REDUCING SOIL EROSION AND AGRICULTURAL CHEMICAL LOSSES WITH CONSERVATION TILLAGE

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Abstract

As nonpoint source contamination of water becomes increasingly apparent, greater attention is being paid to agricultural practices and their impact on water quality. Soil runoff quality from a Maury silt loam (fine mixed mesicTypicPaleudalf) in the Lexington, Kentucky area was compared to those of chisel-plow and no tillage methods in this study. There was a substantial difference in the mean runoff rate, total runoff volume, mean sediment content, and total soil losses between the two groups. More NO3, NH+3, and PO34 were found in NT runoff water than in either CP or CT. Runoff water from CP had a greater concentration of atrazine than water from NT or CT, but not as much as water from NT or CT. Overall runoff water losses of NO3, NH+4, PO34, and atrazine were typically in the order CT > CP > NT, with CT being the largest. More than a third of the entire quantity of each chemical was lost in the process. The University of Kentucky's Department of Agronomy made a significant contribution.

Keywords: Soil, erosion, agriculture

1. Introduction

The degradation of soil happens over time as a result of the slow detachment and removal of soil particles by water or wind. Globally, erosion, runoff, and poor water quality have become serious issues.[1] The land may have to be abandoned because of the difficulty. We may learn from the history of agricultural civilizations that have gone extinct because they mismanaged their land and natural resources.

Agricultural land and water quality are under risk because to erosion. Any soil management strategy that aims to improve water and soil quality must include measures to control sediment. Eroded topsoil can be carried away by wind or water into rivers and other waterways. A major source of sediment is the sheet and rill erosion of highland regions, as well as the cyclic erosion activity in gullies and drainageways, which contributes to sedimentation.[5]

Soil erosion has a considerable influence on water quality, especially as soil surface runoff.[6] There is a strong correlation between sediment generation and soil erosion. As a result, stabilizing the sediment source through erosion management is the most effective strategy to reduce sediment production.. You may utilize a variety of conservation strategies to reduce soil erosion, but you must first understand the variables that contribute to it.[3] Soil erosion occurs when water or wind separates soil particles and moves them away from their original location. For erosion management, reducing the influence of water or wind is the primary goal. In Iowa, the most significant erosion issue is caused by water.

Rainfall that falls on a soil surface with a steep slope can cause runoff if the rainfall intensity is greater than the rate of soil intake or infiltration. Raindrop impact, splash, or running water can cause soil particles to be separated from the rest of the soil and transported away. Soil erosion is a physical process that consumes energy, and it can only be controlled by taking steps to disperse that energy as quickly as possible.[4]

It is impossible for water erosion to occur without the involvement of rainfall and runoff. Erosion and sediment movement can be influenced by surface runoff volume and pace. In order to reduce soil erosion, it is crucial to employ soil conservation methods.[2] Soil erosion can be reduced by increasing the soil infiltration rate, which reduces surface runoff. soil erosion can be controlled by the use of techniques from agrnomic, cultural or structural approaches. The land's shape and topography are physically altered as a result of structural techniques. All of these methods are compatible with one another. Management and structural adjustments may be necessary in some instances when the topography is extremely complicated. A single strategy like installing grassed streams can be used to reduce erosion in some cases, such as in areas where the risk of erosion is low.[4]

There are a variety of methods for cultivating land. Conservation tillage, along with conventional techniques, is becoming more and more commonplace in the United States today. Conservation tillage, when used in conjunction with crop monitoring systems, is an effective method of conserving soil, increasing yields, and promoting agricultural sustainability.[6] Check out conservation tillage's goal, kinds, and impact on land quality in more detail. We'll also take a look at this method's environmental, economic, and agricultural benefits and drawbacks.

Maintaining a permanent cover on the soil surface, such as a pasture or meadow, is the best strategy to prevent erosion. Soil conservation measures should be implemented in places that are particularly vulnerable to water or wind erosion. Water erosion and surface runoff can have a significant impact on Iowa's surface water quality.[7]

Many studies have shown that soil erosion reduces soil production by a substantial amount. For example, a research done at Iowa State University on 40 soil associations found that the influence of soil erosion on soil productivity was mostly dictated by subsurface qualities because they affect root development, soil water availability, and the plow layer's fertility. Soil loss has a significant influence on production, as nutrients, root growth environment and soil water availability are all critical for plant development in the absence of the topsoil. A lack of plow layer soil fertility can have a significant impact on production in soils with adverse subsurface conditions.[4]

Raindrops are intercepted by plant waste, minimizing surface runoff and preserving soil surface particles from separation by raindrop impact. It is possible to optimize snow harvesting in the off-season by using crop waste as a soil cover, which prevents raindrop impact from sealing up the soil surface and so reduces surface runoff. Conservation tillage strategies including no-till, strip-till, and ridge-till are equally significant in reducing soil erosion. To what extent different tillage procedures are successful is determined by how much soil is manipulated, which has an impact on the residue distribution on the soil's top.

