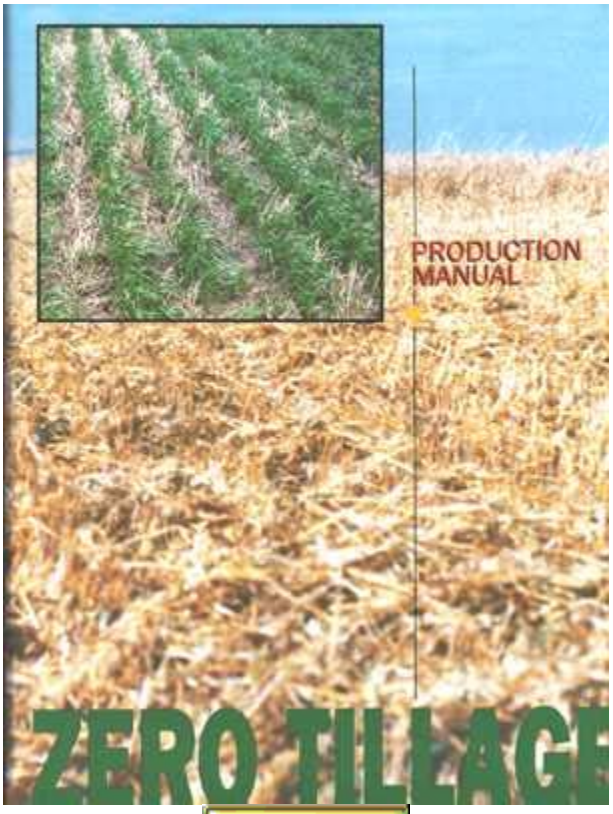

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Production Manual ~ PUBLISHING DETAILS

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The assistance of Zero/No-Till farmers, extension workers and research staff in Canada and the United States is acknowledged with appreciation.

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The Manitoba-North Dakota Zero Tillage Farmers Association

Zero Tillage Production Manual

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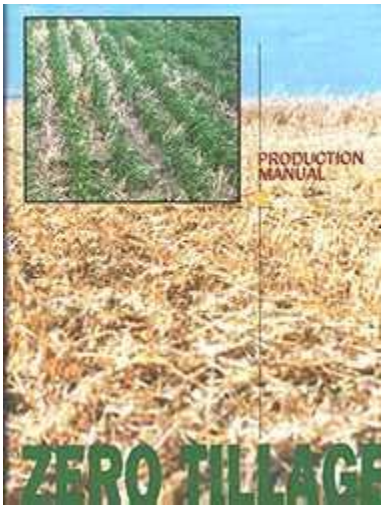

Production Manual ~ FROM THE PUBLISHER

The art of no-till farming is developing every year. This production manual will provide answers to your questions about this new cropping system. The manual contains information from experienced zero / no-till farmers. It is not a specific set of production recommendations; rather it deals with what experienced producers are doing. Registered product uses and official recommendations vary between Manitoba and North Dakota. This means that information in this manual may differ from official recommendations in your area. Some herbicide information in the text varies from what is published on the label of various products. Information in this manual supplements that of the manufacturers and the offical Manitoba and North Dakota Weed Control and Crop Production publications. Farmers have used off-label application rates with various results. Any decision to vary registered or recommended procedures should be based upon experience as you develop your own no-till production system. In the final analysis, read the label.

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Production Manual ~ FROM THE PRESIDENT

Zero tillage is an economical, viable alternative to the conventional methods used to manage our soils this century. Anyone looking for practical methods to reduce soil erosion while at the same time rebuilding organic matter will find this manual contains a wealth of information - information from those who have used zero tillage for a significant period of time.

It's hard to break with tradition, even though conventional ways lead to soil degradation. We now have the technology and the tools to work in residue and all we need is the leap of faith to start rebuilding our most valuable resource. Zero Tillage can play an important role in the future well being of our soil.

Leonard L. Rance

President

Manitoba-North Dakota Zero Tillage Farmers' Association

AS EARLY AS THE MID-1960's,

concerns about erosion. time spent in field work and increasing energy costs had moved a **small** number of Manitoba and North Dakota farmers to try direct seeding a crop into the standing stubble from the previous year. Results were less than exciting because herbicides were not available to do a good job of weed control and available seeding equipment did not do a very good job.

As herbicides improved (most notably as Roundup became available). it was possible to control the weeds without tillage. Adaptations of standard model disc drills with the addition of a third courter in front to cut through the trash allowed for placement of the seed. By about 1975, zero till pioneers like Manitobans Jim McCutcheon at Homewood and Brian Harvey at Durban and North Dakotans Bob Nowatski at Langdon and Luther Bernston at Adams had become serious about converting to zero tillage. Their farms gradually changed over to no-till production as they learned more about the new management style. Efforts by these and many other farmers to make zero till work included many hours in the farm shop adapting and readapting seeding equipment.

The first zero till work at the University of Manitoba took place in 1969 when Chipman Chemical Company funded research on plots at six different sites on a wide range of soil types. The idea was to demonstrate the basics of zero till crop production. About the same time? early work at North Dakota State University's Cassleton station focused on energy costs and showed that no-till offered significantly lower costs of production due mainly to fewer tractor hours.

The objective of the no-till pioneers was to place seed and fertilizer in the ground with absolutely no soil disturbance. They soon found this was virtually impossible. As new equipment became available - in many cases equipment designed specifically for zero till farming. and as farmers' understanding of zero till farming matured. their objective moved from one of NO SOIL DISTURBANCE to a more practical MINIMUM SOIL DISTURBANCE.

The advantages of zero tillage have been demonstrated over two decades of continuous no-till cropping on some farms. Advantages in erosion prevention. moisture management. and reduced fuel costs have gained in importance through the 1980 s and it is apparent they will be even more significant in the 1990 s.

In 1979, this IHC 620 drill of Jim McCutcheon's was modified by adding a cutting coulter in front of the regular double disc opener. No-till farmers have led the way in drill design.

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HERE ARE THE ADVANTAGES

No-till farmers usually describe the advantages to the farming system they have adopted in terms of better management of the soil and improving the soil's ability to produce a crop. However, the ultimate test for any practical farming system is economic does the system offer the same or better returns for the labour and money invested?

Like any system, the no-till system will need to be continually modified in response to changing times and circumstances. To date, however, the zero tillage system has passed both the economic and soil management tests.

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ADVANTAGES AND DRAWBACKS

Be aware of some of the drawbacks to no-till farming. In a system where herbicides replace tillage, herbicide costs will be significantly higher than under conventional farming. Under no-till, soil incorporated herbicides are not used. Greater knowledge of weeds is required, including a changing weed spectrum plus the various stages of their growth' It is vital to know how to use herbicides effectively - timely application, rates, possible use of surfactants and additives. Late spring frost damage to crop seedlings can be more severe under zero tillage although today's hoe-type drills expose more heat retaining black soil. Proper spreading of straw and chaff takes knowledge and experience. A zero-till field may not be as smooth as a conventionally tilled one - spraying, swathing and combining in the same general direction the field was seeded will help. With zero till, you learn a new management system - one in which the use of some herbicides has been altered.

Zero till farmers are aware of these drawbacks but consider them minor compared to the long term benefits of this farming system.

MOISTURE CONSERVATION

Zero tillage improves the soil moisture picture on a field by trapping snow and reducing runoff of both snow and rain water. Better infiltration of surface water and reduction of surface evaporation also contribute to soil moisture availability. The improved soil moisture condition means shallower seeding, uniform germination and early emergence.

[**BACK to ADVANTAGE LIST**]

IMPROVED YIELDS

Zero till farmers are reluctant to boast of major increases in crop yields. The fact is that on average, yields are the same or higher with no-till than with conventional farming. In a dry year, you can expect better returns than under a conventional system. The trapped snow provides that much needed early spring moisture to get the crop started and the surface mulch keeps the existing moisture from evaporating.

[**BACK to ADVANTAGE LIST**]

REDUCED LABOUR, MORE TIME FOR MANAGEMENT

Zero tillage reduces the amount of time and labour required to get the crop in the ground by reducing the number of passes across the field. This means less time pressure during the busy seeding season and often means that the seeding gets done when it should.

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LESS FUEL USED

A traditional tillage system utilizes as many as half a dozen operations to prepare the seedbed and seed the crop. Zero tillage uses only one or two passes over the field. The tillage operations utilize large amounts of fuel - fuel that is becoming increasingly expensive. Zero till farmers' records show that fuel consumption for production of a crop may be half that of their neighbours. The immediate cost reduction plus the reduced use of the non-renewable fuel resource make zero tillage attractive.

Tractor fuel is a variable expense; the tractor is a fixed expense. no-till can cut costs in both cases.

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EQUIPMENT SAVINGS

No tillage means less total horsepower requirement. Depending upon individual situations, this may not mean a change to a smaller tractor but it certainly prevents the need to go to a larger unit. Reduced operating hours annual means greater tractor longevity. Long term, this means lower costs and reduced investment in horse power. Most equipment suitable for zero till seeding have costs comparable to conventional equipment.

The reduced investment in tillage equipment and in 'throw-away' parts such as cultivator shovels is significant.

[**BACK to ADVANTAGE LIST**]

NO INCORPORATION TILLAGE

Herbicides, especially glyphosate,, replace tillage operations under zero tillage. Reductions in cost of glyphosate have helped make the adoption of zero tillage more feasible.

Zero tillage eliminates pre-plant incorporated products from the weed control arsenal. High concentrations of residual-type herbicides used with tillage can be an environmental concern when considered with erosion. Postemergent herbicides applied under zero till can be used in spot or general applications as and if needed after emergence of the weeds.

[**BACK to ADVANTAGE LIST**]

EROSION CONTROL

Simply stated, soil erosion by wind and water is caused by a lack of protection on the soil surface. The field's long term ability to produce a crop is affected. Erosion also results in higher immediate crop production costs - costs like reseeding and higher fertilizer rates. Zero tillage leaves standing stubble and spreads crop residue back on the field to reduce soil erosion.

Zero tillage also helps to reduce the more general costs of erosion which appear off the farm. Everyone bears the cost of clearing soil from roadsides and waterways and the environmental impacts of fertilizer or herbicides eroded from the field. Zero tillage cuts these costs by reducing erosion.

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Production Manual ~ HOW DO I START?

Take a cautious approach. Keep the following in mind:

Start with fields where the straw and chaff from the previous crop was properly spread - or go to a low residue field such as a canola or flax field.

- Use seeding equipment that will do a good job.
- Since tillage is being eliminated, know how to use the herbicides that will replace it.
- Specialized drills may be available on a rental or demonstration basis - try to gain experience without making a large capital investment
- no-till begins at harvest time. Be sure that straw and chaff are well spread across the width of the swath.
- Attend the annual winter workshop and summer field tour of the Manitoba-North Dakota Zero Tillage Farmers Association. Take out a membership.
- Talk to experienced zero till farmers. Learn from their experiences and mistakes.

Production Manual ~ NO-TILL & SOIL MOISTURE

With any crop, the most limiting factor is usually water. Nutrients can be added and weeds, insects or diseases can be controlled but soil moisture is the key ingredient to start the crop and keep it growing. Zero till can have a positive effect upon the amount of moisture in the soil for germination and early crop growth.

Research has shown that soil moisture was increased by leaving stubble standing on a field. In years that are dry going into winter, this could really help next season's crop yields.

