THE INFLUENCE OF NO-TILLAGE MACHINES ON CROP YIELD (and how Cross Slot® no-tillage stacks up)

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Question: It is difficult to believe that a no-tillage drill can influence crop yield. Surely it's the soil, weather, genetics, fertilizers, diseases, and pests and crop husbandry that do that?

Answer: A significant amount of recent scientific research has been devoted to finding out exactly what influence a no-tillage drill and its openers can have on (1) stand establishment and (2) crop yield.

The results are summarised below:

Conservation tillage is often promoted as capable of regenerating damaged soil health, which has a direct influence on crop yield (especially long term). But 50 years of a range of conservation tillage practices casts doubt on whether or not this is being achieved universally. Only low-disturbance no-tillage repeatedly achieves this objective.

(Compared with tillage)

> *There is little, if anything, that conventional tillage ever did to improve soil health. Indeed it is now widely recognised that repeat-tillage has caused most of the soil health problems that the world is experiencing.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Minimum tillage, strip tillage and some forms of aggressive no-tillage (collectively known as conservation tillage) have reduced the damage but not reversed it.
>
> Cross Slot low disturbance no-tillage takes the process to the next level by:
>
> (1) Retaining crop residue from the previous crop on the soil surface and recycling its carbon,
> (2) Minimising the amount of soil disturbance that takes place during seeding,
> (3) Reducing the biological risks associated with seedling establishment,
> (4) Targeting simultaneous fertilizer application.
>
> When those four things are achieved, crop yields inevitably improve.

Here is why:

> *(Note: 9 of the 12 issues outlined below are backed by published international science*. 3 are the result of extensive field observation**)*

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(a)* No-tillage drill openers have a major influence on the micro-environment that seeds and seedlings experience in untilled soils.

(Compared with tillage)

> *Tillage tools, rather than drills, have most influence on the seed's micro-environment in tilled soils.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Cross Slot no-tillage seed drill openers create a seed micro-environment that is more favourable to seeds than any tilled soil or other no-tillage opener design have ever been. Many competing no-tillage seed drill openers create micro-environments that are more hostile to seeds and seedlings than tilled soil. So failure rates with these openers have often exceeded those of tillage.

(b)* This micro-environmental influence is itself largely determined by surface residues, particularly where they finish up relative to the drilled slot after the machine has passed.

(Compared with tillage)

> *Since there are no surface residues in tillage, they play virtually no role in tilled seedbeds.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Cross Slot openers specialise in returning the surface residues over the slot. This does two things:
>
> (1) It allows the slot to trap 90-100% moisture vapour in the seed zone. Seeds will germinate in 90-100% relative humidity. Loose soil (as with strip tillage) traps 60-80% relative humidity, which is not enough for germination. No cover at all allows free exchange of soil humidity with the atmosphere, which leaves no room for unfavourable weather following drilling.
>
> *(2)* It allows the residues to decompose on the surface and the earthworms and other soil fauna to take the carbon-rich organic matter into the soil, thereby reversing organic matter stripping that all forms of soil disturbance otherwise create.

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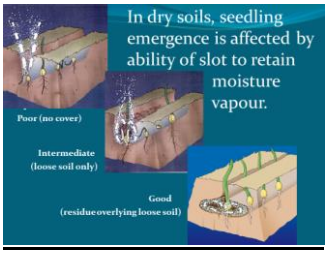
(c)* Drill openers have a major influence on how seeds derive water for germination (known as *imbibition*). In untilled soils, vapour-phase water (or soil humidity) is an important germination resource.

(Compared with tillage)

> *In tilled soils, in-soil humidity usually plays a minor role because of general soil loosening and loss of that humidity to the atmosphere. Liquid-phase water is the main resource in tilled soils as it is also in highly-disturbed no-tillage slots.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Only Cross Slot openers actually utilize the soil-humidity resource unique to untilled soils, which is why germination or seedling emergence failures with Cross Slot no-tillage are rare.



(d)* Similarly, no-tillage drill openers can have an important influence on aeration (or lack of aeration) around seeds and seedling roots in wet soils. Residues returned over the slot in wet soils attract earthworms to the slot zone since residues are the earthworms' main food source. The earthworms, in turn, aerate the slot zone, which has a measurable effect on germination and seedling survival in wet conditions.

(Compared with tillage)

> *Since there are no surface residues on tilled soils and earthworms are usually scarce anyway (because tillage kills large numbers of them) none of this applies to tilled soils.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Cross Slot openers specialise in returning as much of the residues over the slot as possible. By contrast, many other no-tillage openers shift the residues to one side (or both sides) of the slot zone and the earthworms follow the residues to wherever they have been shifted to. Consequently, less bio-aeration occurs in the slot zone with competing openers.