The proportional magnitude of erosion risk associated with various agricultural system combinations.[5]

2. Soil Erosion

Soil deterioration can take several forms. It may be found in practically every environment. Every year, a large quantity of soil is eroded away by flowing water, rains, and even the wind. The loss of topsoil, crop yields, water quality, and drainage infrastructure are all negatively impacted by excessive soil erosion.In order to protect our crops and adjacent ecosystems, it is critical that we decrease soil erosion. Following is an explanation of the many forms of soil erosion.Erosion by Rain Drops or Splash: Raindrop or splash erosion is the erosion that occurs when raindrops strike the soil surface, causing the disintegration of the soil's crumb structure.[7]

Wind-induced sheet eroding is the loss of soil in thin layers from the ground surface in a consistent manner. Over compact soil, loose, shallow topsoil is more susceptible to sheet erosion.Rill erosion is a type of water erosion in which the erosion occurs through multiple short and more or less straight channels, known as streamlets, or head cuts, that are located throughout the landscape. When it rains heavily, you may see the most prevalent type of erosion: rills.

An example of Gully Erosion is the eroding of soil with drainage lines caused by surface water runoff. Once a gully is established, it will continue to progress in either a headward or collapsing direction until and until the appropriate procedures are taken to stabilize the disturbance.[2]Streambank Erosion: The washing away of the banks of a stream or a river is what is meant by bank erosion. Differences exist between this and scouring, which refers to watercourse bed erosion. Stream Bank Erosion is another word for this sort of erosion.

3. Conservation tillage

Conservation tillage is an agricultural management strategy that tries to reduce the frequency or intensity of tillage operations in order to achieve particular economic and environmental objectives.

Reduced greenhouse gas emissions, reduced usage of agricultural machinery, reduced fuel consumption and labor expenses are among the benefits of using renewable energy.[6] According to research, conservation tillage practices promote soil health, minimize water runoff, and restrict erosion. Environmental and economic benefits may accrue to an agricultural system that employs conservation tillage in a well-developed and effectively integrated manner.

Planting preparation, weed management, plant residue removal, and loosening of compacted surface soil have all traditionally been accomplished through the use of tillage techniques. Reducing mechanical operations and soil disturbance on the farm can lead to benefits like reduced soil erosion and the associated air and water pollution; lower fuel costs and production costs; and reduced subsurface soil compaction from tractor passes, even if tillage is an important part of an agro-ecological enterprise.[5]

Classifications and nomenclature have been created by UC ANR's Conservation Agriculture Systems Innovation (CASI) program. There are several different types of conservation tillage, and the term "minimal tillage" encompasses all of them. Soil residues are kept on at least 30% of the soil surface using these methods following tillage. Minimum tillage methods can minimize tillage passes by 40% or more when compared to traditional approaches.[4] For the sake of soil conservation and economic sustainability, these tillage methods all have one thing in common: they aim to minimize the amount of soil disturbed or preserve surface leftovers.

By retaining crop waste on the soil surface all year round, you're helping to protect water and air quality by reducing wind and water erosion, runoff, or the loss of particle matter and nutrients. In addition to improving soil aggregation and biological activity, reducing tillage also has the potential to improve water storage capacity and boost infiltration rates.[7] More moisture is made available, the tilth of the soil is enhanced, and the organic matter content of the soil increases. Reducing tillage has economic benefits for farmers as well as ecological ones. When machinery is moved over a field less frequently, it wears down and uses less fuel, which all contribute to lower labor and time costs.

Many advantages of conservation tillage practices might lead to a decrease in production or profitability if used incorrectly.[8] Tillage is a key technique for many producers who want to lessen their dependency on pesticides by using mechanical weed management. For some farmers, cutting back on tillage and using chemical weedicides may lead them back to the use of additional chemical inputs. Plant residue on the soil's surface can lead to a rise in pests such as insects, rats and pathogens.

Given that conservation tillage has the potential to improve the health of farms and food systems, the University of California is actively involved in spreading knowledge and exchanging information on conservation tillage production methods in the California agricultural community.[3]

Soil erosion is only partially understood, and the influence of organic farming's conservation tillage measures on sediment loss has not been evaluated in the field. Replicated long-term agronomic experiments with four different cropping systems (organic tillage with intensive tillage, organic tillage with reduced tillage, conventional tillage with intense tillage, and conventional farming with no tillage) were used to examine rainfall-induced interrill sediment loss. In comparison to conventional farming, organic farming reduced mean sediment delivery by 30% (0.54 t ha1 h1).[7] In comparison to heavily tilled organic plots (1.87 t ha1 h1), this study found that reduced tillage in organic farming reduced sediment delivery by 61 percent (0.73 t ha1 h1). While the lowest sediment delivery was found in traditional farming with no tillage, the maximum delivery was found in conventional plots that were heavily tilled (3.46 t ha1 h1). In June, while maize was growing (2.92 t ha1 h1), erosion rates were substantially greater than those of fallow land following winter wheat (0.23 t ha1 h1). A reduction in sediment delivery was best predicted by soil organic matter and soil surface cover; in decreased organic treatments, living weed cover appeared to protect soil surfaces better than plant residues in traditional, no-tillage plots. When soil cover was more than 30%, erosion rates were dramatically reduced. So to sum it up, this research shows that organic farming and conservation agriculture both minimize soil losses and that reduced tillage methods are an important benefit in organic farming in terms of soil erosion prevention.[8]