 *This is moisture you can count on when seeding starts.*

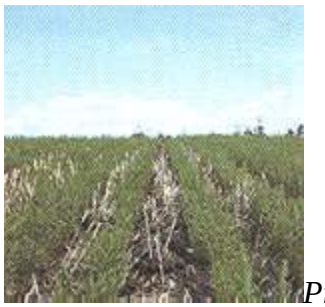
Stubble full to the top with snow is a guaranteed source of readily available soil moisture for spring seeding. Research in North Dakota, Saskatchewan and Manitoba found that the moisture from stubble trapped snow was important. Stubble 8" - 10" high full of snow accounted for 1" -2" of soil available water under these experiments. Every extra inch of water can mean as much as five extra bushels of wheat.

While holding extra snow on a field is one of the benefits of the stubblecover left by zero tillage, a number of other things contribute to the positive side of the soil moisture picture.

- Standing stubble reduces the amount of water which runs off a field. Not only does this reduce erosion, but it also holds more water on the field to soak into the soil.
- Precipitation (both rain and snowfall) tends to stay where it falls. Reduced snow drift and water movement means that every part of a field -including slopes- enjoys the benefits.
- Once the water has soaked into the soil - the mulch at the surface in a zero till field reduces water loss from evaporation.
- When tillage is eliminated, soil moisture loss is reduced. Cultivating dries the soil down to the depth of tillage. This amounts to as much as 1/2 inch of lost moisture per tillage operation.

In a wet year, excess moisture could delay seeding; but most seeding equipment used for zero- till can handle wetter conditions. Some producers in cooler, moister areas find fall banding can make spring seeding operations go more smoothly. The exposure of some

dark soil caused by the banding operation often causes the surface to dry out enough to allow timely seeding.

 *Picture a field of no -till with millions of miniature dams on it - they will pond the water and let it infiltrate before it runs off."* ***Luther Bernston Adams****, North Dakota*

"When we get a two_inch rain - the water seems to go into the ground real well. We don't have the potholes and we don't have the erosion like conventional farmers do. " ***Myron Hahn****, Gardena,, North Dakota*

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INFILTRATION

Most producers and researchers have found more advantages and fewer management problems as the number of years in no-till increases.

The problem of water saturated surface soil at seeding time is often cited as a primary problem of zero tillage. This occurs only until soil conditions improve to allow excess water to move deeper into the soil.

Since root systems are not disturbed by tillage, root channels allow greater movement of water deeper into the soil. Earthworm populations increase significantly under no-till conditions. The positive effects of earthworms may be an important factor in successful no-till programs.

Along with the value of earthworm channels in increasing water infiltration, the importance of earthworm activity in incorporating residue and improving soil aeration should not be underestimated.

Anchoring the stubble in the soil with a fall tillage operation may help reduce wind erosion, but it won't catch and hold snow for much needed spring moisture. Stubble-trapped snow is a kind of "insurance policy"" for your no-till farming operation. Most of the snow in the lower picture ended up in the bush at the edge of the field.

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COMPACTION

One of the myths about zero tillage is that it leads to an increase in soil compaction since there is no tilling of the soil to loosen it. In fact, the opposite appears to be true. Once a field is established in zero till, there is a noticeable improvement in filth. The undisturbed surface mulch and root network of a no-till field better support field equipment.

The freezing and thawing of soils in the northern Great Plains helps but isn't as effective as once thought in breaking up soil compaction. It can take several freeze-thaw cycles to off-set the compaction effects of a single season's traffic.

It is important to remember that not all soil compaction is harmful. For example, firming the soil over the seed row promotes good seedsoil contact for fast germination. The firm soil promotes root branching and formation of secondary roots and results in increased uptake of non-mobile nutrients such as phosphorous. Ideally, crop producing soils should be about 50% pore space with the space shared equally by water and air. This ideal is lost when the soil particles are squeezed together by an outside force such as tractor wheels.

With today's large equipment, there is more field work being done when soils are wet. Since wet soil is most susceptible to soil compaction, problems (under either zero tillage or conventional tillage) can be reduced by avoiding field activity when the soil is wet. This a tough decision to make when the costs of delays are considered. One of the advantages of zero tillage in the spring is reduction of that time pressure since not as many field operations are required. It stands to reason as well that with fewer passes across the field - compaction will be less.

Over the course of time in a no-till field, normal forces will break down any compaction to allow the crop greater access to the moisture and nutrients deeper in the soil.

The wheels of modern agriculture are the major cause of excessive soil compaction - the more passes with equipment, the more the soil packs.

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In Summary:

1. Soil moisture is the major limiting factor to crop production.

2. Zero till increases soil moisture for early crop growth.

3. With no-till there is less evaporation from the soil surface after the crop's in the ground.

4. There is no evidence that zero till contributes to compaction.

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Production Manual ~ RESIDUE MANAGEMENT

Residue Management is important to the success of no-till farming. Residue management affects erosion control, moisture conservation, seed and fertilizer placement, crop emergence and weed control. Residue management starts at harvest time when you handle straw and chaff from the combine.

Spread the straw and chaff as evenly as possible. The best way to do this is with good straw and chaff spreaders on the combine. It may be necessary to harrow after harvest in a year with particularly heavy straw. However, a well adjusted straw chopper/spreader can make harrowing unnecessary most years. It is NOT POSSIBLE to spread chaff effectively by harrowing. An efficient chaff spreader will prevent that two or three inch thick blanket behind the combine. If the chaff is not well spread, there will be problems all season long. The first problem is poor performance of the seeder through the chaff row. Plant growth will be weak with spindly plants which are more susceptible to disease. There will be extra growth of weeds and crop volunteers in the chaff row as well as more weed problems because of reduced competition from the crop. Finally, there will be later maturity in the strips which will delay harvest. Another problem is a biochemical interaction called allelopathy where the residue from certain plant species may exude growth inhibitor. Because of this, in poorly spread chaff rows, there is often noticeably less crop growth in a subsequent year.

While harrowing is not an efficient means of spreading the chaff and straw, there is another reason why some zero tillers harrow after harvest. Harrowing can promote fall growth of weeds and crop volunteers and can be a way to make the fall weed control program more effective.

"The first year, we thought we could get away without chaff spreading, so we didn't bother. In the spring, about mid-May it was 8 degrees celsius cooler at the 4-inch depth of the soil under the chaff row. It delayed emergence by three days and maturity by a week. Because of that, we couldn't straight combine most of the crop that year. "

Robert Stevenson Oak Lake, Manitoba

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Straw & Chaff Spreading

Most combines today spread straw only about 15 to 25 feet . This is narrower than the width of cut most combines can handle. The Prairie Agricultural Machinery Institute says farmers should be concerned with getting straw evenly spread. While choices include sizing the cutting width and purchasing specialized choppers, many farmers have adapted or improved the existing choppers and spreaders on their own combines. PAMI suggests that farmers can do the following to improve existing straw chopper performance. make sure concave knives are sharp and the flails are square Dull knives and rounded flails reduce cutting effectiveness and use extra power. on many combines, using larger deflector fins will give a wider spread

Chaff spreading is usually accomplished by adding a spreader below and behind the sieves. Spreaders are either mechanically or hydraulically driven. Most spreaders move the chaff mechanically using paddles - others use air. Some spreaders must be used in conjunction with a deflector to move chaff from sieves to spreader. In summary, things to look for in a chaff spreader are: ~ low power requirements ~ reasonable uniformity in spread ~ ability to check losses and access adjustments for the cleaning shoe

Cutting Height

While many try to leave as much standing stubble as possible in order to trap snow, leaving too much stubble can result in seeding difficulty the following year. Experience with seeding equipment will help decide what works best. The better the equipment's ability to clear trash, the higher it is possible to leave stubble. Generally, cutting 10 inches high produces the best results. An important addition to harvest equipment is a cutting height indicator. It is especially important on straight cut headers and particularly useful when cutting at night. Either a 'home_made' indicator or one of the commercially available units will do the job.

Cutting height is one of the areas which demands considerable operator judgement The type of crop and amount of growth dictate what is possible. Cutting too low means a loss of snow holding capability and reduction in no_till's ability to improve the soil moisture picture - too high means potential problems with seeding equipment clearance.

"Your stubble must fit the ability of your drill to deal with it. A disc drill might go through - but will it seed properly? - a hoe drill might place the seed properly but act as a 'rake' if stubble is too high or if straw and chaff are poorly spread. It is very important to have good control on swather height. "

Gordon McPhee, Dauphin, Manitoba

This is where zero tillage REALLY starts. Proper spreading of chaff and straw is vital to the successful emergence of next years crop.

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Take Advantage of Residue

Crop residue is an important resource for no-till farmers. Handling large amounts of residue is a challenge - but the rewards are quickly apparent. The immediate benefits of the residue cover in terms of erosion control and snow trap are augmented by the longer term improvements to soil structure. Only in cases where there is too much straw to spread effectively should it be removed from the field. Of course, there are cases where the straw is needed for use in livestock operations or where chaff might be useful as feed.

The idea is not only to maintain a complete cover for moisture conservation purposes but also to leave that residue to maintain soil organic matter.

Standing residue protects the soil from wind erosion and it traps snow but it does not decompose quickly because limited contact between residue and soil allows the residue to dry and reduces microorganism activity. When contact between the residue and soil surface is increased by careful spreading of straw and chaff or other means, the rate of breakdown speeds up because of better soil-residue contact which enhances microorganism activity and water availability.

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Crop Choices for Residue Management

What you decide to grow determines the amount of residue. These same decisions allow you to vary the amount of residue from year to year.

- Small grains have the most residue while row crops or crops such as rapeseed/canola or mustard leave considerably less residue.
- Crops such as lentils or beans which must be cut very low to the ground produce very little residue.
- Choosing a short strewed or semi_dwarf variety will reduce amount of straw being handled.

Residue of some crops and even some varieties breaks down more readily than others. Canola residue breaks down more easily than flax, barley more easily than wheat, durum more easily than spring wheat.

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Weeds, Insects & Diseases

When residue is properly handled, problems with weeds, insects and diseases in a no-till situation are the same as with conventional tillage. It is only when residue is poorly managed that there seem to be extra problems.

More severe weed problems can develop where straw and chaff are not well spread. It usually results because of slower crop emergence in the cooler soil conditions under that residue blanket.

Under these same conditions crop diseases can take hold in the less vigorous plants. A contributing factor may also be the concentration of disease innoculum in the chaff row. However, if disease problems exist in zero till farming (as in conventional tilled fields), they are usually the result of too little attention to good crop rotation practices.

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In Summary:

1. Handling straw and chaff properly is #1 priority.

2. Don't count on harrows - chop and spread crop residue right from the combine.

3. Cutting height depends on the type of crop/ type of soil/ type of drill.

4. Crop choices affect amount of residue.

5. Good rotation will alleviate weed, insect and disease problems.

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Production Manual ~ ROTATIONS

Economics play as big a role as agronomics in the selection of crops grown under any cropping system. Government farm programs and market conditions must be considered in cropping decisions. Unfortunately, these decisions sometimes run contrary to good crop rotation practices.

If choices about rotations are being made on the basis of good crop production practices alone - usually the decisions will be the same regardless of whether it's zero tillage or conventional tillage. No matter what system is used, crops grown in the rotation should be chosen with disease, weed and insect control in mind. It is important to establish a rotation which minimizes the effects of these problems or which allows a wide range of control options.

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Disease Is A Concern

In no-till farming, like ordinary farming, it is not a good idea to plant a crop back into its own residue. In traditional tillage systems, turning straw under plays a role in killing the disease organisms which overw inter in the residue. In zero tillage, attention to good rotations must be an offsetting factor.