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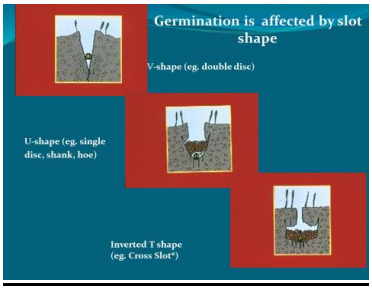
(e) With no-tillage, a slot wall is created between the slot zone and the undisturbed soil alongside. If these no-tillage slot walls are nearly vertical (and even worse are compacted or at least smeared – see below) they may restrict early root growth to the extent that in severe cases the roots never leave the slot zone and the crop performs poorly.**

(Compared with tillage)

In tilled soils, there are no slot walls because all of the soil has been pre-loosened anyway.

(How Cross Slot low-disturbance no-tillage stacks up)

With Cross Slot openers, the slot walls in which the seeds are contained are horizontal and never compacted. They are not vertical and they are always moist, even when smeared. As a result, no root restriction occurs in Cross Slot slots.



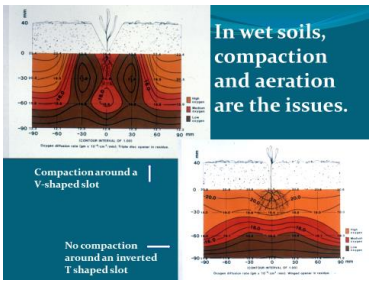
(f)* Drill openers influence soil compaction in the slot. Compaction, in turn, can influence how well or poorly juvenile seedling roots develop.

(Compared with tillage)

Tillage eliminates most of the influence of openers on compaction by uniformly loosening the soil before drilling takes place.

(How Cross Slot low-disturbance no-tillage stacks up)

No-tillage openers that create in-slot compaction (such as single, double or triple disc openers) often restrict root growth, sometimes for the whole growth-cycle of the plant. Openers like Cross Slot that do no compaction at all, do not restrict root growth.



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(g) In-slot smearing is often looked on as a thin layer of compaction. So long as a smear can be kept moist it usually presents little restriction to seedling root growth. But if an in-slot smear is allowed to dry, it becomes a crust where it can be as detrimental as compaction.**

(Compared with tillage)

In tilled soils, any form of smearing is unusual.

(How Cross Slot low-disturbance no-tillage stacks up)

Cross Slot openers can leave a smear under certain circumstances (in common with most other no-tillage openers). But with Cross Slot openers, the important difference is that these smears are prevented from drying by the residue covering medium that retains in-slot water vapour in the smear zone.

(h)* Some no-tillage openers have a negative effect on germination by pushing uncut straw into the slot (called "tucking" or "hairpinning"). In anaerobic conditions especially, if the seeds come to rest in the hairpins (as is common with most disc openers excluding Cross Slot) fermentation of the "hairpinned" straw creates acetic acid that kill seeds and seedlings.

(Compared with tillage)

The absence of surface residues on tilled soils avoids this problem altogether.

(How Cross Slot low-disturbance no-tillage stacks up)

Single, double and triple disc no-tillage drill openers are the worst culprits. Tined openers do not hairpin straw (although any pre-discs can do so). Tines tend to sweep straw aside. In any case, their poor residue-handling qualities ensure that they are seldom used in heavy lying straw anyway. The central disc on Cross Slot openers will hairpin in common with all other disc openers. But Cross Slot openers deliberately separate the seeds from any straw that is pushed in by the central disc by displacing the seeds to one side of the disc slit (10 mm or ½" separation is enough) thereby avoiding the problem, even in heavy straw situations, which Cross Slot openers otherwise benefit from.

(i)* The seed micro-environment is also influenced by depth of seeding. Consistency of depth is important but is difficult to achieve in no-tillage. Therefore, drill design has a major influence on how well this is achieved and this in turn has a major influence on crop yield.

(Compared with tillage)

In tillage, because the soil is made uniformly soft and smooth by the tillage tools, drills have a much simpler job to do in maintaining a consistent seedling depth.

(How Cross Slot low-disturbance no-tillage stacks up)

Any no-tillage opener that is pushed into the ground by a mechanical spring is unlikely to have very good depth control, even traversing over minor ground surface irregularities because springs change their downforces with length. For this reason, Cross Slot openers are pushed into the ground by individual nitrogen-cushioned hydraulic cylinders that maintain the same downforce throughout their entire stroke lengths. Furthermore, electronic sensors within the Cross Slot hydraulic system dictate how much hydraulic pressure is applied as the openers travel along so as to ensure that the applied downforce always matches the hardness of the soil, which otherwise naturally varies across the field. They adjust the oil pressure 3 times per second (which is equivalent to about 1 metre of forward travel).

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(j)* No-tillage drill openers influence how well drilled slots are closed or covered. Covering is harder to achieve than in tilled soils because the soil is usually less friable. Poor slot covering, in turn, influences slot drying together with bird and insect damage.

(Compared with tillage)

> *In tilled soils, slot closure almost happens automatically as the pre-loosened soil, falls back into the slot after the drill has passed or can be encouraged to do so with a light trailing harrow.*

(How Cross Slot low-disturbance no-tillage stacks up)

> The inverted-T shaped slots created uniquely by Cross Slot openers are easier to cover than any form of vertical no-tillage slots, and is achieved automatically by angled press wheels on the openers themselves rather than by the need for a separate covering tool.