4. Possibilities for Positive Effects

It's well established that conservation tillage and no-till methods minimize soil erosion and enhance the overall structure and quality of the soil, particularly near the soil's surface. Increasing water infiltration and soil moisture content while decreasing runoff are both possible with improved soil quality and structure. Pollutants from agricultural runoff can pollute surface and groundwater.[1]

To enhance the quality of the ground's soil microbes, conservation tillage raises soil microbial counts, biomass of fungi and bacteria, and carbon (C) and nitrogen (N) concentrations. Crop tolerance to harsh weather conditions is enhanced by higher levels of soil organic C in the soil. Soil bulk density, accessible water capacity, and pH5 are all enhanced by conservation tillage techniques. The effectiveness of conservation tillage measures varies depending on the site context and the length of time they are employed, with higher increases in soil quality the longer they are utilized. Increased crop residue retention, crop rotations, and cover crops all work together to boost conservation tillage and no-till soil quality improvements10. Conservation tillage procedures are least successful on sandy soils, which are influenced by the texture of the soil.[6]

Crop yields respond differently to the use of no-till techniques depending on the environment and kind of crop, but in general, yields tend to decrease in the first few years before increasing over time.[4]Rainfed conditions in arid areas often generate the greatest yields, which are often on par with or greater than yields obtained from conventional tillage. The use of legumes, or nitrogen-fixing cover crops, in conjunction with no-till farming approaches results in higher yields and greater production stability in the face of adverse environmental circumstances. Farmers may increase N fertilizer applications to minimize production reductions while switching to no-till methods, but doing so raises the risk of N runoff and the emission of nitrous oxide from the soils.[3]

Soil health and nutrient efficiency are all intertwined when it comes to the tillage influence on crop output. For example, root length density increased only in the upper levels of NT and decreased tillage systems, since soil compaction of deeper soil layers under NT may hinder appropriate root growth. Even yet, when comparing NT to CT, Malhi and Lemke found a 22% boost to root mass Maize root mass was found to be similar among tillage methods in the first year, but MT had consistently larger root mass than other tillage treatments in all sample periods. This might be due to the presence of cracks, worm pathways, and higher biopore counts in the soil. At 12 weeks after planting, root masses under MT and CT were substantially greater than under ZT. In ZT plots, root mass was considerably lower than in tilled plots. This suggests soil compaction hampered root formation and expansion of the main root axes, whereas conventional tillage improved root penetration.[8]

MT breaks the compact soil surface that is commonly associated with ZT and prevents the strong soil disruption that occurs under CT, which might subsequently limit root development, resulting in larger root mass under MT than CT. Because of so, it was shown that a minimum-tillage method produces soil with more resilience than more traditional ones.

It has been noted that weather circumstances throughout the growing season play a role in no-till systems' effectiveness, which can have considerable climate adaption advantages. No-till-grown wheat was shown to be more drought- and heat-tolerant, resulting in higher yields than conventionally farmed wheat. Conservation tillage yielded better outcomes in dry years than in rainy years, according to a study. Conservation tillage's higher water storage capacity might account for this; the maize yield from a low tillage system is more likely to be sustained than that from conventional tillage.[2]

5. Conclusion

A producer of air pollutants rather than a sink, disturbance of the soil by traditional tillage is not only unsustainable but also harmful to the ecosystem. Conservation agriculture, rather than just no-tillage, appears to be the preferred approach among international aid groups. The use of MT is suggested in fine-textured and poorly drained soils, whereas the use of NT appears to be helpful in well-drained soils with light to medium texture and low humus content Soil physical improvement begins immediately after CT, and zero or MT is good in this regard. In terms of soil chemical improvement, studies show that conservation tillage, namely MT, is superior to CT. In terms of soil fauna activity and biological property enhancement, all available reports concur that soils under conservation tillage are preferred over CT. Transition to the newer NT system is emphasized as a way to reduce runoff and maintain environmental quality. Crops planted with no-till had higher yields and better climate adaptation (such as drought and high temperatures) than those on tilled plots, whereas crops produced with minimum tillage have higher yields and better climate adaptation (such as mild soil disruption and high temperatures).

It's impossible to overstate the potential reduction in carbon and nitrous-oxide emissions to the environment that conservation tillage and other techniques like soil cover have. As a result, conservation tillage methods are more vital than ever in order to produce sustainable food production with minimal environmental effect.

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