CHALLENGES TO ZERO TILLAGE ON HEAVIER TEXTURED SOILS

The adoption of reduced tillage (RT) cropping systems in Manitoba has not occurred uniformly across the province. The primary reasons for most producers adopting a reduced tillage cropping system has traditionally been for erosion control and moisture conservation. As a result, in many areas of Manitoba where a lack of moisture and higher risk of water erosion (due to hilly topography) are not major problems, producers have not embraced the RT concept. However, there are still many other benefits such as reduced inputs costs, lower risk of wind erosion and increased soil organic matter, that could be realized if some of the inherent soil limitations are addressed and properly managed.

Soils

Understanding the soils on your farm is the foundation for managing a successful RT cropping system*. Texture, internal drainage and agricultural capability are three of the most useful soil properties that can shed light on what the most suitable management strategy is for that particular soil type, portion of a field or entire field. Often this information confirms what the astute producer already knows about his land.

**How soils fit into the agronomic system:*

Soil management→crop/variety selection→soil fertility & crop nutrition→IPM→marketing

- Texture - provides information on moisture storage capacity, infiltration rates, etc.
- Drainage - provides information on net water movement, salinity risk, leaching and runoff risks, etc.
- Ag capability - indications of moisture limitations, erosion risks, soils difficult to till because of dense structure, salinity, etc. Refer to **Table 2** for an assessment of the suitability of various soil types to a reduced tillage or zero tillage system.

For on-farm soil management decisions, detailed soil survey reports are an effective way to assess management considerations based on soil properties. These reports are available for selected areas of agro-Manitoba from your local agricultural representative or from the Manitoba Soil Survey Unit at 474-6112. If no detailed soils information is available for your area, or if you request additional information, call 474-6112.

Drainage

Water is the most important nutrient in crop production. Too much is as devastating to crop yields as is too little. Well drained, sandy to loamy soils are a perfect fit in a RT cropping system. Heavier textured, clay loam to clay soils are more of a challenge. Any soil type, regardless of texture, with imperfect or poor internal drainage represents an extra challenge in successfully establishing a RT cropping system.

Water moves by gravity (ie. from highs to lows) and by capillary action (from wetter to drier areas). In soils, water moves easily from larger pores to smaller pores. However, water only moves from smaller pores to larger pores when conditions become saturated. Until then, water is "held back" by the soil, acting like a check valve that only allows water to move through small pores by capillary action. Infiltration rates in soil can be dramatically increased (10X or more) by having large pores connected to the soil surface that allow water to directly enter these large pores. Tillage cuts off these pores from the surface, rendering them useless for enhanced infiltration until conditions become saturated.

Soils in mid-slope and depressional areas of the landscape, with high water tables at some point during the growing season, or with low infiltration (<1 in/hr) are likely to have wetness (excess water) limitations as the primary reason for downgrading in the Ag capability ratings (eg. 2W, 3W, 4W - See **Table 1**).

To reduce the risk of crop yield impacts due to excess water while establishing a RT cropping system:

- Improve the drainage of the landscape through enhanced surface drains or subsurface (tile) drains. Be sure to check with provincial and local requirements before altering existing field drainage, and take the time to plan a drainage design well in advance of any field operations that alter existing drainage patterns.
- Reduce the number of tillage passes gradually, when possible, to enhance internal drainage of the soil by promoting the development of root channels, earthworm channels and cracks.
- Increase organic matter in the soil through the addition of manures and by leaving as much crop residue on the surface as possible.
- ***Establish alfalfa*** *for 2-4 years to promote the development of a network of deep, large root channels and to dry out the soil profile. Terminate the alfalfa stand with herbicide (eg. glyphosate @ 1L/ac) to keep root channels connected to the surface and to maximize N credit from the alfalfa.*
- If alfalfa or other forages are not a feasible fit in your rotation, consider:
  - Winter cereals (winter wht, fall rye)
  - High water use crops (corn, millet)
  - Crops with a taproot system (sunflowers, canola)
- Continue to use crop rotations with high water use in order to utilize the additional water available in the soil profile from reduced tillage.
- Consider "strategic tillage" - tillage at specific times in the crop rotation when conditions are such that a tillage pass would be beneficial for weed control, soil warm-up, fertilizer application, seedbed preparation, etc.

Figure 1. Alfalfa will help to dry out the soil profile when excess moisture is a concern.

Residue Management

Large amounts of crop residues on heavier textured soils have made the move into a RT cropping system difficult due to challenges with cold, wet soils in spring, equipment plugging problems at seeding and immobilization of nitrogen fertilizer. To avoid these problems, it is recommended to:

Figure 2. Poor wheat residue management shown here hinders emergence of flax.

