No-till and conservation agriculture in the United States: An example from the David Brandt farm, Carroll, Ohio

R. Islam¹ and R. Reeder²

Abstract

No-till (NT) farming (conservation agriculture) began in the US in the 1960s. The state of Ohio has a university research location that began no-till research in 1962. A few innovative Ohio farmers, including NT pioneers David Brandt and Bill Richards, were early adopters of the new conservation practice. Initially, no-till was most successful on sloping, well drained soils, then with improvements to the system, including cover crops, it became more widely adopted on all soil types. David Brandt was an enthusiastic learner and teacher of no-till practices, working with chemical company representatives and Cooperative Extension Specialists to demonstrate the system.

David Brandt’s cooperation with Ohio State University researchers continues to provide a valuable site for studying the long term changes in soil health and ecosystem services. Results showed that total microbial biomass as one of the soil biological health indicators significantly increased with an associated decrease in carbon (C) loss under NT compared with conventional tilled soil (CT). Under NT, there was significantly higher total C and total N compared to CT. Active C, as a composite measure of soil health, significantly increased with NT. When cover crops, especially cover crop cocktail mixes, were used, NT substantially improved soil health. Long-term NT with cover crop cocktail mixes significantly increased the soil aggregate stability, compared with CT. The overall rate of C sequestration by NT suggested that the soils on the Brandt farm act as a consistent sink of atmospheric CO₂ although this tends to level off after about 20 years. The Brandt farm showed that crop yields are increased under long-term NT with cover crops mixes. Results suggested that starting with a cover crop when switching from CT to NT, is more likely to ensure success and to maintain economic crop yields.

Another early adopter, Bill Richards, from Circleville, Ohio, also became a national leader and promoter of no-till farming. He served as head of the United States Department of Agriculture’s Natural Resources Conservation Service in the early 1990s and instituted a program that led to rapid expansion of no-till. He advises that farmers who follow conservation agriculture principles need to be more proactive, from local level to national levels, to influence policy decisions that can lead to robust improvement in soil health.

Key Words: Innovation, Eco-farming, Corn, Soybeans, Wheat, Cover crops, Carbon sequestration, Soil organic matter, Agroecosystems, Carbon management index, Farm bill, Government policy

1 Introduction

The original research on no-till agriculture was done in the USA, as well as in the United Kingdom, Switzerland and Scandinavia in Europe (Kertesz et al., 2014, this issue). The “dust bowl” of the 1930s and Edward Faulkner’s book, “Plowman’s Folly” (Faulkner, 1943), challenged the concept that inversion tillage (conventional tillage) was necessary to produce a good seed bed and ensure germination. These unconventional ideas, that seeds could be planted directly into residues from the previous crop(s), motivated a soil conservation movement in the US that eventually culminated in the development of no-tillage practices as they are applied

¹ Ph. D., Research Scientist; Soil, Water and Bioenergy Resources, Ohio State University South Centers, OH. Corresponding author: E-mail: islam.27@osu.edu
² P. E., Associate Professor (Emeritus), Food, Agricultural and Biological Engineering Dept., Ohio State University. E-mail: reeder.1@osu.edu
today. Many of these concepts and ideas evolved from early soil conservation literature (Bennett and Lowdermilk, 1938; Lowdermilk, 1953; Faulkner, 1943; Triplett et al., 1963; Triplett and Dick, 2008; Harrold et al., 1970; Phillips and Young, 1973; Van Doren et al., 1976; Phillips et al., 1980; Phillips and Phillips, 1984).

However, adoption of NT, even after its successful demonstration in the 1950s, was slow. It required better planters, cheaper herbicides, and accumulated knowledge and experience before NT began to be widely adopted in the 1980s. In the course of time, the no-tillage pioneers revolutionized agricultural systems with better, ecologically based land management systems, with reduced energy, labor, and machinery inputs. At the same time, experience showed that while NT provided effective soil erosion control, it also improved soil water and fertilizer use efficiency. Research also showed that with experience, crop yields were comparable or better than those obtained under conventionally tilled systems. Recent reviews that summarized the benefits of no-tillage in the US include: Reeder (2000); Owens (2001); Triplett and Dick (2008); Huggins and Reganold (2008); Dick et al. (1996); Reicosky et al. (2011). Internationally, the soil conservation movement emanated from several publications, namely: Bennett and Lowdermilk (1938); Lowdermilk (1953); Faulkner (1943); Bennett (1947); Fukuoka (1978), Bäumer (1970); Kuipers (1970), Kassam et al. (2009), and Friedrich et al. (2012).

Although there are many pioneers in soil and water conservation in the US, and the documentation has been extensive, the successes achieved in Ohio, on one farm, were chosen to represent the US success story. This is because the documentation of research on the farm was extensive, innovative, and long term. It was conducted in partnership between the farm owner, David Brandt (Photo 1), and researchers from The Ohio State University. The no-tillage (NT) system (also referred to as direct seeding, zero tillage, and sometimes conservation tillage/conservation agriculture) is evolving as the primary strategy in modern farming that adequately protects the soil from erosion, while concomitantly providing solid economic returns and enhanced environmental benefits. 3

This paper demonstrates the progress that can be made in the farmer-researcher partnership and the valuable information that can be gained. Results from the research on the Brandt farm are described in the paper, whereas the evolution of no-till on the Brandt farm is described in the Appendix.

2 The agricultural industry in Ohio

Agriculture is the leading industry in Ohio, providing farm gate receipts approaching $10 billion, and contributing over $100 billion to the economy of the state. Ohio has a total of 5.8 Mha of farm land (14.3 million acres), and about 75,000 farms, 90% of which are operated as family farms. Soil conservation technologies have been fundamental to the development of the agricultural industry in Ohio, making Ohio one of the nation’s leaders in sustainable agricultural production.

In addition to the rich history of agricultural development, Ohio also has a long history of Conservation Agriculture (no-till) pioneers. In 1962, two researchers at the Ohio State University, Drs. Glover Triplett and David Van Doren (Photo 2) (with assistance from agricultural engineering professor, Dr. William Johnson), began the world’s first research project on no-tillage at the Ohio Agricultural Research and Development Center (OARDC), Wooster, Ohio (Triplett et al., 1963; Triplett et al., 1964). This research continues to this day (Triplett and Dick, 2008; Dick et al., 1991).
3 Agronomic and environmental research and innovation on the Brandt farm

Results of the research conducted on the Brandt farm are outlined below. These are centered on using continuous no-till as the basic land management strategy.

3.1 No-till and cover crop cocktails

Cover crops are central components in the concept of Conservation Agriculture as defined by FAO (Friedrich et al., 2012), and improve the odds of achieving success with continuous no-till farming. Currently, the Brandt farm uses a variety of cover crops, including oilseed radish, Austrian winter pea, Sunhemp, hairy vetch, crimson clover, pearl millet, Sudan-sorghum and sunflowers (Photo 3). This mixture of cover crops is called a cover crop cocktail. While most NT farmers plant just one or two species of cover crops together, a cocktail consists of typically 5 to 10 species with differences in type and architecture (C3 vs. C4), plant height and growth pattern, root distribution, nutrient and allelopathic chemical contents, and adaptability. The goal of a cover crop cocktail is to have plants of different heights and different rooting patterns, including legumes and non-legumes, to capture the synergy of diverse plants working together. This helps to recycle above and below ground biomass, minerals, and most of the carbon that plants accumulate during the growing season. Working closely with USDA scientists and innovative farmers, the Brandt farm contributed to the development of a Cover Crop Chart, which is designed to assist producers with decisions on the use of cover crops in crop production systems (http://www.ars.usda.gov/services/software). The chart, patterned after the periodic table of elements, includes information on different crop species that can be planted individually or in cocktail mixtures. Information on growth cycle, relative water use and plant architecture, are included for most common cover crops.

3.2 No-till and soil health

Studies on the Brandt farm showed that holistic farming approaches, using continuous no-till with or without cover crops, provide a range of agronomic, environmental, ecological, economic and social benefits (Stavi et al., 2012; Khosa et al., 2011; Islam et al., 2013). These include bio-mulch to conserve soil moisture, biological N fixation, reactive nutrient (N and P) recycling, diversified soil biology, improved biocontrol of pests and diseases, increased soil organic matter, improved soil structure, reduced soil compaction, and enhanced protection against wind and water erosion (Photo 4).

Khosa et al. (2011) conducted an extensive study on the Brandt farm comparing long term continuous no-till with conventionally plowed soil (Tables 1 and 2; Fig. 2 and Fig. 3). Results showed that soil health properties at the 0 to 30-cm depth, such as soil microbial biomass (SMB), were distinctly improved under the innovative farming practices of continuous no-till (Table 1). SMB is the living and most dynamic component of soil organic matter (SOM). The highest SMB (264.7 mg kg⁻¹) was achieved under 35 years of continuous no-till (NT35), followed by NT20 (218.3 mg kg⁻¹) and NT6 (177.6 mg kg⁻¹), compared to only 114.9 mg kg⁻¹ under conventional plowing (CT). In other words, SMB was improved by 1.55, 1.90 and 2.30 times.
under NT6, NT20 and NT35, respectively compared to CT. As would be expected, soil biological activity (respiration) also increased with the change from CT to long-term NT, ranging from 17 to 23 mg kg\(^{-1}\) d\(^{-1}\) (Table 1), and increasing by 16%, 19% and 26% under NT6, NT20 and NT35 respectively. However, the ratio of soil respiration to SMB (as a measure of biological C loss), was comparatively higher under CT than under long-term NT (data not shown), and decreased from switching CT to NT. Compared with CT, the NT6 reduced the C loss by 27% followed by 41% under NT20 and 79% under NT35.

The long-term NT significantly improved total soil C (TC) and total N (TN) concentration (Table 1). Under NT, there was significantly higher TC (14.4 to 19.3 g kg\(^{-1}\)) compared to CT (11.7 g kg\(^{-1}\)), and NT significantly increased the active C (AC) from 510 to 600 mg kg\(^{-1}\) over CT (470 mg kg\(^{-1}\)). Total N was significantly higher under NT (1.37 to 1.94 g kg\(^{-1}\)) than under CT (1.13 g kg\(^{-1}\)). The amount of particulate organic matter (POM) varied between 7.2 to 11.5 g kg\(^{-1}\) under the different tillage treatments (Table 1), being highest in NT35 (11.5 g kg\(^{-1}\)) followed by NT20 (8.8 g kg\(^{-1}\)), NT6 (7.6 g kg\(^{-1}\)), and was lowest in CT (7.2 g kg\(^{-1}\)).

### Table 1
Continuous no-till impacts on microbial biomass, microbial activity (respiration), total organic and active carbon, total nitrogen, and particulate organic matter in soil

<table>
<thead>
<tr>
<th>Tillage Trt.</th>
<th>Depth (cm)</th>
<th>SMB (mg kg(^{-1}))</th>
<th>Respiration (mg kg(^{-1}) d(^{-1}))</th>
<th>TC (g kg(^{-1}))</th>
<th>AC (mg kg(^{-1}))</th>
<th>TN (g kg(^{-1}))</th>
<th>POM (g kg(^{-1}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>0-30</td>
<td>115c(^\delta)</td>
<td>17b</td>
<td>11.7c</td>
<td>470c</td>
<td>1.13d</td>
<td>7.2c</td>
</tr>
<tr>
<td>NT6</td>
<td>0-30</td>
<td>178b</td>
<td>20a</td>
<td>14.4b</td>
<td>510b</td>
<td>1.37c</td>
<td>7.6c</td>
</tr>
<tr>
<td>NT20</td>
<td>0-30</td>
<td>218b</td>
<td>21a</td>
<td>19.1a</td>
<td>590a</td>
<td>1.74b</td>
<td>8.8b</td>
</tr>
<tr>
<td>NT35</td>
<td>0-30</td>
<td>265a</td>
<td>23a</td>
<td>19.3a</td>
<td>600a</td>
<td>1.94a</td>
<td>11.5a</td>
</tr>
</tbody>
</table>

SMB=Microbial biomass, TC=Total organic carbon, AC=Active organic carbon, TN=Total nitrogen, and POM=Particulate organic matter. \(\delta\) Treatment means separated by same lower case letter were not significantly different at \(P<0.05\) among tillage treatments.

### 3.3 No-till, cover crops, and soil-plant diversity

Research and innovation on the Brandt farm fuelled development of a novel integration of cover crop cocktail mixes with the NT system, which has provided enhanced environmental and economic benefits through soil-plant ecosystem diversity. Over the years, research studies evaluating the impacts of different cover crop cocktail mixtures demonstrated the improved performance of continuous NT (Islam et al., 2013). Results showed that the type of cover crop and the amount of seed in the mixture produced varied amounts of cover crops biomass, ranging from 12 to 18 mg ha\(^{-1}\) dry biomass (DBM). The best results were obtained with an 8-way mix with 42 kg of seed ha\(^{-1}\) (Table 2). The resultant, biomass diverse, cover crop mix absorbed and held macro- and micronutrients that fertilized the succeeding plants, produced biomass that becomes mulch in the winter, and provided more high energy (sugary) carbon compounds as it stimulated and fed the soil microbes. Also, the legumes in the cover crop mix produced nitrogen that was accumulated and later made available for subsequent crops, especially corn.

### Table 2
Biomass production of different cover crop cocktails (ccrop) in continuous no-till (NT) systems

<table>
<thead>
<tr>
<th>Cover crop type</th>
<th>NTcontrol</th>
<th>NTccrop-1</th>
<th>NTccrop-2</th>
<th>NTccrop-3</th>
<th>NTccrop-4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total dry-matter (Mg ha(^{-1}))</td>
<td>18</td>
<td>15</td>
<td>13</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Cover crop</td>
<td>No cover</td>
<td>Clover</td>
<td>Cowpea</td>
<td>Winter pea</td>
<td>Buckwheat</td>
</tr>
<tr>
<td>type</td>
<td>crop</td>
<td>Cowpea</td>
<td>Pearl millet</td>
<td>Phacelia</td>
<td>Cowpea</td>
</tr>
<tr>
<td></td>
<td>Pearl millet</td>
<td>Ryegrass</td>
<td>Rape seed</td>
<td>Cabbage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sudan-sorghum</td>
<td>Soybeans</td>
<td>Triticale</td>
<td>Pearl millet</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Soybean</td>
<td>Sunflower</td>
<td>Turnip</td>
<td>Soybeans</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sunflower</td>
<td>Sun hemp</td>
<td>Hairy vetch</td>
<td>Sunhemp</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Radish</td>
<td>Sweet clover</td>
<td>Radish</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Turnip</td>
<td>Radish</td>
<td>Triticale</td>
<td>Turnip</td>
<td></td>
</tr>
<tr>
<td>Total seed used (kg ha(^{-1}))</td>
<td>42</td>
<td>44</td>
<td>117</td>
<td>82</td>
<td></td>
</tr>
</tbody>
</table>
Table 3 illustrates the increased benefits of the NT cover crop cocktail on soil health (4 years of cover crop cocktails in corn-soybean-wheat rotation under 37 years of continuous NT). Both the chemical and physical properties of the soil were improved over time under the NT and cover crop management practices (Tables 3 and 4, Fig. 4). The NT-cover crop mixtures 2 (NTccrop-2), 1 (NTccrop-1) and 3 (NTccrop-3) (but not NTccrop-4) increased the TC, AC and TN concentration at the 0 to 30-cm depth, compared with NT alone. The highest TC was obtained under NTccrop-2, followed by NTccrop-3 and NTccrop-1, compared with NT alone. The AC concentration, as a measure of soil health, increased significantly in NTccrop-2 and NTccrop-1 (Table 3), which produced an expected, although irregular increase in TN. The NT and cover crops mixes stored more soil moisture in dry areas, as observed during the drought in 2012, and used-up excess moisture in wet areas. Due to the high biomass and SOM accumulation, $\rho_b$ decreased and total soil porosity increased. However, soil pH did not vary significantly.

