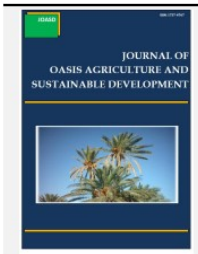

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Carbon footprint estimation for tillage operations

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Abstract

As a larger use of agricultural machinery, the measurement of carbon emission is highly important. Quantification of the carbon footprint is important for the identification of more sustainable and environmentally friendly practices. Information about input energy (fuel energy) used by some tillage techniques was collected and converted into carbon. In order to use low emission tillage operations, the equivalent carbon emission factors of each tillage technique were determined. The carbon equivalents for using traditional tillage system were the highest comparing with other tillage systems (158.63 kg CE ha^{-1} and 55.63 kg CO_2e ha^{-1}), while No-till system which give (5.8 kg CE ha^{-1} and 5.45 kg CO_2e ha^{-1}). Improved conservation technology and management equipment can all help minimize the carbon footprints of farm machinery.

1. INTRODUCTION

Agricultural mechanization has become increasingly important for agricultural production. In Brazil, agricultural machinery production increased by 23.8% from 2017 to 2018, with approximately 66,000 units of tractors, combine harvesters, cultivators and sugarcane harvesters (Edemilson et. al., 2020). In addition, the production of agricultural machinery increases indirect energy use and emissions, while agricultural sustainability is approached in many ways, focusing on economic, environmental, and social indicators (Lombardi et al., 2017). Energy analyses consider the physical quantities involved in the production processes, transforming them in terms of energy by means of their energy content. The emission of gases can be assessed by the carbon footprint, defined as "the total amount of carbon dioxide emissions directly and indirectly caused by an activity or accumulated over the life of the product. The carbon footprint is calculated as total direct and indirect CO2 and other greenhouse gases (GHG) emissions of a given product, process or activity over its lifetime (Wu et al., 2013). (CEMA 2022) developed an approach using the use of alternative energy sources that deliver the same amount of energy but emitting less CO2 such as biofuels, electric drives and hybrid drives. This short communication will provide a state on the different approaches to reduce CO2 emissions from fossil fuel combustion during the use of machinery in agriculture.

Three key questions have been identified:

1- How can the optimized use of the most suitable machinery help reduce CO2 from fuel combustion?

2-What alternatives are available for traditional tillage techniques? What are the benefits and what are the challenges?

2. MATERIALS AND METHODS

Conversion coefficient

The conversion coefficient of diesel fuel was adopted as 0.94 equivalent carbon emission (Kg CE), using kg CE having an advantage over other energy units because of its direct application to the rate of enrichment of atmospheric CO2 (Lal 2019). In earlier studies, the carbon equivalent

of diesel was taken as 3.32 L/Kg CO2eunit-1 (Lal 2020). (Prabhat et al., 2022) recalculated the carbon equivalent of diesel was 2.68 Kg CO2/l and the data of 10,180 grams of CO2/gallon of diesel was taken from the (Federal Register 2010). This value assumes that all the carbon in the diesel is converted to CO2. Two equations used to calculate the carbon equivalent and equivalent carbon emission are presented below:

Carbon equivalent (kg CO2e ha-1) = Carbon equivalent of diesel (kg CO2e l-1) × Fuel consumption (l ha-1)
Carbon equivalent (kg CE ha-1) = Equivalent carbon emission (kg CE) × Fuel consumption (kg ha-1)
From previous studies (Khater 2000) at West Nubaria in Egypt, data of some field preparation on sandy loam soil for corn silage cropping was collected and presented in Table 1.

- A MTZ 90 4 cylinders (U.S.S.R.) Tractor was used with 90 hp.
- A mounted locally manufactured chisel plow with 7 blades, 3 in front and 4 in rear (double point shares, with working width of 175 cm.
- A Fortshrilt mounted (double acting) disk harrow with width of cut 200 cm. The disks diameters were rear 56 cm, front 52 cm. and number of working elements 9 front, 9 rear.
- A locally manufactured mounted type Landleveller with working width of 250 cm.
- A Monosem mounted planter with 5 furrows and working width of 380 cm.

This study used fuel consumption and carbon footprints to evaluate the environmental load of 4 tillage operations during their assembly to minimize environmental impact. Methods presented how some tillage operations are translated into environmental impact on the energy and carbon perspectives.

3. RESULTS AND DISCUSSION

The equivalent carbon emission for both traditional and conservation tillage operations and implements was calculated and presented in Fig. 1. The carbon equivalents for using traditional tillage system were the highest comparing with other tillage systems (158.63 kg CE ha-1 and 55.63 kg CO2e ha-1), that is due to the multi-use of different tillage tools and more fuel consumption, so as a result more carbon emission. On vice versa the lowest carbon equivalents were obtained with using No-till

Table 1. Brief information about tillage operations and farm implements.