- Begin to manage crop residues at harvest - ensure straw choppers and chaff spreaders on combines are in optimum working condition.
- When dealing with heavy amounts of cereal crop residues, consider:
  - Baling straw for alternate uses
  - Chaff collection for livestock feed, weed seed removal
  - Heavy harrowing to break up, spread straw
  - Mowing stubble to further chop straw
- Fall band ammonia to reduce immobilization of N and to enhance spring soil warm-up
- Design a crop rotation that utilizes crops/varieties with higher crop residue production in alternate years with crops having lower residue production (eg. cereals before and after pulses, flax, etc.)

Seed Openers

A variety of openers are available to perform well under certain types of conditions. Soil type, residue clearance, amount of disturbance, draught requirements, and fertilizer placement must be considered when selecting the desired opener for your seeding operation under RT. Consult with your local equipment dealer or Prairie Agricultural Machinery Institute for more information on openers.

Conclusion

A change in the cropping system where tillage is reduced or removed must be compensated by an increase in management, particularly in *water management* (through enhanced drainage and crop rotation) and in *residue management* (harvest management and crop rotation). Know your soil type and general seeding conditions to ensure you select the best opener for seeding.

Table 2. Suitability of Reduced/Zero Tillage Systems According to Ag Capability Rating of Soil Series.

Ag Cap	Soil Description	Suitability to RT or ZT systems
1	No significant limitations	Suitable
2T	2 - 5% slopes	Suitable (prevents water erosion)
3T	5 - 10% slopes	Suitable (prevents water erosion)
4T	10 - 15% slopes	Suitable (use 2/3 forages, 1/3 annual crops)
5T	15 - 30% slopes	Not suitable - perennial forages only
6T	30 - 45% slopes	Not suitable - perennial forages only
2E	Topsoil removed; subsoil partially removed by erosion	Suitable (use for erosion control)
3E	No topsoil or subsoil remaining	Not suitable - perennial forages only
4E	No topsoil or subsoil remaining	Not suitable - perennial forages only
5E	No topsoil or subsoil remaining	Not suitable - perennial forages only
6E	No topsoil or subsoil remaining	Not suitable - perennial forages only
2M	Stratified loams	Suitable (use to conserve moisture, prevent erosion)
3M	Loamy sands	Suitable (use to conserve moisture, prevent erosion)
4M	Sands	Suitable (use 2/3 forages, 1/3 annual crops)
5M	Coarse sands	Not suitable - perennial forages only
6M	Stabilized sand dunes	Not suitable - perennial forages only
2W	Well & Imperfectly drained soils	Suitable following forages or high water use crops
3W	Wet soils, loam to clay textures w/improved drainage	Suitable following forages or high water use crops
4W	Wet soils, sandy textures w/improved drainage	Suitable following forages tolerant to excess water
5W	Poorly drained soils, no improvements	Not suitable - artificial drainage required prior to annual cropping
6W	Very poorly drained soils	Not suitable
2P	Moderately stony soils	Suitable with rock removal practices
3P	Very stony soils	Suitable with rock removal practices
4P	Exceedingly stony soils	Not suitable - perennial forages only
5P	Exceedingly stony soils	Not suitable - perennial forages only
6P	Excessively stony soils	Not suitable - perennial forages only
2D	Massive clay or till soils, slow infiltration	Suitable following forages or high water use crops
3D	Solonetzic intergrade soils, very slow infiltration	Suitable following forages or high water use crops
4D	Black solonetzic soils, extremely slow infiltration	Not suitable - perennial forages only
2N	Weak salinity: 2-4 dS/m (0-2 ft), 4-8 dS/m (2-4 ft)	Suitable with appropriate crop selection
3N	Moderate salinity: 4-8 dS/m (0-2 ft), 8-16 dS/m (2-4 ft)	Suitable with appropriate crop selection
4N	Strong salinity: 8-16 dS/m (0-2 ft), 16-24 dS/m (2-4 ft)	Suitable with appropriate forage crop selection
5N	Very strong salinity: 16-24 dS/m (0-2 ft), >24 dS/m (2-4 ft)	Not suitable - perennial forages only
6N	Very strong salinity: 16-24 dS/m (0-2 ft), >24 dS/m (2-4 ft)	Not suitable - perennial forages only
4R	Bedrock 50-100 cm from surface	Not suitable - perennial forages only
5R	Bedrock 20-50 cm from surface	Not suitable - perennial forages only
6R	Bedrock <20 cm from surface	Not suitable - perennial forages only
7	No capability for agriculture	Not suitable

AGRICULTURE CAPABILITY

Agricultural Capability is a 7-class rating of mineral soils based on the **severity of limitations for dryland farming***, which implies a risk to regional production capacity when soils are farmed and the way these soils respond to management.*

- *Class 1, 2 and 3 soils are capable of sustained production of common field crops*
- Class 4 soils are marginal for sustained arable agriculture and should be in permanent forage production
- Class 5 soils are suitable only for improved permanent pasture
- Class 6 soils are capable only for native pasture use
- Class 7 soils are incapable of use for arable agriculture or permanent pasture.

