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Choosing the Right Tillage System for Row Crop Production

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Systematically consider 19 criteria, in addition to the cost of conversion, in choosing a tillage system for your farming operation.

Using the right tillage system may contribute to profit, crop yields, soil improvement and protection of water resources. Numerous criteria, in addition to the cost of conversion, need to be considered when weighing the advantages and disadvantages of various tillage options. A decision guide is presented for systematic consideration of 19 criteria.

Water erosion control. Erosion causes loss of the more productive soil and causes contamination of surface waters. The impact of raindrops hitting bare soil causes detachment of soil particles, surface soil compaction and sealing with reduced infiltration. Raindrop splashes then move soil particles downhill, and runoff increases. Crop residue protects the soil from these raindrop effects. The volume and velocity of the flowing water, which determine the soil carrying capacity in water erosion, are affected by crop residue on the soil surface. When water flow is obstructed by crop residues, soil particles are deposited. Good groundcover and reduced erosion can be achieved with reduced tillage or no-tillage.

Wind erosion control. Wind carries small soil particles long distances. Larger particles are lifted and dropped, bombarding other particles to release more soil particles to be carried by the wind. Wind erosion is less when the ground is well covered. Standing crop residue is more effective than flat residue as it intercepts flying soil particles, and reduces wind velocity and the wind's soil carrying capacity near the soil surface.

Water conservation. Water infiltration is generally increased immediately after tillage, but tillage tends to break down soil structure by reducing soil aggregation and pore openings, eventually reducing the rate of water movement into the soil. Maintaining a cover of crop residue helps to trap and hold snow during the winter, to reduce runoff during heavy rainfall events, and to reduce evaporation. More water is available for crop growth.

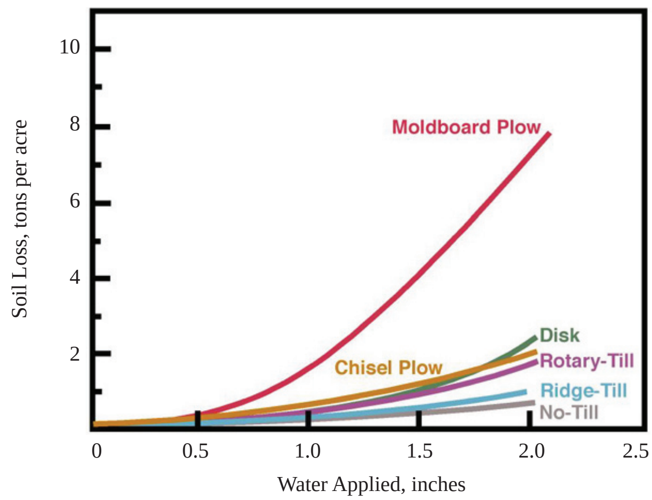

Figure 1. Soil loss to water erosion as affected by tillage system.

Soil fertility management. Tillage may increase nutrient losses due to erosion and oxidation of soil organic matter. Nutrient losses from erosion, while small compared to crop removal, have a major impact on the quality of surface waters. Soil organic matter is important as a source of nutrients, in regulation of nutrient availability, and in maintenance of soil physical and biological conditions for optimal crop growth. Soil organic matter tends to decline with increased tillage and may increase with no tillage.

With no-till, however, stratification of immobile nutrients such as phosphorus is likely to occur. This is due to surface application, little downward movement of P, and cycling of P from deep soil layers to the surface. In southeast Nebraska, available phosphorus was found to be typically very low below the 2-inch depth with no-till *(Table I)*, while high to very high in the top two inches. Phosphorus supply may be inadequate for early seedling growth and for optimal crop growth during times of water deficits. Nutrient stratification develops with other reduced tillage systems as well, but less so than with no-till.

Table I. Stratification of soil phosphorus availability with no-till in southeast Nebraska.

Soil depth	*Bottomland*	*Upland*
0 - 1"	21.3	31.0
1 - 2"	18.0	19.5
2 - 4"	13.2	6.2
4 - 8"	14.5	4.2

Nutrient management in no-till may be further complicated as residue mulch delays soil warming in the spring resulting in slower release of nitrogen and sulfur from soil organic matter, and slower plant growth and root development.

Band application of phosphorus fertilizer results in uneven spatial distribution. This may not be a problem for crop growth but makes it more difficult to collect a representative soil sample.