Again it is important to stress the need for a good chaff spreading program. If chaff is not well spread, there may be a concentration of disease in the chaff row. Even where this potential disease problem exists, a disease outbreak will only occur where environmental conditions are right, control measures such as the use of fungicides are absent and a susceptible host crop is grown.

Crop residue has little influence on diseases such as rusts which are windborne but diseases such as leaf diseases can present major problems unless properly planned crop rotations are employed.

Many insect related disease problems can also be controlled through proper rotation and sanitation. Insect related disease problems such as wheat streak mosaic and barley yellow dwarf are controlled by keeping stubble free of volunteer grain and by late planting of winter grains. Insect problems such as flea beetle of canola may not be solved by rotation but their severity can be affected by rotation and other management practices such as seeding date and control of volunteer growth.

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The Ideal Rotation

The ideal crop rotation alternates between cereal crops and oilseeds or legumes from one year to the next. For example, a wheat_canola_barley_flax rotation allows you to avoid disease carryover from one crop to the next. It allows for control of volunteer plants from the previous crop. It also allows for control of weeds which might not have been controlled by herbicides used the year before. The yearly switch from cereals to broadleaf crops makes it possible to break the cycle of insects and diseases attacking a crop grown continuously on the same field.

With this type of rotation, the stubble of cereal crops will provide two years of soil protection. The standing stubble from the previous year continues to provide protection during the crop year where the lower residue broadleaf crops come into the rotation.

"Residue of wheat contains survival structures for many pathogens such as tan spot fungus, septoria leaf and glume blotch fungi, scab or head blight. Zero tillage increases risks of diseases because the fungal structures are not incorporated into the soil where microbes degrade straw and destroy the disease organism. That's why it is very important to use good rotation in a no-till program. "

Marcia McMullen, Plant Pathologist, North Dakota StateUniversity

There is a further benefit to the alternating cereal/broadleaf rotation. It's in the timing of the spring seeding operations. Fields In broadleaf crops the previous year are usually dry enough to seed before the cereal stubble. With a cereal/broadleaf rotation, the cereals which should be seeded first due to soil temperature and frost resistance are going into the lower residue broadleaf stubble which is ready first. This allows for early planting at optimum seeding dates.

But of course, the ideal is often not achieved. Many rotations designed with specific management and economic considerations in mind have worked well for zero till farmers in Manitoba and North Dakota.

"I strive for a broadleaf between cereal crops - it doesn't always workout that way but I'm fairly close to that in most years." Garth Butcher - Birtle, Manitoba

"Because of our farm programs, the only rotation we have is that we put wheat onto our barley ground and barley on wheat. However, we would like to use flax or soybeans - anything to break up the wheat on wheat or barley. " Myron Hahn - Gardena, North Dakota

'We have had peas canola and some flax and rotated with barley and wheat. Generally, in that sort of rotation, you would have to put wheat on wheat or barley on barley very little." Leonard Rance - Sperling, Manitoba

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Wide Variety of Cropping Choices

The choice of crops available for no-till production is virtually the same as in conventional farming. As with any cropping system, it makes sense to start with crops like wheat, oats, barley and flax which present few production problems. As experience and confidence are gained, other crops can be added to the program.

Zero tillage provides ideal conditions for the establishment of forage crops. There has also been great success in growing crops like canola, mustard, peas, lentils and sunflowers although herbicide options are more limited with zero till. In particular, weed control with pre_plant incorporated herbicides is not available. Greater attention to preventing weed problems, to crop rotation, and to crop competition are essential in ensuring good weed control when zero tilling these types of crops.

While there are no crops which can not be grown using zero tillage, crops like corn and sugar 'beets could present special problems. no-till corn and soybeans have been very successful particularly in south eastern North Dakota. In regions where heat units are more marginal for production of heat loving crops, cooler soil conditions found with zero till could affect early development.

Planning A Rotation

There are many things to consider in planning a rotation. Most of these are the same as in conventional farming programs. However, a zero till program does include some unique challenges and opportunities.

a) A low residue crop grown in the year between cereal crops will maintain a trash cover on the field but prevent a residue buildup which becomes a problem for seeding equipment.

b) Switching from cereal to broadleaf (or broadleaf to cereal) allows easy control of volunteer growth the next year.

c) Switching from cereal to broadleaf allows use of a different group of herbicides to control weeds - weeds difficult to control the previous year.

d) Planting a crop back into its own residue can result in increased disease problems in that crop.

e) There is more cropping flexibility at seeding time. Because no herbicides were applied the previous fall, it is possible to change seeding plans if special circumstances make this necessary. At the same time, non_availability of some soil incorporated products may force changes in cropping programs to allow control of some weed problems.

f) Legumes such as lentils, beans or peas have a nitrogen fixing capability which can reduce your nitrogen fertilizer requirement.

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In Summary:

1. If you can grow the crop - you can grow it under zero tillage.

2. The reasons for rotations are the same in zero till and conventional till farming.

3. Rotations must be planned with disease, weeds, insects and amount of residue in mind.

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Production Manual ~ SEEDING

Zero tillage ensures an ideal seed bed. It is firm and protected from wind and water erosion. Soil moisture is near the surface.

Zero till seedbeds look different and they are different from conventional till seedbeds. Many people initially see no-till seedbeds as messy, unkept and poorly managed. But just the opposite is true. Over time, you realize the beauty of a zero till seedbed..

The zero till seed bed evolves from a conventional till seedbed into a seedbed which has these characteristics: 1) Consistent residue cover means no crop loss due to wind or water erosion 2) Improved soil moisture conditions - a firm, moist seedbed 3) More suited to shallow seeding 4) More friable 5) Better trafficability - surface residue means seed, spray and harvest operations can be done with less soil compaction 6) Greater biological activity and more active organic fraction 7) Cooler

"Seed as shallow as possible. Generally our seed is placed about 1/2 to 3/4 of an inch deep and we've always got moisture for germination. The crop gets out of the ground quickly and then we rely on what acquired moisture we can get from there on. "

Bob McNabb, Minnedosa, Manitoba

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The Zero Till Seedbed

THE IDEAL

The ideal seed bed for crops grown in the Northern Great Plains is moist and firm - characteristics almost always guaranteed with no-till. The consistent residue cover provided by zero tillage traps snow and helps reduce the evaporation from the soil surface.

Obtaining good seedsoil contact was one of the largest problems faced by zero till pioneers. Thanks to vast improvements in seeding equipment and greater knowledge of the crop's germination requirements, crop establishment is now one of the greatest advantages of zero till.

Another aspect of a no-till seedbed worth considering is better trafficability. Over time, the undisturbed surface mulch and root network on zero till fields helps to improve water infiltration and aggregate stability so you can get on the field sooner after a rain

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IT'S COOLER The Advantages

There are several major advantages to a no-till seedbed. First of all, a no-till seedbed is initially cooler and moister. Unlike a conventional field, you can seed 'into moisture' on a zero till field at a much shallower depth. The surface of the soil warms more quickly and seedlings emerge quicker and stronger when seeded shallow. More favourable root growth and much less incidence of heat canker are two additional benefits found with the moister, cooler zero till seedbed. Fall and winter soil temperatures under the snow are actually higher with zero till. The warmer soil temperatures associated with the insulating value of trapped snow has been the reason for the successful no-till production of winter wheat in Manitoba and northern North Dakota.

IT'S COOLER Things To Watch For

There are two cases where cooler spring soil temperatures can pose a problem. The first is with heat loving crops like corn and soybeans especially in areas with marginal heat units. The cooler zero till conditions may retard crop development. As well, frost sensitive crops like canola are more likely to freeze on a zero till field than on a conventionally tilled field. The mulch cover on the zero till field has an insulating effect which keeps ground heat from radiating up at night to protect the crop from frost. In areas where frost has been a problem, no-till farmers have used a fall fertilizer banding operation and/ or a more aggressive hoe drill. By disturbing the mulch cover somewhat, more heat will be radiated from the exposed soil to provide protection from frost.

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NO DELAYS

Right from the start, zero till is able to trap more moisture. A concern of some farmers starting zero till is that seeding could be delayed in a wet spring. While this has happened occasionally, delays in seeding are generally not a problem. Seeding delays will only occur when there is an excessive amount of fall and spring moisture and on soils with poor internal drainage due to poor structure, excessive tillage or hard pans. The extra moisture available for crop growth on the zero till field will likely cancel any effect the delay may have caused.

A moister seedbed and a seedbed protected from erosion are the two most immediate and important changes which occur when switching to no-till. Other changes such as improved trafficability, greater biological activity and improved filth take longer to develop. Improved seedbed quality is a major benefit of zero tillage.

"A lot of the problems that farmers have had with zero tillage is seeding too deep. If you are used to seeding to moisture (under conventional seeding) and that is 2" to 3" and you are going to do that under zero till, you are going to penalize yourself pretty dramatically. "

Elmer Stobbe, Professor of Plant Science, University of Manitoba

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SEEDING EQUIPMENT

The choice of seeding equipment is one of the major equipment decisions faced by a zero till farmer.

There is no simple answer to the question of what is the best zero till seeder as no single machine will meet the needs of all farmers. Most machines will do the job under the right circumstances. Therefore, it is important to do a complete evaluation of both the requirements of the farm and of the machine's design.

The most important characteristics to look for in a drill are:

- seed/soil contact - The seed must be placed in moist soil away from crop residue. (Hairpinning of straw was a common problem with early double disc drills used for zero tillage.)
- ability to work in varying soil types under wet and dry conditions
- soil disturbance - How much residue remains and how much stubble is still standing after seeding? These are the keys to reduced erosion, reduced run_off and reduced evaporation.
- mechanical simplicity and reliability
- accurate seed placement - uniform, shallow seeding is important
- packing - should be adequate to produce good seed/soil contact
- trash clearance - front to back and top to bottom
- shank spacing - The narrower the row spacing, the more difficult trash clearance can become. On the other hand, too wide a row space should also be avoided.

fertilizer placement - Can it be done in one operation or is a separate banding operation needed?

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The Choice

There is a wide range of makes and models of zero till drills. There have been many changes since the modifications of the double disc press drills which were the first notill drills. Those double disc drills are no longer considered acceptable for zero tillage. Specialized zero till disc and hoe type drills and air seeders have replaced those early seeders. Some of the features to look for when considering the purchase of a zero till seeder are outlined on the next two pages.

'I found that the condition of our fields (after 10 years of zero till) was such that seeding with my disc drill was like trying to cut fresh bread with a dull knife."

Jim Mc Cutcheon, Homewood, Manitoba (on switching to a hoe drill)

HOEDRILLS

Standard two rank hoedrills should be differentiated from the high clearance three and four rank hoedrills. The standard two rank and some of the three rank drills do not have the clearance or the penetration capability of the high clearance drills and should not be considered for seeding under extreme trash conditions. Where stones are a problem, it is important to ensure a hoedrill is strong enough to operate in these conditions.

ADVANTAGES

- positive depth control
- even penetration in hard soil conditions
- good seed to soil contact
- clears heavy straw and chaff
- good packing

rugged construction with few wear points

DISADVANTAGES

- small seed and fertilizer capacity
- high draft compared to disc type drills
- slow to transport

HOEDRILLS With Banding Capability

Banding hoedrills combine the advantages of hoedrills with the capability of side banding high rates of fertilizers. The benefits of a single pass approach to seeding and fertilizing have resulted in a number of machines coming on the market capable of side banding under no-till conditions.

