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Impact of tillage on soil health, crop, and environment: A review

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Abstract
This review paper examines at how various tillage techniques affect agricultural productivity, soil health, and environmental implications. The preparation and disturbance of soil through tillage is a crucial aspect of soil management in agriculture. This study investigates the effects of various techniques related to tillage, including conventional, conservation, and zero tillage, on crop productivity and soil attributes. Zero tillage is related to higher soil organic matter and microbiological activity, which enhances water retention and soil structure. Conventional tillage, however, has the potential to harm soil organisms and cause erosion of the soil. The advantages of various tillage techniques reported in the article, including the possible cost savings, improved soil qualities, and increased crop yields in semi-arid regions with conservation tillage. However, poor tillage techniques can lead to problems including increased runoff and lower soil fertility. The study underscores the significance of selecting suitable tillage techniques that are tailored to the unique soil and environmental conditions to optimize agricultural output and sustainability.

Keywords: Conservation tillage, minimum tillage, no- tillage, soil respiration, yield

Introduction
One method of soil management is tillage. To build a soil structure suitable for producing crops, humans must disturb, turn, and repair soil through this process. The soil is crushed, granulated, loosen, and even compacted during tillage activities. The distribution of pore sizes, soil permeability, water retention capacity, and soil erosion are all affected by tillage operations that modify soil density. A tillage strategy that works well in one place might not work at all in another (Khan *et al*., 1999) [16]. The impact of various tillage techniques and the soil water content (Heard *et al*., 1988, and Unger *et al*., 1991) [14, 23].

Because timely and right method of soil applications boosts output, land plays a crucial role in agricultural production processing themes and manufacturers. Benefits like conservation are added to the improvement in managing soil erosion through soil protection and soil water content control.

An essential part of agricultural production methods from the dawn of agriculture has been tillage. The sixth century was when the Chinese made the first plough, preparing soil or tilling has come a long way. Several tillage systems and pieces of equipment prepared for agriculture and seedbed preparation (Mitchell *et al*., 2009) [20].

Erosion cannot be stopped because it is a natural occurrence. Every minute, a process is underway somewhere. The unaided eye may observe this process in things like sizes that can last for centuries and have an effect in a few years. Trees and other plants should be buried in the earth to protect the existing soil and grasses. Trees and herbaceous plants provide less effective realization of wind and rain erosion, but they decrease its impacts (Funda and Meryem).

When precipitation levels decline due to global climate change, soil sustainability will have a major impact on crop yield. Reducing tillage or using cover crops did not raise the soil water content when comparing fields that had adopted conservation techniques to those that had not. SOC and moisture retention are used in tillage practices to improve potential management candidates' soil's capacity to hold water. Conservation farming, often known as zero tillage, leaves crop residue on the surface, rotates crops over time, and does not involve tilling the land. While delaying the historically faster degradation of soil structure and soil organic matter

(SOM), agriculture enhances soil biological activity (Chawala & Kahlon., 2018 and Landers *et al*., 2013) [6, 17].

Objective: The aim of this paper is to explore different ploughing methods and their impact on ground fertility, plants and the atmosphere.

Material and Methods

What is tillage

Method of physically converting soil into the appropriate condition by means of tools to achieve certain objectives known as tillage. Tilling the soil removes weeds, changes its composition, and manages agricultural residue. It is often necessary to modify the soil structure. The effects of farming systems are now more visible and measurable than ever before in the social, ecological, economic, and environmental sectors. Tillage, a vital and important part of agricultural production technology, affects crop development, soil properties, and processes, which in turn affects agricultural sustainability (Khursheed *et al*., 2019) [24].

An essential part of agricultural production methods from the dawn of agriculture has been tillage. Since the Chinese invented the first plow in the sixth century, a variety of tillage techniques and equipment have been developed for seedbed preparation and cultivation, substantially refining making up the soil and procedure of tilling (Mitchell *et al*., 2009) [20].

