



Study on assessment of carbon accumulation capacity (CAC) of certain cropping systems by quantifying post harvest soil organic carbon status

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Abstract

Carbon is one of the basic elements in the universe and found virtually everywhere on earth: in the air, the ocean, soil and rock. Among this, the largest portion of active carbon holds in soil. Plants take carbon from the air and convert it to plant tissue, some of which returns to the soil as plant residue. To improving soil quality, increasing crop yields, and reducing soil loss, soil carbon management plays an important role. Capture and store carbon in the soil helps to improve soil health and productivity, and stabilize the global carbon cycle, benefiting agricultural production sustainably. To assess the carbon accumulation capacity of seven cropping systems (Rice-Groundnut, Rice-cotton, Rice-Rice-pulse, Rice-pulse, Rice-Rice, Rice-maize, Rice-Rice-Sesame), the post-harvest soil (PHS) sample were collected during 2021 in Chidambaram block, Tamil Nadu, India, and determined the pH, EC, Bulk Density (BD) and Organic Carbon (OC). Among the seven cropping systems PHS tested Rice-pulse and Rice-Rice-Pulse cropping sequences recorded higher organic carbon content of 3.94% & 2.93% respectively. From this study, it can be concluded that inclusion of pulses in rice-based cropping system increased the yield of succeeding crops with higher carbon accumulation capacity (CAC).

Keywords: bulk density, carbon accumulation capacity, cropping system, organic carbon

Introduction

The productivity of different crops is affected by various factors, such as input, crop varieties and other biogeochemical properties etc. In India, there are different cropping systems are prevailed under varying agro climatic regions. Based on the agro climatic regions, soil type and irrigation facilities the cropping systems are chosen by the Indian farmers. Concerning Tamil Nadu, the major cropping systems are start with rice- based cropping sequences such rice-rice, rice-pulse, rice-sunflower, rice-maize etc. The sustainability of these cropping systems mainly relied on water availability, input source, and the economy of farmers along with the monsoon pattern. Every cropping system removes and adds certain nutrients and other naturals to soils. Based on the nutrient availability in postharvest soil decides the next crops nutrient addition as inputs. Providing manorial inputs as per the crop recommendation to a crop or cropping sequence basically line up with blanket recommendation of particular agro - climatic region. Hence, continuous addition of fertilizers and manures in a particular cropping system not realized with the targeted yields. The achievement of particular crop, target yield or expected yield should be line up with proceeding and succeeding crop rotations with available sources. Every crop as its own carbon neutral capacity based on the bio mass produced as economical yield and residue return in-situ i.e., the soil organic carbon addition. Globally, one third of the arable land comes under agricultural production system, it is one of the possible ways to increase soil carbon in agricultural production system using the soils as a sink. Many agricultural management practices are emerging to sequestering soil carbon by increasing carbon inputs to

soil and enhancing various soil processes that protect carbon from microbial turnover (Nandhini *et al.*, 2021) [6]. This could be a better way of carbon addition possible only through following different cropping system instead of mono cropping.

In agriculture soils carbon addition is a complex process it can be controlled by the environmental factors and farming practices (Yadav *et al.*, 2020) [9]. Understanding the changes in soil properties under agriculture is essential, because if soil health declines it directly affect the cropping system productivity. To make this effective assessing soil organic status is a promising way of enhancing the crop productivity. Monitoring quality of agricultural soils has become an integral part of farming nowadays so as to improve the soil quality. Assessing soil physico - chemical properties is a must way to get the sustainable of crop productivity in a long run. Soil organic carbon is the key attribute of soil fertility and productivity. It has immense potential to influence soil bio-geo-biochemical properties made soil C as most important criteria for judging soil health (Ghosh *et al.*, 2020) [3]. Therefore, maintenance of organic matter is difficult task faced by many farmers under cultivated soils. There are certain evidences shows that modified soil management has the potential to increase SOC in agricultural system (Eynard *et al.*, 2005; Porpavai *et al.*, 2011) [2, 8]. With this back ground assessment of carbon accumulation capacity of different cropping systems of the study area was estimated via testing the post-harvest soil properties to negotiate the system is carbon negative or carbon positive and to pave the way of bringing the cropping system carbon neutral and appropriating the cropping systems in beneficial and sustainable one.

Methodology

Initially, a survey on different cropping system of certain farm holds for collecting soil samples was done to assess the physicochemical properties of post- harvest soils in kurunjipadi block, cuddalore district, Tamil Nadu, India. Soil samples collected by using standard protocol (15 cm depth) from the following cropping sequences such as, Rice-Groundnut, Rice- cotton, Rice- maize, Rice- pulse, Rice-rice-pulse, Rice-rice-sesame. The post-harvest samples are tested in the soil laboratory for soil pH, EC, bulk density and soil organic carbon. Based on the soil test results regression analysis was carried out in excel.

