NO-TILL: THE BASICS
Acknowledgements

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Conservation in Ontario

In Ontario, soil erosion has moved thousands of tonnes of topsoil off cropland and into streams. This loss of topsoil leads to reduced organic matter levels, lower fertility and water-holding capacity which, in turn, reduces crop yields. Farmers find they may use more fertilizer to achieve a similar crop yield as in past years and soils tend to dry out faster. Water quality is also affected by the sediment and phosphorus loading causing poor aeration and loss of fish habitat. Costly dredging of harbours and drains is an end result of sediment loading.

Many farmers in Ontario are realizing the need to save their precious resource—the soil. A number of conservation systems have been developed. Of these, the no-till system leaves the maximum amount of residue on the soil surface giving it the greatest potential for erosion control.

For the last decade innovative farmers have been perfecting the no-till system. Many of the innovators have spent time experimenting and fine tuning the system to suit their farming conditions. Mistakes were made by all farmers the first years they tried no-till but as technology improved and more people became familiar with the system, no-till has proven successful on many farming operations across Ontario.

The following is a summary of Ontario experience with the adoption of a no-till system. There is no set recipe for success with no-till, but with the consideration of the points made in this manual, the steps from conventional to no-till practices should be easier.

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**No-till is a system of planting and growing crops in previously untilled soil. During planting, just enough tillage is done for adequate seed and fertilizer placement and to remove previous crop residue off the row area.**

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*I believe that each of us came into this world with a responsibility to leave it a better place than we found it. And I believe that those land managers who practice conservation will prosper and enjoy great satisfaction in fulfilling that responsibility.*

*Don Lobb, Huron County*

*We are happy we made the choice to go to no-till. We've had some problems but nothing that we weren't able to survive.*

*Shawn VanSickle,*

*Brant County*
No-till Advantages

✔ Reduced Soil Erosion
No-till is a planting system that leaves the maximum amount of residue on the soil surface. Residue acts like "mini-dams" to collect the water, and let it infiltrate into the soil instead of running across the soil surface. Residue also intercepts raindrops, protecting the soil from the pounding force of rain. Under a no-till system, the increased residue levels protect the soil and minimize erosion. The result is improved water quality due to less sediment and phosphorus entering the streams and lakes.

✔ Improved Soil Structure
With minimum soil disturbance and increased levels of residue on the surface, no-till increases the levels of organic matter. More life is found in the soil (earthworms and microbes) which helps mix the organic matter and aerate the soil profile. This leads to improved soil structure making the soil easier to work with. To the farmer this means improved drainage over time.

✔ Increased Yields
Once fields are established in no-till and farmers are familiar with the management of no-till, yields will meet or exceed conventional yields on the coarse-textured soils. Fine-textured clay soils may require more fine tuning of the system but many farmers are reporting yields comparable to their conventional system.

✔ Less Machinery
With a no-till system, machinery capital costs are reduced dramatically. All the equipment a farmer needs is a tractor, planter/drill, sprayer and combine. No-till eliminates the need for tillage implements and allows farmers the opportunity to sell some of their surplus equipment.

✔ Economics
No-till makes "CENTS". With reduced labour requirements, less fuel usage and fewer trips over the field, farmers come out money ahead. The Tillage 2000 economic study conducted by Deloitte and Touche reported that the net return to labour for a farmer in a no-till corn crop was $234/hour compared to a return of $149.69/hour for a conventional system. This means more money in your pocket.

Yields have been comparable to what we had in the past and comparable to other neighbours in the area. You don't need big yields. It's the bottom line that you're interested in.
Elwin and Cliff Vince, Kent County

Common sense says if I get the same yield with minimum investment in equipment I am money ahead.
Doug Albin, Brant County

Figure 1. No-till soybeans into corn stalks works well.
✔ **Improved Soil Moisture Conditions**

With an increase in organic matter, the water-holding capacity of the soil increases.

Studies have shown increased soil moisture levels in no-till plots compared to conventional. Higher amounts of residue on the soil surface in no-till reduces evaporation. This is especially important on the sandy soils where moisture loss can be a problem in the summer months.

Over the winter, residue left on the soil surface traps snow, helping increase soil moisture and providing insulation for winter cereals.

✔ **More Spare Time**

With a no-till system, fewer hours are needed to farm the same number of acres. This cut in labour requirements allows the farmer to farm more acres with the same number of people. This is a big plus for farmers who need more time to manage livestock or other aspects of their business.

No-till gives you time for your family and more time for leisure. It gives you a chance to get away from the farm for a while.

*Peter Cummings, Kent County*

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### No-till Advantages

✔ Reduced soil erosion

✔ Improved soil structure

✔ Increased yields

✔ Less machinery

✔ Wider profit margins

✔ Improved moisture conditions

✔ More time for other activities
Think Systems

Equipment makes up only a small part of a no-till system. When a new crop is adopted into a conventional operation, all factors of the system must evolve to create the new system. In the no-till system, tillage (or lack of it) may not affect crop yield more than fertilizer management, weed control, careful variety selection... etc. A change of any one component can affect any other component within a crop production system.

When adopting a no-till system evaluate all the factors which make up a new system. The wheel below identifies many of the factors that should be considered for successful adoption of a no-till system (see Diagram I).

Diagram 1. No-till systems wheel
(concept by Don Lobb)
Residue management may be the most overlooked aspect of a conservation crop production system. Baling cereal straw reduces the amount of residue to deal with. Problems occur when residue is not spread or baled at harvest time. Imagine a 20 foot (6 m) combine header; if all the crop residue entering that header was spread over 20 feet you would have a nice even spread of residue (see Figure 2). The field would dry a little slower but in a uniform fashion. However, dropping residue directly behind the combine results in concentrated windrows of residue which limit the amount of sunlight reaching the soil surface. A thick mat of residue can keep the soil cool and wet delaying germination, slowing early plant growth and increasing the risk of disease and pests.

Figure 2. Uniform spreading of residue at harvest makes planting easier.

**Poor residue distribution leads to:**

1/ variable soil moisture condition at time of planting.
2/ improper seed and fertilizer placement as a result of poor planter or drill performance.
3/ poor seed-to-soil contact—if the drill or planter cannot cut through the residue, it may bunch the residue around the seed in the soil. This is often referred to as "hair-pinning".
4/ uneven weed emergence, weed seed concentration and poor weed control.
5/ changes in pest levels—heavy windrows of residue may provide a better habitat for insects and rodents and encourage disease.
Improving Residue Distribution

Managing crop residues for soil surface protection requires advanced planning. Careful consideration of many factors must take place prior to adopting a no-till system.

1 / Leave long stubble—by harvesting crops as high as possible, there will be less crop material passing through the combine and less to spread.

2/ Avoid stopping the combine—whenever the combine stops moving during a clean out, it normally results in piles of residue. If you must stop, back up to spread the residue.

3/ Improve or add on spreaders—most combines have spreaders or choppers; if not, kits are available to modify existing systems. If spreader bats are worn and have rounded edges, replace them. Square edges on new rubber bats will normally increase spreading width. If chopper knives are dull, sharpen or replace them. Adjust choppers to spread over the full cutting width of the combine if possible.

4/ Add chaff spreaders—straw choppers or spreaders do not handle the chaff which comes off the sieves. Chaff can be as much or more of a problem than the straw since a denser mat can be created with the chaff. Chaff spreading units consisting of spinning disks, air fans or mechanical blades are available.

Residue management is the one part that made the most significant improvement in our system. The only modification we made to our combine was to add a chaff spreader so cereal chaff is spread over a wider area.

Bruce Shillinglaw, Huron County

Even residue distribution is a must

It is essential that crop residues are evenly distributed across the field. Uniform distribution will enhance weed control, reduce the need for specialized planters or drills, and generally improve crop emergence and overall performance.
Soil Suitability

The suitability of Ontario soils to conservation tillage is dependent on a number of soil characteristics. Some of these characteristics can be influenced by people; however, most are part of the soil. The characteristics which should be considered are discussed below.

Texture

Soil texture relates to the actual soil particles which are mixed together to make up your soil. Particles of sand, silt, and clay are combined with organic matter to form soil. The amount of sand, silt and clay in your soil determines the texture. In general, research and demonstration work in the 1980s found that conservation tillage practices can be adapted to most soil textures; however, finer textured soils generally required more management changes than coarse textured soils.

Drainage

Soil drainage is also important to consider in a no-till system. In general, the poorer the natural drainage, the greater the need for management changes to offset the negative impact of poor drainage. If you are planning to adopt a no-till system on a poorly drained field, tile drainage should be installed. Residue cover further aggravates existing drainage problems resulting in delays in soil drying.

Structure

Soil structure can cause major problems with the adoption of new systems. Soil structure refers to the way in which soil particles are arranged into small units. The soil units are arranged in a pattern to give areas of empty space or voids. The voids allow roots to grow down into the soil and water to move throughout the soil (see Figure 3). Gases are also exchanged between the roots and the void areas. In general, good soil structure means there are a lot of voids (large or small) or empty space, giving the plant the best conditions to grow in. Good soil structure is not common because most farm soils have been intensively tilled and cropped.