The soil resource is not as well protected by conservation tillage systems that minimize or combine passes as it is by no-tillage or strip tillage techniques (J.P. *et al*., 2009). This is because these systems typically involve significant levels of soil disturbance. Apart from fertilizer injection, the soil remains undisturbed from harvest to planting in no-tillage or direct sowing methods (Gesellschaftfiir *et al*., 2003) [11].

Result of tillage on soil health

Zero tillage practice

The climate and availability of nitrogen have a major impact on the benefits of zero tillage and conservation residue in maize cultivation. In the current study, successive wet in three years and dry seasons in central Mexico were used to farm maize under various treatments that combined tillage with nitrogen rates and residue management strategies. Jack bean was also interplanted with maize in several trials (*Canavalia ensiformis* L.,). For the third year of cultivation, physiological parameters, soil characteristics, and yield and its components were evaluated in both the wet and dry seasons. Zero tillage was linked to lower biomass and grain yield during the wet season. Under zero tillage, the concentration of leaf chlorophyll was lower, indicating a lower uptake of nitrogen. Remainder conservation and zero tillage both significantly increased ear rot and inhibited early growth. By measuring electrical capacitance, zero tillage was linked to higher root mass throughout the dry season. The anthesis silking interval was shortened by residue conservation, indicating improved water absorption. Tillage and residue management techniques, however, had no appreciable impact on yield. Increases in bulk density of soil, content of nitrogen has all been linked to zero tillage. Both the concentration in carbon which is present in soil and the total of organic carbon microbial biomass increased with residue conservation. Soil nitrogen concentration was raised by intercropping jackbean and preserving its residues along with maize residues.

Before the cash crop being planted, the cover crop was chemically destroyed and controlled with a roller-crimper (J.K. Ward *et al*, 2013) [15]. Data were gathered on cover crop biomass, soil moisture, leaf temperature, yield, and cover crop chemical analysis. The first two years of this study's results show that crop yields have been adversely affected by winter cover crops, possibly because of the soil's availability of nitrogen. Cash crop yields were greatly enhanced by spring tillage. The findings of this study, which is still ongoing, should show which cover crop and tillage techniques improve quality of soil, yield, and give profit in severely soil degradation.

Dangolani *et al*., (2013) [7] revealed the techniques of four different techniques that effect tillage on moisture of soil, three different cotton varieties' morphology, and yield at Tajik Agrarian University. It was done at the Cotton Research Institute of Hashemabad Agricultural Station. There were four tillage techniques used in this study. They were compared using split-plot design with randomized full block design for their effects on yield of cotton grown with three different varieties. In terms of low-till cultivation, the treatment caused an increase in crop productivity by 695.8 kg/ha, 227.8 kg/ha and 129.5 kg/ha when contrasted against disk ploughing, chisel/disk ploughing and mouldboard/disk ploughing respectively as shown by these results which were obtained from this research work based on performance indicators only without considering other factors such as cost or labor requirements associated with each method employed during tillage operations. Additionally, there has been a 99% confidence interval rise in the quantity of bolls, but there hasn't been a significant increase in boll size. Ultimately, the findings demonstrate that a no-till strategy improves the soil's ability to store water.

Alam K. *et al*., (2014) [25] reported that cropping cycles needed to increase the organic matter (OM), status of the soil and look into how medium-term tillage techniques affect crop yields and soil characteristics in Bangladesh's Grey Terrace soil, which is used for wheat and mung beans. The characteristics of the soil and crop yields were positively impacted by tillage techniques. Following four cropping cycles, the conservational tillage techniques showed the largest accumulation of organic matter and a greater number of density in root mass (Depth of the soil 0-15 cm). Tillage procedures resulted in a drop in bulk and particle densities; zero tillage showed the greatest gain in field capacity and porosity while exhibiting the least decline in these attributes. Following four cropping cycles, the yield from each tillage technique was comparable. To achieve the best possible yield under the cropping system and to maintain the soil health on Grey Terrace soil, zero tillage with a 20% residue retention was determined to be appropriate.