Agriculture capability (ag cap) subclasses identify the soil properties or landscape conditions that may limit use. A capital letter immediately following the class number identifies the limitation (eg. 2W, 3N, etc.) Refer to Table 1 for detailed criteria of ag capability classes.

Subclasses

C – adverse climate (outside the boundaries of agro-Manitoba)
D – dense soils (undesirable soil structure/low permeability)
E – erosion damage
F – low inherent fertility
I – inundation (flooding) by streams and lakes
M – moisture (droughtiness)/low water holding capacity
N – salinity
P – stoniness
R – consolidated bedrock
T – topography (slopes)
W – excess water other than flooding (inadequate soil drainage or high water table)
X – two or more minor limitations

How does this compare to MCIC's A-J Soil Productivity Index ratings?

Manitoba Crop Insurance Corporation uses a 10-category classification system for cultivated land based on **soil productivity as determined by crop yields**. Each quarter section receives a single rating and the ratings are calculated based on moving average cropping data.

Table 1. Dryland Agriculture Capability Guidelines for Manitoba - Based on the Canada Land Inventory Soil Capability Classification for Agriculture (1965), with modifications made for soil application at larger mapping scales.

Subclass Limitations	Class 1	Class 2	Class 3	Class 4	Class 5	Class 6	Class 7
	No significant limitations in use for crops.	Moderate limitations that restrict the range of crops or require moderate conservation practices.	Moderate severe limitation that restrict the range of crops or require special conservation practices.	Severe limitations that restrict the range of crops or require special conservation practices or both.	Very severe limitations that restrict soil capability to produce perennial forage crops, and improvement practices are feasible.	Soils are capable only of producing perennial forage crops, and improvement practices are not feasible.	No capability for arable culture or permanent pasture.
Climate (C)	All Ecodistricts[1] within ARDA boundary not explicitly listed under 2C and 3C.	Ecodistricts: 664, 666, 668, 670, 671, 672, 674, 675, 676, 677, 714, 715, 716	Ecodistricts: 356, 357, 358, 359, 363, 366, 663, 665	None within ARDA boundary			
Consolidated Bedrock (R)				50-100 cm	20-50 cm	< 20 cm	Surface bedrock Fragmental over bedrock
Moisture limitation[2] (M)		Stratified loams Moderate moisture holding capacity	Loamy Sands Low moisture holding capacity	Sands Very low moisture holding capacity	Skeletal Sands Very severe moisture deficiency	Stabilized sand dunes	Active sand dunes
Topography[3] (T)	a, b (0-2%)	c (>2-5%)	d (>5-10%)	e (>10-15%)	f (>15-30%)	g (>30-45%) Eroded slope complex	h (>45 - 70%) i (>70 - 100%) j (> 100%)
Structure and/or Permeability (D)	Granular Clay	Massive clay or till soils[4] Slow permeability	Solonetzic intergrades Very slow Permeability	Black Solonetz Extremely slow Permeability			
Salinity[5] (N) a.00-60cm depth b.60-120cm depth	NONE < 2dS/m < 4ds/m	WEAK 2-4 dS/m 4-8 dS/m	MODERATE (s) 4-8 dS/m 8-16 dS/m	STRONG (t) 8-16 dS/m 16-24 dS/m	VERY STRONG (u) [6] 16-24 dS/m >24 dS/m		Salt Flats
Inundation[7] (I)	No overflow during growing season	Occasional overflow (1 in 10 years)	Frequent overflow (1 in 5 years) Some crop damage	Frequent overflow Severe crop damage	Very frequent (1 in 3 years) Grazing > 10 weeks	Very frequent Grazing 5-10 weeks	Land is inundated for most of the season
Excess Water (W)	Well and Imperfectly drained		Loamy to fine textured Gleysols with improved drainage	Coarse textured Gleysols with improved drainage	Poorly drained, no improvements	Very Poorly drained	Open water, marsh
Stoniness (P)	Nonstony (0) and Slightly Stony (1)	Moderately Stony (2)	Very Stony [8] (3)	Exceedingly Stony (4) [9]		Excessively Stony (5)	Cobbly Beach Fragmental
Erosion[10] (E)		Moderate erosion (2)	Severe wind or water erosion (3) lowers the basic rating by one class to a minimum rating of Class 6 [11].				
Cumulative minor Adverse Characteristics[12] (x)							

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