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Zones of Soil Loosening Produced at Differing Depths by a New “Variable Depth Ripper” as Compared with Other Deep Tillage Machines

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Introduction

A large body of knowledge exists regarding the nature and agronomic importance of dense “tillage pans” in soils. This is the result of numerous excellent research studies from several institutions. It is also reflected in the fact that from their personal experience many farmers in the Southeastern Coastal Plain from Virginia to Texas consider some form of deep tillage as a necessity in order to achieve their yield potential. This is typically done with in-row subsoilers or “rippers”; now sometimes it is done with the DMI “no till point,” the Terra Max (The Work Saver Company) or the ParaTill offered by the Tye Equipment Company and the Bigham Brothers Company.

Research has shown that the objective of deep tillage is to loosen the dense soil pan zone, which generally is found at the lower inch or two (about 5 cm) of the Ap soil horizon and the E horizon, if present. This is typically found in coarse loamy, loamy and fine loamy families of Typic and Arenic Paleudults and Hapludults. Crop yield response to deep tillage is generally not found where no E horizon is present, and especially not where the underlying B horizon is clayey in texture. (See the publication by Denton, Naderman, Buol and Nelson, 1986, SSSAJ 50:1309-1314; note Results and Discussion, page 1311).

Of major practical importance is the common recent experience that modern “strip tillage” equipment actually causes problems where the soil texture is clayey at the surface or within a few inches (up to 15 or 20 cm) of the surface. In this case rippers tend to bring the clayey, infertile soil material upwards into the seedbed zone, where the various disks and wheels intended to close the ripper slit and prepare the seedbed area fail to function well. This often leaves the seed furrow open or partially open, with high risk of poor soil firming, poor moisture wicking towards the germinating seedling and resulting stand skips. Depending on the crop and subsequent growing conditions this leads to poor crop growth, poor weed control, yield losses and poor organic matter return to these soil areas. Needless to say, it is also seen as a disincentive to the use of this otherwise very promising technology–which could combine the merits of deep tillage with those of conservation tillage.

A key missing link (until now) has been the practical mechanical equipment capability to readily adjust the ripper depth to that known to be appropriate for the varying soil characteristics within fields and across the range of field areas of typical farm operations today--which often are spread across two or more counties. We have tested the effectiveness of this new PATS brand of strip tillage equipment by comparing the zone of loosening of its special ripper point, operated at two depths, with that of several different types of subsoiler points and other deep tillage tools.


A field example of very poor cotton stand in a sloping, eroded area of a field in Halifax County, NC. Strip tillage with subsoilers reaching into the clayey textured soil just below the surface often provides very inadequate seed furrow closure resulting in stand skips. Note the 60-inch (1.5 m) distance between cotton plants in the picture on the right.


Note the red, clayey soil texture at about 7 inches (18 cm) below the surface. A “clay skin” is evident on the face of the soil clod at the point of the pen in picture on the right.

Methodology

We used a commercial pocket penetrometer to evaluate the zone of soil loosening by excavating a pit perpendicular to the direction of travel of each deep tillage tool, and then making resistance measurements at grid positions on 2 in X 2 in (5 cm X 5 cm) grid as shown here. Readings were made at 13 positions (26 inches) in width and at 7 positions (16 inches) in depth. Depending on soil moisture and general soil hardness, this technique generally clearly reveals the zone where the soil is markedly less hard, which is a good indication of the two-dimensional area of loosening by the tillage tool. Note the accompanying photographs of the penetrometer used and the grid sampling procedure.

After studying the data we can plot the results on a chart, showing the apparent width of loosening at each depth. We place special emphasis on the depths of 8, 10, and 12 inches (20 through 30 cm) where the most severe, dense, root-limiting pan layers are found in the soils that are pan-layer prone. As a more practical display in the field, we can go back to the excavated soil pits and attach a visible ribbon to identify the zone of loosening found by the penetrometer measurements. The results of various of these comparisons are shown here. Most of the tillage comparisons shown here were done in a Norfolk soil located near Princeton, in eastern Johnston County, NC. The corn study comparing the DMI with “no-till” point and the KMC-Strip Till were done in a Norfolk soil near Lumber Bridge, in Robeson County, NC.

The blunt ended, “pocket penetrometer” we used. It gives readings in kilograms per square centimeter. We converted these readings to pounds per square inch (PSI).

(PSI = Kg/cm ^{2} X 14.21)

The plastic sheet with holes at 2 inch X 2 inch grid positions. We took penetrometer readings in 13 positions from left to right, and at 2, 4, 6, 8, 10, 12, 14, and 16 inches in depth from the surface.

Rippers and Other Deep Tillage Tools Tested

The widths of KMC rippers tested (inches)

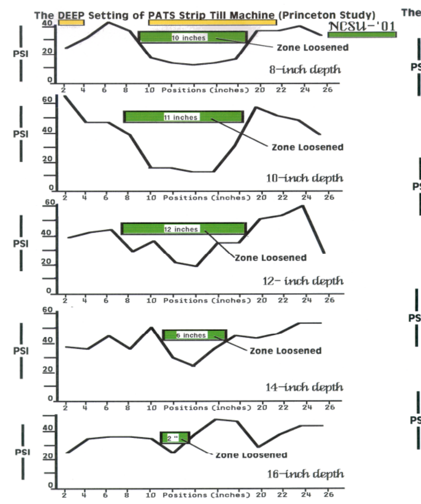
The KMC “Halifax Ripper” (width 1-1/4 inches; 3.2 cm) Note the forward position of the point below the coulter and the more angled shank. This was designed to minimize the problem of clayey uplift and “blowout.”