### Table 3 Long-term effects of continuous no-till (37 years) and cover crop cocktail mixtures (4 years) on pH, bulk density, active and total carbon, and total nitrogen

<table>
<thead>
<tr>
<th>Farming Systems</th>
<th>Depth (cm)</th>
<th>pHw (1 : 1)</th>
<th>$\rho_b$ (g cm$^{-3}$)</th>
<th>AC (mg kg$^{-1}$)</th>
<th>TC (g kg$^{-1}$)</th>
<th>TN (g kg$^{-1}$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTcontrol</td>
<td>0-30</td>
<td>6.3a</td>
<td>1.45ab</td>
<td>619.7c</td>
<td>13.4c</td>
<td>1.28b</td>
</tr>
<tr>
<td>NTccrop-1</td>
<td>0-30</td>
<td>6.4a</td>
<td>1.30c</td>
<td>757.3a</td>
<td>17.7b</td>
<td>1.61a</td>
</tr>
<tr>
<td>NTccrop-2</td>
<td>0-30</td>
<td>6.3a</td>
<td>1.31c</td>
<td>766.7a</td>
<td>22.1a</td>
<td>1.99a</td>
</tr>
<tr>
<td>NTccrop-3</td>
<td>0-30</td>
<td>6.2a</td>
<td>1.38b</td>
<td>698.0b</td>
<td>18.0b</td>
<td>1.61a</td>
</tr>
<tr>
<td>NTccrop-4</td>
<td>0-30</td>
<td>6.4a</td>
<td>1.43ab</td>
<td>587.7c</td>
<td>13.4c</td>
<td>1.24b</td>
</tr>
</tbody>
</table>

$\rho_b$=Bulk density, AC=Active carbon, TOC=Total organic carbon, and TN=Total nitrogen. *Treatment means separated by same lower case letter were not significantly different among farming systems at $P<0.05$.

### 3.4 No-till, aggregate stability, bulk density, and soil compaction

Soil aggregate properties were significantly affected by years of continuous NT (6 to 35 years) treatments (Table 4). The effects were greatest on both macroaggregate and microaggregate stability (MaA; aggregates >250 $\mu$m; MiA; aggregates <250 $\mu$m) under continuous NT. Long-term NT significantly increased the MaA (from 43.3% to 67.2%) with an associated decrease in MiA (from 44.4% to 25.8%), compared with CT. The aggregate ratio (MaA/MiA) showed the consistent and progressive effects of years of continuous NT on soil aggregation. Mean weight diameter (MWD) of aggregates increased by 16% in NT6 and 59% in NT35, compared to CT. Similarly, a consistent effect of long-term NT was observed on the geometric mean diameter (GMD) of soil aggregates.

### Table 4 Continuous no-till impacts on aggregate properties and water aggregate stability of soil

<table>
<thead>
<tr>
<th>Tillage Trt.</th>
<th>Depth (cm)</th>
<th>MaA (%)</th>
<th>MiA (%)</th>
<th>Aggregate ratio</th>
<th>GMD (mm)</th>
<th>MWD (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>0-30</td>
<td>43.3d</td>
<td>44.4a</td>
<td>0.98d</td>
<td>0.78c</td>
<td>0.94d</td>
</tr>
<tr>
<td>NT6</td>
<td>0-30</td>
<td>52.2c</td>
<td>34.9b</td>
<td>1.50c</td>
<td>0.83c</td>
<td>1.09c</td>
</tr>
<tr>
<td>NT20</td>
<td>0-30</td>
<td>57.3b</td>
<td>27.5c</td>
<td>2.08b</td>
<td>0.96b</td>
<td>1.28b</td>
</tr>
<tr>
<td>NT35</td>
<td>0-30</td>
<td>67.2a</td>
<td>25.8c</td>
<td>2.60a</td>
<td>1.18a</td>
<td>1.49a</td>
</tr>
</tbody>
</table>

MaA=Macroaggregate stability, MiA=Microaggregate stability, GMD=Geometric weight diameter, and MWD=Mean weight diameter. *Treatment means separated by same lower case letter were not significantly different at $P<0.05$ among tillage treatments.

Soil bulk density ($\rho_b$) at 0 to 15 and 15 to 30-cm depths under long term NT decreased significantly compared to CT (Fig. 1). At the 0 to 15-cm depth, the lowest $\rho_b$ (1.44 g cm$^{-3}$) was measured in the NT35 and highest in CT. The $\rho_b$ decreased linearly over the years of NT at the 15 to 30-cm depth. A decrease in $\rho_b$ is associated with an increase in total soil porosity.