Before starting no-till, the soil should be in the best shape (best structure) that is possible. Proper soil management practices must be in place to promote good soil structure. This may mean examining your cropping and tillage practices and making the necessary changes. Including legumes in your rotation, eliminating tillage passes, careful application of manure, or not working land that is too wet will help enhance soil structure.

Shawn VanSickle, Brant County

Remember: Crop production on dense, structureless soils usually means poor yields, no-till will not be an exception.

Figure 3. Good soil structure improves root growth.

Adoption of no-till is easier on well structured soils.
Soil Compaction

The compaction of soil is a serious barrier to the success of no-till systems. In ideal soil conditions about 50% of the total soil volume should be voids or empty space filled with equal amounts of air and water (see Diagram 2). Compaction alters this ratio by eliminating the larger voids. Compaction in the upper plant rooting zone destroys the pathways for air, water and plant roots to move through.

Compacted soils can complicate no-till systems since these soils remain cold and wet longer in the spring. In reality most agricultural soils have been subjected to compactive forces at some time. When adapting a no-till system to your land, evaluate the condition of the soil first. Factors that may indicate compaction problems are: ponding, uneven crop growth, shallow root system, nutrient deficiencies and poor emergence. Soils which are compacted will cause problems. Try to alleviate compaction problems while still in a conventional system.

Diagram 2. Soil composition.

Processes that Reduce Compaction

1/ Nature has the ability to slowly reduce the effects of soil compaction. These processes involve frost action and the shrinking and swelling of some clay soils during the wetting and drying process. In most cases the natural processes take a lot of time and will not correct compaction which occurs below the plough depth.

2/ Rotation with deep rooted crops may also be used to reduce compaction problems.

3/ Tillage is often used to break up compacted zones. Extreme care must be exercised when tilling below the normal plough zone. If the soil is not dry at the depth of tillage, further and more extensive damage may be done. Current research indicates the effects of subsoiling last up to two years.
Reducing Compaction Risks

The best way to deal with compaction is to avoid it wherever possible. This is accomplished by reducing your risks.

**Timing**
Use a crop rotation that spreads your field operations over the full season.

**Soil Moisture**
Avoid field operations when soil is wet at working depth. This may require tile for the wet areas which tend to dry slower than the rest of the field.

**Controlled Traffic**
Under conventional tillage systems as much as 90% of the land area is tracked at least once. By matching equipment widths, wheel traffic can be significantly reduced.

**Axle Weight**
Keep axle weight to below 5 tonnes/axle. Removable ballast should be used where possible.

**Long Narrow Footprint**
A long, narrow footprint should be used rather than a short, wide footprint to reduce the compacted area (ie. larger diameter tire as opposed to duals).

**Radials**
Choose radial tires where extra traction is needed as they have up to 27% more soil surface contact area than similar sized bias tires.

**4-Wheel Drive vs. 2-Wheel Drive**
A 4-wheel drive tractor pulling an implement will distribute the weight of the pulled implement more evenly over both the front and rear axles of the tractor, whereas a 2-wheel drive tractor pulling an implement will transfer the weight to the rear axle.

*We thought a lot of trips were being made across our clay se compaction was occurring. By reducing the number of trips have better soil structure.*

*Cliff and Elwin Vince, Kent County*
Soil Improvements Over Time

The benefits of a no-till system often take time to be fully realized. The soil responds slowly but gradual improvements in soil structure do occur. Without tillage, voids or channels left by worms or decaying roots are not destroyed. Over time this leads to an increase in the number of continuous pores and improves drainage.

The ability for the soil to carry heavy equipment is quite evident. Many refer to the no-till soil as being hard or compacted. A better description is the soil has become consolidated. Even though the soil is firmer, it is able to grow good crops and provide adequate drainage. The big payoff for this comes at harvest. During wet falls the no-till crops can be harvested with minimal damage while conventional soils tend to become rutted.

CAUTION:
Avoid rutting or compacting the soil at harvest. Rutted and compacted soils are definite yield threats for following crops. This is especially detrimental to no-till crops.

![Figure 4. A uniform stand of no-till corn.](image)
Rotations The Benefits

Crop rotation is more important in a no-till system than it is in a conventional system. If a crop is not planted into the same crop residue the chances of success are much greater. Yields will be higher when crops are rotated because there is less chance for insect and disease problems. One thing to keep in mind when planning a rotation is to avoid no-tilling wheat into corn stubble. The corn residue may carry fusarium which could cause quality problems in the wheat. Rotations provide the opportunity to use a wider selection of herbicides and a longer period to apply them. This is especially important when it comes to controlling some perennial weeds. Rotations planned with insect, disease and weed management in mind will allow a variety of control strategies and result in good quality crops.

Another benefit of rotations is the ability to spread the workload over the whole cropping season. This may free up some valuable time to consider other management aspects of the farming operation.

With different crops being grown in any one year, rotations provide marketing flexibility and decrease the risk if adverse weather hits the area (see Figure 5). The benefits of rotations are numerous and although the economics of the day may not always call for the ideal rotation, consideration of long term soil health and productivity will prove the benefits of rotations.

The Ideal Rotation

The ideal rotation in a no-till system is a rotation where a crop is only grown one year in succession, i.e. corn-soybeans-wheat-red clover (alternating between cereal and broadleaf crops). The soil will dry out faster under a broadleaf crop residue than it will under cereal residue since broadleaf crops produce less residue than cereal crops. Less residue on the soil surface makes it easier to plant into but at the same time the residual cereal residue will help protect the soil from erosion.

Figure 5. Strip cropping no-till wheat and alfalfa improves yields and helps protect the soil.
Planning A Rotation

A rotation must be carefully planned to fit the goals of the farming operation. It must provide satisfactory economic returns, fit the equipment available and improve or maintain soil structure. Any crop and any number of crops can be added to the rotation. Care should be taken to design a crop sequence which will break disease cycles and improve timeliness of operations throughout the year. Varieties which are disease resistant, have good standability, and high yields should be chosen. The following are some key points to remember:

✔ A high residue crop following a low residue crop will help maintain residue levels on the field.
✔ Alternating broadleaf and cereal crops will facilitate volunteer crop control. Legumes in the rotation may provide some nitrogen for the following crop.
✔ Planting a crop back into its own residue increases disease and pest problems.
✔ The different herbicides available for broadleaf and cereal crops improve weed control.

In Summary

* All crops can be no-tilled, some with more success than others.
* Rotations in no-till are more important than in a conventional system.
* Disease, weeds, insects and the amount of crop residue should be considered when designing a rotation.
Insects and Diseases — What to Consider

No-till will influence certain insects and diseases in cropping situations. To date, however, the magnitude of its effect is unknown. Control of diseases and insects in a no-till cropping system may be accomplished by a variety of methods. These methods involve basic crop and disease management principles.

Diseases
Rotation becomes more important in no-till. A monoculture system (a crop planted back into its own residue) is more likely to aggravate certain plant disease situations than a system where a crop is planted into the residue of a non-related crop (see Figure 6). Grow disease-resistant varieties, follow good insect and weed control and use seed treatments.

Avoid planting wheat into corn residue because of the increase in risk of Fusarium Head Blight.

Insects
Crop sequencing is important for insect control. No-till planting of soybeans into wheat stubble underseeded to clover, can result in spider mite infestation in hot, dry years. Cutworm moths are attracted to heavy residue and winter annuals in early spring (April). If egglaying conditions are favourable (warm, calm, clear nights following storm fronts from the south-west), be on guard for cutworm problems in no-till corn.

Good residue management is another way to avoid insect problems. Removing residue from the row (with coulters or trash whippers) will help reduce slug problems.

Another control measure is good weed and cover crop control. No live vegetation should be present during planting and early crop growth.

We had some minor slug damage in the past but clearing a wider band of residue at planting helped eliminate the problem.

Peter Cumming, Kent County

Figure 6. No-till wheat into soybean stubble.
Fertility Management

Fertility levels should be known prior to starting the shift to a no-till system. Soil sampling to a depth of six inches and lab analysis is the best method of obtaining this information. In the event that a field test is low in one of the major plant nutrients, correction of the deficiency should be undertaken while still in a conventional system. Once in a no-till system, maintain fertility levels by applying nutrients recommended by the soil test. Methods which incorporate or inject the nutrients should be used whenever possible. Starter fertilizers are recommended in a no-till system to assist in early seedling growth (see OMAF Publication 296 for maximum safe rates of nutrients). Check to see that the starter placement is accurate. Larger quantities of nutrients, if required, should be broadcast prior to planting. The tillage action of many no-till planters or drills will work a portion of this fertilizer into the soil.

Figure 7. A coulter in front of the knife cuts residue and improves nitrogen placement below the residue.

Nitrogen should always be applied below the residue. Apply all phosphorus and at least part of the potash in a side band with the planter.