The effect of unincorporated lime is slow to move through the soil profile *(Table II)*. The typical rate of downward movement on fine-textured soils appears to be about 1/2 inch per year. Lime application recommendations for no-till in both Iowa and Nebraska call for application of enough to raise only the top 2-3 inches to a desired pH, but followed by occasional applications.

Incorporation of manure into the soil may be preferred to reduce nitrogen loss, odor problems, and nutrient loss in runoff and erosion. In many cases, however, surface application of manure is a sound management practice.

Table II. Downward movement of the effect of surface applied lime with no-till may be less than 1/2 inch per year.

Years since lime application	*Soil depth*		
	0 - 1"	*1 - 2"*	*2 - 4"*
4	6.6	6.0	5.3
2 or 3	6.4	5.5	5.3
No lime applied	5.4	5.4	5.6

Observations were made on farmers' fields to which lime had or had not been applied. The higher pH at 2-4" with no lime applied was due to less acidification on these fields.

Irrigation. Ridge tillage is compatible with furrow irrigation but may result in faster water infiltration, requiring more time for water to advance in the furrow as compared to conventional tillage. Adoption of ridge tillage may require some change in the furrow irrigation system to avoid excessive deep percolation of water, e.g., modification of furrow length or slope.

Residue cover on the soil improves sprinkler irrigation due to improved infiltration and reduced crusting and runoff.

Compaction and hardpan management. Wheel traffic causes compaction, and 70% of the total compaction can occur with the first pass. Severe compaction results from traffic or tillage on wet soils. It is better to confine the traffic to the same inter-row areas rather than distributing it (NebGuide G896). Compactive forces may be reduced by less tillage due to less traffic in the field and less pulverization of soil aggregates.

Tillage with disks or plows can cause tillage pans. Reduced compaction with surface tillage is usually only a temporary effect with increased hardness following large rainfall events or wheel traffic.

Properly conducted sub-soiling may effectively break-up a compacted layer. Once conducted, traffic and tillage should be managed and minimized to avoid further compaction.

Weed control. Tillage kills annual and biennial weeds but shallow tillage often stimulates weed seed germination. Tillage only suppresses perennial weeds that can grow back from vegetative parts. Winter annual weeds (downy brome, field pennycress, horseweed, and mustards) and early spring germinating weeds (kochia, Lambsquarter, Pennsylvania smartweed, and Russian thistle) are problematic with no-till and ridge-till systems as they may be well established at planting. Summer annuals (velvetleaf, foxtail, pigweed, and shattercane) and perennials are problematic both with tilled and no-till systems.

When clearing the ridge in a ridge-till system, weed seeds are moved away from the row to the inter-row area where the weeds might be controlled with subsequent ridge-forming cultivation. With ridge-till, band application of herbicide is especially effective for control of annual weeds.

With no-till, producers rely on herbicides to control weeds with few opportunities to correct mistakes and to control escaped weeds. Herbicide treatments need to be tailored to the particular situation for maximum weed control at the least cost. No-till fields often become accessible sooner after rainfall or irrigation events than with tillage allowing for timely herbicide application.

Insect pest management. Insect pest management strategies generally are similar for all tillage systems. Rotation can be beneficial with all tillage systems, for example in control of corn rootworm. Winter survival of corn borers in crop residue is reduced by fall tillage, but because emerging moths often fly and lay their eggs in other fields, tillage of a single field is not a solution. Cutworm problems may be worse with no-till corn planted into wheat or alfalfa stubble, or into fields which were weedy at the time of moth flight, regardless of tillage system. Effects of tillage system on rootworm injury have been inconsistent, but inadequate incorporation may reduce insecticide effectiveness with no-till. Wireworm may be a greater problem with no-till but not always. Bean leaf beetles may increase in number with no-till, but early leaf feeding is most associated with early planting, irrespective of tillage system. Beneficial insect numbers in fields apparently are not affected much by tillage system.

Disease management. Reduced soil temperature increased moisture, and crop residue on the surface may result in an increase, decrease, or no effect on severity of a disease. Seed rots are at their worst with cool, wet conditions and delayed germination. Seedling blights are less with vigorous seedling growth. Gray leaf spot of corn may be worse with reduced tillage. Corn ear disease and stalk rot pathogens of corn and sorghum survive in crop residues, but stalk rot of grain sorghum was found to be much less with reduced tillage as compared to conventional tillage (Doupnik and Boosalis, 1980).

