A GUIDE TO BUILDING HEALTHY SOIL IN NORTH DAKOTA

As farmers prepare for the future, they cannot overlook the importance of soil health. In this guide we examine how barley farmers like you can improve soil health through regenerative practices like no-till and cover cropping. These practices can improve soil structure and water-holding capacity, combat water and nutrient loss, and prevent erosion across North Dakota.

Soil health tests are important for effectively adopting regenerative farming practices; they give you data about your soil and help you track changes to its health. The information from soil health tests can help you determine which management practices to change to increase soil organic matter and build healthy soil.
Soil building practices are important to select soil building practices that complement productivity and cost you more money in the long term.

Increasing the organic matter of soil can take years. It is important to select soil building practices that complement North Dakota’s average annual rainfall (between 15 to 19 inches), irrigated dryland cropping systems, and saline soils.

Tillage
According to the 2017 United States Agriculture Census, of the 16 million acres of total cropland in North Dakota, 7.7 million acres were under no-till cultivation. Continuous tillage on a field can lead to soil erosion, nutrient depletion, and a reduction in soil organic matter over time. Moving away from continuous tillage and adopting no-till or reduced tillage practices will improve soil health. Table 1 below illustrates the benefits and challenges of various tillage systems.
### Table 1: Benefits and Challenges of Tillage Systems

<table>
<thead>
<tr>
<th>Continuous Tillage</th>
<th>Reduced Tillage Practices</th>
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<tr>
<td><strong>What It Does</strong></td>
<td><strong>Benefits</strong></td>
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<td>Tillage occurs frequently on the farm. It is used for creating seedbeds, weed suppression, soil aeration, removing crop residue, and leveling the soil.</td>
<td>Results in warmer soil at planting.</td>
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<td></td>
<td>Easily allows for soil preparation.</td>
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<td><strong>Strip Tillage</strong></td>
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<td>Strip tillage systems slightly disturb soil, but not as severely as conventional tillage. Strip tillage incorporates residue into a narrow strip before planting.</td>
<td>Can be a great form of reduced tillage to adopt while transitioning to no-till.</td>
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<td>Is ideal for poorly drained soils.</td>
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<td>Increases soil temperature and decreases soil moisture at planting compared with no-till.</td>
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<td>Is effective for building soil organic matter.</td>
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<td><strong>No-Till</strong></td>
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<td>No-till leaves crop residues on soil surface. Minimizes disturbance to the soil except at planting and harvesting and when applying nutrients.</td>
<td>Decaying crop residues contribute organic matter to the soil.</td>
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<td>Crop residues on the soil protect it from wind, preventing erosion.</td>
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<td>Reduces fuel and labor costs.</td>
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If you are continuously tilling your fields and have issues with compaction, you may want to consider moving to a reduced tillage system, like strip tillage, before switching completely to a no-till system. No-till involves leaving all crop residues on a soil surface after harvest and not disturbing the soil except to plant, harvest, or apply nutrients. Crop residues contribute organic matter to the soil and reduce the potential for erosion. However, if your soil is compacted, transitioning directly to no-till could cause yields to decrease in the first year because your soil has relied on tillage for releasing nutrients and relieving compaction. Lower yields may result because organic matter has not had enough time to build and adapt to the new, healthier soil conditions. Transitioning to strip tillage first will help you build organic matter and improve your soil structure before moving to a long-term no-till system.

According to the U.S. Department of Agriculture, a farmer growing on 1,000 acres can reduce fuel costs by $6,600 annually by switching from continuous tillage to no-till. Additionally, there is the time a farmer saves from not having to till his or her fields. It takes time to establish a no-till system, but after the initial transition no-till soils typically outyield conventionally tilled systems.

Leaving residues on soil can be ideal for North Dakota’s irrigated dryland cropping system. However, if you flood irrigate, leaving too much crop residue can inhibit consistent watering across a field because the residue may block the flow of water.

**Cover Crops**

Cover cropping refers to planting a crop as part of a rotation that is not intended for harvest, but rather is planted to improve soil health and provide other agronomic benefits. **Cover crops naturally fix carbon and nitrogen in the soil, reducing the need for synthetic inputs.** Cover crops also introduce crop diversity into a rotation, which helps reintroduce living organisms to the soil, build soil structure, and promote a soil environment that naturally controls pests and insects, thus reducing the need for costly chemicals. Cover crops can fit into a rotation multiple times a year and can be planted in lieu of a fallow period. There is a growing interest in cover cropping in North Dakota, and farmers in the state are adopting the practice with increasing rates of success.

