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Soil fertility and crop yield response to reduced tillage under organic management: A review

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Abstract
Conventional tillage as a indigenous tillage, it doesn't maintain the soil fertility so to counter act or to maintain the soil fertility usage of conservation tillage is more beneficial than the conventional tillage. In this article our objective will be quantifying adaptation of reduce tillage in organic farming to see the effect on soil fertility, fertilization, biodynamic preparation. Lots of researches have also been done in this field to see whether reduced tillage effect increases Corg present in the soil or not. Analyzation of organic carbon, microbial biomass, dehydrogenase activity (DHA) has been done under the implementation of reduced tillage in organic farming. In a research in 2002, scientist observed that Corg increased by 7.4% in 0-10 cm soil layer in reduced tillage between 2002-2005, but remain constant with conventional tillage. Similarly Cmicrobial was 28% higher and DHA (dehydrogenase activity) was 27% higher in reduced tillage then conventional tillage. In the sense of crop yield wheat decreases by 14% under reduced tillage but sunflower yield higher in reduced tillage.

Keywords: Conventional tillage, conservation tillage, Organic carbon, soil fertility, soil structure.

Introduction
As we know, conventional tillage doesn't maintain the fertility of soil. In conservation tillage (no tillage or reduced tillage), the maintenance of soil is more effective than conventional tillage. Conservation tillage also prevents soil erosion, and it also maintains soil fertility. As we know, due to conventional tillage, the physical properties of soil (moisture, soil temperature) are highly affected. Corg (soil organic matter) is an important indicator of soil fertility, and it has increased in the last 25 years due to the adoption of conservation tillage. Due to the adoption of no tillage or reduced tillage, it is observed that soils in which conservation tillage is practised have 12 tonne/hac more CORG than the soils in which conventional tillage has been practiced, and also, after 25 years of conversion of conventional to conservation, we observe that in temperate wet climates the soils have 16% more CORG and in temperate dry climates 10% more CORG than conventional tillage soils (Alvarez, 2005) [6]. Carbon sequestration (the storage of CO2 in a carbon pool by plants through photosynthesis) takes 25–30 years to achieve a new study state in no-tillage or reduced-tillage systems (Alvarez 2005) [6].
We know organic farming is very beneficial for the environment, and if we associate conservation tillage with organic farming, then it will be more effective and give us benefits. Some soils have the problem of nitrogen mineralization, and that can be difficult to solve under organic farming, but some experiments or tests have been done with the association of conservation tillage with organic farming in recent decades. So after those experiments, we see that reduced tillage has been effective, but it needs to be developed more under organic management.

Objectives
Objective of our topic is to associate the conservation tillage with organic farming.as we know that there are lots of research going on reduce tillage on how it associate with organic farming so that it will beneficial for soil. Our ultimate goal is to increase productivity without harness or affect the soil or its fertility .so now a days organic farming is in high demand because synthetic fertiliser and pesticide creates lots of health issues and also they affects the soil also because production or yield is directional proportional to soil fertility and conventional tillage affects or it doesn't maintain the soil fertility so we need to do some research on reduced tillage or no tillage with organic farming so that we can maintain the soil organic carbon i.e. humus (Corg) and maintain the fertility of soil and ultimately it will enhance the crop yield.

1. To maintain the soil fertility through reduce tillage associate with organic farming.
2. To increase the Corg (soil organic matter) in a soil.
3. To incorporate reduce tillage with organic farming for betterment of soil and for increase the crop yield.

Conventional tillage in organic farming:

The tillage system affects physical, chemical, and biological properties of soil that have a major impact on soil fertility. Conventional tillage, in which we do tillage by different farm equipment, may adversely affect long-term soil fertility, erosion, and productivity due to loss of organic matter in soils.

There are lots of tillage practices that can cause changes in soil physical properties such as bulk density, water holding capacity, pore size distribution, and aggregation. Stratification of soil organic matter in nutrient distribution has not been observed in a long-term conventional tillage system. Due to higher residue in surface soil in conventional tillage, it will decrease soil organic carbon. Conventional tillage buries most of the crop residue into the soil. The mould board plough is the primary implement used in this tillage, followed by other implements. This tillage entails turning and thoroughly mixing crop residues or crops into the top 6 to 10 inches of soil.

It also has advantages and disadvantages. The advantages of conventional tillage are that the needed machinery is widely available and the techniques are well known to farmers. If we are talking about the disadvantages of this tillage system, it is the limited amount of crop residues left on the field that can lead to soil erosion or wind erosion.

