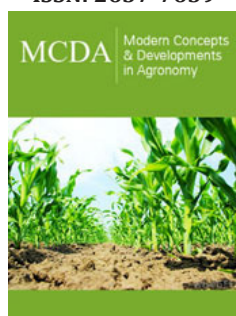


What is Wrong with No Tillage System?

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ISSN: 2637-7659



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Submission: 📅 January 03, 2022

Published: 📅 January 07, 2022

Volume 10 - Issue 1

How to cite this article: David Kwaw-Mensah. What is Wrong with No Tillage System?. Mod Concep Dev Agrono. 10(1). MCDA. 000729. 2022. DOI: [10.31031/MCDA.2022.10.000729](https://doi.org/10.31031/MCDA.2022.10.000729)

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Abstract

Agriculture is the world's largest industry and employs over one billion people and generates over \$1.3 trillion dollar worth of food annually. The concept of no-tillage as the planting of crops with minimum soil disturbance after harvesting previous crops has been used by indigenous cultures in ancient times. No tillage agriculture represents an agricultural management system that mitigates soil erosion, decreases production input costs, and sustains long-term crop productivity. There is the notion that no tillage systems can mitigate climate change without any equivocal evidence that no-tillage can lead to carbon sequestration let alone climate change mitigation. In the Kyoto protocol, the potential mitigation of greenhouse gas emissions by terrestrial ecosystems with soil organic matter dynamics is central to soil carbon sequestration. The intensification of farming and the increase in biomass production increases soil carbon sequestration. There appears to be some advantages of no till agricultural systems regarding environmental quality, and the economic benefit of fewer inputs with reduced time and energy input. No tillage agricultural systems are gaining popularity in terms of environmental impact and economic advantages. However, concerns remain regarding its economies of scale vis-à-vis world population growth and food security. Hence the question, "What is wrong with No tillage?".

Perspective on No Tillage Agriculture

Agriculture is the world's largest industry employing over one billion people and generating over \$1.3 trillion dollar worth of food annually (World Wildlife Fund, 2021). According to the WWF (2021), 50% of the earth's habitable surface is occupied by pasture and cropland that provide habitat and food for a multiple species. The concept of no-tillage, which underpins the planting of crops with minimum soil disturbance after harvesting previous crops has been used by indigenous cultures in ancient times [1,2]. Therefore, no tillage agriculture represents an agricultural management system that mitigates soil erosion, decreases production input costs, and sustains long-term crop productivity [3]. Conversely, soil disturbance from conventional tillage is a major cause of organic matter loss and the reduction in stable soil aggregates when native ecosystems are converted to agriculture [4]. According to Six et al. [4], no-till cropping systems exhibit increased soil aggregation and soil organic matter relative to conventional soil tillage. Therefore, the rationale for no-tillage as a conservation agricultural practice is to avoid soil degradation, reduced soil productivity, and crop yield with the traditional soil cultivation of intensive soil tillage [5]. The Dust Bowl of the southern plains region of the United States in the 1930s, a severe dust storm that resulted in the dry period in the 1930s from intensive soil cultivation led to the famous quote by the American President Franklin D. Roosevelt, that "The nation that destroys its soil, destroys itself, and that forests are the lungs of our land, purifying the air and giving fresh strength to our people."

Conventional tillage of bare soils exposes soils to severe erosion from wind and water, which can cost growers in soil productivity, poor water use and limited crop yield. The interaction between weather, soil properties, and farming practices including irrigation,

impact soil erosion [6]. Alternatively, conservation tillage limits soil erosion, conserves soil, improves soil productivity, soil water use efficiency by crops. Therefore, the goal of soil conservation is to control soil erosion by water or air [7]. Soil tillage degrades soil organic carbon. In a long-term study to quantify soil carbon change in across Iowa landscape, soil tillage had significant effect on soil organic carbon (SOC) change at all sites with conservation tillage storing more SOC in the top 0-30 cm compared with conventional tillage systems [8]. This finding is consistent with Six et al. [4], that no-till cropping system increase soil aggregation and soil organic matter relative to conventional soil tillage.

