Assessment of Energy Efficiency and Life Cycle Greenhouse Gas Emission of Wheat Production on Conservation Agriculture to Achieve Soil Carbon Footprint in Bangladesh

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Abstract : Emerging conservation agriculture (CA) is an option for improving soil health and maintaining environmental sustainability for intensive agriculture, especially in the tropical climate. Three years lengthy research experiment was performed in arid climate from 2018 to 2020 at research field of Bangladesh Agricultural Research Station (RARS)F, Jamalpur (soil texture belongs to Agro-Ecological Zone (AEZ)-8/9, 24˚56'11''N latitude and 89˚55'54''E longitude and an altitude of 16.46m) to evaluate the effect of CA approaches on energy use efficiency and a streamlined life cycle greenhouse gas (GHG) emission of wheat production. For this, the conservation tillage practices (strip tillage (ST) and minimum tillage (MT)) were adopted in comparison to the conventional farmers' tillage (CT), with retained a fixed level (30 cm) of residue retention. This study examined the relationship between energy consumption and life cycle greenhouse gas (GHG) emission of wheat cultivation in Jamalpur region of Bangladesh. Standard energy equivalents megajoules (MJ) were used to measure energy from different inputs and output, similarly, the global warming potential values for the 100-year timescale and a standard unit kilogram of carbon dioxide equivalent (kg CO_2eq) was used to estimate direct and indirect GHG emissions from the use of on-farm and off-farm inputs. Farm efficiency analysis tool (FEAT) was used to analyze GHG emission and its intensity. A non-parametric data envelopment (DEA) analysis was used to estimate the optimum energy requirement of wheat production. The results showed that the treatment combination having MT with optimum energy inputs is the best suit for cost-effective, sustainable CA practice in wheat cultivation without compromising with the yield during the dry season. A total of 22045.86 MJ ha^{-1}, 22158.82 MJ ha^{-1}, and 23656.63 MJ ha^{-1} input energy for the practice of ST, MT, and CT was used in wheat production, and output energy was calculated as 158657.40 MJ ha^{-1}, 162070.55 MJ ha^{-1}, and 149501.58 MJ ha^{-1}, respectively; where energy use efficiency/net energy ratio was found to be 7.20, 7.31 and 6.32. Among these, MT is the most effective practice option taken into account in the wheat production process. The optimum energy requirement was found to be 18236.71 MJ ha^{-1} demonstrating for the practice of MT that if recommendations are followed, 18.7% of input energy can be saved. The total greenhouse gas (GHG) emission was calculated to be 2288 kgCO_2eq ha^{-1}, 2293 kgCO_2eq ha^{-1} and 2331 kgCO_2eq ha^{-1}, where GHG intensity is the ratio of kg CO_2eq emission per MJ of output energy produced was estimated to be 0.014 kg CO_2/MJ, 0.014 kg CO_2/MJ and 0.015 kg CO_2/MJ in wheat production. Therefore, CA approaches ST practice with 30 cm residue retention was the most effective GHG mitigation option when the net life cycle GHG emission was considered in wheat production in the silt clay loam soil of Bangladesh. In conclusion, the CA approaches being implemented for wheat production involving MT practice have the potential to mitigate global warming potential in Bangladesh to achieve soil carbon footprint, where the life cycle assessment approach needs to be applied to a more diverse range of wheat-based cropping systems.

Keywords : conservation agriculture and tillage, energy use efficiency, life cycle GHG, Bangladesh
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