Reduced Tillage Systems are a Key Component of Sustainable Agriculture, Soil Health and Mitigating Climate Change

Overview

Soil health depends on the continued capacity of soil to function as a living ecosystem to sustain plants, animals, humans and the environment [1]. Tillage involves mechanically turning the soil to prepare the seed bed for planting crops which can contribute to soil erosion and is an environmental problem worldwide [2]. In addition, tillage releases CO_2, a greenhouse gas, from the ground into the atmosphere. Fuel used for tillage also contributes to carbon emissions. Reduced tillage is one sustainable management practice that can help protect the environment, mitigate climate change, support soil health and improve food security [3, 4].

Conventional Tillage | **Strip Till** | **No-Till**

Decreasing soil disturbance & passes across the field; Increasing crop residue left on the surface

Conventional Tillage

- // Involves multiple passes across the field
- // 100% soil surface disturbance
- // Leaves less than 15% residue on the soil surface after planting
- // All residue is incorporated into the soil
- // Management: 1st) Broadcast phosphorus (P) and potassium (K); 2nd) plow; 3rd) knife in Nitrogen (N); 4th) one or two spring diskings or field cultivations; 5th) plant; 6th) cultivate again if needed

Strip Till

- // In fall a raised berm is created by tilling a zone 5 to 9 inches deep and 6 to 10 inches wide
- // Leaves 30% of the residue on the surface between the undisturbed and tilled zones
- // Residue is removed from the tilled zone where crop is planted
- // Management: 1st) Fall strip-till may include band application of fertilizer (P & K) and spray herbicide; 2nd) plant row crops on cleared strips; 3rd) post-emergent herbicide spray as needed

No-Till

- // Provides the greatest erosion control
- // Leaves the greatest amount of residue cover (>70%) on the soil surface
- // Fertilizers may be broadcast, but band applications during or after planting are preferred
- // Biotech herbicide resistant crops used with herbicides for weed control make this system possible
- // Management: 1st) Herbicide spray; 2nd) plant into undisturbed surface; 3rd) post-emergent herbicide spray as needed

Figure 1. Comparison of three different tillage systems: conventional and two types of reduced tillage (Strip-till and No-till). Adapted from [5, 11]. Photo credit Bayer Crop Science.

Types of Tillage

Conventional tillage (Fig. 1) is the most disruptive form of seed bed preparation as it includes multiple passes across the field, 100% disturbance of the soil surface, and less than 15% residue left on the soil surface [5]. The goals of conventional tillage systems are to: minimize weed competition, incorporate crop residue and fertilizer or manure as well as aerate and warm the soil [2, 5]; however, conventional tillage systems are a major contributor to soil erosion. Events, like the Dust Bowl of the 1930's, initiated the need for improved soil management practices which included reduced tillage systems such as strip till and no-till [2, 6]. Technologies, such as herbicides used with herbicide tolerant biotech crops and diversified management practices, have enabled the improvement and adoption of reduced tillage practices [7, 8].

Reduced or conservation tillage systems decrease soil disturbance and retain some of the previous crop's residue on the soil surface. To be considered reduced tillage, a minimum of 30% of the soil surface must be covered by the previous crop's residue following the planting operation [9]. There are many different types of reduced tillage systems, two common types, strip-till and no-till, are compared to conventional tillage in Figure 1. No-till is the least disruptive to soil and leaves the greatest amount of residue cover; which is therefore, the most beneficial for soil health and the environment [3, 10]. When selecting the tillage system for their farm, farmers must consider many factors such as soil type, environmental conditions and management strategies.

Benefits of Reduced Tillage

Reduced tillage systems increase soil organic matter and microbial activity which are two of the main characteristics that influence soil health [12]. Furthermore, reduced tillage helps to mitigate climate change by sequestering organic carbon [4]. Additional benefits of reduced tillage are highlighted in Table 1. Other sustainable management practices, e.g. planting cover crops, can also increase organic matter and microbial activity as well as sequester carbon.

Table 1. Benefits of Reduced Tillage Systems [2, 12, 14].

Benefits of Reduced Tillage
Benefits the environment: Reduces soil erosion from wind and water; Improves water quality; Improves air quality; Increases habitat for wildlife; Decreases energy use
Improves soil health: Increases soil organic matter and builds soil structure, soil biodiversity (micro- and macro-organisms), nutrient supply, water holding capacity (soil moisture) and water infiltration; Improves soil pH; Decreases soil compaction; Improves crop production
Mitigates global warming: Sequesters carbon or captures and stores carbon dioxide
Improves farmers lives: Decreases required hours of labor

Adoption of Reduced Tillage

The adoption of reduced tillage systems resulted in a 42% decrease in soil erosion from 1982 to 1997 along with an increase in soil organic matter levels [11]. Genetically modified (GM) herbicide tolerant (HT) crops became available in 1996 and helped accelerate the adoption of no-till and reduced tillage systems (Figure 3) by greatly reducing the need for tillage to decrease weed competition.