Tillage System	Treatments
Traditional till.	Chisel plow (twice) + disk harrow + landleveller + planter
Conservation tillage (Stubble mulching).	Disk harrow (once) + planter.
Conservation tillage (Minimum till.)	Chisel (once) + planter
Conservation tillage (No-till.)	planter

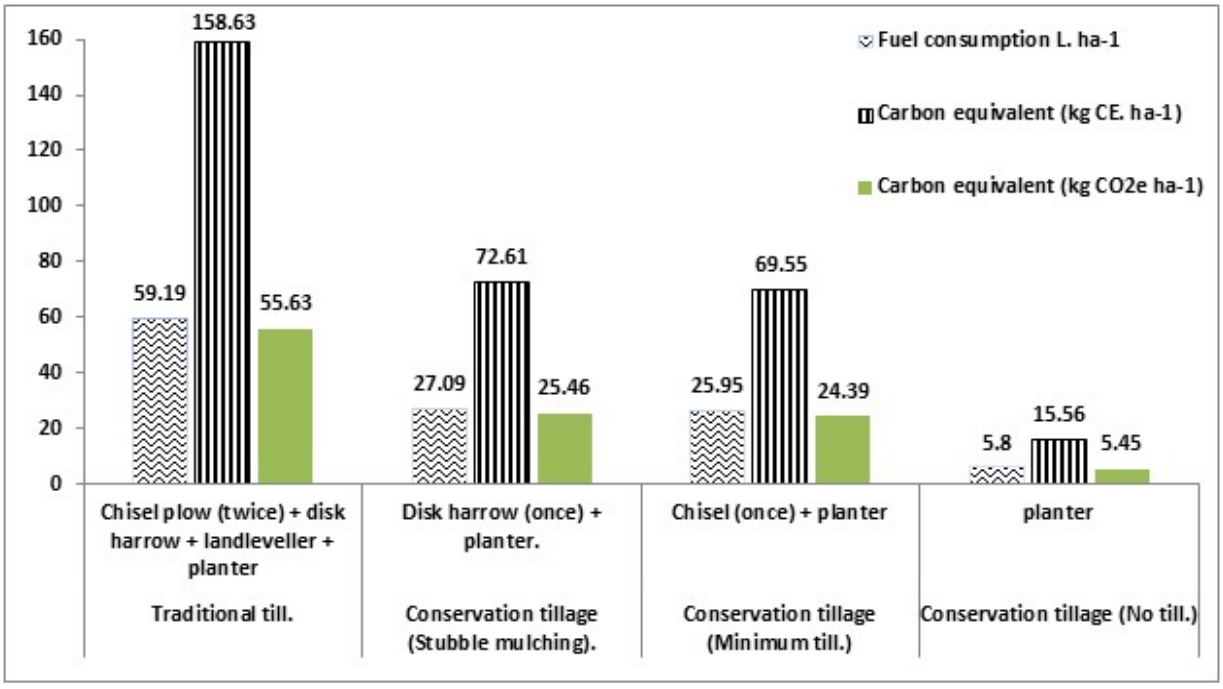

Fig. 1. The equivalent carbon emission for both traditional and conservation tillage operations and implements.

system which gives (5.8 kg CE ha-1 and 5.45 kg CO2e ha-1).

4. CONCLUSION

In present climate change scenarios, the main challenge is to reduce the emission of CO2 from agricultural practices. A careful assessment is needed to reduce their use. Carbon equivalents of different tillage techniques can help in the quantification of carbon emission. Enhance the resource conservation technology or conservation agriculture practices have the potential to reduce the tillage and also save C emission. Conservation tillage technologies and precision farm equipment's need to be promoted to reduce the carbon emission and also maximize the input use efficiency.

REFERENCES

Cema (2022). The role of agricultural machinery in decarbonising agriculture. https://www.cema-agri.org/images/publications/position-papers/CEMA_decarbonising_agriculture_27-04-22.pdf.

Edemilson, J., Graciele, A., Mesfin, M. and Thiago, L. (2020). Energy, carbon and water footprints on agricultural machinery. Biosystems Engineering ., 198, 304-322.

Federal Register (2010). Light-Duty Vehicle Greenhouse Gas Emission Standards and Corporate Average Fuel Economy Standards; Final Rule, 25, 330-407.

Khater, I., (2000). Comparison Study on Different Conservation Tillage Systems Under Conditions of New Reclaimed Soils. M.Sc. Agri. Eng., Dept., Fac. Agri. Zagazig Univ. Egypt.

Prabhat, K., Atul, K., Priyanka, T., Suryakant, K. and Narendra, S. (2022). Estimation of carbon emissions of agricultural machinery use in India. Oryza Vol. 59 (3), 260-268.

Lal, R . (2019). Energy and carbon budgeting of tillage for environmentally clean and resilient soil health of rice-maize cropping system. Journal of cleaner production 226: 815-830.

Lal, R . (2020). Identification of energy and carbonefficient cropping system for ecological sustainability of rice fallow. Ecological Indicators 115: 1-11.

Lombardi, M., Elisabetta, L., Caterina, T. and Roberto, R. (2017). Assessing the urban carbon footprint: An overview. Environmental Impact Assessment Review 66, 43-52.

Wu, X., Shan, H. and Shaojia, M. (2013). Carbon footprint model for evaluating the global warming impact of food transport refrigeration systems. Journal of Cleaner Production. 54,. 115-124.