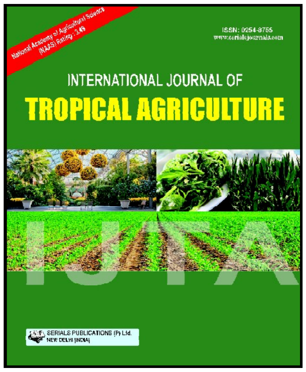

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Carbon Footprint of Rice and Wheat Crop under Conventional and Conservation Agricultural Practices

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Abstract: Adoption of conservation agriculture practices is beneficial in terms of resource utilization and environmental sustainability. Carbon footprint (CFP) estimation is key to measure the sustainability of rice and wheat crops under conventional and conservation agriculture practices. In the srudy InfoRCT (Information on Use of Resource-Conserving Technologies) model was used to calculate CFP of rice and wheat crops in Taraori village, Karnal, Haryana. The model is programmed in Microsoft Excel containing different parameters organized in different worksheets. Four different technologies were selected i.e. Transplanted rice + Conventionally tilled wheat (T1), Direct seeded rice + Zero tilled wheat with residue retention (T2), Transplanted rice + Zero tilled wheat (T3), Transplanted rice + Zero tilled wheat with residue retention (T4). Results showed that total carbon footprint of rice crop was highest in T1 treatment (0.67 kg CO_2 eq kg^{-1}) and least in T2 treatment (0.38 kg CO_2 eq kg^{-1}). In wheat, CFP was maximum in conventionally tilled plots (0.09 kg CO_2 eq kg^{-1}) and least (0.07 kg CO_2 eq kg^{-1}) in zero tilled treatment with residue retention. Less water use in direct seeded rice (DSR) and less use of farm machinery in zero tillage treatment in wheat resulted in lower GHG emission thereby lowering the CFP in those treatments. CFP estimation can be used to identify efficient management technologies for crops to obtain higher yield with lower Global warming potential (GWP) values.

Keywords: Carbon footprint (CFP), Global warming potential (GWP), Rice, and Wheat

INTRODUCTION

Agriculture sector is contributing nearly 35% of the anthropogenic greenhouse gas (GHG) emission whereas Indian agriculture is contributing 17% of the GHG emission of the country [1,2]. The total quantity of GHG emission related to a product is known as its carbon footprint (CFP) and it is expressed in terms of carbon dioxide (CO_2) equivalent [3]. Recently there is a growing interest in CFP of agricultural products [4]. CFP of a product can be quantified by assessing GHG emissions throughout its life cycle. For agricultural produce GHG emission need to be quantified for different stages of crop production like land preparation, fertilizer application, pesticide application, machinery use, harvesting of crop, storage, processing, packaging and transport [5]. GHG emission data can be obtained by direct field measurement or by estimation using default emission factors given by IPCC.

Several researchers referred CFP as GHG intensity [6, 7]. Cheng et al. [8] assessed CFP of crops in China and found that fertilizer use and electricity use accounted for 89% to the total CFP. Rice and wheat are the two major crops of the Indo Gangetic plains (IGP). But cultivation of these crops is associated with greenhouse gas (GHG) emission. Submerged rice fields are potential source of methane (CH_4) emission and application of nitrogenous fertilizers in rice and wheat crops is the source of nitrous oxide (N_2O) emission [9]. Conservation agricultural (CA) practices provide opportunities to obtain sustainable yield, increase input use efficiency, improve soil properties and also mitigate GHG emission [10]. According to Gupta et al [11], conservation technologies like direct seeded rice (DSR), zero tillage, integrated nutrient and pest management may cause reduction in GHG emission indifferent parts of the IGP. Various CA technologies like intermittent wetting and drying in rice, DSR, zero tillage in wheat, retention of crop residue on soil, use of nitrification inhibitors etc. have been identified for as measure to mitigate GHG emission from rice-wheat cropping system [12, 13, 14, 15].

In the present study an attempt was made to quantify the CFP of rice and wheat crop grown under conventional and different conservation agricultural practices.