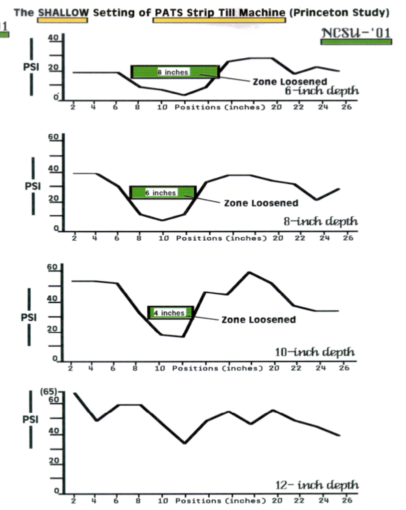
The KMC “straight” shank (also offered in response to problems of soil “blowout” and need to improve row zone preparation) Width of the point is 1-3/4 inches (4.5 cm).

Zones of soil loosening noted in the Princeton test area


Zone of soil loosened by the PATS ripper at deep (15 in; 38 cm) and shallow (9 in; 23 cm) settings. Change of ripper depth was achieved in about 40 inches (1 m) of running distance.

Penetrometer Data Charts






This is the ripper point used by the current PATS machine. It has a width of about 2.25 inches (5.7 cm) with a sharpened vertical divider to force the soil to split to either side as it passes over the point. Dense soil is fractured by the uplift forces along both sides (shoulders) of the point, providing a zone of soil loosening at least comparable to those of other current subsoiler points we tested.

The TerraMax tool and its curved shank and point

These are the main bolt positions that attach the PATS ripper to the toolbar. The lower hole allows minimum and maximum ripper depths of 9 and 15 inches (23 and 38 cm), the upper hole provides depths of 5 and 11 inches (13 and 28 cm), with the center hole offering depths at the midpoints of these.

We acknowledge with appreciation the interest and help of Mr. Frank Baumgartner of Princeton for the use of his land and equipment

Adding one to three of these spacer rings limits the contraction of the hydraulic cylinders, thus limiting the maximum ripper depth for any bolt setting.

Zone of soil loosened by the TerraMax

The appearance and dimensions of the DMI “no Till” point

The DMI “No Till Point” used in this study. When new, the wing tips span about 8 1/2 inches.

The DMI “no-till” points wear rather rapidly in abrasive soils which have sandy influences, as shown here. Replacement cost of the points is significant, as is the power required to pull the point through soil.

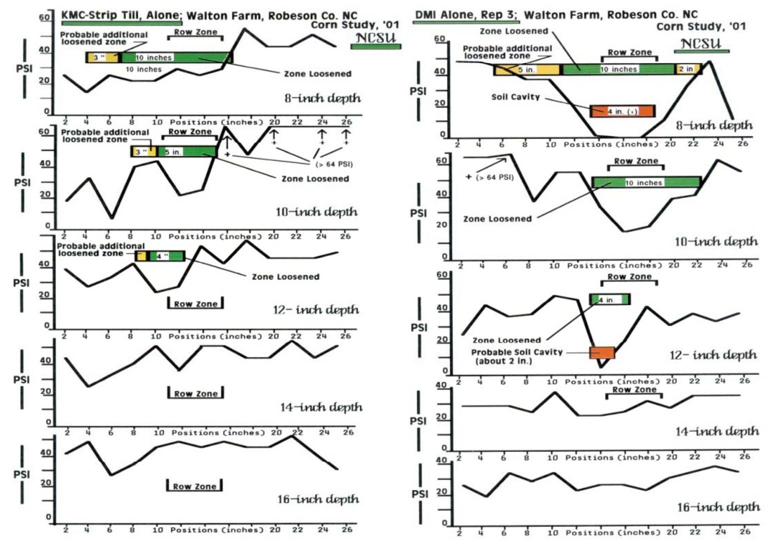
The position and nature of soil cavities left by the DMI “no till” point

Vertical view of the soil pit where only the DMI deep tillage treatment was applied before planting. Note the form and size of the soil cavity found. This was noted in each soil pit of this tillage treatment that we studied. The top of the cavity is generally rounded, apparently reflecting some degree of smoothing of the moist soil as it passes over the wings of the point. As upward-facing steel of any tillage tool passes through moist or wet soil it compresses the soil, especially the first eighth inch which is directly above the steel. This pressure from the wings of the DMI point acts much as the troweling of concrete, perhaps bringing some of the finer soil particles toward the steel surface, and giving the “ceiling” of the cavity increased durability as it dries. Unfortunately, this compression of the soil at the top of the cavity, where it passed over the wings, tends to “seal” or “crust” it, and this does not favor root growth into and through the soil cavity.