Soybean diseases that are worse with reduced tillage include phytophtora root rot and brown stem rot. White mold and charcoal rot may be less with reduced tillage. Selection of adapted varieties, rotation with non-legume crops, good weed control, and other management practices contribute to reduced severity of root and stem diseases in all tillage systems.

Costs and returns. Gross returns to crop production are related to yield. High yields, however, may be obtainable with any of several well-managed tillage systems. Yields with no-till or ridge tillage may be similar, more, or less than yields with tillage. The no-till yield advantage is likely to be greater on upland soils than on bottomlands and with non-irrigated as compared to irrigated conditions. Crop yield in situations of poor drainage may be higher with increased tillage.

Less labor is required with no-till than with a conventional tillage system. This labor savings often comes in the spring at a time of relatively high labor demand. Timeliness of field operations is important to productivity; timely planting is easier to achieve with fewer operations to be completed at or near planting time.

Machinery costs may be the major short-term consideration of converting to an alternative tillage system. Over the long term, tillage costs should be lower with reduced tillage, and least with no-till. No-till and ridge tillage may require a greater investment in planting equipment, while less tillage equipment is needed and smaller tractors may be sufficient.

Pesticide, including herbicide, costs may be greater with no-till than with conventional tillage systems. Herbicide costs may be least with ridge-till in combining a band application of herbicide with row-clearing before or at planting and with inter-row, ridge-forming cultivation.

Choosing the Right Tillage System

A decision guide is presented in *Table III* to assist a producer to consider 19 criteria in the choice of a tillage system. Preference values of four tillage systems are given for different criteria. These are not universally true, and while reasonable for most farming operations in Nebraska, producers may adjust these in applying the decision guide to their operation; however, the sum of the preference values for a criterion should equal 20.

Step 1. Evaluate the relative importance of each criterion for your farming operation and enter the score in the column called "**Farm Wt**.". **Farm wt.** scores should range from 0 to 5 with 0 being of no importance and 5 being very important. For example, the Farm Wt. score for the line "Ease of furrow irrigation" is "0" if furrow irrigation is not practiced, but may be "5" if most fields are furrow irrigated. The score for water erosion may be "4" or "5" if erosion is of high importance, but it might have a "1" or "2" for where very little erosion occurs.

Step 2. Multiply the **Preference** score by the **Farm Wt.** score for each of the four tillage systems and enter the product in the respective right-hand columns.

Step 3. Add the products for each tillage system (from the right-hand columns) and write the sums in the **sub-total** line. The tillage system with the highest total should be the most preferred for your farming operation.

Step 4. Weigh the cost of converting to the alternative tillage system against the expected benefits.

Other Related NebGuides and Extension Circulars

Doupnik, B. and M.G. Boosalis, *Ecofallow—a reduced tillage system and plant diseases.* Plant Disease 64:31-35.

Management Strategies to Minimize and Reduce Soil Compaction. NebGuide G896.

Table III. Worksheet to aid individual producers to select a tillage system in consideration of 19 criteria.

Criteria	*Disk*	*Chisel*	*Ridge till*	*No till*		*Disk*	*Chisel*	*Ridge till*	*No till*
					Farm Wt				
Water erosion	1	1	7	11					
Wind erosion	1	1	7	11					
Runoff/water infiltration	2	4	6	8					
Early soil temperature	9	8	2	1					
Early soil moisture	4	1	5	10					
Water retention	3	1	6	10					
Disease management	7	7	3	3					
Insect pest management	7	7	3	3					
Weed management	4	4	6	6					
Soil fertility management	6	6	4	4					
Compaction/hardpan management	2	6	6	6					
Crusting management	2	2	7	9					
Time required for operations	5	1	4	10					
Management required	7	4	4	5					
Fuel required	4	1	5	10					
Ease of furrow irrigation	5	4	11	0					
Ease of sprinkler irrigation	5	5	5	5					
Manure management	7	7	4	2					
Cost of pesticides	6	6	4	4					
Sub-total	XXX	XXX	XXX	XXX	XX				
Conversion costs: purchase/hire	XXX	XXX	XXX	XXX	XX				
Total	XXX	XXX	XXX	XXX	XX				

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