In raising of vegetable, tillage activities usually include significant costs of time, energy, labour, and equipment, frequently contributing to more than pre-harvest budgets of production which is 25% of the total (Mitchal J *et al*., 2004). Vegetable production systems with a variety of reduced-tillage, or minimum-tillage, techniques work effectively to minimize expenses and improve soil management.

Conventional tillage practice

Tillage treatments were assessed in the context of a winter wheat - common peas - spring barley - single cropping (Kovac *et al*., 2005) [26]. Three times a year, in April, May, and July, soil samples were taken from six layers up to 0.8 meters to determine the moisture content by gravimetric analysis. The importance of the soil moisture was substantially influenced by the year, the date of the sample, the crops that were grown, the treatments of the tillage, the layer of soil, and the interactions. Compared to tested reduced till, mulching, and no-tillage treatments, the soil which is under traditional tillage had a

noticeably higher content of moisture.

Bisrat *et al*., (2015) [27] reported that on title of Evaluation of Conservation Tillage Techniques for Evaluation of Conservation Techniques in maize production in the Central Rift Valley of Ethiopia. Conservation plough is a good method of decreasing surface runoff and soil erosion, though minimum tillage systems might also serve as partial solution. The intention of this research was to experiment with various conservation plough approaches and observe their effects on water savings, pre- plus post-planting labour input, soil physicochemical characteristics, crop growth performance. The experiment involved different planting techniques such as: ripping with manual planting; conventional tillage which comprised two passes using an animal drawn mouldboard plow; ripping once with ripping attached row planter; pitting and no-tillage performed by hand pushed jab planter were tested using Melkassa II maize variety. These findings were compared against those obtained from conventional tillage involving two passes made by an animal drawn mouldboard plow. Although there were no significant differences between soil chemical properties measured pre-and post-tillage at 15cm depth; this may not mean that these two events had same effect on them since such relationship might have been masked by other factors or due to limited sensitivity of our measurement method(s). The research indicated that ripping followed by manual planting performed better than any other four tillage treatments in terms of time taken for tilling land as well as weeding except the conventional system where it took lesser hours than both methods combined together (ripping once then planting). Ripping once then planting saves more time than any other treatment when it comes to tilling.

Conservation tillage practice

Conservation tillage will save the costs of fuel, labor, and equipment while improving the physical characteristics of the soil and its capacity to store carbon (C) (Sitaula *et al*. 2017) 28[].

The short-term impacts of no tillage (NT) and reduced tillage (RT) on the dynamics of N2O emission were studied. The economics of producing cereals and the composition of the soil in comparison to traditional tillage (CT). Because of the high expenditures associated with weed management and the low yields in both years, NT produced environmentally unacceptable results. As a result, RT may offer environmental and agronomic advantages for crop production. Any tillage or planting technique that leaves plant residue covering at least 30% on the surface of soil after planting to decrease erosion from wind and water is known as conservation tillage.

In California, crop production methods that reduce tillage beyond the traditional minimum tillage approach are known as conservation tillage (CT). This approach is built around three main planting techniques that limit soil disruption: no-till, ridge-till, and strip-till. These methods form the basis of most CT systems and aim to improve soil health, conserve water, and enhance sustainability in agriculture. When there is zero or no till, the only soil disturbance in a small opening made by seed openers or coulters is known as tillage. The soil's surface is not disturbed outside of planting time. Ridge tillage is a technique which helps in reduction of soil disturbance. Ridge-till planters do not significantly alter the interrow soil surface; instead, they wash or break off soil residues and the seed line.