Don Lobb,
Huron County
Nutrient Management

Nutrient requirements for no-till crops are the same as the current OMAF recommendations for conventionally grown crops—rates as listed in "Field Crop Recommendations" (see OMAF publication 296). Nutrient deficiencies may develop when the wrong product is used or if the nutrients are improperly placed.

The major crop nutrients are Nitrogen (N), Phosphorus (P), and Potash (K). Table I outlines the characteristics and management considerations which should be addressed in a no-till system.

Table 1. Nutrient Considerations

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Characteristics</th>
<th>Management Considerations (Recommendations)</th>
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<tbody>
<tr>
<td>Nitrogen (N)</td>
<td>- very mobile</td>
<td>- early spring N application on cereals are similar to the conventional system</td>
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<tr>
<td></td>
<td>- leaches readily</td>
<td>- for corn, inject N below residue and avoid broadcasting urea based products</td>
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<tr>
<td></td>
<td>- high residue and warm temperature may cause significant losses with surface broadcast urea based products</td>
<td>- include a portion in starter fertilizer - do not exceed maximum safe rate (See OMAF Publication 296, Soil Section)</td>
</tr>
<tr>
<td>Phosphorus (P)</td>
<td>- relatively immobile</td>
<td>- except in low test soils, the entire P requirement is best met with a starter fertilizer</td>
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<tr>
<td></td>
<td>- high crop demand early in growing season</td>
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</tr>
<tr>
<td>Potash (K)</td>
<td>- relatively immobile</td>
<td>- place requirement in starter fertilizer (See maximums allowed in OMAF Publication 296, Soils Section)</td>
</tr>
<tr>
<td></td>
<td>- more movement in sandy soil</td>
<td>- exceeding maximum safe rate may cause seed burn—remainder should be broadcast prior to planting</td>
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NOTE: Proper placement of starter fertilizer is critical. Too close may burn seed and too far from the row reduces uptake. (See reference list for fertility factsheets.)
No-till Weed Control

Weed control without tillage is somewhat new and challenging, but certainly not impossible. The proof can be seen around the countryside in the variety of weed-free healthy crops grown by no-till farmers over a wide range of soil and climatic conditions. The ideal situation in a no-till system, as in any other system, is no weeds present as the crop emerges. This is often achieved by the application of a non-selective herbicide just before, during or shortly after seeding the crop. Weeds that emerge just after the burndown of vegetation may have significant impact on crop performance. They are controlled by the same pre-emergent and post-emergent herbicides used in conventional tillage systems. Farmers should be aware that crop selection and rotation considerations are more critical in a no-till crop system since some forms of mechanical control and incorporated herbicides are generally not viable options. Although herbicides are a significant part of a no-till weed control program, a successful program requires a careful combination of all weed control methods.

CULTURAL WEED CONTROL

Reduce Weed Sources

Farmers can reduce weed pressure in their fields by not allowing new weed species an opportunity to infest their fields, and by minimizing seed production of existing weeds. Farmers must be vigilant in using only weed-free seed on their fields. Harvesting and seeding equipment should be free of weed seeds before starting operations in a new field.

It is important to keep field borders free of weeds. Often fence rows and hedge rows are a source of seed for troublesome weeds. Keep these areas sprayed or mowed to prevent seed production. Keep a good grass sod border, and be careful to prevent over spraying these grass buffers with non-selective herbicides like glyphosate. When the sod is killed it is often quickly replaced with weeds.

Selection and Rotation of Crops

Select a cropping program that offers maximum competition to the particular weed and an opportunity to put maximum pressure on the weed with herbicides. Use crop rotation to keep the pressure on such troublesome weeds until they are brought under control. By rotating crops and herbicide treatments, specific weed species that are favoured by one particular crop and volunteer crop species, are not allowed to build up over time.
**Seeding The Crop**
1/ Timely seeding of the crop is important in order to give the crop the edge over weeds.
2/ Narrower rows and higher seeding rates speed development of the crop canopy crowding out weed seedlings.
3/ Placing fertilizer in bands, with the seed or near the seed, is preferred over broadcast applications. This feeds the crop instead of the weeds.
4/ Seeding and fertilizing should be performed with minimal soil disturbance.

**Cover Crops For Weed Control—Factors to Consider**
1/ Cover crops offer competition to late season weeds and tend to reduce their numbers and the amount of weed seeds produced.
2/ The residue from cover crops impedes the germination and early growth of many annual weed species the following spring.
3/ Some cover crops may act as weeds themselves and require special management to prevent their interference with the succeeding crop.

Ideally a cover crop would grow after harvest of the main crop, crowd out and smother the weeds, and die completely before seeding time the next spring.

**Mechanical Weed Control**
Mowing stubble is still an effective way of preventing some weeds from producing seeds after a crop has been harvested. A second option is inter-row cultivation in no-till seeded row crops. With the availability of improved heavy duty cultivators, primarily designed for ridge-tillage, it is practical to cultivate a crop like no-till corn. The cultivator is designed to operate in heavy crop residue and firm soil. When properly adjusted, it will penetrate the soil just deep enough to shear off weeds between the crop rows. The seed bed is left relatively level and the crop residue remains on the soil surface. This allows about a 60% reduction in herbicide use if only a narrow band of herbicide is used over each row. If the cultivation process can be coupled with side-dress nitrogen application, the concept has even more practical appeal.

For mechanical weed control, we trade the cost of herbicides for the cost of time and equipment. The real gain is environmental protection and less potential for the development of weed resistance to herbicides.

**In Summary**
Anything a farmer can do that favours the crop, without favouring the weeds, results in less competition from weeds, cleaner fields and higher yields. The most appealing aspect about cultural control measures is that they generally do not cost a lot of dollars and the additive effects have a significant impact on the numbers and kinds of weeds that remain in the field to be controlled with herbicides.

Figure 8. Inter-row cultivation of no-till corn reduces herbicide costs.
Chemical Weed Control

Chemical weed control in no-till production systems is no more or less difficult than in conventional production systems. Successful no-till farmers are confident that herbicides are worth the investment and that they have the management ability to apply them accurately, timely, and judiciously. They recognize the need for well maintained and properly adjusted equipment, and the need for a thorough understanding of the herbicides they intend to use. They also realize the value of being able to identify their problem weeds and the importance of knowing when specific weed species are most vulnerable to herbicide treatment (see Figure 9).

Weed management in the absence of tillage will require the development of a new strategy. There are fewer options available and the weed species and populations tend to change over time. The weed species that need control in an established no-till system are usually different from those found in conventional systems. In the transition years, (three to five years during the conversion from conventional to no-till) farmers may have to contend with new species such as dandelion, wild carrot or goldenrod, while at the same time continuing to fight the array of annual and perennial weeds left over from the conventional system. Once the seed supply in the top few inches of soil dwindles, competition from this group is less intensive. Learning to recognize unfamiliar weeds and developing a sound management program for them is the main challenge for no-till growers.

A field with serious perennial weed problems is not a good prospect for no-till. Take the opportunity before no-tilling to use chemical and mechanical means to bring those specific perennials under control while the use of tillage is still practical.

The same basic common sense rules that apply to weed management and, in particular, to herbicide use in conventional weed management programs, also apply in no-till systems. Planning, selecting the herbicide, the rate, application accuracy, and timing are the keys to success.

### Head Start

Planning ahead for the next crop is a necessity in no-till weed management. Planning must begin in the fall for a spring planted crop.

Many weeds have been successfully controlled with late summer or fall applications of herbicides like glyphosate, dicamba, and 2,4-D. Weeds that have escaped control in the previous crop, or weeds that tend to flourish after a grain crop has been harvested, are well suited to control in this manner. Also, weeds that tend to germinate in the fall and form rosettes for overwintering are vulnerable at this time.

If weeds have been disturbed by harvesting operations, allow them to regrow before applying herbicide. Herbicides used at this time need actively growing plants with lots of leaf area to absorb and translocate the herbicide throughout the entire plant. Most perennial weeds, like Canada thistle, field bindweed, sow thistles, milkweed and dogbane, are most susceptible to herbicides when they are in early bud to bloom stage. Application should be made at least two weeks before a killing frost to allow sufficient time for the herbicide to move down into underground plant parts. Applications can be made even after light frost provided the weeds are not damaged and continue to grow.

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*Your basic weeds are similar in no-till but there is a shift to perennials. With no-till you are not spreading weeds around with the tillage and they are much easier to control.*

Peter Cumming, Kent County

*Our timing is different in our spray program. You have to be thinking about the weeds in the fall.*

Shawn VanSickle, Brant County
If germinating winter annuals, like chickweed, shepherds' purse and false flax, or the seedlings of perennials, like dandelion, wild carrot and Canada thistle are the primary target, wait until most of these have formed rosettes before treatment.

Of the herbicides mentioned, 2,4-D and dicamba are effective on broadleaf plants, while glyphosate is effective on both broadleaf and grass species. **For herbicide rates consult the herbicide labels, Ontario Publication #75—Guide to Weed Control, and/or your local extension person.** The rate recommended will be determined by the most difficult to control species in the field. Keep in mind that rates of glyphosate used to control quackgrass are generally too low to provide effective control of broadleaf perennials like field bindweed, Canada thistle and milkweed. Also, remember that deep rooted perennial weeds are seldom killed by a single application. Repeated treatments over two to three years is often required to bring weeds like field bindweed and milkweed under satisfactory control.

Unlike many broadleaf perennials, quackgrass grows actively, often late into the fall, and resumes growth early the following spring allowing an excellent opportunity for either a spring or a fall application of glyphosate without interfering with the crop. Either timing provides excellent quackgrass control. The fall application has advantages over spring treatments. Escapes go into winter in a severely weakened state and would not be as likely to survive. The potential for allelopathic effects of the quackgrass residue may be less from a fall treatment.

Dandelion is a frequent invader of no-till fields. If dandelion plants are left untreated and allowed to become well established, they become very difficult to kill. The best strategy is to treat them while they are still seedlings and more susceptible. It is most susceptible to 2,4-D herbicide and fall applications provide the best control. Spring applications of glyphosate have generally not provided satisfactory control. Fall applied glyphosate works more effectively.

**Figure 9.** Scouting for problem weeds helps with weed management programs.
Sod and Cover Crops
Old established grass pastures, grass legume mixtures, alfalfa and clover cover crops are usually best killed in the fall if those fields are to be seeded the following spring (see figure 10). If left until spring they can waste valuable moisture needed for the next crop.

Alfalfa and red clover must be killed in the fall. I want the field dead by spring to no-till the next crop into.
Bruce Shillinglaw, Huron County

When grasses like quackgrass, brome grass, timothy and orchard grass are part of the vegetation makeup, glyphosate is necessary. Quackgrass is readily controlled by 0.9 kg/ha glyphosate plus surfactants, if populations are sparse. On the other hand, dense populations of quackgrass or even low populations of brome or orchard grass, require a stronger dose of 1.8 kg/ha glyphosate plus surfactants, in order to achieve acceptable control.

Legumes and broadleaf weeds vary in their susceptibility to glyphosate and many will escape even a 1.8 kg/ha rate of glyphosate. Alfalfa and dandelion are usually controlled by the 1.8 kg/ha glyphosate rate applied in the fall. Clovers—red clover and white clover—are much more tolerant of glyphosate and frequently escape.

Legumes and broadleaf weeds are generally more susceptible to dicamba (0.6 to 1.2 kg/ha) and 2,4-D (2.5 L/ha or 500 g/ha). Dicamba usually provides a more consistent level of control than 2,4-D. Dicamba also controls a broader spectrum of broadleaf weeds but costs more per hectare than 2,4-D. A few legume escapes can be tolerated if a good control measure is available for use in the succeeding crop. If the following crop is soybeans, the choice of herbicides for escaped legumes or perennial broadleaf weeds are limited.

Herbicide labels contain information about tank mixtures for use at lower rates on stubble or fallow for control of specific perennial weeds like Canada thistle. Tank mixtures of other herbicides with glyphosate have been shown to reduce the activity of glyphosate on perennial grasses, sometimes as much as 30%.

Figure 10. In the fall, clover fields should look like the field on the right if you want to plant no-till in the spring.
Proper burndown at seeding ensures good crop emergence.

Burndown At Seeding

For successful establishment of a crop in no-till, as in any tillage systems, it is important for the crop to have an even start with the weeds. Tillage provides the even start in conventional systems. The burndown herbicide treatment which is designed to kill existing vegetation prior to crop emergence does the same in no-till (see Figure 11). The crop is least competitive in the early stages, therefore, a complete and timely burndown is essential for success.

The Backbone of the Burndown Treatment

Glyphosate is non-selective, non-residual, cost effective and dependable when properly applied. When quackgrass is present the 0.9 kg/ha rate is the lowest rate recommended. As cover crops (ie. rye and wheat), and annual weeds get older and more vigorous they become more difficult to control and rates of 0.9 kg/ha - 1.25 kg/ha are needed.

Considerations

1. Apply burndown treatments close to seeding time. If applied too early, a second flush of weeds may emerge prior to seeding. There are two common situations. The first situation occurs when perennials, winter annuals or a cover crop are present. Applying a burndown two to three weeks prior to planting will ensure these are dead at seeding. Keep in mind, it is possible that the crop may not emerge for four to six weeks after this treatment and a second flush of annuals may emerge requiring another burndown. The second situation is where the weeds are just emerging or are small (cover crops and perennials absent or controlled). In this case a farmer should aim to apply the burndown treatment the same day as seeding, just in front of the planter, or wait two to three days after planting. This allows for weeds disturbed in the planting process to right themselves and grow from beneath crop residue.
By waiting to apply the burndown until sometime after seeding, the herbicide can be applied to weeds free of dust and debris. However, when non-selective herbicides such as glyphosate or paraquat are used, they must be applied before the crop emerges. Glyphosate and paraquat have no residual activity and other herbicides must be used to control weeds that emerge after the burndown treatment.

Remember that delayed burndown increases the potential for slug and insect damage and the potential for cold and wet soils at planting.

You can even go and spray Roundup after planting before the seedlings are up for control of weeds... that's one advantage to no-till.

Clinton Pottruff, Brant County

2. **Other herbicides can be used as burndown treatments.** Dicamba and 2,4-D can be used as burndown herbicides if the succeeding crop is not susceptible to the residue left in the soil. Crops like soybeans, however, are sensitive and can be severely injured from lingering herbicide residue.

3. **Residual herbicides as burndown treatments.** Residual herbicides, like atrazine, cyanazine, linuron, imazethapyr, metribuzin, metobromuron and monolinuron, all have post-emergent activity on small annual weeds (5 cm or less). These herbicides can give adequate control of annual weeds if applied to small, actively-growing weeds. A word of caution; these herbicides do not have as broad a weed spectrum and are not as dependable as glyphosate or paraquat, particularly when conditions are less than ideal for control.

4. **Tank mixtures of various herbicides with glyphosate or paraquat are frequently considered.** Some are registered for use, but most are not. Remember—when herbicides are mixed with glyphosate, in some cases grass control from glyphosate can be significantly reduced. **Read and follow product labels before applying tank mixtures.**

**Additives**

When treating weeds and cover crops in the fall or in the spring, in the absence of a crop, the use of additives such as surfactants, crop oil, corn oil concentrates and fertilizer such as, 28% UAN solution and ammonium sulfate, can significantly improve the uptake of herbicides by weeds, particularly when growing conditions for the weeds are less than ideal. These additives can greatly enhance herbicide performance at lower rates and provide similar control as higher rates without additives. By using additives according to label instruction, growers can reduce the cost of effective control and reduce the risk to the environment.

**Control of Weeds After Burndown**

After the burndown application with glyphosate, paraquat, 2,4-D, or any other herbicide with no or short residual activity, weeds will continue to germinate and emerge. Farmers have a wide variety of herbicides to choose from for use on various crops. All pre-emergent and post-emergent herbicide treatments registered for use in conventional systems can be used in no-till systems. When large amounts of crop residue are present, such that they impede soil active herbicides from reaching the soil, farmers should put more emphasis on post-emergence treatments, particularly if dry conditions are in the forecast.

Once no-till farmers get familiar with the weed spectrum and the growth habits of the weeds they have in their no-till field, they soon devise a management plan. Typically that plan centres on the use of glyphosate as a perennial grass burndown; using glyphosate, dicamba and/or 2,4-D for perennial broadleaf control; and a host of optional pre and post-emergent herbicide treatments in various crops. They then integrate the chemical and cultural options they have available to them into a complete weed management strategy that is no less effective and frequently less costly than a comparable plan developed for conventional tillage systems.

Other than applying a burndown, the rest of my weed control program is no different than my conventional program was. Basically, I would say, weeds are no worse in no-till and I think it is gradually improving.

Clinton Pottruff, Brant County
No-till is a different farming system than conventional tillage. Many farmers have had some bad and good experiences in the switch to no-till. Read what some innovative farmers of Ontario have to say on their experience with no-till. Remember… Experience Talks

We had yield reductions when we no-tilled into cereal residue (wheat/rye/oats) on clay soils, particularly when the early growing season was cold and wet.

I like no-till because it simplifies weed control, lowers equipment investment, reduces soil erosion and improves crop yields, especially on formerly degraded soils.

Don Lobb, Huron County

I had a bad experience with dandelions. They were developing in my minimum tillage system but I didn’t notice them. I learned quickly that perennial weeds have to be controlled before you start no-till.

No-till simplifies my equipment. It is quicker to get the crop in the ground and equipment runs easier when you work on solid ground. No-till is much more pleasant to work with.

Doug Albin, Brant County

The first year we no-tilled we had some seed burn from anhydrous. If using anhydrous sidedressed ahead of planting, make sure you put it on a week ahead of planting, and make sure it is off to one side.