Cross Slot openers do not invert or burst the soil. The press wheels fold the covering soil plus whatever residues are present (in this case very little) back over the horizontal slots.

(k) Post-drilling slot shrinkage occurs in many no-tillage slots, especially when warm windy (drying) weather follows drilling into an otherwise damp mouldable ("plastic") soil. When this occurs, most vertical (or near-vertical) no-tillage slots shrink open, exposing the seeds.**

(Compared with tillage)

> *The friable nature of tilled soils usually avoids post-drilling slot shrinkage problems altogether. On the other hand, crusting or capping is a common problem with rain on tilled soils and this seldom occurs in no-tillage.*

(How Cross Slot low-disturbance no-tillage stacks up)

> While the vertical central slit in Cross Slot inverted-T shaped no-tillage slots may also shrink open, the seeds are deliberately tucked off to one side under horizontal soil flaps and are therefore never exposed.

Arrow in right hand photo (in which the covering soil has been removed) shows where these brassica seeds had germinated (on left hand shelf).

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(l)* Finally, seed drill openers determine if and where fertilizer is placed (banded) during the seed drilling process. Some no-tillage openers are capable of banding fertilizer (often referred to as "double shooting"). Others are not do this (referred to as "single shooting").

(Compared with tillage)

> *Even although tillage destroys soil structure and fauna (which has long-term detrimental effects on crop yield); in the short term, tillage mineralizes nitrogen already in the soil, making seedlings less dependent on banded fertilizer at seeding time than with no-tillage. Further, because tillage also destroys bio-channels and replaces them with a more-or-less uniform (and very temporary) artificial pore system, broadcast nutrients move more uniformly through tilled soils than untilled soils and are therefore more likely to reach juvenile roots. This makes broadcasting of fertilizers a viable option in tilled soils but less so in untilled soils.*

(How Cross Slot low-disturbance no-tillage stacks up)

> Cross Slot openers specialise in banding fertilize under the ground separately from the seed with the same opener. Banded fertilizer during no-tillage can have a strong positive influence on crop yield, which does not occur in tilled soils, especially with spring-sown crops*. Nitrogen and phosphorous are the two most responsive nutrients to banding in no-tillage for different reasons.
>
> **With nitrogen**, the microbes that decompose surface residues consume large quantities of available soil nitrogen in doing so. This often creates a nitrogen-deficiency in no-tilled seedlings. It is easily and effectively countered by banding nitrogen fertilizer (liquid, dry or gaseous) alongside (but not touching) the seeds with Cross Slot no-tillage openers. The alternative of mixing nitrogenous fertilizers with the seeds risks chemical "burn" of the seeds. And the other alternative of surface broadcasting the nitrogenous fertilizer is often ineffective in no-tillage because the soluble nitrogen from broadcast fertilizers tends to flow preferentially down bio-channels left by dead roots and earthworms in untilled soils and may largely bi-pass the juvenile roots of the new crop.
>
> **With phosphorous**, this relatively insoluble nutrient benefits from placement in the soil close to (but not touching) the seed with Cross Slot openers because of its immobility and this benefit is almost invariably measured in terms of increased crop yields.

Pea seeds on left shelf.
Dry fertilizer or right.

> **There is a common belief that there is no need to apply nitrogen fertilizer with autumn-sown arable crops. That might be the case when conventional tillage is used because tillage mineralises nitrogen from the organic matter that remains in the soil (albeit that over time this mineralisation reduces the organic matter content of those soils, which in turn reduces soil health). With low disturbance no-tillage, less mineralisation occurs and decomposition of surface organic matter locks up nitrogen in a similar manner to how it happens in spring. Therefore application of limited amounts of nitrogen fertilizer is also beneficial with most autumn low-disturbance no-tillage, favouring Cross Slot and other openers that can band the fertilizer separately.*

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Summary:

From the above, it would be easy to conclude that most of the issues outlined simply do not occur if the soil is tilled before seeding. But mechanical tillage does so much long-term harm to soil structure, organic matter retention, porosity, infiltration, erosion, water holding capacity, fertility, weed seed proliferation, compaction and biological health, (all of which manifest themselves as declining crop yields) that tillage is no-longer a viable option for producing the world's food.

On the other hand, unless no-tillage is practiced properly, it is not always reliable substitute for tillage. The real role of Cross Slot low-disturbance no-tillage has been to eliminate the weaknesses of other less-exacting and less-focused conservation tillage options. The end result of prolonged Cross Slot low-disturbance no-tillage is the regeneration of soil health, improved crop yields and with them, the sustainability of world food production.

Of course soil, weather, genetic makeup, fertilizers, husbandry, weeds, pests and diseases are also fundamental determinants of crop yield. But even when these resources are optimised, the effect can be negative (or no better than neutral) unless no-tillage openers are able to position seeds, seedlings and growing plants to take full advantage of such resources.

Put another way: Sub-standard no-tillage opener designs can negate the positive effects offered by good soil, weather, genetics, fertilizers, weed, pest and disease control and husbandry, while good designs encourage plants to utilize these resources to advantage.

End: