An Overview of Tillage Options for Low Carbon Emission

Aftab Khaliq, Fiaz Ahmad, Sarfraz Hashim, Muhammad Awais and Sadia Iqbal

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AN OVERVİEW OF TİLLAGE OPTİONS FOR LOW CARBON EMİSSİON

Aftab Khaliq [1,2], Fiaz Ahmad [1,*], Sarfraz Hasim[2], Muhammad Awais [1], Sadia Iqbal[1]

[1] *Department of Agricultural Engineering, Faculty of Agriculture Science and Technology, Bahauddin Zakariya University, Multan 60800, Pakistan*

[2]*Department of Agricultural Engineering, MNS University of Agriculture Multan, Pakistan*

** Corresponding author: fiazahmad@bzu.edu.pk*

Abstract – The main focus of the current agriculture on the intensification of the productivity of cultivated crops and concentrated land use. Soil tillage is one of the most energy and labor intensive procedure in productive cultivatable farming. Conventional tillage system requires more fuel supplies for land preparation that conserve more energy and exhaust the smoke in the form of CO_2 into the environment. Besides, zero-tillage (ZT) is the domain of the conservation tillage system that aims to combine the environmental benefits of organic farming and increase sustainability and soil fertility. Zero tillage (ZT) systems should significantly mitigate greenhouse gas emissions from low fuel consumption without affecting crop yields. However, recent advancements in agriculture conservation tillage are feasible for agriculture farmers.

Keywords – Conventional, Conservational, Carbon Emission, Organic farming, Zero tillage

I. Introduction

Long-term intensive farming has a significant effect on the climate and the environment [1]. However, agriculture is the only sector that can meet the food requirements of the population. Till now, the tractor is the main power unit in almost all agriculture production processes, including tillage [2]. Soil tillage is one of the most energy and labor-intensive procedure in productive cultivatable farming. The conventional tillage system is use more than 50 percent of fuel for arable farming [3]. In Pakistan, the conventional tillage (CT) system used for land preparation for cultivation is not economically feasible for ers and environmentally for crop productivity and soil health. Conventional tillage system (CT) requires more fuel supplies for land preparation that consume more energy and exhausts the smoke in the form of CO_2 into the environment. Carbon emissions from the tilled land also the most important contributor which is mostly derived from crop residue decomposition [4]. The amount of carbon emission from the decomposition of crop residues with conventional tillage affects soil fertility and reduce crop productivity. Many studies researched the conventional tillage effect on soil health and carbon emission. Mileusnić et al. and Petrov et al., studied the soil tillage efficiency enhancement to reduce carbon emission [2], [5]. Gorriz et al. Conducted a research study on carbon emission with different tillage practices [6], further huang et al., lal et al.; and voltr et al., also investigate the carbon emission from the greenhouse and crop yield with zero tillage [1], [7], [8]. The reviewed studies suggested that the conservation tillage practices had a positive impact on agriculture outcomes

The main focus of this study to provide a short review of efficient tillage options to reduce carbon emission to enhance soil fertility and crop production, and environmental protection.

II. Tillage System For Smart Agriculture.

A. *Effective Tillage for Soil Health*

Soil health is a limiting and essential part of agriculture production. Tillage is a common practice in agroecosystems worldwide and major use for changing the soil condition for crop plantation [9]. The conservational tillage system includes reduced tillage (RT) system and a zero tillage (ZT) system [10]. Reduce tillage practices include less tillage, planting, and spraying, while Zero tillage (ZT) or No-tillage (NT) have only single pass cultivation. In the zero-till system, directly seeding mechanism takes place without pulverization of soil. Due to this, the crop residues remain on the soil for maintaining the soil fertility, saving the soil moisture, temperature reducing the carbon emission process with crop residue dissipation. Furthermore, control of zero tillage practices on carbon protection might be related to carbon emission depletion which enhanced soil aggregation and decreased soil temperature. Zero tillage systems manage the soil under different environmental, climatic, and physical conditions. Globally different research conducted on zero tillage and conventional practices comparison and concluded that Zero tillage is widely recommended for crop production to improve soil health and enhance soil carbon and organic matter as compared to conventional tillage [11]. The effect of ZT and CT practices shows in Fig. 1. However, the effect of ZT on climate change mitigation by controlling carbon emission was intensively debated was concluded by many research studies. The trade-off relationship may counteract the effect of ZT on GHG emission and mitigation.

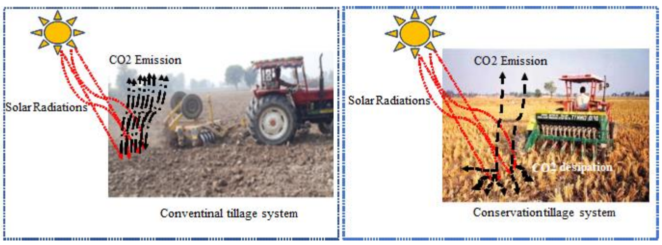

Fig. 1 Conventional and conservational tillage practices affect on soil

B. *Effective Tillage for Environment*

During agricultural practices, the burning of fossil fuels for energy is a major contributor to the emission of GHGs. The emission of Greenhouse Gas (GHGs) has a very strong adverse effect on the environment. The foot-print of the carbon emission from agriculture is very large. Several agricultural practices including tillage of soil will also increase the absorption of greenhouse gases (GHGs) namely carbon dioxide (CO_2), methane CH_4, and Nitrogen (N_2O) [12]. Although CO_2 is the most hazardous gas, N_2O and CH_4 are also vigorous because they have global warming potential. Sequestration of carbon in the soil is a very crucial strategy to mitigate the atmospheric abundance of CO_2 with the help of Conservation tillage practices [13]. Effects of gas emission on the environment show in Fig. 2. Conventional machinery operates with heavy engines that consume more fuel which has a very adverse effect on the atmosphere. These hazardous gases increase the atmospheric temperature which is effective for crop yield. Zero Tillage system has significantly mitigate the greenhouse gas emissions by less tillage passes without affecting crop yields. Energy, economics and the environment are mutually dependent. Environment degradation, soil fertility, and crop yield depend on energy consumption. Conventional tillage system needs 75% more energy as compare to conservational tillage [14].

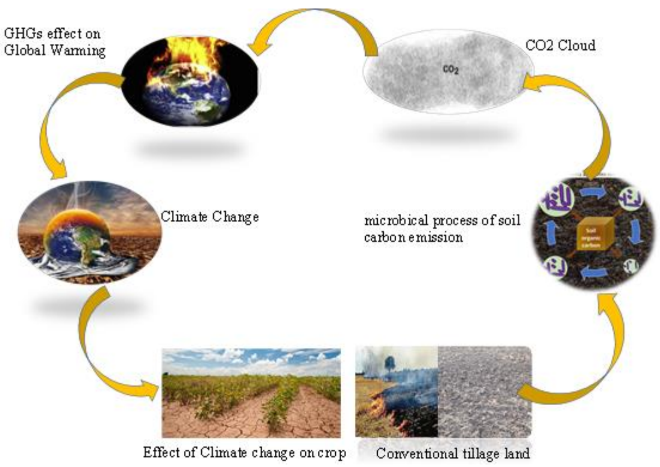

Fig. 2 Effect of carbon emission from the traditional practices on the environment and crop growth

C. *Configuration of Conservation Tillage System*

Assessing fossil fuel consumption for farm fieldwork should also be part of the strategy to minimize greenhouse gas emissions from agriculture. Climate and soil conditions determine the effects of tillage systems on yield [3]. Organic reduced tillage aims to combine the environmental benefits of organic farming and conservation tillage to increase sustainability and soil quality. Conservation tillage has proven to be advantageous in terms of soil erosion control and water conservation and e.g. no-till farming (NT) is widely adopted, particularly in dryer regions[15]. No-tillage (NT) or ZT has been touted as one of several climate-smart agriculture (CSA) management practices that improve food security and enhance agroecosystem resilience to climate change. The main focus of the conservation tillage system is to reduce the influence of machinery on agriculture practices. Zero tillage (ZT) is one of the best practices in the conservation tillage system which performs the planting and weeding process in a single pass. The agriculture tillage system framework shows in Fig. 3.

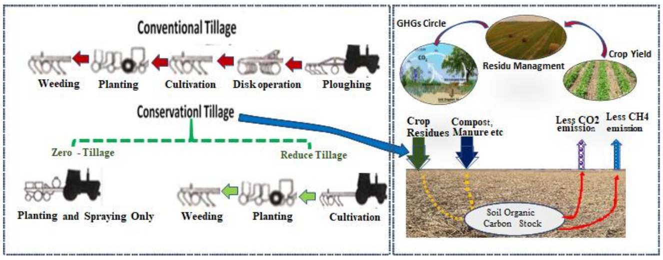

Fig.3 Conceptual framework of diverse tillage practices impact on greenhouse gas (GHG) emissions, and crop yields [7].

III. Conclusion

This study discusses the short introduction of the conventional and conservational tillage practices' impact on carbon emission. The literature review cleared that the conservation tillage system is the best option for smart agriculture. However, we concluded that in the conservation tillage system Zero-tillage (ZT) is an efficient practice for smart agriculture as compared to reduce tillage (RT) option. The researchers, framers, and industrial partners should focus on the ZT technology.