The biggest advantage of no-till is, it saves machinery use and we can do 50% more acres with almost the same yield.

Clinton Pottruff, Brant County

Our worst problem is the amount of residue that we encounter with winter wheat. The residue seems to hold moisture in the ground and the crop is slow to get up and establish a root system. Weed problems have also been difficult. You have a different pressure of weeds at different times of the year.

No-till drastically reduces the number of trips across the field and we are using 40-50% less fuel. We are finding we have very little wind erosion during the winter because the crop residue is sitting there.

Elwin and Cliff Vince, Kent County
Residue Spreading
Residue management begins with the harvest of the crop. Proper handling of residue at harvest will reduce future problems. It is essential that the residue be spread evenly behind the combine. Residue that is left in windrows behind the combine will slow the drying and warming of the soil in those strips and make it difficult to achieve good seed to soil contact. The cooler, wetter soil will slow growth and the windrow may harbour diseases. Together these may increase disease potential. Modifications to existing spreaders or the addition of spreaders on the back of the combine will spread the residue evenly over the field. A chopper may help to distribute the residue more evenly. Growth inhibitors from residue may be worse if a crop is planted into areas of heavy residue.

Cover Crop Seeding
Cover crops such as rye or oats may be necessary to protect the soil from erosion after a light residue crop such as beans or vegetables. Cover crops are also valuable in the soil building process. The fibrous root systems and added organic matter help to improve soil tilth. It is important to choose the best cover crop for the job: legumes for nitrogen production, quick growing cover crops for erodible fields, and good root systems for soil structure improvement. Ideally these crops should be drilled in with little soil disturbance using a no-till drill but can be broadcast and worked in lightly or flown on. Be sure to consider the management of the cover crop the following spring.

Summer Forage Seeding
No-till seeding is ideally suited for establishment of forages on highly erodible fields. All existing vegetation should be suppressed or killed by overgrazing or sprayed with glyphosate or paraquat prior to seeding.

Fall Weed and Legume Control
The fall is a good time to control many perennial and winter annual weeds in your fields. This usually takes place between harvest and the first killing frost. It is also the time to kill existing sod, red clover and alfalfa in fields to be no-tilled next spring. Killing these in the fall ensures they are dead before seeding and prevents them from removing to much soil moisture in the spring. There can be an advantage to leaving sod, red clover and alfalfa on heavy soils until the spring to help them dry out.

Fall Fertilization / Fall Seeding
Banding of fertilizer with the seed is the preferred method of application. It places the nutrients where they are needed and reduces the potential for loss in runoff. When the soil test recommends more potash than can be safely banded or more phosphorus than the drill/planter can apply it may be broadcast in the fall. Note these nutrients are not very mobile and will concentrate near the surface with repeated surface applications. Fall seeding of cereals or canola can be accomplished with a conventional drill on some soil types but consistent results on all soil types will be achieved with a no-till drill or coulter caddy arrangements. The coulters and/or specially designed openers cut residue and place the seed in contact with the soil.

Snow Trap
The residue and standing stubble on the soil surface will act like a series of tiny snow fences trapping snow on the field. This helps to recharge the soil with moisture. The residue will protect a crop from harsh winter winds, reduce wind and water erosion and help conserve moisture the following spring.

Spring Fertilization
The preferred method of fertilizer application is to band it at seeding. This is usually done by placing the nutrients 2" (5 cm) to the side and 2" (5 cm) below the seed or with the seed. Any phosphorus or potash over and above what can be safely applied with the planting equipment should be broadcast. Fertilizer that is broadcast before planting will be incorporated slightly with the coulters on the drill or planter. Broadcast nitrogen fertilizer in the spring on cereals similar to a conventional system.

Spring Seeding
Spring cereals, spring canola, soybeans, and forages can be seeded with a conventional drill on some soil types but a no-till drill or coulter caddy arrangement will perform better on a wide range of soil types. Corn, soybeans, and field beans can be seeded with a conventional planter on some soil types but for consistent seed to soil placement on a variety of soils, no-till attachments should be added in front of the seed and fertilizer placement units.
Spring Burndown / Pre-emergence Crop Protection
A spring burndown is an important step in a no-till weed control program. The purpose of the burndown treatment is to kill existing vegetation prior to crop emergence. Perennial, winter annual, biennial weeds or emerging annuals are the main targets. Cover crops or sod that was not killed the previous fall may also be targeted. Glyphosate, paraquat, dicamba and 2,4-D are the common burndown herbicides, but residual herbicides with post-emergence foliar activity such as atrazine, cyanazine or metribuzin are also effective. The spring pre-emergence herbicide treatments are similar to the herbicide treatments used in minimum or conventional tillage.

Spring Post-emergence Crop Protection
The spring post-emergence herbicide treatments are similar to the herbicide treatments used in tillage systems. Post-emergence weed control becomes more important in a no-till system as pre-plant incorporated treatments are not an option. Where a burndown treatment is applied there is the opportunity to scout fields and target post-emergent treatments to weeds present. In that situation it would be the only herbicide treatment used apart from the burndown.

Sidedress Nitrogen
Now that the corn is up and the weeds are controlled, it is time to consider sidedressing the nitrogen. The residue on the soil surface can affect the efficiency of the nitrogen applied. If nitrogen is broadcast on the soil surface this biologically rich layer converts a portion of the nitrogen to ammonia gas which is lost to the atmosphere. To prevent this from happening, all nitrogen should be placed under the residue. This is usually done by knives into the soil.

Harvest
The harvesting of a no-till crop is similar to the harvest of conventionally tilled crops. The main difference between the two systems is that in no-till the residue must be spread evenly over the field. The crop should be cut at a height which matches the clearance height of the seeding equipment. You should attempt to harvest when soil conditions are fit. Fields rutted at harvest will require corrective tillage before planting no-till.
Experience Talks

Our bad experiences have been no-till corn onto heavy clay soils. We had poor yields and poor economic returns. Having equipment in proper condition can make the difference between success and failure.

Economics is the biggest advantage to no-till. We don't have to hire help and there are fewer trips over the field. We don't think erosion is as severe and soil is staying in place because of all the residue and roots that are left in and on the soil surface.

Shawn VanSickle, Brant County

Our major problem was planting when it was too wet. We had to replant because of poor emergence. But that is a management thing that was easily corrected.

No-till saves on fuel, time and one person can handle a lot more land. Instead of working until midnight, you work until dark and you don't have to rush like you used to. You have more time for your family.

Peter Cumming, Kent County

We had two bad experiences with no-till. One problem is wheat residue and the problem of the soil drying and warming up in the spring. The second problem associated with wheat residue (red clover cover crop) is slug infestation. To overcome these problems we are doing some light tillage after wheat/red clover.

The biggest reason we went to no-till was the reduced labour requirement. Another advantage to no-till is we have lowered our production costs.

Bruce Shillinglaw, Huron County

My worst experience was putting no-till wheat into corn stalks. There are disease problems and yield reductions. Wheat should be planted into bean ground.

The no-till system's main benefit is reduced soil erosion. It has allowed for more timely seedings, better time management and has reduced my capital investment on equipment.

Bruce Cruickshank, Brant County
No-till Equipment

The no-till cropping system has evolved since the slot plant or zero-till systems of the early 1980s. No-till cropping now refers to planting systems where seed is placed in a narrow strip of tilled soil. Enough tillage is done to facilitate proper seed and fertilizer placement.

The means used to accomplish this tillage is similar for both drills and planters. The type of equipment used may differ depending on the crop to be planted and type of drill or planter used (see Figure I2). In general, 13 criteria should be used when evaluating a drill or planter.

1/ RESIDUE CUTTING—All no-till seeding equipment should have sharp coulters and/or offset double disc openers to cut through crop residue.

2/ COULTER SELECTION—Each coulter differs in its use and appropriate function (see Table 2). All are designed to penetrate and till soil. Coulter cutting capability is limited if coulters are too large or too small. Large coulters tend to fold residue into ground (i.e. hairpinning). Coulters smaller than 17 inches push residue causing plugging. The optimum coulter size is approximately 17 inches (43 cm).

Figure 12. An extra frame and coulters are added to this conventional planter for no-till.
Farmers can overcome residue plugging problems in no-till drills by planting directly across or at an angle across last year's crop rows.

Don Lobb, Huron County
We find that the two 2-inch fluted coulters actually incorporate and flip the residue out of the row area and that seems to be quite adequate.

Bruce Shillinglaw, Huron County

7/ RESIDUE REMOVAL — No-till corn crops require a 6-8" (15-20 cm) residue-free zone over the new row (see Figure 13). This is facilitated by adding either:
A. The coulter till system consisting of two or more aggressive coulters designed to incorporate residue into or toss residue off of the new row. OR
B. Disc furrows or trash whipper units using rotating discs to sweep residue off the row area (see Figure 14).