The adoption of GM technology has enabled decreases in fuel use and tillage changes which lowered greenhouse gas emissions equivalent to removing 16.7 million cars from the roads [9]. By 2012, 173.1 million acres (~62.08 % of US crop land) were managed using some form of reduced tillage system (Figure 3) [13].

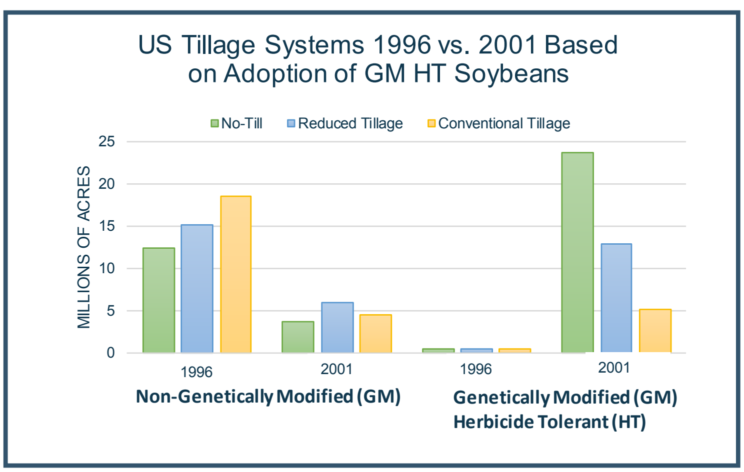

Figure 3. No-till and reduced tillage acres increased in US soybeans increased from 1996 to 2001 due to the introduction of genetically modified (GM) herbicide tolerant (HT) soybeans. In 1996 and 2001 there were 47.4 and 56.8 million acres of total soybeans grown in the US, respectively [8].

[1] A GM HT crop allows a specific broad-spectrum herbicide, such as glyphosate, to be sprayed on the crop and kill emerged weeds in the critical early season period.

Recent data from the USDA US Ag Census shows from 2012 to 2017 no-till and other reduced tillage acres increased by 8 M and 21 M acres respectively (Figure 4) [15]. In addition, conventional tillage decreased by 25.7 M acres from 2012 to 2017 (Figure 4) [15]. Lessiter 2018, estimates by 2030 US no-till acres will be planted on 145 M acres or 45% of US cropland and an estimated 466 M acres worldwide [16]. Strip-till is estimated to be planted on 11.7 M acres by 2030 [16].

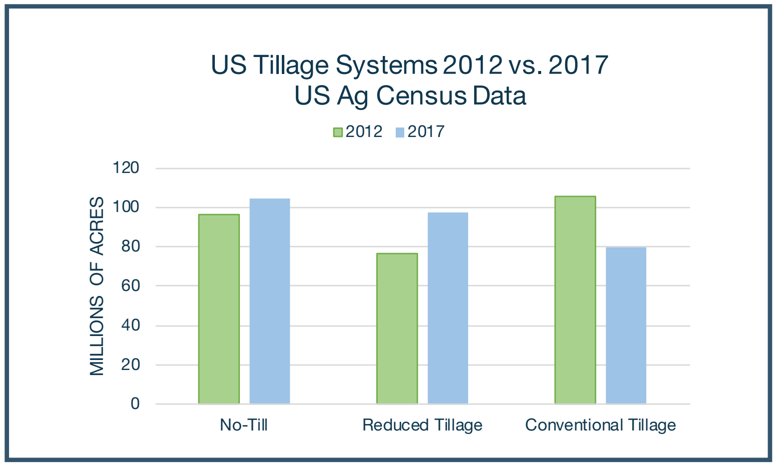

Figure 4. Acreage comparison of US Tillage Systems (No-Till, Reduced Tillage and Conventional Tillage) across all agricultural corps in 2012 verses 2017 reported by the US Ag Census [15].

Conclusion

The adoption of reduced tillage systems benefit the environment and soil health, mitigate climate change and protect food security. To maximize the benefits, reduced tillage should be paired with other sustainable practices as one integrated management system. The type of reduced tillage system growers implement depends on many factors, including soil type, environmental conditions, etc. Adoption continues to increase as awareness of reduced tillage as a key component of sustainable agriculture, soil health and mitigating climate change grows.

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