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References

[1] V. Voltr, J. Wollnerov, and P. Fuksa, "Influence of Tillage on the Production Inputs , Outputs , Soil Compaction and GHG Emissions," 2021.

[2] Z. I. Mileusnić, D. V. Petrović, and M. S. Dević, "Comparison of tillage systems according to fuel consumption," *Energy*, vol. 35, no. 1, pp. 221–228, 2010, doi: 10.1016/j.energy.2009.09.012.

[3] G. Moitzi, R. W. Neugschwandtner, H. P. Kaul, and H. Wagentristl, "Effect of tillage systems on energy input and energy efficiency for sugar beet and soybean under pannonian climate conditions," *Plant, Soil Environ.*, vol. 67, no. 3, pp. 137–146, 2021, doi: 10.17221/615/2020-PSE.

[4] C. Liu, H. Cutforth, Q. Chai, and Y. Gan, "Farming tactics to reduce the carbon footprint of crop cultivation in semiarid areas. A review," *Agron. Sustain. Dev.*, vol. 36, no. 4, 2016, doi: 10.1007/s13593-016-0404-8.

[5] A. Petrov, Y. Saveliev, P. Ishkin, and M. Petrov, "Soil tillage energy efficiency increase," *BIO Web Conf.*, vol. 17, p. 00177, 2020, doi: 10.1051/bioconf/20201700177.

[6] B. Martin-Gorriz, J. F. Maestre-Valero, M. Almagro, C. Boix-Fayos, and M. Martínez-Mena, "Carbon emissions and economic assessment of farm operations under different tillage practices in organic rainfed almond orchards in semiarid Mediterranean conditions," *Sci. Hortic. (Amsterdam).*, vol. 261, no. July 2019, p. 108978, 2020, doi: 10.1016/j.scienta.2019.108978.

[7] Y. Huang *et al.*, "Greenhouse gas emissions and crop yield in no-tillage systems: A meta-analysis," *Agric. Ecosyst. Environ.*, vol. 268, no. August, pp. 144–153, 2018, doi: 10.1016/j.agee.2018.09.002.

[8] B. Lal *et al.*, "Energy and carbon budgeting of tillage for environmentally clean and resilient soil health of rice-maize cropping system," *J. Clean. Prod.*, vol. 226, pp. 815–830, 2019, doi: 10.1016/j.jclepro.2019.04.041.

[9] Y. Feng and K. S. Balkcom, "Nutrient cycling and soil biology in row crop systems under intensive tillage," in *Soil health and intensification of agroecosytems*, Elsevier, 2017, pp. 231–255.

[10] G. Wu, Z. Chen, N. Jiang, H. Jiang, and L. Chen, "Effects of long-term no-tillage with different residue application rates on soil nitrogen cycling," *Soil Tillage Res.*, vol. 212, no. January, p. 105044, 2021, doi: 10.1016/j.still.2021.105044.

[11] R. Alvarez and H. S. Steinbach, "A review of the effects of tillage systems on some soil physical properties, water content, nitrate availability and crops yield in the Argentine Pampas," *Soil Tillage Res.*, vol. 104, no. 1, pp. 1–15, 2009, doi: 10.1016/j.still.2009.02.005.

[12] C. Maucieri, M. Tolomio, M. D. McDaniel, Y. Zhang, J. Robatjazi, and M. Borin, "No-tillage effects on soil CH4 fluxes: A meta-analysis," *Soil Tillage Res.*, vol. 212, no. March, p. 105042, 2021, doi: 10.1016/j.still.2021.105042.

[13] M. D. McDaniel, D. Saha, M. G. Dumont, M. Hernández, and M. A. Adams, "The effect of land-use change on soil CH4 and N2O fluxes: A global meta-analysis," *Ecosystems*, vol. 22, no. 6, pp. 1424–1443, 2019.

[14] R. Benković *et al.*, "Influence of aggregated tillage implements on fuel consumption and wheel slippage," *Teh. Vjesn.*, vol. 28, no. 3, pp. 956–962, 2021, doi: 10.17559/TV-20201130162613.

[15] M. Krauss, R. Ruser, T. Müller, S. Hansen, P. Mäder, and A. Gattinger, "Impact of reduced tillage on greenhouse gas emissions and soil carbon stocks in an organic grass-clover ley - winter wheat cropping sequence," *Agric. Ecosyst. Environ.*, vol. 239, pp. 324–333, 2017, doi: 10.1016/j.agee.2017.01.029.