![An example of a field planting sorghum as a cover crop.](https://via.placeholder.com/150)
Cover crops can be a valuable tool to improve soil health, but since different cover crops have different outcomes for soil health, it is important to decide what you want your cover crops to achieve. With cover crops, you can:

**Build Soil Organic Matter**
Planting cover crops that produce the greatest biomass can help boost your soil’s organic matter. A grass (e.g., cereal rye, oat, triticale, s undan grass) produces large amounts of biomass and, in some cases, can outcompete weeds—another benefit of cover crops.27

**Sequester and Scavenge Nitrogen for Your Crops**
Cover crops from the legume family naturally fix nitrogen from the atmosphere into your soil, reducing the need for fertilizer. For example, a legume cover crop like alfalfa could add 60 pounds of nitrogen per acre, leading to substantial savings in fertilizer costs.28 Some common legume cover crops include, forage pea, field pear, winter Australian pea, fava bean, clovers, hairy vetch, lupin, and chickling vetch.29 Dryland farmers must terminate cover crop at the first bloom to ensure that the cover crop does not compete for the cash crop’s water supply.30

Cover crops can also scavenge nitrogen already in the soil for your crops to use. It’s possible that your soil already has enough nitrogen for healthy plant growth. However, the nitrogen may be inaccessible in the plant root zone. Planting a cover crop with a taproot (e.g. radish, rapeseed, flax, and turnips) can help scavenge the nitrogen and make it available to future crops.31

**Salt-Tolerant Crops**
Saline soils are common in North Dakota. Salt-tolerant cover crops (e.g. rapeseed, rye, Siberian millet, and sorghum-sudangrass) can help combat soil salinity while adding soil organic matter.32

**SOIL AMENDMENTS—COMPOST AND MANURE**
Composts and manures improve soil structure over time by increasing organic matter, buffer capacity, and soil water-holding capacity.33 Composts and manures also add critical soil nutrients like nitrogen, phosphorus, potassium, and other micronutrients—again, helping reduce fertilizer costs.34 A few key differences between composts and manures are detailed in Table 2.

| TABLE 2: COMPARISON BETWEEN COMPOSTS AND MANURES |
|-------------------------------|-----------------|-----------------|-----------------|
| What It Is | Benefits | Challenges |
| Compost | A nutrient-stable product created from decomposed manure, crop residue, and organic matter in the presence of oxygen.35 | The composting process typically kills pathogens and weed seeds, making it less likely for weed seeds to spread on your fields. | Can be more difficult to locate, and can be costlier. |
| Manure | A by-product of animals that has not undergone the composting process. | Is typically easier to locate. | Can spread weed seeds or pathogens. |

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A close up image of cover crops in a field in North Dakota.
While composts and manures can improve soil health, they can also increase a soil’s salinity. If you are concerned with salinity, focus on cover cropping and reduced tillage. If manure is applied incorrectly, the nitrogen it contains can be lost to the atmosphere instead of being absorbed by the soil. When applying manure to a field, use a method, such as a sweep or knife injection, that minimizes the potential of losing nitrogen to the atmosphere through volatilization. Available nitrogen will continually decrease over time. Leaving the manure outside for even one day after receiving it could result in a 35 percent loss of plant-available nitrogen from manure. Waiting just one week to incorporate manure could result in a 95 percent loss.

If you are farming in a no-till system, apply compost instead of manure to ensure nutrients are not lost to the atmosphere. If you till to prepare your fields for seeding, apply manure at the same time as you prepare your beds. This way, instead of tilling twice (during field preparation and during manure incorporation), you till only once (incorporating manure as you prepare your field for seeding).

The nutrient availability in manure or compost will vary according to the source and application method. The plant-available nutrients from manure are typically released over two years. Most manure releases about 35 percent of its available nitrogen in the first year of application and 50 percent of the remaining nitrogen in the following year. For composts, about 10–25 percent of the available nitrogen, and 40–60 percent of the phosphorus and potassium, will be released in the first year after a compost application.

When planning your nitrogen applications, include the nitrogen credits from manure and compost to eliminate the potential for overfertilization.

CONCLUSION
Soil health is incredibly important to the health of our land, water, and food. Building soil health can yield a plethora of benefits. In the first year of using soil-building practices, farmers can expect to save time and fuel costs by switching to strip or no-till, and to save fertilizer costs from using cover crops or animal by-products. Incorporating the practices discussed in this fact sheet can improve soil health, structure, and composition year after year. As you incorporate no-till, cover crops, and soil amendments, share your experiences with your agronomists, regional experts, and other farmers.
ENDNOTES

2. Ibid.
7. Wade Bott, Interview by Abigail M. Zlotnick, Phone Interview, February, 2019
12. Our use of 55 pounds available nitrogen in soil is based on the average available nitrogen from a database of 20,000 soil samples collected by USDA’s Agriculture Research Service lab and analyzed by USDA soil scientist Richard L. Haney.
16. Ibid.
17. Ibid.
18. Ibid.
19. Ibid.
22. Magdoff and Van Es, “Reducing Tillage.”
24. Kent McCay, “Montana Data on Cover Crops.”
26. Ibid.
27. Ibid.
29. Marisol Berti, “How to Select a Cover Crop or Cover Crop Mix?”
31. Marisol Berti, “How to Select a Cover Crop or Cover Crop Mix?”
32. Ibid.
33. Havlin et al., Soil Fertility and Fertilizers.
36. Havlin et al., Soil Fertility and Fertilizers.
37. Ibid.
38. Ibid.
39. Ibid.
41. Ibid.
42. Rittenhouse, “Tipsheet: Compost.”