In this treatment, some roots were also found to depths of at least 17 inches, but most of these were not directly below the cavity zone. This pattern and depth of rooting gave an average of 29 bu/acre yield increase over the “no till” with no deep tillage. However, this was still 23 bu/acre less than the increase produced by the more effective deep tillage by the KMC-Strip Till (133.2 vs 156.7 bu/ac).

Some of the results from a comparison of KMC-Strip Till (equipped with their “Halifax” rippers) and the DMI with their “No-Till” point in a corn tillage study conducted in 2001 in Robeson County, NC

We appreciate the cooperation of Mr. David Walton in this work.



Closeup of the bottom of the soil pit where the KMC Strip Till rig was used. Note the vigorous roots at 17 inches depth and located directly beneath the corn plant. This root activity is some 5 inches below the depth reached by the subsoiler, because once the roots passed through the shattered tillage pan region, the soil was soft enough for additional root growth. Deeper excavation in this pit later revealed corn root presence to at least 27 inches depth. In this study this pattern and depth of rooting gave an additional 52 bu/acre average corn yield as compared to the “no-till” with no deep tillage. This yield increase is somewhat greater than the typical response to loosening of the tillage pan in soils such as this. Differing weather patterns and soil properties will vary the yield response.

Crop Yields in a Field Study of Strip Tillage and DMI Deep Tillage at Angle to Row Crops Norfolk Soil; Robeson County, NC

Yield Results of 2001 and 2000

	Corn (2001) Bu/Ac	Sign.	Cotton (2000) Lbs Lint/Ac	Sign.
NT	104.2		956	
DMI Alone	133.2	*	985	N S
DMI + KMC-ST	143.5	*	Not Determined	-
KMC-ST Alone	156.7	* *	979	N S

* and ** = Significantly different from the NT Check treatment at 95% and 99% certainty.

The zone of soil loosened by the ParaPlow or ParaTill tools (from an earlier study done in a poorly drained soil). The zone on the soil pit wall resembles a “check mark.” The longer side reaching nearer the surface is due to the loosening provided by the tapered face of the angled portion of the shank (called “leg” by the company). This zone is somewhat wider than that of current ripper points. The ParaTill points did not leave soil cavities. The special design of this tillage tool is shown below.

Conclusions

1. The version of PATS strip till equipment currently being offered appears to produce a zone of soil loosening at least as large as any of the KMC ripper points tested, with the exception of the older, 2.5 inch (6.4 cm) point. That wide point was mainly offered with ripper-bedders sold about two decades ago. In general, all current commercial brands of what the authors consider “capable strip-tillage” equipment now use rippers comparable to those tested here.
2. When the PATS unit is run at its shallow depth (about 5 to 9 inches--13 to 23 cm; depending on the ripper bolt position chosen) it loosens a much narrower zone. When the ripper is operated at such shallow depth the topsoil normally provides little resistance, meaning that the loosened pattern tends to be more vertical rather than in a wider “V” angle. If operated at the proper depth (the ripper point is kept above a clayey-textured layer) this essentially eliminates any soil “blowout”.
3. It can be observed (in the accompanying videotape) that the PATS unit may disturb a narrow zone of about eight inches or less (20 cm or less) at the surface. This is very protective of existing surface residue—a major objective of conservation tillage management today.
4. Because of the design features of the new PATS unit its wheel assemblies carry the weight of the “floating” row units at the selected depth, close the ripper slit and prepare the row zone equally effectively regardless of the depth setting (assuming the ripper depth is properly kept above any shallow, clayey layer within about six inches (15 cm) of the soil surface). This can be observed in the accompanying videotape.
5. The TerraMax did not loosen a greatly increased soil zone from that of any of the current subsoilers tested. This loosening would certainly be adequate for crop rooting in a pan layer-prone soil, IF the shanks are positioned approximately beneath each row. If not, or if run at an angle to the rows it may not be as effective as properly -operated strip tillage, with under-each-row rippers.
6. The DMI with “No-Till” point was found to leave soil cavities which are judged “less-than-ideal” from the standpoint of soil tillage objectives. When operated at an angle to the intended crop row (corn) in the Robeson County study in 2001 it gave significantly less yield than the KMC-strip till unit with rippers directly under each row. (These results are available from the senior author -- data not shown here).
7. Earlier observations with the ParaPlow or ParaTill point have shown the zone of soil loosened to be somewhat wider than current subsoilers, and of a “check mark” pattern, with no observed tendency to leave soil cavities.
8. In more than two decades of making practical recommendations to North Carolina farmers they have often stated that adjusting ripper depth within a field, or even within their entire operation, was not practical because of the major bolt adjusting changes required. Because of those mechanical limitations, much published research and educational information (note the materials in the accompanying notebook) have received incomplete emphasis and application.
9. Depending on the future commercial success of this “on-the-go” variable depth ripper, professional agronomists may now have the opportunity to help their farmer clients apply this information more completely than ever possible in the past. We may also soon have the practical opportunity to develop new technology, such as GIS-based soil maps which include the spatial recommendations for ripper depth control, along with the necessary digital receiver and equipment control technology.