Disadvantages of conventional tillage in organic farming

We know that tillage is one of the most time-consuming, labors-requiring, and machinery-required processes on the farm. Tillage mainly damages organic matter present in the soil. Conventional tillage crushes the soil structure; it makes soil more eroded and has less water-holding capacity in the soil. On the other hand, if we talk about the biological aspect of soil, then conventional tillage kills those microorganisms that are more beneficial for soil. Conventional tillage breaks apart the fungi and the aggregates, which makes the soil less eroded and more water-observant.

Conventional tillage also affects the soil's chemical properties; like it accelerates the oxidation of organic matter and that it promotes short-term releases of fertility. The destruction of organic matter releases carbon, and it results in lead carbon sequestration.

Impacts of reduced tillage on soil fertility

Soil management based on conservation tillage (reduced tillage) is well suited to integrated production systems in an effort to preserve soil fertility and prevent erosion (Cannel *et al*., 1986; Carter, 1994; Pekrun and Claupein, 1998) [7]. Conservation tillage includes soil moisture preservation and increased soil biodiversity (Holland, 2004). Conservation tillage leaves an organic mulch on the soil surface, which reduces run-off and increases surface soil organic matter (SOM), promoting greater aggregate stability and limiting soil erosion (Franzluebbers, 2002a) [8]. Conservation tillage stratifies soil organic matter and microbiological activity in the soil profile based on crop residue and manure burial depth (Franzluebbers, 2002a) [8]. Climate, topography, soil type, and crop management history (fertiliser use, tillage, rotation, and time) all have an impact on the amount of SOM in the topsoil (Kay & Vanden Bygaart, 2002) [9]. SOM, organic C, and soil microbial biomass increase in the tilled layer but remain unchanged or decrease in the untilled layer below conservation tillage when compared to conventional tillage (Table 1). Similarly, total N, organic N and mineralizable N, phosphorus (P), and potassium (K) follow the same pattern as C and SOM, with higher concentrations in the soil surface layer (tilled layer) in conservation tillage but no significant increase in the entire topsoil. Organic farming increased soil microbial biomass and activity when compared to conventional management. After comparing the properties of 28 commercial farms' organically and conventionally managed soils, Munro *et al*. (2002) [10] discovered that organically managed soils contained more organic matter and total N than conventionally farmed soils. The most likely cause of the increasing percentage of organic matter and biological activity found in organic systems is the frequent input of fresh organic matter with no pesticide use. The quality and amount of crop residues and animal manures will determine the amount of available nitrogen. (Berry *et al*., 2002) [11].

Although we anticipate that the combined effects of organic farming and conservation tillage will improve SOM content and, as a result, soil nutrient reserves in organic stockless systems, more research on the combined effects is needed. In comparison to conventional tillage, conservation increases the number of earthworms and their activity (Table 1). Ploughing destroys earthworm soil habitats, particularly those of deep-burrowing species (Holland, 2004) [12].

Increased fresh organic matter in organic farming is an additional resource that stimulates earthworm trophic and burrowing activity (Glover *et al*., 2000; Shepherd *et al*., 2000) [13, 15]. Organic farming and conservation tillage both increase earthworm activity, which helps to improve soil fertility. Reduced tillage this will increase soil organic carbon and nutrient enrichment, as well as labile carbon in the top 10 cm layer.

Table 1: Effects of tillage systems on SOM, organic C and N, soil microbial biomass.

Soil components	Comparison of conservation tillage relative to conventional tillage	References
Organic matter	More in the tilled layer	Andrade *et al*. (2003)
	Similar in the untilled layer	Kay & VandenBygaart (2002) [9]
Organic carbon	More in the tilled layer	Tebru¨gge & Du¨ring (1999) and Andrade *et al*. (2003)
	Similar in the untilled layer	Balesdent *et al*. (2000) and Deen & Kataki (2003)
	Similar throughout the topsoil	Anken *et al*. (2004)
Total carbon	More in the 0–5 cm layer but similar in the 5–20 cm. Layer under no tillage.	Six *et al*. (1999)
Microbial biomass	More in the tilled layer.	Stockfisch *et al*. (1999) and Kay & VandenBygaart (2002) [9]
	Similar in the untilled layer. More active microbial biomass in the 0–5 cm layer under no tillage.	Aon *et al*. (2001) and Kay & VandenBygaart (2002) [9]
Microbial diversity	More fungi than bacteria in crop residue at soil surface	Kladivko (2001)
Macro-organisms	More Earthworms, nematodes	Chan (2001), Kladivko (2001) and Birkas *et al*. (2004)