ADVANTAGES

- one pass seed and fertilizer operation
- side banded fertilizer is efficient
- high rates of fertilizer can be applied during seeding without germination damage
- high residue clearance capabilities
- good packing

DISADVANTAGES

- seedbed quality (firmness) can be affected by side banding due to soil disturbance by the fertilizer banding opener
- power requirements can be high
- soil disturbance can be high and leave fields rough
- complicated fertilizer delivery system
- seeding efficiency slowed due to down time required to handle large volumes of fertilizer

AIR SEEDERS

Since the late seventies, air seeders have become popular with farmers. Design improvements have resulted in machines that do an excellent job of seeding. Air seeders with narrow openers and onrow packers can be excellent zero till seeders.

ADVANTAGES

- efficiency - Air seeders are designed for relatively high speed operation but are also designed for rapid refilling of the fertilizer and seed tanks as well as rapid transport
- large seed and fertilizer capacity. Some machines are capable of side banding fertilizer while seeding
- rugged construction with few moving parts
- high residue clearance capability
- new, better designs of hoe drill ground tool

DISADVANTAGES

- standard cultivator is the weak link - poor depth control and front to back levelling can be a problem (newer designs address these problems)
- seed damage is possible with some seeds such as peas and beans
- effectiveness of in-seedrow granular insecticides (e.g. Furadan and Counter) can be less when used with air seeders with a spread pattern greater than one inch
- tow-between tanks can obstruct view
- packing by tow-behind tanks may cause reduced crop emergence and increase weed seed germination in tire tracks

DISC DRILLS

Disc drills include double disc drills, triple disc drills and double offset disc drills. The latter design provides better penetration under heavy trash conditions compared to the old double disc zero till drills.

ADVANTAGES

- good seed placement if straw and chaff are evenly spread
- minimum soil disturbance
- machines with gauge wheels provide more accurate seeding depth
- some machines are capable of banding while seeding
- good packing

DISADVANTAGES

- will not cut through heavy or tough straw conditions
- chaff punched into furrow opening (hairpinning) can reduce germination
- pressure on discs/ bearings can mean higher repair costs
- small seed and fertilizer capacity

- slow to transport

disc replacement can be expensive compared to replacing shovels or hoe openers

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DON'T HARROW AFTER SEEDING

Behind the seeder, there is no doubt that a zero till field may be a bit rough but it is not necessary to harrow the field to improve the crop.

The negatives of harrowing after seeding outweigh the benefit of creating an evener land surface. Harrowing destroys the stubble cover which has been retained through zero tillage. In heavy wind, even no-tilled fields have been seen blowing when harrowed after seeding.

Harrowing also promotes weed growth at the same time as it delays emergence since the seed has been buried deeper by filling the seed furrow.

The seed furrow increases water availability to the crop by concentrating rainfall in the bottom of the furrow. Destroying the seed furrow reduces the extent to which the field benefits from small rains.

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Production Manual ~ TALKING FROM EXPERIENCE

Every farmer has experienced good and bad times in developing his own unique style of farming. Zero-till farmers are no different. Following are some of the highlights and low points in the zero till experiences of the Manitoba and North Dakota farmers who provided information for this manual. They could help you avoid some of the pitfalls and share in the benefits of this erosion-proof method of farming.

Bob McNabb

Minnedosa, Manitoba

Robert Stevenson

Oak Lake, Manitoba

Luther Bernston

Adams, North Dakota

Scott Halley

Bisbee, North Dakota

Leonard Rance

Sperling, Manitoba

Gordon McPhee

Dauphin, Manitoba

Garth Butcher

Birtle, Manitoba

Jim McCutcheon

Homewood, Manitoba

Myron Hahn

Gardena, North Dakota

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 BOB McNABB

Minnedosa,, Manitoba

"I had a scare the first year when I decided to zero till a third of my acreage. The Roundup bill was $4,000 and I had to ask myself if this made economic sense compared to cultivation - it did. At the end of the first three years (it was really the first time I had the whole farm in zero till) I was asking myself if this was going to work - if I could count on good weed control in the years ahead if I kept on with zero till. That was a tough decision to make - I'm glad I did. "

"In 1981, we had a tremendous wind storm during seeding time in southern Manitoba. I was seeding and my soil wasn't blowing."

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 ROBERT STEVENSON

Oak Lake, Manitoba

"In 1986, the third year we were in zero till, it was a wet spring and a wet summer. We had made a lot of mistakes - especially not spreading straw and chaff properly, not controlling the weeds properly, not placing the seed in the ground properly. Nearly 25% of our crop was less than it should have been.

"Spring of '85, when the big windstorm of June 5 hit, our zero till fields stayed put and we had to reseed our conventionally seeded fields. Also, it's important to know that good soil moisture is something we can count on every spring. "

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 LUTHER BERNSTON

Adams, North Dakota

"In spring of '83, we were so wet around here it was difficult - very difficult - to get the no-till seeder on the fields. That was scary - definitely the low point. "

"When your soil stays in place during a gale force wind, to see the grain actually growing out of the stubble that first year- these are definitely high points. "

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SCOTT HALLEY

Bisbee, North Dakota

"I am concerned about the lack of support and recognition from government departments and chemical companies. They've been slow to jump on the band wagon. "

"The soil loss from my farm is virtually zero. "

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 Leonard Rance

Sperling, Manitoba

"I harrowed after seeding one year and a big wind caused a lot of wind erosion on that field - even though it was seeded zero-till. I don't do that anymore. "

"When I get my soil tests back, they indicate that organic matter is going up.... since I started to zero till. The land is easier to work now."

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 GORDON McPHEE

Dauphin, Manitoba

"I've had some poor results based upon inadequate equipment. We needed guidelines and benchmarks to help us proceed and we didn't have them in the first few years. "

"I get good crops - consistently- under a wider range of weather conditions. "

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GARTH BUTCHER

Birtle, Manitoba

"Any time we didn't spread the straw and chaff properly, we had troubles. "

"In 1984, our whole crop was zero till. It was a dry year_ the only significant rain was a three inch downpour in midsummer. So, with the additional spring moisture on my field from snow trap, plus that rain, I had significantly higher yields than the rest of the district - more than a 30% yield increase. "

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JIM McCUTCHEON

Homewood, Manitoba

"A low point?- trying to make a disc drill work and failing. "

"Knowing my top soil is secure while conventional tilled fields are blowing is a plus. "

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MYRON HAHN

Gardena, North Dakota

"I was concerned the first year we no_tilled. We seeded flax and had a great crop of kochia. "

"The last few years when it has been dry - we see a definite yield advantage with no-till. "

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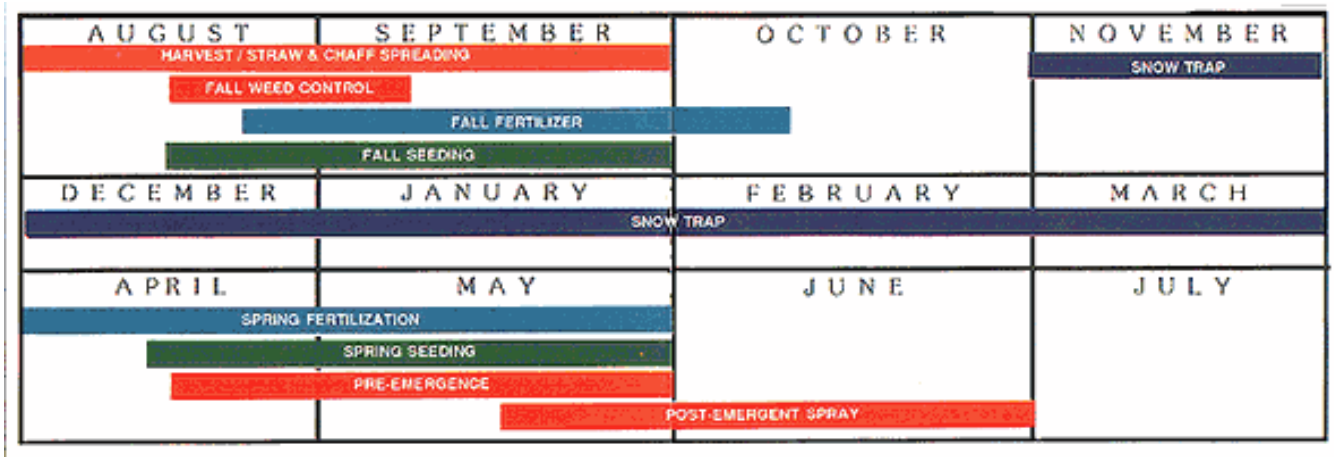
Production Manual ~ THE ZERO TILL CALENDER



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STRAW & CHAFF SPREADING

Residue management is the first thing to consider in zero tillage. Whether you plan to seed a fall crop that same year, or a spring crop next year, it is essential the straw and chaff be spread evenly after harvest. The best time to deal with crop residue is during harvest. Modifications to existing straw and chaff spreaders can do the job. Commercially produced spreaders are also available. The attachment is not expensive but some time will be needed to install and adjust. Harrowing shortly after harvest is an option if uniform distribution isn't achieved with the spreader but the harrow will not spread chaff effectively. Without a good residue management program, the rest of the zero till system is very difficult.

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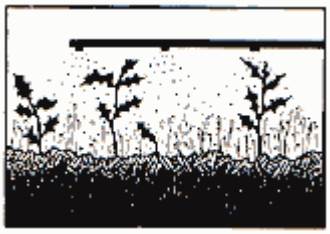
FALL WEED CONTROL



Fall is a good time to control winter annuals, quackgrass and other perennial weeds. The time between harvest and the first killing frost provides an excellent opportunity for weed growth and weed control. If fall growth allows, good control is possible. Spring pre-plant or in-crop control are good alternatives if fall applications are impractical. Generally, glyphosate is used for early spot treatment of quackgrass and 2 - 4, D is recommended in late fall before freeze-up for broadleaf weeds. A total field application of glyphosate is recommended only if excessive weed growth makes it necessary. If a fall seeded crop is to be planted, spray a day before or at least four days after seeding and before crop emergence A good marker or tramline system is important for accurate spraying in stubble.

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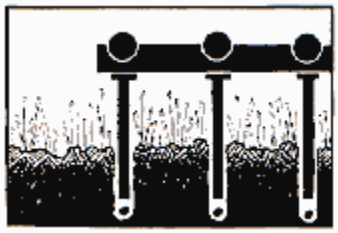
FALL FERTILIZATION FALL SEEDING



Banding fertilizer offers the same advantages in zero till as in conventional tillage. Likewise, broadcasting fertilizer has the same inefficiencies in both systems. Many implements which can be used for zero till seeding can also be used for fertilizer banding. Some drills, which allow fertilizer banding and seeding at the same time, reduce field passes and application costs.

Fall seeded cereals survive better with the trash cover offered by zero tillage. The challenge of seeding into the zero till trash cover has been simplified by the availability of a variety of equipment types. Zero till drills with hoe or disc type openers and air seeders have been used. It is important to match crop choices to the available drill type. Lesser residue crops should be grown if the drills is one with low trash clearance. While it is not recommended, trash removal may occasionally be necessary.

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SNOW TRAP

Trapping snow and saving that moisture for the use of the crop is what zero tillage is all about. A third of the annual precipitation in the prairie region comes in the form of snow. Standing stubble is a proven effective means of capturing and retaining the moisture for the next year's crop. The standing stubble and trash layer minimize wind erosion, run_off and water erosion, as well as evaporation from the soil surface in spring time. The higher moisture content of zero tilled fields allows for shallower seeding. This will offset any early soil warming advantage which tillage might have and allow for seeding as early or earlier on zero tilled fields. In wet years, excessive moisture may be a problem in zero till as it is in conventionally tilled fields. Shallow seeding, properly adjusted equipment, some field scouting and good judgment will help avoid problems. The undisturbed crop root systems and trash layer on the surface provide good support for farm equipment.