Conservation production systems combine soil tillage and planting practices to mitigate soil erosion and loss of water from the farmland. The USDA-NRCS, define conservation tillage as any crop production system that leaves at least 30% of the soil surface covered with crop residue after planting. Therefore, conservation tillage according to the USDA-NRCS has the two basic advantages of soil, water, and organic matter conservation on one hand, and the reduction of costly agricultural production input, while improving and maintaining crop yield and profits for the farmer on the other hand. The international Maize and Wheat Improvement Center (CIMMYT), define conservation agriculture as a sustainable farming method that is based on the three principles of crop diversification, minimal soil movement, and permanent soil cover [9]. Currently, conservation agriculture is regarded as a viable agricultural concept for sustainable agriculture [10], with global empirical evidence of farmer-led transformation of agricultural systems [11].

The world population is growing, which requires adequate food, fiber, and water, to sustain the growing world population. Therefore, the need for sustainable resource management for sustainable agriculture globally, is becoming an imperative. No-tillage cropping system has been presented as a viable crop production system with positive environmental and economic advantages to meet the ideals of a sustainable resource management. The advantages of a no tillage cropping system include reduced soil erosion, improved soil carbon sequestration, and increased soil biodiversity [12,13]. However, the advantages and ideals of no-till systems remain controversial with highly variable data over time and space [14]. Pittelkow et al. [3] reported that crop category as the most important factor that influences the overall yield response to no tillage systems followed by aridity index, residue management, no-till duration, and N rate. Their report further indicated that no-till yield matched conventional tillage yields for oilseed, cotton, and legume crop categories. Among cereal crops, the negative impacts of no-tillage were smallest for wheat (-2.6%), and largest for rice (-7.5%) and maize (-7.6%). No-till performance was reported to have performed best under rainfed conditions in dry climates with crop yield being equal to or higher than conventional tillage [3]. In a study by Al Kaisi et al. [15], yield and economic penalty of corn with no tillage in a rotation study with corn in Iowa, was greater in poorly drained soils compared with conventional tillage system, yet the opposite was true at locations in Iowa with well-drained soils. In the same study, the findings suggested a location specific

adoption of tillage and crop rotation to achieve optimum crop yield [15]. Al Kaisi et al. [15] reported that input cost for corn production was greater with conventional tillage system over no tillage and strip tillage systems by 7.5% and 5.7%, respectively.

There is also the notion that no tillage systems can mitigate climate change. According to Vanden Bygaart the myth that no-till agriculture can mitigate global climate change are highly overstated. There appears not to be any equivocal evidence that no-tillage can lead to carbon sequestration let alone climate change mitigation. Studies have shown that soil emission of carbon dioxide is closely linked to soil degradation and decrease in soil organic carbon [16]. Mrabet [13] reported that no tillage agricultural ecosystem has the potential to sequester atmospheric carbon dioxide and mitigate global climate change. In the Kyoto protocol, the potential mitigation of greenhouse gas emissions by terrestrial ecosystems with soil organic matter dynamics is central to soil carbon sequestration and the focus on soil carbon sequestration after the afforestation of previous arable land [17]. The intensification of farming and the increase in biomass production increases soil carbon sequestration, which according to Lal and Bruce [16], partly meet commitments under the Kyoto Protocol at national and global scales.

Conclusion

There appears to be some advantages of no till agricultural systems over conventional tillage agricultural systems regarding environmental quality (soil, air, and water quality), and the economic benefit of fewer inputs and reduced time and energy use [18]. No tillage agricultural systems are gaining popularity in terms of environmental impact and economic advantages. However, concerns remain regarding its economies of scale vis-à-vis world population growth and food security. Hence the question, "What is wrong with No tillage?".

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