Soil compaction, based on penetrometer resistance, was estimated to a depth 75-cm, at 7.5-cm intervals, using a cone penetrometer. Results showed that soil compaction was significantly reduced with the cover crop cocktail, especially when root crops such as oilseed radish were included (Fig. 2). Also, oilseed radish significantly reduced compaction to about 75-cm, an average amelioration effect of about 40% compared with soil between the rows of oilseed radish.
3.5 No-till and carbon sequestration

The relationship between NT and soil carbon sequestration (TC) are shown in Fig. 3. The TC stock at the 0 to 30-cm depth increased with the duration of NT, in comparison with CT, the TC stock for the 0 to 30-cm depth was higher by 10% under NT6, 35% under NT20 and by 61% under NT35. Thus, the overall rate of sequestration by NT was 960 kg C ha⁻¹ yr⁻¹ for the 0 to 30-cm depth. The data showed that the soils on the Brandt farm act as a consistent sink of atmospheric CO₂ although this tends to level off after about 20 years.

A carbon management index (CMI), was calculated based on, AC, SMB, POC, SC and Ext-C, as a measure of SOM quality and C sequestration (Blair et al., 1995). Long-term NT with cover crop mixes had significantly higher values of (CMI) than NT alone, although this varied significantly (Table 5). The highest values and general uniformity was with cover crop treatments NTccrop-1, NTccrop-2, and NTccrop-3, respectively.

Table 5  Cover crop cocktail mix effects on carbon management indices based on active carbon, microbial biomass carbon, particulate organic carbon, soluble carbon, and extractable carbon under long-term no-till

<table>
<thead>
<tr>
<th>Farming Systems</th>
<th>Depth (cm)</th>
<th>AC</th>
<th>SBM</th>
<th>POC</th>
<th>SC</th>
<th>Ext-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTcontrol</td>
<td>0 to 30</td>
<td>42.1b</td>
<td>6.4b</td>
<td>12.3b</td>
<td>15.7b</td>
<td>30.9b</td>
</tr>
<tr>
<td>NTccrop-1</td>
<td>0 to 30</td>
<td>54.2a</td>
<td>16.3a</td>
<td>26.2a</td>
<td>19.7ab</td>
<td>45.3a</td>
</tr>
</tbody>
</table>
Table 1  Carbon management index (% CMI) for different farming systems and soil depths.

<table>
<thead>
<tr>
<th>Farming Systems</th>
<th>Depth (cm)</th>
<th>AC</th>
<th>SBM</th>
<th>POC</th>
<th>SC</th>
<th>Ext-C</th>
</tr>
</thead>
<tbody>
<tr>
<td>NTcrop-2</td>
<td>0 to 30</td>
<td>53.5a</td>
<td>20.0a</td>
<td>27.9a</td>
<td>18.0ab</td>
<td>47.7a</td>
</tr>
<tr>
<td>NTcrop-3</td>
<td>0 to 30</td>
<td>50.6a</td>
<td>17.0a</td>
<td>30.5a</td>
<td>20.7a</td>
<td>46.4a</td>
</tr>
<tr>
<td>NTcrop-4</td>
<td>0 to 30</td>
<td>43.5b</td>
<td>9.8b</td>
<td>5.6b</td>
<td>26.8a</td>
<td>40.5a</td>
</tr>
</tbody>
</table>

CMI_{AC}=Carbon management index based on active carbon (AC), CMI_{SBM}=Carbon management index based on soil microbial biomass carbon (SBM), CMI_{POC}=Carbon management index based on particulate organic carbon (POC), CMI_{SC}=Carbon management index based on soluble carbon (SC), and CMI_{Ext-C}=Carbon management index based on extractable carbon (EC). Treatment means separated by same lower case letter were not significantly different at $P<0.05$ among farming systems.

### 3.6  No-till and yield performance

Data on long-term NT, with or without cover crops, on the Brandt farm showed that crop yields are increased or at least maintained under NT (Fig. 4). Corn yields were significantly increased (36% to 44%) with all the cover crop cocktail mixtures compared with the NT control, while using the same rates of supplemental N fertilization. Significant increases in crop yield by NT cover crop mixtures suggest adequate amounts of N are mineralized from cover crop biomass to feed the subsequent corn crop.