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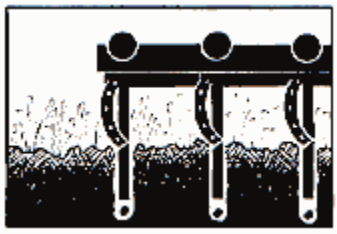
SPRING FERTILIZATION



As better equipment has become available for zero till farming, there has been a swing to spring application. Where equipment is available to side band fertilizer at the time of seeding, the operator enjoys the efficiency of one_pass seeding and fertilizer application. Placing the fertilizer with the seed is also possible with some zero_till seeding equipment but may require an additional pass with banding or broadcast equipment to provide the fertilizer required to meet yield goals. Spring banding is an option to consider as well, but it does involve an early operation on the field which disturbs and dries the soil surface. This will often add to trash clearance problems in the seeding operation - in particular making uniform seeding difficult.

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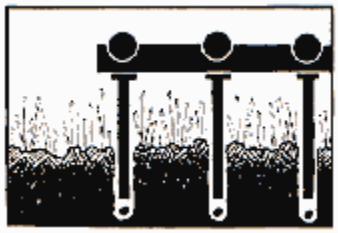
SPRING SEEDING



Farmers find that virtually any spring seeded crop can be grown successfully under zero tillage. The extra soil moisture retained in the field by the stubble is available when the crop needs it most - for germination and early growth. The extra moisture near the surface make shallow seeding possible under zero tillage. A uniform seeding pattern and accurate depth control on seeding equipment are essential.

Cropping decisions should be made on the same basis as under conventional tillage - with consideration of available equipment and labour, as well as with weed, disease and insect problems in mind. A combination of spring seeded and fall seeded crops in the zero till rotation makes it possible to spread the pressure on machinery and labour over a longer time span. Crop rotations should be designed to break disease and insect cycles and to allow for control of the weeds in each field.

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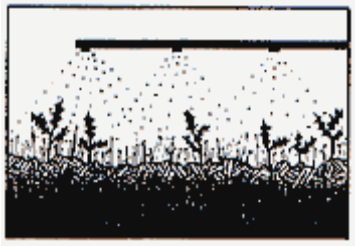
SPRING PRE-EMERGENCE CROP PROTECTION



Prior to the emergence of the crop, weeds represent the primary crop protection concern. Known weed problems should be considered in planning the crop rotation. There are some situations where chemical weed control options are limited. For example, no-till means no soil incorporated herbicides so some gaps do exist for control of weeds in crops such as canola.

Spring weed growth may be controlled with glyphosate before crop emergence. This application may be made just before or just after seeding. If pre-seeding, the application should be made a day ahead to allow product activity before the seeding operation. If it is postseeding, a couple of days should be allowed for the weeds to recover from the disturbance which occurs at seeding. Depending upon weed populations - spot treatments may be all that is required. To ensure the most efficient possible operation, sprayer and nozzle calibrations must be correct and the weed must be in the correct stage for control. Spray surfactants should be used where appropriate to improve product effectiveness. Ammonium sulfate will enhance the effectiveness of glyphosate on certain weeds.

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SPRING POST-EMERGENCE CROP PROTECTION

Once the crop has emerged from the ground, the same crop protection concerns exist in zero tillage as in conventional tillage. Weed competition as well as disease and insect problems must be addressed in the same way in both systems. Careful planning is essential. Because tillage and soil incorporation are not a part of zero tillage, crop/weed combinations which can not be addressed with post_emergent applications should be avoided. Alternating broadleaf and cereal crops aids in breaking insect and disease cycles and control of volunteer crops as well as allowing more effective use of post emergent herbicides. Careful monitoring of crop conditions allows for proper identification of the nature and extent of weed, disease and insect problems. Proper product selection and use are important for successful crop production. Keep in the mind the availability of product tank mixes to reduce the number of operations.

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HARVEST

Fall is the time to begin a zero tillage program. Once the decision to go "zero till" is made, attention must be paid to residue management in harvesting that fall's crop. Harvesting the zero tillage crop is only different from conventional tillage in the way you must think about residue management. Stubble height must be matched with the clearance capability of seeding equipment. Generally, a stubble height in the range of 10 inches has produced the best results. Be sure that straw and chaff spreaders are properly adjusted to spread residue adequately.

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Production Manual ~ FERTILIZER USE

In zero tillage - as in any crop management system - the nutrients that are hauled off the field as grain at harvest time have to be replaced for successful production of a crop next year.

A good way to determine a field's fertility needs is through a soil test. When a recognized lab analyses a soil sample representative of an entire field - its results are a reliable guide to what must be applied to achieve the expected yield goal.

Fertilizer requirements for growing a crop under zero tillage are generally the same as those under conventional tillage. Getting the fertilizer close to the seed - but not too close - is a challenge for both.

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FERTILIZER PLACEMENT

It is important to place fertilizer accurately where it can be used most efficiently by the crop. Progress has been made in fertilizer equipment since the first adaptation of an ordinary drill for no-till. Gradually, more equipment is becoming available which will handle seeding and fertilizing in one operation and at the same time minimize disruption of the zero till seed-bed.

Broadcasting fertilizer has the same inefficiencies in zero till as it does in a conventional till program. Likewise, banding offers the same advantages in the two systems. The pros and cons (see next page) of various fertilizer application systems should be considered as they apply to the particular farm operation.

No-till farmers in North Dakota and Manitoba are using a wide range of fertilizer application techniques. The choice of application system depends on the type and rate of fertilizer needed; the type of seeding and fertilizing equipment available and manpower availability at peak seasons.

The variety of systems which are working for no-till farmers are proof that the best way is the way which works for the individual.

Fall banding a complete liquid or granular blend of N,, P,, K, and S in amounts needed for individual fields with a half inch knife on a 12 inch centre cultivator is one farmer's system. Fall banding NH3 and applying a blend of P, K, and S with the seed in the spring works for another farmer. In another case, as much fertilizer as possible goes on with seed, then any extra that is needed is broadcast before or after seeding. A fourth successful system has been to use an air seeder to split apply the seed and fertilizer.

In each situation, the fertilizer/seeding system has been developed through experience to allow best use of all available resources including time, equipment and finances. As the examples show, many different variations are practical in zero tillage.

" We are producing more grain with no-till than conventional till because of more water available. This implies that fertilizer requirements should be higher on no-till. However, the no-till system involves a more active organic master fraction such that larger amounts of fertilizer may not be necessary. "

Guy Lafond, Cereals Agronomist Agriculture Canada, Indian Head, Saskatchewan

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VARIOUS FERTILIZER OPTIONS

THE PROS & THE CONS

Fall Banding

- allows use of the least expensive source of nitrogen (ammonia) and it spreads the work load by getting all or part of the fertilizer applied in the fall. This means the spring operation concentrates on seeding. While some farmers can use the same equipment for seeding and for fertilizer banding, this split in the work load is particularly important if available seeding equipment does not have the ability to side band fertilizer and a separate fertilizer application will be needed in spring. Fall banding increases the choices of seeding equipment available since there are many good seeding equipment options which do not have fertilizer application capability. Fall banding does require some pre-planning but it allows the correct amount of fertilizer to be applied for each crop without risk of crop damage. It has also been noted that in cooler, wetter areas, the fall banding operation can contribute to earlier soil warming and earlier seeding the next spring.
- requires separate equipment and an additional trip across the field which is expensive in both fuel and labour. The extra fall operation has a drying effect upon the field and it tends to promote volunteer growth in the following spring.

Spring Banding

- offers the same advantages as a fall banding operation with the added benefit that fertilizer rates can be adjusted in direct response to spring moisture conditions. All types of fertilizer, including NH3, can be used in a spring banding application. On soils where denitrification causes losses of fertilizer over winter, spring banding can result in more efficient use of fertilizer compared with fall application.
- includes the extra expense of the added operation. It can be extremely disruptive to the zero till seed bed. The first pass over a zero till field is often the most foolproof. Because the first pass fertilizer operation tends to 'd-anchor' the residue, the second pass seeding operation can be hindered somewhat by clearance problems. This can make uniform seed placement more difficult.

Seed Placed

- is generally considered the simplest fertilizer placement system. A one pass seeding/fertilization operation is efficient in time and fuel cost. Many available machines are capable of placing seed and fertilizer together. While there are limitations on amounts of fertilizer which can be placed with the seed, that which is with the seed is used very efficiently by the plant.

- fertilizer amounts are limited by *e danger of seedling injury. Reduced plant populations which result from excess fertilizer placed with the seed can mean later maturity and/or lower yields. Seed placed fertilizer may have to be supplemented with an additional fertilizer operation to ensure that sufficient nutrient amounts have been provided for the crop. The fact that more fertilizer must be handled at seeding time can slow down that operation. *(Further information on fertilizer use restrictions is included elsewhere in this section of the manual)*

Side Banding at Time of Seeding

- allows the total fertilizer requirement to be placed with one pass at seeding time. Placement is near enough to the seed to offer efficient use of the fertilizer but sufficiently separated from the seed to minimize toxicity concerns. Because of proximity to the seed row side banded fertilizer is most accessible to the seed and least accessible to weed seeds between rows. The single operation seeding/fertilizer application is cost efficient in fuel and labour. It also offers considerable planting flexibility in that last minute plan changes are not limited by any pre-plant operations. Because the one pass operation is the first pass over the field, there tend to be fewer problems with crop residue plugging the equipment.
- requires specialized equipment. Some types of side banding equipment may disturb the seed bed and cause problems with uniform seed placement. There may be high horsepower requirements at seeding because of high draft requirements of some side banding drills. Large amounts of product must be handled at time of seeding. Generally, anhydrous ammonia is not used for side banding so overall fertilizer cost may be higher.

Spring Broadcasting

- allows flexibility in application rates at time of seeding. It is a useful means of applying extra nitrogen when restricted to seed-placed equipment or when growing conditions warrant a higher total nitrogen application. Broadcasting is a fast method of application with a low power requirement which can be used when it is convenient from before seeding until after the crop has emerged. When fertilizer is broadcast before seeding, even zero till seeding will provide some minimal incorporation. Generally, ammonium nitrate (34_0_0) is the most efficient form of broadcast nitrogen.
- can be an inefficient fertilizer application method. In particular, there is inconsistent fertilizer efficiency in high residue situations and in dry years. Broadcasting also means an additional operation in the spring when time is limited.

ONE PASS SEED AND FERTILIZER APPLICATION

Many farmers prefer a one pass seed and fertilizer system. In this case however, there are some special considerations. Among the most important concerns are how much fertilizer can be placed with the seed and how close can the fertilizer band be to the seed.

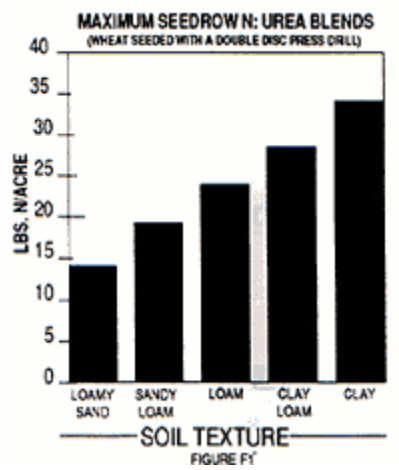

FIGURE F1

Factors which influence the amount of fertilizer which can be seed placed include:

SOIL FACTORS

(soil texture, organic matter content, salt content, moisture content and uniformity of fields)

Crops grown in soils which are at or near field capacity, have high clay content, high organic matter and low salt content can tolerate higher seed placed fertilizer rates than soils which are dry, sandy with low organic matter content and high levels of salts. Since the combination of these factors differs on every field and can change over time, the maximum amount of fertilizer which can be placed with seed is dependent on the conditions present in the field at the time of seeding. The 'safe' level of urea nitrogen which can be seed placed for a wheat crop using a double disc press drill on various soil textures is shown in Figure F1 (at left).

