should we have to by fertilizer if there is that much in this soil?

After four years of operating a free till machine technology, starting in 1983, we had our answer. The soil system through careful attention to chemical and biological systems had contributed almost 1500 kg per hectare to the production system. The base saturation levels of potash reported on the soil test meant that no additional supplementation was required following a short four-years of the operation of this tillage technology.

An interesting sidenote, these soils reported serious magnesium deficiencies when first examined in 1979. At the conclusion of 1985 the magnesium deficiency was totally eliminated from the report. No magnesium was applied. By 1986 the report indicated the need for additions of calcium carbonate.

Soils Contain Naturally Occurring Phosphorus –

Just ADD Aerobic Bacteria

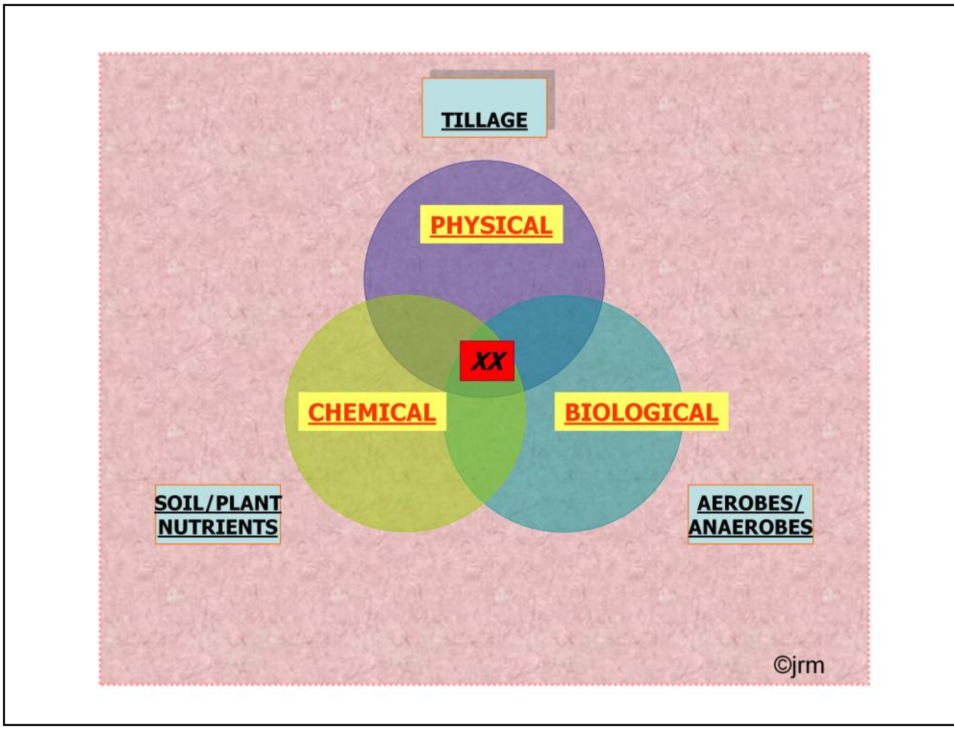
YEAR	1979	1980	1981	1982	1983	1984	1985	1986	TOTAL	SOIL TEST LEVEL
CROP	CORN	CORN	ALF	ALF	ALF	ALF	ALF	ALF/CORN		
P- APPLIED	130	130	160	0	0	30	70	20/70	**565**	
P-REMOVAL	37	44	60	60	90	90	90	90/66	**549**	
BALANCE									**16**	
# FOUND	191	323	279	279	360/249	412/302	358/231	453/175		PLUS 103#/ACRE
Net from Parent Material= 87#/ ACRE					**98 kg/ha**					

More Phosphorus for Growing Crops than was added From ALL SOURCES

©jrm

The same accounting procedure was applied to tracking phosphorus levels in the same soils. After tracking additions and removals and soil tests level increases it was calculated that current material had contributed 98 kg per hectare to the phosphorus present in plant available form in the soil.

The recommendations made for this soil as a result of soil testing procedures performed in 1979 were completely wrong by 1986. The vertical tillage technology was not utilized on this soil until the fall of 1983. History for this soil for the previous 30 years had been annual moldlboard plowing and secondary tillage. The only crop grown was corn for silage.



So there you have what happens when the three pieces of the soil system puzzle align properly to support each other. Obviously, the experience of the author indicates to him that tillage is the key that unlocks the door for the chemical and biological well-being of the soil system.

Agricultural soils whether decades or thousands of years old are not bankrupt. There are rich blessings held in the soils of earth. The blessings will come to those who will properly steward soils through tillage. That will require attention to naturally and man-made layers which restrict air and water exchange.

Leaving biological zones of habitation arranged the way in which they naturally occur on a long-term basis is part of the solution to creating enhanced mycorrhizal and biological systems. This must include maintenance of shelter and food sources for beneficial insects such as beetles and earthworms so that they can perform their job of digesting lignified plant material. In order to do this we must physically restore the system mechanically to efficiently transport water and exchange soil air.

The endless shopping lists of commercial fertilizers and soil amendments is not sustainable. Since we realize that fundamentally soil contains nearly all of the minerals necessary for normal plant production and health, with a few exceptions, we must look toward comprehensive all-encompassing production systems which build soil biological systems to transform these inorganic minerals into living compounds in our soil systems.

For Further Information:
Visit- www.soilcursebuster.com

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