8/ DRIVE SYSTEM
To reduce wheel slippage:
- add fluid to drive wheel
- increase down pressure on drive coulter
- change to a more aggressive tread on wheel
- add weight to planter
To reduce coulter slippage (on coulter driven drills):
- increase down pressure on drive coulter
- switch to a wider, more aggressive coulter, i.e. wavy coulter

9/ CHAIN GUARDS — No-till planting into corn residue can often dislodge drive chains. Guards are needed to prevent stalks from dislodging chains.

10/ PRESS WHEEL — No-till coulters tend to leave a very loose fluffy seedbed. Firming of this seedbed using a press wheel is very important. Selection of the most suitable type of press wheel depends on the width of the tilled seedbed. Use of a 4" (10 cm) wide press wheel is not suitable when trying to firm soil in a 2" (5 cm) wide seedbed (see Diagram 3).

![Diagram 3. Press wheel selection](image)

**Incorrect**
Press wheel too wide to properly firm seedbed

**Correct**
Press wheel matches tilled width of seedbed for proper firming.

![Figure 14. Residue removal with disc furrows/trash whippers.](image)
11/ **PLANTING AROUND CORNERS**

The distance from the front no-till coulters to the rear openers makes turning corners in no-till conditions very difficult. If you require the ability to turn corners, check to see that the tillage coulters have some swivel capabilities. (Turning will still be difficult because of the lack of tilled soil.)

12/ **MARKERS**—Soil conditions at time of planting may resist the penetration of conventional markers. Marking can be improved by:
   a/ adding weight to the marker arm,
   b/ using a weight hub on the marker disc blade
   c/ using a notched disc blade

13/ **HARROWS**—Seed coverage and subsequent emergence can be improved by adding harrows to many drills.

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*I have a 3 pt hitch drill and I like the system. The only thing that I would change would be adding a harrow on the back to improve seed coverage.*

**Clinton Pottruff, Brant County**

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**Figure 15.** No-till drill with harrows added improves seed coverage.
No-till Planter Coulter Set-up

Selection and placement of no-till coulters on a planter can be very confusing. In general three basic concepts are used. Configurations and alignments of the systems are sketched below. Individual farmers will make modifications to these concepts to suit their equipment and soil conditions.

Three Coulter System

The three coulter system employs coulters for tillage and residue removal. The two outside coulters are a minimum of 2” (5 cm) away from seed zone. Normally a fertilizer shoe or knife will follow one of these two coulters and in some cases both. The centre coulter ensures that the seed slot opener is able to place seed at the proper depth in tilled soil without hairpinning residue around the seed. When the two outside coulters are wide apart the ground between them remains untilled and the centre coulter can easily cut residue when installed directly in front of the seed unit.

Caution needs to be used if the two outside coulters are only 2” (5 cm) off the seed zone. In this situation the soil between the coulters will be very loose. If the centre coulter is located behind these coulters it will be unable to cut the residue directly in front of the seed unit. The solution in this case is to install the centre coulter in front of the outside coulters if you are tilling a narrow zone.

Two Coulter System

The two coulter system is very similar to the three coulter system. The coulters used are usually more aggressive, making up for the loss of one coulter. In this system the two coulters are set relatively close together (in front of the seed and fertilizer openers) and the tilled zone is narrower than that found in the previous system.

When setting up the coulters make sure you purchase coulters with left and right hand arms. This allows residue to flow between them more easily. If residue continues to be a problem then the coulters will have to be staggered. Mounting one coulter to the front of the auxiliary frame and the next on the backside of the frame is all that is needed. The two coulters should be aligned with the following seed and fertilizer openers.

Note: Speed is required to make coulter systems work. Increasing speed throws more residue off the new seedbed. Caution must be exercised as too much speed will throw soil out of the seedbed.

The addition of each coulter comes with increased power requirements. Be sure to match the coulter system to the tractors available. Increased weight may be needed with the addition of coulters.

(See legend next page.)
Coulters Plus Disc Furrows (trash whippers)

This system normally uses two coulters, however if the fertilizer units are capable of penetrating untilled soil a single coulter in front of the seed unit can be used. This system is set up similarly to the double coulter system but uses less aggressive bubble or ripple coulters. The tilled seedbed is very narrow.

Residue removal is accomplished using the disc furrows. The preferred location of these units would be linked to the seeding units. This location allows direct depth control using the existing seed unit depth gauge wheels.

Disc furrows come in many configurations. The smooth discs are used where sod has to be removed. The notched or spider discs should be used to move row crop residue. This disc reduces the potential for moving soil along with residue.

Clinton Pottruff,
Brant County

I have a ripple blade coulter in line with the seeding units to cut trash and twitchgrass so you don't get hairpinning of the seed.
To make no-till successful, you must take your time at planting and make sure your equipment is properly adjusted for your soil conditions.

Elwin and Cliff Vince, Kent County

Equipment Adjustment

In addition to the standard adjustments and checks performed at planting a few extras may be required for no-till.

1/ **Coulter Alignment**—Coulters set up to cut residue and till soil in front of seed or fertilizer openers should be checked to see that they are aligned with the openers.

2/ **Level Equipment**—Start with seeding equipment which is level. This will allow proper depth control of both seeding units and tillage coulters.

3/ **Soil Conditions**—Delay planting until field is ready. If conditions are wet, the residue will not be cut and the soil will tend to smear.

4/ **Adjusting Coulter Depth**—When dealing with variable soil conditions, depth adjustment can be very difficult. A shallow seedbed is more of a problem than a deep one. Set coulter depth so that planting equipment prepares an adequate seedbed in the heaviest part of the field. Adjust coulters to run approximately 1/2" (1 cm) below desired seed or fertilizer placement depth. In the lighter soils the gauge wheels or press wheels will have to maintain an adequate seed depth. **NOTE:** In extremely variable conditions it may be necessary to mount coulters on a hydraulically controlled frame.

5/ **Spring Tension**—Do not over tighten. Rocks and stones in untilled soil will not move so the coulters must have the ability to ride over these.

6/ **Starter Placement**—Placement of starter fertilizers in no-till is critical—too close to seed will burn it and too far from seed will reduce the early uptake. Check OMAF publication 296 for starter fertilizer placement and rate recommendations.

7/ **Press wheels**—Press wheels should be adjusted to firm soil around seed, not pack it in.

8/ **Residue Removal**—When planting corn, check to see that a 6-8" (15-20 cm) zone over the new row is relatively free of residue. The following adjustments may help achieve this.
   a) Disc furrows (trash whippers) could be lowered to move more residue as long as a trench is not created.
   b) A second option if using strictly coulters is to increase speed to toss residue off of the row.
Seedbed Changes —
Factors to Consider

The Advantages
The advantages of a no-till seedbed are numerous. The soil is moist and unlike a conventional seedbed you can place seed shallow and still be into moisture. Shallow planted seeds will emerge quicker as they are closer to the warm soil surface. Residue on the soil surface is definitely an advantage to a no-till seedbed. Residue protects the soil from wind and water erosion and also helps protect young seedlings from wind damage. With high levels of residue, planters must have residue handling devices—coulters or trash whippers and the proper press wheels to get good seed-to-soil contact.

Under no-till conditions the top few inches of topsoil is in good shape with lots of organic matter and biological activity. The bugs and worms that are close to the surface break down the previous crop's residue which helps increase the organic matter and humus levels in the soil. This is beneficial as a nutrient source and helps retain soil moisture. The seedbed is friable (good structure), firm, and moist, and the crop roots will not be hampered by poor soil structure.

Things to Watch For
In a no-till seedbed soils tend to be cooler and wetter than tilled fields in the spring which may cause problems with insects and diseases. Planting seeds in cold, wet soils only invites problems with insects and diseases and reduces emergence. Because of the cooler soil temperature, you may have to wait a few extra days for the soil to warm up before starting to plant. All seed should be treated with a seed treatment to protect it from insects/diseases. Care must be exercised when selecting varieties/hybrids of crops. Early planted spring crops should have good cold tolerance and be capable of producing strong roots quickly. Be patient and wait those extra days (even though your conventional neighbour is out working fields), and you will reap the benefits. Spring planting delays experienced in the first few years will disappear as soil conditions improve.

No Delays
The delay in planting during the adoption period (2-3 years) does not cause a delay at harvest. The no-till crop "catches up" to a conventionally planted field and yields are comparable in both systems. At harvest minimal delays occur with a no-till system. Because the soil has better structure and carrying capacity, a combine can harvest crops without damaging the soil and making ruts. Generally, after a rain, a conventional farmer may be delayed a few days before the soil will carry his combine. In a wet fall this may mean the difference of harvesting good quality crops versus poor quality crops.
How to Start

Now that you are familiar with the various components of a no-till system, it is time to put it all together. The following are some pointers to keep in mind when first starting into no-till.

- If possible select fields that are well drained, have medium levels of potash, few perennial weed problems and adequate pH levels.
- No-till starts at harvest. Straw and chaff must be spread evenly across the soil surface to help eliminate possible problems of residue plugging in the planting equipment. The field should be dry at harvest to eliminate the chance of making ruts in the field. If ruts are evident, it is better to work them out to ensure the planting equipment works properly.
- Start with a cereal crop. Winter wheat is the easiest crop to no-till because soil conditions are warm and dry at seeding. After planting, no-till winter wheat management is similar to a conventional system. No-tilling into a field with low amounts of residue will ease you into residue management.