TYPE OF CROP

Crops vary in their tolerance to seed placed fertilizer. Wheat is one of the most tolerant crops. Flax is one of the least tolerant.

TYPE OF FERTILIZER

Crops vary in their tolerance to various types of fertilizer.

Generally crop emergence is least affected by phosphate fertilizers, whereas it can be very sensitive to nitrogen and potassium. Crops are especially sensitive to urea based fertilizers. Figure F2 (overleaf) shows the sensitivity of wheat to various rates of urea and ammonium nitrate fertilizer. Anhydrous ammonia can not be placed directly with the seed due to extreme toxic effects.

ROW SPACING AND ROW WIDTH

Generally, the narrower the row spacing and/or the wider the spread of seed within the row, the higher the amount of fertilizer which can be safely applied with the seed. Figure F2 also shows the dilution effect on safe levels of seed placed fertilizer. An alternative to distributing both the seed and fertilizer over a larger area is to distribute the seed as far as possible while keeping the fertilizer in a concentrated row. This can be accomplished using a dual air stream air seeder or by using liquid fertilizer. In this hybrid system, any negative effect of the fertilizer on germination will be limited to only the small percentage of seed in the band area.

A one pass seed placed fertilizer system is often used with air seeders which distribute seed and fertilizer in a wide band and which cause considerable soil disturbance. Since soil disturbance must not be excessive in a no-till system, the maximum width of the band should be about five inches on a 12 inch shank spacing. This system is usually used with crops with low fertilizer sensitivity and when fertilizer requirements are within 'safe' limits. When fertilizer rates are above the safe limit or sensitive crops are involved, farmers who usually use a one pass seed placed fertilizer system may revert to a two pass system. This flexibility allows each crop to receive the optimum amount of fertilizer.

While a one pass side band system requires more specialized equipment than the one pass seed placed fertilizer system, side banding offers much greater fertilizing flexibility. Provided the side banding attachment does not interfere with seed placement as some early types did, moving the fertilizer only a short distance from the seed can allow complete freedom to choose fertilizer rates without harming the emerging crop. As a rough rule of thumb, anhydrous ammonia should be two to three inches away from the seed, urea based fertilizer can be closer (1_2 inches) and fertilizers such as ammonium nitrate or liquid N can be safely placed with minimal separation (1/2 to 1 inch) from the seed.

One caution in the side banding method can arise when all the phosphate fertilizer is placed in the band with the nitrogen. Because of the greater mobility and initial toxicity of the nitrogen, the uptake of the phosphate stranded in the middle of the nitrogen can be delayed resulting in slower initial crop growth. This will be particularly noticeable on soils low in phosphate and can be avoided by placing at least some of the phosphate with the seed.

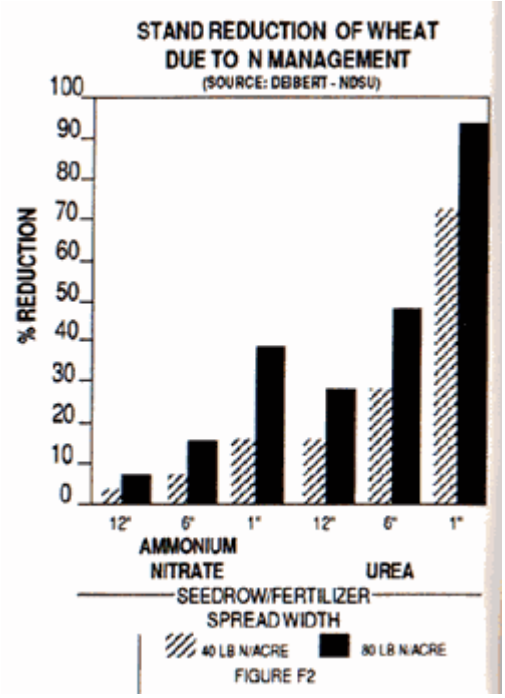

FIGURE F2

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Production Manual ~ ZERO TILL WEED CONTROL

The differences between a conventional and zero tillage system are most apparent in the area of weed control. Controlling weeds without tillage is new and challenging but not impossible. The proof can be seen in the clean, healthy crops grown by no-till farmers over a wide range of conditions.

Ideally, in a zero till system (as in any crop production system) there are no weeds present as crops emerge. Weeds of economic importance which develop after the crop emerges are controlled with the same post-emergence herbicides used in conventional tillage systems.

Application of a non-selective herbicide at seeding time is often a component of the system, but there are other controls available to the no-till farmer. Any practice that favors crop development over weed development means cleaner fields and higher yields. Time of seeding, variety selection, optimum placement of seed and fertilizer, field border sanitation, and the selection and rotation of crops are all important in improving a crop's ability to compete with weeds.

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Cultural Weed Control

Time of Seeding

A common practice used by no-till farmers is early seeding of spring crops before weeds emerge. This can mean that a spring glyphosate application may not be necessary. Of course, this is only possible if winter annuals and perennial weeds such as quackgrass and foxtail barley have been taken care of. Early seeding means the crop being grown must be able to germinate and develop in the cooler soil conditions. Usually, early seeding is restricted to cereal grains such as wheat and barley and occasionally to flax, field peas and lentils.

The firm, moist zero till seed-bed allows shallow seeding and ensures quick emergence for maximum crop competition.

Variety Selection

A variety which germinates and emerges quickly and then grows rapidly to cover the ground is important in reducing weed competition. This is especially important when growing crops like canola as there are broadleaf weeds such as lamb's quarters and shepherd's purse which can not be controlled with any of the post-emergence herbicides presently available.

Optimum Placement of Seed and Fertilizer

Shallow zero till seeding into a moist seed-bed encourages quick emergence. Packing directly on the row (compared to the random packing of a harrow or harrow-packer operation) improves seed germination but does not stimulate germination of weed seeds between the rows.

With on-row packing only, the area between the rows often has a covering of loose soil. As this layer quickly dries out, it is an environment that discourages weed seed germination. This effect is more evident with hoe type openers with their greater soil throwing action.

"Post-emergent crop care reduces pesticide use because we treat only problems which exist - not problems we **think** ***are going to exist. "***

Scott Halley Bisbee, North Dakota

Side banded or seed placed fertilizer can also improve a crop's competitiveness. Weeds isolated between the row and away from the fertilizer band are much less vigourous than the crop growing close to the fertilizer band.

The object of zero tillage is to minimize soil disturbance with seeding and fertilizer placement operations. The combination of low soil disturbance with high residue levels discourages growth and reduces populations of annual weeds such as green foxtail (pigeon grass).

Field Border Sanitation

Be careful not to bring weeds into the field from the border. This is particularly true with some grassy species such as smooth brome grass. Mowing headlands in mid-summer prevents heads from being cut and spread further into the field by the swather or combine.

Control by sanitation is important since brome grass control requires as much as 2.0 litres/acre of 356 g/L cone. (2.0 U.S. quarts/acre of 3 lb. cone.) of glyphosate. Spraying field perimeters at this rate may occasionally be necessary but spraying into the actual grass headland should be avoided as grasses that are controlled will only be replaced by other weeds such as Canada thistle.

Selection and Rotation of Crops

Crop selection and rotation considerations are more critical in a no till crop system since tillage and soil incorporated herbicide options are not available.

When choosing a crop to be grown on a particular field, it is important to know the control options for potential weed problems. A good knowledge of field weed history and a practical knowledge of available post-emergent herbicides is essential. Sometimes there are no post-emergent weed control options. For example, zero tilling field peas into a field with a wild buckwheat problem could be risky and should be avoided.

Crop selection must also be considered in relation to perennial weed problems. For example, selective herbicides are available to control or suppress quackgrass in broadleaf crops but not in cereals. In-crop control of Canada thistle with Lontrel (or Stinger) and Curtail is also possible in many crops. Selecting the right crop can mean addressing a weed problem that you were unable to address the previous fall or earlier in the growing season. Avoid situations where perennial weeds are left uncontrolled. On heavy or persistent perennial weed areas, choose a cropping sequence which will place maximum pressure on the weed through crop competition and chemical control measures.

Rotation from a cereal to a broadleaf crop (and the reverse) allows for effective control of volunteer cereals or broadleafs.

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Chemical Weed Control

Farmers who are going to adopt zero tillage need to be comfortable with controlling weeds with herbicides**.** This 'comfort' will come from developing a system that makes timely, accurate applications possible as well as from the knowledge that the money being spent on herbicides is good value relative to the alternative - tillage.

General Tips for Spraying

Preparation for a season of weed control must be more than an afterthought. Sprayers must be maintained so they are trouble free, given the narrow time period that weather and weed growth are suitable for application.

This maintenance program probably takes place twice a year, in preparation for fall spraying and then again in preparation for the spring spray program first thing in the spring.

Equipment that can operate on somewhat rougher ground conditions is an advantage. Large boom gauge wheels and shock absorber setups are ideal.

A good marking system or a tramline system is almost mandatory. A marking system that is adequate for in-crop spraying may not do the job in stubble spraying conditions.

Stubble spraying operations can be very frustrating. First time no-tillers will find a challenge in spraying a residue covered field with no overlaps or missed spots. In fact, it is easy to 'get lost' in a no-till field unless a very good marker system is employed.

As noted in the foreward of this Zero Tillage Production Manual farmers have used off-label application rates with various results. While the Chemical Weed Control section of this manual is based upon on-farm experience, the Manitoba - North Dakota Zero Tillage Farmers Association does not recommend or endorse any off-label application rates.

"Minimize chemical costs by knowing weed species and the capabilities of various herbicides, applying control measures in a timely manner, and using equipment that is performance proven in your production area."

Carl Fanning, Extension Soils Specialist, North Dakota *State University*

"If a diverse annual cropping system is used, we have reduced the average number of herbicide applications needed to 1.3 per crop per year in the spring wheat-winter wheat sunflower rotation compared to 2.5 to 3.0 applications per crop per year for spring wheat fallow. "

Al Black, Director USDA/ARS Research Laboratory, Mandan, ND

One of the best marker systems is a tramline system established at seeding time to serve as a permanent marker throughout the season. One simple tramline system is created by moving an opener and packer three or four inches so that a wider row space is left. The wide space will be visible season long as a marker for spray operations.

Blocking a run on seeders with wider row spacing is not advisable as it leaves a space so large that weeds can become a problem due to lack of crop competition.

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Fall Weed Control

Fall is the first opportunity to control winter annuals and perennials such as Canada thistle, quackgrass and foxtail barley.

CANADA THISTLE

Fall control of Canada thistle is often variable. Good control is dependant upon thistle regrowth since herbicide uptake is enhanced by a large area of new, actively growing leaf material. Regrowth occurs in situations where there is an early harvest followed by moist, warm growing conditions. A further requirement for good herbicidal effect is good growing conditions for several weeks after treatment to allow translocation of the herbicide. Hence, treatment in early fall will be more effective than later treatments when frost is more likely.

Fall treatment by itself may not give good control of Canada thistle.

Applications of high rates of products such as dicamba or glyphosate are expensive and can result in only marginal control unless fall growing conditions are good. Generally, Canada thistle control can only be achieved through a combination of treatments including use of competitive crops, in-crop herbicides and use of post-harvest treatments when adequate growth exists.