Matecka *et al*., (2012) [18] reveal those different methods: conventional, no tillage and reduced tillage. When spring barley reaches the stage of stem elongation growth, compared to conventional tillage, conservation tillage techniques produced a higher bulk density and content of water. The surface of soil accumulation of accessible K and Mg, as well as that of total N and organic C, was encouraged by reduced and no tillage practices. Our findings imply that conservation tillage methods have little to no impact on crop productivity but gradually enhance the nutritional condition of the soil. The yield of spring barley was negatively impacted by the no-tillage approach alone, by 6.8% which is related to conventional tillage (Matecka *et al*., 2012) [18].

Tan., *et al* (2015) [29] revealed that in areas where erosion from wind and water occurs frequently, conservation tillage is employed. An experiment was established in an area of the plateau known as the Loess that is impacted by wind erosion to comprehend the impacts of yield, soil nutrients on conservation tillageOur findings show that during the first few years of the experiment, the amount of accessible soil nutrients treated with tillage treatments which are nontraditional were dropped, and at the time of final few years, the amount stayed consistent. Apart from CK, all treatments saw a progressive rise in all over content in nitrogen and organic matter in soil over a 6-year period. Soils treated with techniques of conservation tillage, such NT and SM, had more nutrient contents than soils treated with CK. A decline in soybean output was significantly mitigated using film mulching and straw mulching.

Impact of properties of on tillage and Crop Production

Impact of various techniques of extended tillage on specific biological, chemical characteristics of soil. Reduced tillage, or even complete tillage, is one strategy to prevent undesirable phenomena associated with conventional tillage from occurring in soil ecosystems giving up on the cultivation process. Comparing with conventional, reduced, and no tillage on various chemicals of soil and microbiological properties was the main goal of the conducted investigation (Swedrzynska *et al*. 2013) [30].

The soil's capacity to take in and retain water from irrigation or precipitation is established by its hydraulic properties, which are influenced by tillage treatments either directly or indirectly. Tillage reorganizes distribution of aggregate sizes, altering the water's flow channel and rate. Technique of tillage that preserve moisture of soil are therefore crucial for development of plants in arid and semi-arid environments (Blanco *et al*., 2017) [5].

Tillage had little discernible impact on yield. Applying straw also resulted in an increase in mean stover yield. The season-long mean soil water content increased by around 20% when tied-ridging was used instead of other tillage techniques, and by roughly 16% when 3 mg ha of straw was applied instead of none. The most promising tillage method is tied ridging, and to get an adequate yield with minimal tillage, ground cover made of crop left overs is required (Mesfine *et al*., 2005) [22].

The adverse impact of tillage on soil and crop production

Repeated tillage more significant issues start to arise when farmers plow too much ground. Soil structure can completely collapse if tillage is not stopped. There may be an impact on soil organisms, which would stop microbial activity. Due to the closure of soil pores, runoff increases and infiltration is severely restricted.

A reduced amount of nitrogen taken up by plants due to its immobilization in the soil, a decrease in springtime temperatures, a greater bulk density of soil, and a soil that is resistant to allowing roots to grow can all create negative reactions to RT and NT. Reduces in soil tillage mainly result in a drop in plant density in the number of ears in the tillering, which in turn causes a drop in cereal production.

With moderate levels of erosion, production loss may even occur initially. Over a few years of repeated tillage, topsoil loss

starts to outweigh replacement. Because to the nutrition depletion, physical property degradation, and organic matter decrease, the soil eventually faces yield setbacks. Compared to conventional tillage, conservation tillage produced a lower penetration resistance in the 0-10 cm layer (Stanek *et al*., 2018) [21].

Conclusion

Tillage played a significant role in agricultural progress, particularly in the production of food, as technology has advanced. Tilling the soil has three main goals: controlling weeds, conserving water, and soil, and preparing the seedbed. Physical factors that specifically affect soil productivity and sustainability are aggregate stability, infiltration rate, and soil and water conservation. Different tillage methods showed that, under different crop production circumstances, they improved the SOM status while also changing the physical and chemical properties of the soil. Tillage affects the qualities of the soil, including its pH, capacity of holding the water, bulk density, organic matter and residue assimilation, both positively and negatively. It also conserves moisture in the soil.

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