Impacts of reduced tillage on Corg and physical properties of soil

Impact on Corg of soil: Soil is assessed by running an experiment for three winters and two summers, nearly two and a half years, to monitor the change in carbon in soil. Even after a very short period of time, the result is that corg at 0–10 cm soil depth is increased by 7%, corresponding to 1.5 g corg kg-1 soil. Remain nearly constant under conventional tillage. At 10–20 cm of soil depth, no significant differences were observed in either tillage treatment. The relatively high organic carbon increase in reduced tillage plots can be associated with a large amount of plant byproducts left on the field plots, which supplements the input via manure. In addition to crop roots, the soil was amended with winter wheat stubble and a large amount of shredded sunflower residue. Heavy rain caused the clay soil to become temporarily waterlogged. As a result, oxygen concentrations became limited, preventing faster decomposition in the low-tillage plots, but if they were mixed superficially with the upper 0–5 cm of soil with the rototiller, then the soil would completely decompose under reduced tillage. According to the experiment,

The total carbon stock/sequestration in soil is 2 tc/ha within two and a half years up to the layer of 0–20 cm of the soil under the reduced tillage/conservation tillage, but under conventional tillage there is no such carbon stock/sequestration. The average of the Corg found above, under reduced tillage, is almost similar to the result of the Alvarez (2005) [6].

As we know, Corg is considered an important indicator of soil fertility, and crop yield is an important indicator of soil fertility, so we take into account some crop yield data under different tillage systems like conventional and reduced tillage systems.

Table 2: Yields of winter wheat 2003, intercrop 2003, sunflower 2004 and spelt 2005

System	Winter wheat (mg dm ha-1)	Intercrop (mg dm ha-1)	Sunflower (mg dm ha-1)	Spelta (mg dm ha-1)
Conventional tillage	5.18	0.82	3.19	2.43
Reduced tillage	4.43	0.87	3.33	2.23

Impact on Physical properties of soil: Soil erosion reduction is one of the primary goals of conservation tillage (Holland, 2004) [12]. Also prevents physical and biological degradation of the soil (Siegrist *et al*., 1998) [17]. Conservation tillage is essential for aggregation and soil structure stabilization. Because there is no tillage, crop residues on the soil surface prevent surface crusting (Azooz & Arshad, 1996) [16]. Organic matter is essential for the preservation of soil structure. Shepherd *et al*. (2002) [14] observed that the potential for structural improvement in organic soils was greater than in conventional soils due to increased biological and earthworm activity stimulated by regular organic matter application, which improved aggregate stability and biological porosity and also improved the soil aggregate and soil structure. The abundance of micro-organisms in the upper layer of the soil helps in the aggregation of soil and stabilization of the soil structure. Organic carbon present on the top soil helps in the improvement of the soil bulk density and soil porosity, which is important for both the soil health and crop yield. And this justifies the statement “feed the soil, not the plant”.

Table 2: Effects of tillage systems on soil porosity and aggregate stability

Soil components	Comparison of conservation tillage vs. conventional tillage	References
Aggregate stability	More stable in surface layer	Stenberg *et al*. (2000)
Total porosity	Greater or no difference in surface layer (0–5 cm) with no tillage No difference in tilled layer with shallow tillage	Guerif (1994) and Rasmussen (1999)
	Less in the untilled layer and the whole topsoil	Kay & VandenBygaart (2002) [9]
Soil bulk density	Smaller or no difference in surface layer (0–5 cm) With no tillage	Tebru¨gge & Du¨ring (1999)
	Greater in the untilled layer and the whole topsoil	Deen & Kataki (2003)
	No difference or higher in the subsoil	Tebru¨gge & Du¨ring (1999)

Advantages of reduced tillage in organic farming

- Reduces soil erosion (Holland, 2004) [12]
- Prevent surface crusting (Azooz & Arshad, 1996) [16].
- Earthworm and microbial abundance of fungi and protozoa more than doubled with reduced tillage. (Kuntz, *et al*.22, 2011)
- Earthworms were 70% higher under reduced than conventional tillage.
- Increase in soil organic carbon (SOC) and nutrients, In the tilled top 10 cm layer.
- Make the soil Surface layer more stable.
- Improve the porosity of the soil.
- Improve the overall soil health.

Conclusion

The aim of long-term reduced tillage under organic farming is to enhance the soil fertility and crop yield by applying reduced tillage, fertilization, and biodynamic preparation. After lots of research, we reviewed that soil fertility indicator, Corg, enhances while talking about crop yield. Then it showed an average yield between conservation tillage and conventional tillage. Based on some research, we can conclude that reduced tillage can be applicable in clay soil and also under organic management. Some of the results also showed that reduced tillage systems may be a valid option for carbon sequestration, which is of paramount importance with respect to climate change (Barker *et al*., 2007).

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