The use of glyphosate for fall treatment of Canada thistle poses less of a financial risk where control of other perennial weeds such as quackgrass or foxtail barley is being undertaken. Refer to provincial or state chemical weed control recommendations for more information.

QUACKGRASS

Quackgrass is a concern to many considering zero tillage but it is not a problem in a well managed no-till system. Fall control of quackgrass with glyphosate can be effective, especially where there is good regrowth. If quackgrass patches are heavy and/ or early seeding is planned, fall control is preferred because quackgrass patches will draw moisture and nutrients from the seed bed in spring. Quackgrass left for spring control can also have allelopathic or toxic effects on subsequent crop growth resulting in poor germination and crop growth. Fall treatment eliminates the need to wait for adequate quackgrass regrowth in the spring.

Waiting for adequate regrowth often means that seeding is delayed and subsequent yields lowered.

For good control, the plants must be actively growing. Height of the plant is not so important as the fact that there are two to four healthy, growing leaves and that the

quackgrass rhizomes are also actively growing with shoots from several buds along the rhizome. Fall control of quackgrass can take place after frosts as low as _5 C (23 F). Do not apply after the first damaging frost in the fall. If frost has occurred, wait several days to determine if the quackgrass has recovered. At least 60% of the leaf should be undamaged by frost.

The recommended rate of glyphosate for season long control of quackgrass is one litre (one quart) per acre. Experienced no-till farmers have found that since glyphosate is used on an annual basis, quackgrass control can be achieved by using low rates of glyphosate (0.5 - 1.0 litre/acre of 356 g/L cone. or 0.5_1.0 U.S. quart/acre of 3 lb/gal cone.) and adding ammonium sulphate and a non-ionic surfactant. This reduces the financial risk of achieving quackgrass control as the effectiveness of glyphosate on quackgrass can vary greatly from one set of conditions to another. While quackgrass is not a' problem in well-managed zero till fields, if starting zero till on a field with heavy infestations, it is best to clean it up first. In this case, rates of one litre (one quart) per acre or higher may be warranted. Provided there is adequate growth of quackgrass, treatment in the fall is the ideal.

Attention to fall control of quackgrass is especially important if early seeding is anticipated. There will be little opportunity in the spring to treat quackgrass in this situation as the regrowth is usually not adequate.

Of course, quackgrass can be controlled with spring applications but waiting for ideal growth is not a good strategy. Seeding on time and getting some control from earlier than optimum glyphosate application is preferred to waiting and losing yield potential. In some situations, quackgrass can be controlled by spraying after seeding but before crop emergence.

In any case, it should be remembered that glyphosate is usually applied on an annual basis and that less than perfect control in one year can usually be compensated for in a subsequent treatment.

FOXTAIL BARLEY

The potential for foxtail barley to become a problem weed increases when tillage is eliminated. Half a litre of 356 g/L cone. (0.5 U.S. quart of 3 lb./gal.) per acre of glyphosate as a fall application is effective in controlling foxtail barley. It is also effective in spring at the same rates. The addition of surfactant and ammonium sulphate is critical to achieve control of this hard-to-kill weed at this low rate.

WINTER ANNUALS

These weeds germinate in the fall and grow forming a ground hugging 'rosette'. They overwinter and resume growth early in spring. Winter annuals are very competitive with fall or spring seeded crops if left uncontrolled. In the spring, they quickly drain the soil surface of moisture and can severely affect the germination of a spring seeded crop.

If winter annuals are present, fall treatment is recommended. Application of 2,4_D at 0.45 litre/ acre of 500 g/L cone. (0.45 U.S. quart/ acre of 4 pounds/gallon cone.) is recommended to control stinkweed, shepherd's purse and flixweed.

Narrow-leaved hawk's beard is more difficult to control and requires a higher rate of 2,4_D (0.7_0.9 litre/acre 500 g/L cone. (0.7_0.9 U.S. quart/acre of 4 pounds/ gallon conc.)). It is important to control narrow-leaved hawk's beard in fall as spring treatments with 2,4_D or glyphosate are not effective.

Without fall tillage, there are some annual weeds that can exhibit winter annual growth. A weed like American dragonhead does not seem to be of economic importance but an annual such as cleavers is more troublesome. Spring or fall treatment with 0.5 litre of 356 g/L cone. (0.5 U.S. quart/ acre of 3 pound/gallon cone.) of glyphosate with ammonium sulphate and surfactant gives good control.

Winter annuals should be sprayed between early October and freeze-up. Spraying earlier can mean missing weeds which germinate late. As freeze-up approaches, sprayer freezing problems are more common but effectiveness of the treatment is good right to freeze-up.

Treatment of winter annuals is especially important if early seeding is anticipated. If perennial weeds are under control and winter annuals have been eliminated, a spring application of glyphosate may not be necessary.

VOLUNTEER CROPS

While separate control of volunteers is not usually necessary, there are cases where it might be considered. An early harvested barley field in a fall with good growing conditions might be a candidate for a volunteer control program. Volunteer growth of winter wheat or fall rye which will continue growing in the spring might also merit fall herbicide treatment. In these cases, very low rates of glyphosate will be effective.

Growth of volunteer crops in the fall has not usually been a problem in zero till fields. Good chaff spreading eliminates the 'mat' of volunteers that can grow in the chaff row. Since there is no tillage to bury the seed, fall growth is usually not excessive. Seeds that sit on the surface over winter often lose viability due to weathering.

"In cereal growing areas, fall applied 2,4_D does an excellent job on winter annuals. 1 feel this application has been undersold. "Martin Entz, Plant Science Department, University of Manitoba

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Weed Control at Time of Seeding (Spring Burn-off)

Research into no-till spring weed control has been very limited in both North Dakota and Manitoba. There are some recommendations in the respective weed control guides but most recognized practices have been developed through farmer experience.

For successful crop production, weed competition must be eliminated at the time of crop emergence as this is when the crop is least competitive.

Glyphosate is currently the most important herbicide for zero till 'burn-off' treatments. It is non-selective, nonresidual, and effective when properly applied. The main deterrent to glyphosate use in the early years of no-till was price. The need to keep herbicide use affordable encouraged farmers to fine-tune application methods. Price reductions have made its use more reasonable.

The rate of glyphosate used in spring treatments can be adjusted according to the species and growth of weeds being targeted. The rates of glyphosate needed to control various common weeds can be found in Table W1:

TABLE W1. GLYPHOSATE RATES

Weeds (1)	Rate*	Rate*
.	0.3-0.4 litre/acre (356 g/L conc.) 0.3-0.4 U.S. quart/acre (3 lb./gal. conc.)	0.5 litre/acre (356 g/L conc) 0.5 U.S. quart/acre (3 lb./gal. conc.)
Green Foxtail (Pigeon Grass)	C	C
Volunteer Cereal	C	C
Wild Oats	C	C
Downy Brome	C	C
Foxtail Barley	S	S/C
Wild Mustard	C	C
Volunteer Canola	C	C
Stinkweed	C	C

(Field Pennycress)		
Ladies Thumb	C	C
Cleavers	?	C
Kochia	S/C	C
Flixweed (tansy mustard)	S/C	C
Wild Buckwheat	?	C

(1) Most other annual and winter annual weeds are controlled at the 0.5 litre

(0.5 U.S. quart) rate.

* Control ratings assume the addition of ammonium sulphate and use of surfactant where applicable. Best control can be achieved when weeds are small (less than 6" tall)

S = Suppression C = Control ? = Insufficient Information Available

NOTE - Addition of 2,4-D or dicamba either in tank mix or pre-mix form could increase the weed control spectrum.

The addition of ammonium sulphate as well as one of the recommended non-ionic surfactants to glyphosate is a practise used by zero till farmers. These products work in a number of ways. The present commercial formulation of glyphosate does not contain sufficient surfactant for adequate wetting when used at lower rates. The ammonium sulphate enhances the activity of the herbicide -making control of weeds like wild buckwheat and foxtail barley more complete. Ammonium sulphate makes control with glyphosate more consistent and less sensitive to environmental conditions.

Experience has shown that 0.5 litre/acre (0.5 U.S. quart /acre) of glyphosate with ammonium sulphate and surfactant controls most weeds present at time of seeding. This includes good suppression of quackgrass. Premixes or tank mixes containing 0.3-0.5 litre/acre of 2,4-D 500 g/L cone. (0.30.5 U.S. quart/acre of 4 Ibs./ gal) OR 0.1 litre of 480 g/L cone. (0.1 U.S. quart of 4 lbs./gal cone.) of dicamba per acre can help to increase the weed control spectrum. Keep in mind that tank mixing reduces the grassy weed control capability of glyphosate to some degree and therefore the effectiveness of mixing should be balanced against the cost of increasing the glyphosate rate. Dicamba and 2,4-D residues left after a spring application can cause emergence problems in susceptible crops such as canola, flax, field peas, and lentils.

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Getting The Most From Your Glyphosate Dollar

Getting the most from your glyphosate dollar starts with reading the label. The Roundup label, for instance, has many useful tips to improve performance. Considerable experimentation has been done to develop spring burn-off application rates to the point where they are competitive with tillage is terms of price and consistency of control.

RATES

Rates as low as 0.3 litre (0.3 U.S. quart) per acre have been used in situations where only the most susceptible weeds are present. This includes wild oats (2-3 leaf stage), green foxtail, wild mustard, volunteer cereals and stinkweed. For adequate control, weeds must be actively growing and less than 10 cm. (4 inches) in height. Of course, the possibility of inadequate control increases at these lower rates. Using higher rates for spring control is necessary for harder to kill weeds, large weeds, or less than ideal growing conditions.

WATER QUALITY

Clean water is ideal for glyphosate application and using high quality water will improve the effectiveness of the application. Foreign materials such as soil particles in spray water will deactivate glyphosate. Water containing high amounts of magnesium or calcium, when mixed with Roundup, can reduce the product's performance. Water containing over 700 ppm of magnesium or 500 ppm of calcium should NOT be used. Reduced performance can also be expected as magnesium and calcium content approaches these levels.

"Sprayers need to be ready even though it freezes at night in the fall and spring, to do weed control. These operations are often critical to successful zero tillage. Without them weed competition can become too great and post emergent options may not be effective."

Terry Gregoire Area Agronomist North Dakota State University, Devils Lake, North Dakota

WATER VOLUME

Lower water volumes increase the effectiveness of glyphosate. Applications at five gallons per acre are more effective than at ten gallons per acre.

SURFACTANT

Addition of a non-ionic surfactant improves the performance of glyphosate when it is being used at lower rates. The surfactant requirements for use with the current formulation of Roundup are outlined in Table W2:

AMMONIUM SULPHATE

Ammonium sulphate is registered as an additive to glyphosate in North Dakota and in some situations in Saskatchewan. Its use is not registered in Manitoba but its ability to enhance the performance of glyphosate is well known. The effect is more pronounced on some species than on others. Ammonium sulphate also seems to improve glyphosate effectiveness more when treatment conditions are less than ideal. Where applicable, the recommended rate of ammonium sulphate to use with Roundup is 2% weight per weight of spray solution OR one pound/acre when using 5 gallons of water per acre. If using ten gallons, the rate of ammonium sulphate can be doubled. Consult herbicide labels for mixing details and for use of ammonium sulphate with other glyphosate based products.

Technical or spray grade ammonium sulphate is available but bagged fertilizer grade is also used. Sherritt Gordon 21-0-0-24 is a source of ammonium sulphate which is effective and less expensive to use than most technical grade liquid or granular formulations of ammonium sulphate. Bulk fertilizer is not recommended as there could be problems with impurities.