It is recommended to start with a cover crop (especially after wheat harvest) when switching from CT to NT, to ensure success and to maintain crop yields at economic levels. The positive impacts of cover crop mixes on soil health and crop yields are greater with NT than with CT. For a corn/soybean rotation, it is recommended to start with a cover crop after corn.

### 4  Summary

#### 4.1  On-farm research, innovation, and farmer to farmer Extension

David Brandt is one of the most innovative farmers in Ohio. He learned the basics of no-till in the 1970s and over the last 40 years he has followed holistic approaches to integrate continuous no-till and cover crops to sustain his yields and to enhance agroecological services.

Research studies conducted on the Brandt farm convincingly demonstrate that years of continuous no-till with cover crop diversity, and surface mulch provide a wide range of agronomic, environmental, and economic benefits to the producers and to society. These results show that long-term no-till with cover crops significantly increases carbon sequestration, improves soil health, increases crop yield, and enhances ecosystem services.
When switching to no-till, results suggest that it is better to start with a cover crop (especially after wheat harvest) for greater success and to sustain higher crop yields. Results also show that soil health improves quickly, while crop yield improvements may take longer.

In summary, extending the principles and technologies of soil and water conservation and improving resource use efficiency are fundamental objectives to meet the food security challenges of the 21st century. The principles and technologies of Conservation Agriculture and no-tillage agriculture are increasingly being demonstrated as part of the strategies needed to meet these objectives. They also provide expanded market opportunities for farmers, as well as enhanced environmental benefits. For example, the technologies enable farmers in low rainfall areas to grow a crop every year instead of alternate years, and in many cases allow a switch to higher value crops, such as corn replacing small grains. They are also applicable for transforming sub-optimal farmland from low value agricultural systems to more productive cropland.

Conservation Agriculture, including no-till, crop rotations, and soil-plant diversity is becoming a global movement transforming how food is produced and how to better manage the ecology in agricultural landscapes. It is proving to be the central approach to global sustainable agriculture.

4.2 Agriculture policy: No-till and the 2014 US Farm Bill

Experience gained in Ohio shows that farmers need to be more proactive and need to get more directly involved in development and interpretation of policies concerning soil and water conservation, and need to be more proactive to ensure that the intent of the legislation is carried out. If the right policies are in place and applied, it is more likely that adoption of Conservation Agriculture would proceed faster.

The 2014 Farm Bill in the U.S., signed into law in February, 2014, provides opportunities for farmers to advance agricultural production. The new law extends conservation compliance requirements in order to qualify for the crop insurance subsidy, and hopefully eliminate or reduce the need for disaster payments. The direct commodity support payments for certain crops, a staple of previous farm bills for many years, have been eliminated. Bill Richards⁴ (Photo 5), an early no-till pioneer farmer and former Soil Conservation Service (SCS) administrator stresses that, “Compliance is not regulation; it is regulation prevention. If we don’t meet our responsibilities we’ll eventually come under the Water Quality Act. Imagine if crop producers had to protect against sediment runoff the way contractors do at construction sites. Does a farmer want to surround each field with a watertight plastic fence?”

Each state in the USA has “technical committees” that advise government agencies on development and application of legislation and regulations. “These technical committees tend to be dominated by federal agencies, commodity groups, and environmental organizations,” says Richards. “(NGO’s such as) Nature Conservancy and Farmland Preservation are always there, and that’s good. But farmers also need to be well represented. With fewer farmers and land owners in the country, they had better show up. And politically on the local level, good farmers need to be active on Soil and Water Conservation boards and various county organizations.” It is increasingly important that no-till farmers become active on these committees, especially for the Natural Resources Conservation Service (NRCS) and Farm Service Agency (FSA) of the USDA. Many of the no-till principles and concepts were “pioneered” in the United States, but adoption of no-till practices has been more rapid in South America, Canada, and Australia/New Zealand.

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⁴ A prominent no-till pioneer, formerly Chief, USDA-Soil Conservation Service (now Natural Resources Conservation Service). He began farming in the mid-1960s with the no-till practices being researched at The Ohio State University. His farm has remained in continuous no-till, using controlled traffic since the early 1980s. The farm has planted cover crops after corn silage harvest the last five years.
continued educational efforts, through presentations at conferences and consulting with other farmers, are critical components for the acceptance of the technology required for sustainable production. These pioneers are leading examples of the many American farmers who have worked closely with researchers and University Extension to develop and improve Conservation Agriculture systems.