Controlling weeds is the key to making no-till work. A chemical treatment in the fall to control grasses and perennials such as alfalfa and red clover, is an effective way to control these weeds. A spring burndown may be required to ensure you are planting into dead material.

Be prepared to change your herbicide program. Weeds will shift from the annual type to perennials and winter annuals. Scout your fields and spray according to your weed population. Keep in mind there is no chance to incorporate herbicides in a no-till situation.

- In wet conditions coulters will not cut through the residue very easily. Instead, residue will be pushed down into the soil and seed wedged into the residue (hair pinning). This leads to poor seed-to-soil contact and results in poor emergence. If residue is dry, then it decreases the chances for plugging and allows the equipment to run smoothly.
- Attitude is the most important factor. If you have an open mind and are willing to make changes to your management practices, then you will make no-till work. Talk to experienced farmers to learn how they are making the no-till system work on their farm and learn from their mistakes. Be patient, it will take a few years to develop a system that works on your farm.
Advice to Beginning No-till Farmers

Adopt slowly. Develop a systems approach to no-till crop production.

**Don Lobb, Huron County**

No-till wheat is a good place to get started. If you plant into soybean stubble, your conventional drill may work, or rent a no-till drill. For corn ground you must have the proper equipment. Coulters are necessary for medium to heavier soils. On lighter soils you can make a lot of mistakes and get away with it.

**Doug Albin, Brant County**

Don't start like I did with 700 acres. You should start gradually and learn how to handle the residue.

**Clinton Pottruff, Brant County**

No-till requires a system change. You don't just look at a piece of equipment, you must look at the whole system. I think to make the system work properly you should be doing all of the known parts of it such as: banding fertilizer, using starter nitrogen, proper weed control, planned variety selection, proper equipment modifications, and residue management. All of these factors are important to make no-till work.

**Bruce Shillinglaw, Huron County**

Start with wheat into bean stubble. Working with a grain drill is a good place to start. Make sure you have perennial weeds in check and the field is well drained. But most of all use some patience and common sense when planting the crop.

**Bruce Cruickshank, Brant County**

Try a little bit at a time and talk to farmers who have done it. Make use of local resource people for information. We now have a lot of information in Ontario and it is a lot easier for someone today to get into no-till.

**Peter Cumming, Kent County**

Talk to other farmers and see what problems they have encountered and what problems you should look for in a no-till system.

**Cliff and Elwin Vince, Kent County**
Appendices
# Appendix I: Trouble Shooting The No-till System

## Poor Germination and Emergence

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cool soil temperature</td>
<td>- install tile drainage in poorly drained areas</td>
</tr>
<tr>
<td></td>
<td>- delay planting until the soil warms up</td>
</tr>
<tr>
<td></td>
<td>- clear residue out of the new plant row</td>
</tr>
<tr>
<td></td>
<td>- till the soil in the new plant row</td>
</tr>
<tr>
<td>Seed and seedling disease</td>
<td>- use a seed treatment</td>
</tr>
<tr>
<td></td>
<td>- identify the specific disease and take appropriate control measures</td>
</tr>
<tr>
<td></td>
<td>- rotate crops</td>
</tr>
<tr>
<td></td>
<td>- plant when soils are warm to encourage quick germination</td>
</tr>
<tr>
<td>Inadequate soil moisture</td>
<td>- plant into dead residue, ie. bum off weeds or cover crops well before planting</td>
</tr>
<tr>
<td></td>
<td>- control red clover and alfalfa in the fall</td>
</tr>
<tr>
<td></td>
<td>- reduce depth of coulter tillage</td>
</tr>
<tr>
<td>Poor seed placement</td>
<td>- adjust planter depth setting</td>
</tr>
<tr>
<td>(seed too shallow or</td>
<td>- adjust pressure on press wheels</td>
</tr>
<tr>
<td>poor seed to soil contact)</td>
<td>- utilize oscillating depth stops</td>
</tr>
<tr>
<td></td>
<td>- add weight to the planter</td>
</tr>
<tr>
<td></td>
<td>- spread residue evenly at harvest</td>
</tr>
<tr>
<td></td>
<td>- kill existing vegetation before planting</td>
</tr>
<tr>
<td></td>
<td>- replace worn out double disc openers</td>
</tr>
<tr>
<td>Seed placement too deep</td>
<td>- adjust planter depth setting</td>
</tr>
<tr>
<td></td>
<td>- adjust pressure on press wheels</td>
</tr>
<tr>
<td></td>
<td>- add depth stops to lift wheels</td>
</tr>
<tr>
<td>Poor seed slot closure</td>
<td>- use proper size and style of press wheels (match to coulters)</td>
</tr>
<tr>
<td></td>
<td>- avoid planting when the soil is too wet</td>
</tr>
</tbody>
</table>
### Poor Early Growth and Reduced Stand

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nutrient deficiency</td>
<td>- utilize starter fertilizer to improve chance of early uptake</td>
</tr>
</tbody>
</table>
| Cool, wet soil         | - select varieties and hybrids with good seeding vigour and cold stress tolerance  
- avoid planting corn (and some other crops) into cereal residue ie. rotate to different crops or remove residue from the new row area  
- improve drainage  
- kill cover crops and weeds earlier |
| Poor seed placement    | - ensure residue is not hairpinning in seed slot  
- ensure that the coulters and seed unit cut through the residue and place seed in contact with the soil  
- check alignment of coulters and seed units |
| Insect damage          | - cutworm damage can be reduced by killing all green vegetation  
- slug damage is reduced by clearing residue from row |

### Poor Root Growth

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Soil compaction         | - avoid wheel traffic on the field when it is wet  
- subsoiling may help in the short term but the problem will return if the cause is not corrected  
- utilize rotations or cover crops to produce good soil structure |
| Wet soils               | - improve soil drainage |
| Fertilizer burn         | - use safe rates of product  
- use safe product  
- check that the placement is not too close to the seed |

### Diseases

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
</table>
| Poor crop rotation      | - follow a good cropping sequence  
- if cover crops are used, ensure the ones chosen provide a break in the disease cycle  
- avoid wheat after corn |
| Susceptible varieties   | - plant disease resistant varieties |
## Poor Weed Control

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vegetation not controlled prior to emergence</td>
<td>- use a burndown prior to crop emergence</td>
</tr>
<tr>
<td></td>
<td>- identify weeds prior to planting</td>
</tr>
<tr>
<td></td>
<td>- match burndown treatment to the weeds present</td>
</tr>
<tr>
<td>Failure to recognize change in weed spectrum</td>
<td>- scout the fields on a regular basis</td>
</tr>
<tr>
<td></td>
<td>- select appropriate weed control method for your weeds</td>
</tr>
<tr>
<td>Improper timing</td>
<td>- control the weeds at the proper growth stage</td>
</tr>
<tr>
<td></td>
<td>(remember no-till weeds get off to an earlier start)</td>
</tr>
</tbody>
</table>

## Nutrient Deficiency

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improper nutrient levels</td>
<td>- soil test and fertilize according to recommendations</td>
</tr>
<tr>
<td></td>
<td>- band phosphorus and potash where possible to maintain soil test levels</td>
</tr>
<tr>
<td>Poor nitrogen placement</td>
<td>- inject all nitrogen for corn below the residue where possible</td>
</tr>
<tr>
<td></td>
<td>- legume crops in rotation will provide some nitrogen to the following crop</td>
</tr>
<tr>
<td>pH level in soil</td>
<td>- adjust pH according to soil test</td>
</tr>
</tbody>
</table>
Appendix II: Trouble Shooting No-till Equipment — Planters and Drills

### Shallow Seed/Fertilizer Placement

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor coulter penetration</td>
<td>- add weight to the planter frame</td>
</tr>
<tr>
<td></td>
<td>- adjust tillage coulter depth</td>
</tr>
<tr>
<td></td>
<td>- change type of coulter—a narrower coulter is easier to get into the ground</td>
</tr>
<tr>
<td></td>
<td>- avoid planting when the soil is too dry</td>
</tr>
<tr>
<td></td>
<td>- ensure coulters are sharp</td>
</tr>
<tr>
<td>Poor tracking of seed/fertilizer unit</td>
<td>- line up tillage coulter with fertilizer or seed opener</td>
</tr>
<tr>
<td></td>
<td>- on coulter caddies a wider, more aggressive coulter may be necessary</td>
</tr>
<tr>
<td>Planter unit bounce</td>
<td>- install oscillating depth stops</td>
</tr>
<tr>
<td>Poor seed unit penetration</td>
<td>- increase seed unit down pressure</td>
</tr>
<tr>
<td></td>
<td>- adjust seeding depth of unit</td>
</tr>
<tr>
<td></td>
<td>- adjust spring pressure on the unit and on the press wheel(s)</td>
</tr>
<tr>
<td></td>
<td>- adjust depth of tillage coulters</td>
</tr>
<tr>
<td></td>
<td>- align tillage coulters with openers</td>
</tr>
</tbody>
</table>