TABLE W2. Rate of Surfactant Required*

.	Water Volume	
Roundup Rate**	**10 gallons/acre**	**5 gallons/acre**
1.0	0	0
0.8	40 ml (1.3 fl. oz.)	0
0.6	80 ml (2.7 fl. oz.)	0
0.5	100 ml (3.3 fl. oz.)	0
0.4	120 ml (4.0 fl. oz.)	20 ml (0.6 fl. oz.)
0.3	140 ml (4.7 fl. oz.)	40 ml (1.3 fl. oz.)

* rate in ml/acre (fl. oz. U.S./acre). Surfactant rate based on 90% active ingredient non-ionic surfactant such as Agrol 90 or AgSurf. See Roundup and surfactant label for further instructions.

** rate in litres of U.S. quarts/acre. (Roundup-356 g/L glyphosate)

Ammonium sulphate is very soluble and can be added directly to a sprayer tank if it is being bottom filled. If it is being added when the spray solution is being agitated, care should be taken not to drop the granules into the sump as plugging of the main filter can occur. The ammonium sulphate should be dissolved before glyphosate is added. Since ammonium sulphate is corrosive to metal parts, the tank should be rinsed after use.

GROWTH STAGES

For control of perennial weeds, active new growth and good growing conditions after application are important to ensure translocation of the product occurs in the weed. Glyphosate is not effective in controlling Canada thistle in the spring. In-crop treatment should be considered.

For annual grassy weeds such as wild oats and volunteer grains, control is poor in the one leaf stage. Growth must be in the two leaf stage or later for good control.

AVOID DE-ACTIVATION OF GLYPHOSATE

Care should be taken that glyphosate is being applied to plants free of dust or not covered with soil. These conditions greatly reduce the effectiveness of the product. Operations such as harrowing or seeding just before spraying should be avoided. Dust from application equipment should be minimized as well. An ideal situation is to apply glyphosate to clean, dry leaves.

TIMING OF SPRING BURN-OFF

Spring burn-off applications should be made either a day before or several days after seeding.

Timing is critical. Applications several days before seeding allow weeds a longer period of time to emerge between application and crop emergence

There is some concern about the tillage effect of the seeding operation on the quackgrass when seeding occurs soon after the glyphosate application. However, reasonable control can be expected as most no-till seeding operations leave much of the rhizome system intact.

Applications immediately after seeding are also not recommended. Herbicide effectiveness is reduced by dust left on leaf surfaces by seeding. Spray coverage is also reduced because weeds are partially buried by soil during seeding. This effect is more pronounced with the more aggressive hoe-type drills. Waiting several days can reduce some of these problems, but there is a risk of not being able to complete the spray application before crop emergence.

In earlier seeding situations where soil temperatures are cooler and emergence is slower, the after seeding window of application is longer and the opportunity to burn-off is

greater. Spot treatments for quackgrass that develops after seeding is often possible in this case as well.

NEW PRODUCTS

The patent expired on glyphosate in 1990. Farmers should watch not only for new sources of glyphosate but new products designed for cost effective weed control in zero tillage.

"The last few years, I've been able to reduce my use of wild oat herbicide. I also have reduced my use of herbicides to control millet. My most troublesome broadleaf weed is Canada Thistle and I use suitable herbicides for that. I just don't worry about quack grass any more - low rates of glyphosate, used annually, is the answer for me. "

Bob McNabb, Minnedosa, Manitoba

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ANNUAL GLYPHOSATE USE

Through a combination of early seeding, spring burn-off and fall weed control and practical weed prevention measures such as field border sanitation, the annual application of glyphosate on long term zero till fields has been 0.5 litres/ acre (0.5 U.S. quarts). This figure represents a reasonable target level for beginning no-till farmers to aim toward. On farms where there are perennial weed problems, farmers starting zero tillage may need to use more to ensure good control.

Researchers and zero till farmers are continually looking for methods to enhance the performance of glyphosate or reduce the cost of it. It is important to look for situations where control of other weeds besides the main target will be a side benefit. Take advantage of opportunities to treat a weed problem if growth is good. Hold onto your money if possibilities for good control look marginal and wait for a better opportunity.

HERBICIDE RESISTANCE

Herbicide resistant weeds were first observed about the mid 80's when trifluralin resistant green foxtail plants were noted. Since that time, kochia and wild oats resistant to a number of products have also been observed.

In all cases, excessive use of the same product year after year was involved.

Herbicide resistance should be suspected if a weed which has been successfully controlled in previous years is not affected by a herbicide which has worked on other weeds which are on the label. In particular, resistance should be suspected if the 'escapes' cannot be attributed to adverse weather or emergence after application. If this situation develops, consult field records to determine if the same product or combination of products has been used repeatedly.

It is easier to avoid development of resistant weed strains than it is to eradicate or control them after they develop. When possible, herbicides should be rotated so that the same product is not used year after year.

When resistance to a product develops in a weed population, it can mean the weed population has developed resistance to other weeds which act in a similar manner. Herbicide planning should ensure against using products from within the same group year after year. Accurate herbicide use records are an important part of planning the weed control program.

Non-chemical weed control methods are also an important aspect of avoiding herbicide resistance. As outlined earlier in this zero tillage production manual, cultural weed control practices should be used to supplement herbicide programs as much as possible.

POST-EMERGENCE CROP PROTECTION

Once the crop is out of the ground, zero till weed control becomes the same as in any other field using available post-emergent in-crop herbicides.

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Production Manual ~ ECONOMICS OF NO-TILL

Of all the reasons to consider zero tillage, none is more important than economics. Erosion control and soil building are vital and have long term economic benefits, but the economic bottom line is an annual concern whether you no-till farm or not.

While small plot demonstrations at research stations in Canada and the United States have confirmed the experiences of no-till farmers regarding the economic advantages of reduced tillage, it is only recently that farm field scale trials have been carried out. One such trial over a 5 year period was completed in the fall of 1990 on a farm in western Manitoba. This farm has clay loam soil and an average long term precipitation of 17 inches per year. In co-operation with Manitoba Agriculture, the study was carried out on a 90 acre field divided into thirds with one third farmed conventionally (one to two cultivations in the fall plus fertilizer application - cultivation, harrow and seeding in spring). one third minimum tillage (fall banding of fertilizer, cultivation, harrow and seeding in spring) and the final third no-till (fall banding, spring seeding).

Costs were actual costs and the herbicide rates were the rates actually used. Cost of tillage was estimated at 80% of the custom rate normally charged. Labor was figured at $8.00 per hour, insurance taxes and other costs came from the Crop Planning Guide of Manitoba Agriculture. In other words, every effort was made to make a fair comparison. Gross return per acre was actual measured yields x actual price. Net returns were gross return minus total expenses. Results are summarized in the chart below.

5 YEAR MANITOBA STUDY

Year	Crop	Zero Till Field Yield	Minimum Till Field Yield	Conventional Till Field Yield
1986	Durum Wheat	56.0	56.0	54.0
1987	Barley	77.3	73.2	66.2
1988	Barley	77.1	69.6	63.2
1989*	Canola	11.1	8.2	6.5
1990	Durum Wheat	64.2	61.3	54.9

*1989 was a very dry year

Average Gross Return/Acre			
1986-1990	$146.91	$136.60	$124.18
Average Total Expenses/Acre			
1986-1990	$116.46	$113.63	$110.78

Average Net Returns/Acre

1986-1990	$30.45	$22.97	$13.40

Yields on the zero till field exceeded the conventional or minimum till fields every year except one when they were equal.

This study was taken one step further. A projection was made for costs in 1991 based on the more recent reality of lower glyphosate prices and higher fuel prices. The projected expenses per acre for 1991 are as follows:

Zero Till _____$121.20
Minimum Till_____$117.30
Conventional Till_____$120.00

A closer look at the costs indicates that in the zero tillage system increases in the cost of herbicides are approximately equal to a decrease in the cost of tillage when comparing it to the conventional systems. Most other costs are comparable. This confirms the recent experience of many zero till operators. This fact, coupled with the potential for further increases in fuel prices and decreases in glyphosate prices, as well as the good potential for yield increases makes the future economics for no till very attractive.

Economic research in the United States indicates similar results. A North Dakota State University study in the mid-80's involved a fallow-durum wheat rotation with the chisel plow as the main tillage implement - the traditional crop management system in western North Dakota. In this study a realized net revenue of $27 per acre also resulted in a 10 ton per acre loss of soil. The study also revealed that a number of alternate crop management systems could yield about $10 more net revenue per acre, reduce soil erosion by 50%, and reduce the variability in income. A four year rotation of chem-fallow, durum wheat, winter wheat (no-till), sunflowers (no-till) proved to be the most practical and profitable.

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SOIL CONSERVATION SOIL QUALITY

Erosion isn't a cash cost that will show up on this year's balance sheet, or next year's. Yet it definitely represents a costly mortgage on the land's future crop production potential. no-till farming can virtually eliminate water and wind erosion. The filth and organic matter soon improves noticeably - it's a healthier soil. Today's conservation-minded producers recognize that in the final analysis, the soil itself is a valuable economic asset.

The zero till farm, whether sold or passed on to the next generation, will be a better farm in the future. Protected from erosion with basic soil nutrients intact, it is sure to appreciate in value.

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Production Manual ~ OTHER INFORMATION SOURCES

Agri-Industry, Research and Extension Services in both the United States and Canada are valuable sources of information for zero till farmers. A number of reference publications and bulletins have been recommended by North Dakota State University Extension Service and Manitoba Agriculture.

NORTH DAKOTA

- Agriculture Weed Control Guide
- Crop Rotations for North Dakota
- North Dakota Insect Control Guide
- Field Crop Fungicide Guide
- Winter Wheat Production in North Dakota

MANITOBA

- Guide to Chemical Weed Control (with Crop Rotation Chart Insert)
- Manitoba Field Crop Recommendations
- Manitoba Crop Varieties Recommendations
- Manitoba Agriculture Fact Sheets - Crop Residue Management - Soil Moisture Management - Weather and Weed Control

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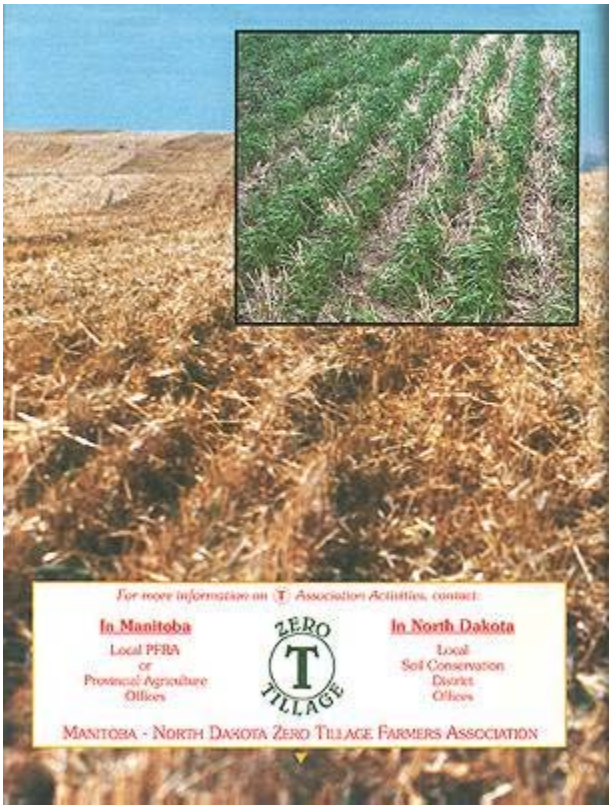

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