References


Appendix

History of no-till development on the Brandt farm

David Brandt is part of the new generation of innovative no-till pioneers in Ohio. After serving in the Vietnam War, he returned to Fairfield County to work at the J.C. Penny farm, where the farm manager, Chris Boerger, introduced him to no-till agriculture. After learning the basics, David began applying them on his farm, starting in 1971 with a 4-row, Allis-Chalmers no-till planter. In 1975, he imported a Moore drill from Ireland, the first no-till drill (seeder) in the U.S. A model of the Moore drill had been demonstrated at a workshop at Ohio State University for pasture renovation, but David wanted to use it for planting wheat and soybeans. And it worked. Later, through meetings sponsored by Chevron, Ohio State University Extension, and other agencies, David taught farmers in central and southern Ohio about no-till planting for wheat, soybeans, oats, and rye, as well as pasture seeding. The Moore Drill and ultimately a John Deere 7000 planter replaced the old Allis-Chalmers no-till planter. Today, he has a White 8-row planter with splitter units (Photo 6). He plants corn in 30-inch rows, and soybeans, wheat and cover crops in 15-inch rows. The planter gives him the option to plant cover crops in alternating rows, for example, oilseed radish and Austrian winter pea. His first sprayer, purchased in 1985, was a Hardi with a 42-foot boom, and 800-gallon tank on a tandem axle frame.

In the early 1970s, no-till was being promoted by Chevron. Bill Haddad, one of the innovative educators working for Chevron, organized a program that “recruited” eight farmers to serve as consultants to work with the company. These farmers, including David Brandt, were required to host a field day each year, and give three talks. This expanded his experience in farmer-to-farmer extension. When the Chevron program ended in 1980, David became involved with somewhat similar programs for Dow Elanco and Monsanto. For Monsanto, he was one of about 40 no-till farmers that met twice a year to offer advice and feedback, and also to work as trainers to other farmers.

David got started with cover crops in 1978, first using cereal rye and later adding sweet clover and hairy vetch. The legumes were introduced to add organic matter and biological nitrogen fixation for the subsequent cereal crops. Being the eternal innovator, David used cover crops creatively in the USDA program called “set aside”. This program was developed to remove about 20% of crop land from production, thereby reducing crop inventories and improving commodity prices. Most farmers in that program would choose their least productive areas for “set aside”, typically planting it to grass cover and leaving it for the duration of the program, usually several years. In deference to this, David rotated his “set aside” areas, planting cover crops for a year and then

Photo 6  Brandt’s White planter
(It plants corn in 30-inch rows, and with the splitter units, it will plant cover crops in 15-inch rows.)
moving to a different “20%” the next year, and so on. In this way, all areas eventually benefitted from being idled a year, allowing the soil quality to improve.

Incorporation of cover crops in no-till is not always successful nor without problems. But they are often worth the extra effort as mitigation against the adverse effects of tillage. For example, during the “wet” springs of the 1980s, slugs became a problem on fields with heavy residue cover. David worked with Ron Hammond, an Ohio State University Extension entomologist on solutions.

David Brandt’s work with no-till has given him many opportunities to educate and provide leadership to farmers, and it has earned him several recognitions. In 2011, he was honored as the outstanding supporter of the year for his role in promoting sustainable agricultural practices for enhanced ecosystem services by the Ohio State University South Centers at Piketon. In 2012, he was nominated for the Ohio Agricultural Hall of Fame. In 2013, he testified at a congressional hearing in Washington on benefits of cover crops and no-till agriculture. At the 2014 National Conference on Cover Crops & Soil Health, he was a featured farmer-speaker.

Recently he has been organizing sustainable agriculture and soil health workshops on his farm to train farmers and NRCS personnel and to demonstrate his research and field operations. About 500 trainers and farmers attend the annual workshops. He is the president of the Ohio No-till Council, which organizes an annual no-till conference and field days in spring and late summer. He is in demand as a professional speaker, delivering lectures and presentations across the country, including international professional meetings.