### Poor Seed Trench Closure

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inadequate firming of soil</td>
<td>- increase down pressure on press wheel</td>
</tr>
<tr>
<td></td>
<td>- change to a narrower press wheel or wider tilled strip</td>
</tr>
<tr>
<td>Soil too wet</td>
<td>- plant when the soil is at proper moisture</td>
</tr>
<tr>
<td></td>
<td>- use a burndown to speed soil drying</td>
</tr>
<tr>
<td></td>
<td>- install tile drainage to improve variable soil moisture conditions</td>
</tr>
</tbody>
</table>

### Erratic Seed Drop/Skips

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slipping drive wheel /coulter</td>
<td>- add weight to the planter or drill</td>
</tr>
<tr>
<td></td>
<td>- add fluid to the drive wheel</td>
</tr>
<tr>
<td></td>
<td>- change to a more aggressive drive wheel/coulter</td>
</tr>
</tbody>
</table>
### Seed Placed Too Deep

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage coulters set</td>
<td>- raise the coulters up</td>
</tr>
<tr>
<td>too deep</td>
<td>- reduce the pressure on the springs (drills)</td>
</tr>
<tr>
<td>Planters running too</td>
<td>- adjust depth setting on the units</td>
</tr>
<tr>
<td>deep</td>
<td>- add pressure to the press wheels</td>
</tr>
<tr>
<td></td>
<td>- remove weight from the drill or planter</td>
</tr>
<tr>
<td></td>
<td>- add depth stops to the hydraulic cylinders on the lift wheels</td>
</tr>
</tbody>
</table>

### Residue Plugging

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor residue flow</td>
<td>- there should be adequate space between seed units, press wheels, lift</td>
</tr>
<tr>
<td></td>
<td>wheels etc. to allow for good residue flow</td>
</tr>
<tr>
<td></td>
<td>- residue flow can be improved on drills by staggering the seed units</td>
</tr>
<tr>
<td>Too much residue</td>
<td>- drive at an angle to old crop rows</td>
</tr>
<tr>
<td></td>
<td>- plant between the old rows</td>
</tr>
<tr>
<td></td>
<td>- remove the straw from cereal fields</td>
</tr>
<tr>
<td></td>
<td>- spread residue evenly at harvest</td>
</tr>
<tr>
<td>Residue not cut</td>
<td>- use a 17” coulter</td>
</tr>
<tr>
<td></td>
<td>- make sure coulter blades are sharp</td>
</tr>
<tr>
<td></td>
<td>- delay planting until residue is dry</td>
</tr>
<tr>
<td></td>
<td>- adjust coulter depth</td>
</tr>
</tbody>
</table>

### Excessive Horsepower Requirements

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tillage coulters too</td>
<td>- raise tillage coulters</td>
</tr>
<tr>
<td>deep</td>
<td></td>
</tr>
<tr>
<td>Too much coulter</td>
<td>- use fewer coulters</td>
</tr>
<tr>
<td>tillage</td>
<td>- till shallower</td>
</tr>
<tr>
<td>Disc furrowers set</td>
<td>- raise disc furrowers to just clear residue from row area</td>
</tr>
</tbody>
</table>
Appendix III: Control of Problem Weeds

**Alfalfa**  
(perennial forage)  
- fall application of glyphosate, dicamba or 2,4-D

**Canada Fleabane**  
(annual)  
- spot sprays of dicamba, 2,4-D, 2,4-D/mecoprop/dicamba, or glyphosate  
- these are most effective at the flowering stage  
- spot spray bentazon (two applications are best)

**Chickweed**  
(common, mouse-eared -annual or winter annual)  
- 2,4-D and MCPA do not control these  
- dicamba or 2,4-D/mecoprop/dicamba at the flower stage will give good control  
- glyphosate prior to planting

**Dandelion**  
(perennial)  
- high rates of 2,4-D are usually effective  
- glyphosate may also be used (fall application)  
- first year plants are easier to control  
- fall applications are recommended
**Dogbane**
(hemp and spreading - perennial)
- difficult to control
- repeated treatments of amitrol or 2,4-D/mecoprop/dicamba may reduce it
- amitrol, 2,4-D/mecoprop/dicamba, 2,4-D/dicamba or glyphosate as a spot treatment will control it

**Field Bindweed**
(perennial)
- chemical controls are most effective at the flowering stage
- spot sprays of dicamba, 2,4-D/mecoprop/dicamba, or glyphosate

**Field Horsetail**
(perennial)
- suppression with MCPA or linuron by burning off the tops
- drop nozzle into corn or spray after cereal harvest
- amitrol as a spot treatment

**Goldenrod**
(perennial)
- dicamba will give some control if a split application is used
- high rates of glyphosate are also effective
**Groundcherry**  
(perennial)  
- spot treatment with glyphosate, dicamba or bromoxynil  
  (controls top growth only)

**Milkweed**  
(perennial)  
- spot sprays of dicamba, amitrol or glyphosate may need to be repeated  
- wick weeders are ideal for treating this weed in soybeans  
- these are most effective at the early bloom stage

**Prickly Lettuce**  
(winter annual, annual and biennial)  
- 2,4-D, MCPA, dicamba, glyphosate

**Prostrate Knotweed**  
(annual)  
- dicamba, glyphosate
**Quackgrass**  
(perennial)  
- glyphosate when the grass is actively growing is effective

**Red Clover**  
(short lived perennial)  
- fall application of glyphosate (if grasses are present) and a separate application of 2,4-D or dicamba

**Thistles**  
(Canada and Sow - perennial)  
- 2,4-D/mecoprop/dicamba, dicamba, bentazon, 2,4-D or 2,4-DB give control  
- spot treatment with glyphosate is also effective
## Wild Carrot
*biennial, perennial*

- dicamba, high rates of glyphosate
- difficult to control

## Wirestem Muhly
*perennial*

- apply glyphosate in midsummer
- fluazifop-butyl or sethoxydim may be used in soybeans

## Yellow Nutsedge
*perennial*

- post application of atrazine and oil or bentazon plus oil or linuron plus oil will control top growth
- spot spray with glyphosate or amitrol

---

**Note:**
The table above is intended only as a quick reference guide for some problem weeds. For the correct rates and timing of applications you should always refer to the label of the product to be used, OMAF Publication #75—Guide to Weed Control or consult your local extension person.
Appendix IV
No-till Equipment Checklist

Factors to be checked prior to purchasing any no-till equipment:

<table>
<thead>
<tr>
<th>Drill</th>
<th>Planter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- coulter type—ripple (plow), wavy (fluted), bubble</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- depth adjustment for coulter</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- down pressure system for coulters and seed/fertilizer openers</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- residue flow past coulters and openers</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- seed/fertilizer openers in line with coulters</td>
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<td></td>
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<tr>
<td>- structural strength</td>
<td></td>
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<td></td>
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<tr>
<td>- built in weight or ability to add weight</td>
<td></td>
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<td></td>
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<tr>
<td>- ability to travel over rougher seedbed, ie. oscillating depth stops</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>- units down pressure system</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- ability to plant around corners</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- match press wheel to coulter type</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>- exposed chains or drive mechanisms</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- drive system, ground vs. coulter</td>
<td></td>
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<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>- fertilizer options</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>- seed delivery system</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>- heavy duty marker</td>
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<tr>
<td>- ability to add harrows</td>
<td></td>
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<tr>
<td></td>
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</tr>
</tbody>
</table>
Appendix V: Additional Reading

OMAF Factsheets
Coulters and Press Wheels (Agdex 570/740)—publication # 90047
Cover Crops in Conservation Farming (Agdex 537)—publication # 90196
Fertilizer Management in Conservation Tillage Systems: Phosphate and Potash
(Agdex 540)—publication # 90067
Nitrogen Management in Conservation Tillage Systems for Corn
(Agdex 111/570) Publication # 90048
No-till Grain Drills (Agdex 516/742)—publication # 88080 Soil Compaction
(Agdex 510)—publication # 88082
Suitability of Conservation Tillage Systems to Ontario Soil Types
(Agdex 512) publication # 90198
What You Should Know About Soil (Agdex 500/010)—publication # 87079
Planter Modifications for No-till (Agdex 100/742)—publication # 90159

Other OMAF Publications
Cropland Conservation Farm Planning
Conservation Tillage Handbook—Equipment Modification and Practical Tips for Use
Tillage 2000—Final Report
Publication 296—Field Crop Recommendations
Publication 75—Guide to Weed Control
Land Stewardship Practices Manual
Soil Erosion Control Manual

Audio Visual Resource Materials
Conservation Tillage—Making the Switch Conservation Tillage and Residue Management

Other Resources
OMAF Extension Staff
Soil and Water Conservation Information Bureau Local Conservation Authorities