METHODOLOGY

Survey was conducted in farmers' field in Taraori village in Karnal, Haryana to collect data related to climate, soil type, major crops and input use in rice and wheat crops. The InfoRCT model was used to calculate CFP of crops in the study region. InfoRCT (Information on Use of Resource-Conserving Technologies) is a model, developed for simulating GHG emissions, C, and N fluxes [16, 17]. GHGs emission was calculated based on the amount of input used and its related soil-plant-atmospheric processes. The model is programmed in Microsoft Excel containing different parameters organized in different worksheets. Four different technologies were selected i.e. Transplanted rice + Conventionally tilled wheat (T1), Direct seeded rice + Zero tilled wheat with residue retention (T2), Transplanted rice + Zero tilled wheat (T3), Transplanted rice + Zero tilled wheat with residue retention (T4). T1 is conventional agricultural practices whereas T2, T3 and T4 comes under conservation agriculture practices. GHG emissions were estimated from inputs that includes general information about soil and climate, crop duration, the set of management options on the farm, fertilization, pesticide and herbicide use, residue management, machinery use, labour required, crop yield and energy use. GHG emissions were quantified for the crop growth period up to farm gate and were not considered for processing or transport operations. In order to obtain the total global warming potential (GWP) from emission, N_2O and CH_4 were converted into CO_2 equivalents (CO_2-eq) using 100-year time horizon factors of 310 for N_2O and 21 for CH_4 [18]. To obtain CFP of rice and wheat crop, the cumulative CO_2-eq of emission per hectare (GWP) was divided by grain yield per hectare of each crop [19].

$$CFP_{rice} = GWP_{rice}\ (CO_2\ eq.) / \text{Rice yield (kg)} \quad (1)$$

$$CFP_{wheat} = GWP_{wheat}(CO_2\ eq.) / Wheat\ yield\ (kg) \quad (2)$$

RESULTS AND DISCUSSION

Results showed that total carbon footprint of rice crop was highest in T1 treatment (0.67 kg CO_2 eq kg^{-1}) followed by T3 (0.63 kg CO_2 eq kg^{-1}) and T4 (0.61 kg CO_2 eq kg^{-1}) and least in T2 treatment (0.38 kg CO_2 eq kg^{-1}) (Fig. 1). T2 treatment included direct seeded rice (DSR) which required less water and had lower CH_4 emission thereby reducing the CFP of rice crop. In wheat, CFP was maximum in conventionally tilled plots (0.09 kg CO_2 eq kg^{-1}) and least (0.07 kg CO_2 eq kg^{-1}) in zero tilled treatment with residue retention (Fig. 1). Less use of farm machinery in zero tillage treatment resulted in less GHG emission thereby lowering the CFP in those treatments.

Pathak *et al.,* [20] also reported that dry DSR on raised beds or zero tillage (ZT) decreased GHG emissions in terms of CO_2 equivalent per hectare by 40-44% compared with conventionally tilled transplanted rice. There are reports that with midseason drainage in DSR, methane emissions may be suppressed by up to 50% [21]. Besides this under conservation agricultural practices like zero tillage, soil gets less disturbed resulting in retention of more organic carbon in soil.

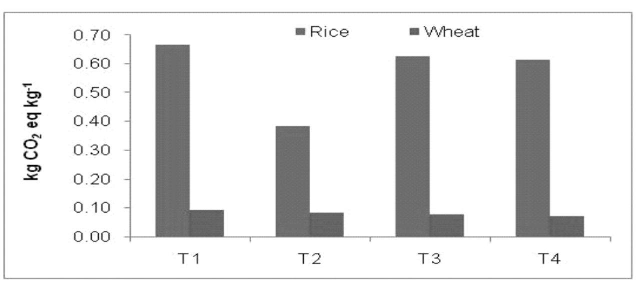

Figure 1: Carbon footprint of rice and wheat crop in different treatments

CONCLUSIONS

CFP estimation can be used to identify efficient management technologies for crops to obtain higher yield with lower GWP values. The highest CFP value is indicative of a net source of CO_2 equivalent per kg of yield whilst a lower value indicates a better mitigation strategy. This study also provides insight on what is CFP and how to calculate CFP in rice-wheat cropping system.The advancement of conservation agriculture in the farmer's field was viewed as a potential alternative to reduce carbon footprint in rice wheat cropping system.

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