Results and Discussion

Soil Texture and bulk density

The sand, silt and clay of collected samples ranges 67.25 – 79.32, 2.50-16.75 and 9.00 – 90.00 respectively and these soils were categorized as sandy loam, sandy loam and sandy clay loam. Bulk density is the mass of soil per unit volume including pore spaces. Besides workability of soils, it affects crop performance in various ways including controlling soil moisture availability, aeration and root penetration. Bulk density ranges from 1.25-1.57 Mg m⁻³ in different cropping system. The BD value of clay soil (1.26 Mg m⁻³) is less than sandy soil (1.57 Mg m⁻³). This is due to attributed to organic residue recycling. The organic recycling on account of crops and cropping may be one of the reasons for lower bulk density. The lower bulk density indicated the good physical condition. In rice-pulse cropping system the higher amount of added biomass from leguminous crop made loose soil, more pore space and less squeezed; so, the lower BD was found in rice-legume cropping system. The similar research findings were also recorded by (kumar *et al.*, 2020) [5].

pH and EC

Soil reaction is an indication of nature of soils whether it is acidic, neutral or saline/alkaline and controls the nutrient availability to the plants. The pH value of different cropping system ranged from 5.89-7.53. The clay soil pH 7.53, it's higher than the other soil type. This may be due to the presence of certain bases, especially calcium and magnesium. The pH of rice-pulse cropping system was higher and this result has been accredited to the well-known soil acidification effects induced by leguminous crops. Soil acidification under rice-pulse cropping system has been attributed to the short-term or long- term imbalances in the carbon and nitrogen cycle. These, similar results were also observed by (Kumar *et al.*, 2020) [5]. Soil electrical conductivity is used to measure quantity of salts present and also an important indicator of soil health. It affects soil health, crop yields, crop suitability, plant nutrient availability, and activity of soil microorganisms. The EC of different cropping system in this study ranged from 0.08-0.24 dsm⁻¹.

Organic carbon

Soil organic carbon is most essential constituent of soil for maintaining its quality, sustaining biological activity, regulating water flow, buffering, storing, cycling of nutrients and sustain soil productivity etc. The organic carbon status of different cropping system ranged from 1.29-3.94.

The organic carbon status of rice-pulse cropping system was higher (3.94) than other cropping system studied. This may

be due to higher root biomass, higher carbon sequestration capacity and less carbon release by rice-pulse cropping system. The similar findings were observed by (Kumar *et al.*, 2020).

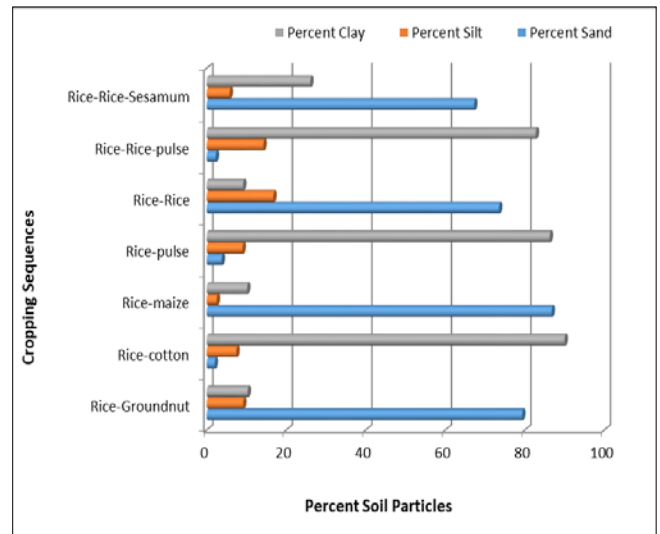


Fig 1: Cropping sequences and its percent soil particles

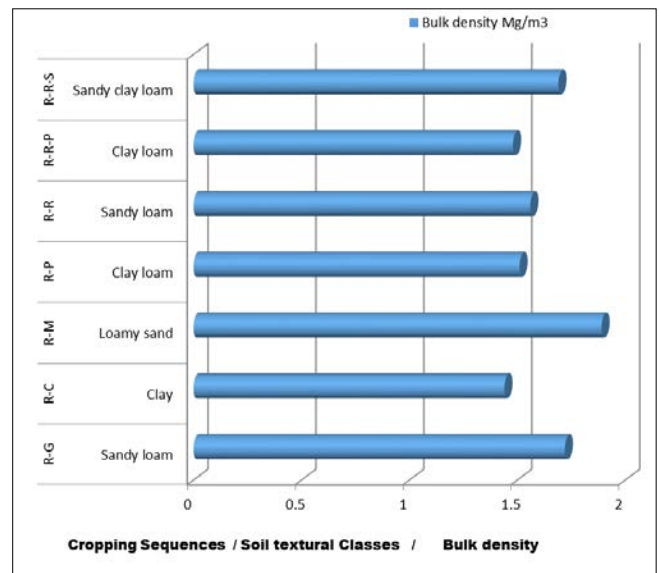


Fig 2: Assessed soil textural classes and bulk density under studied cropping sequences

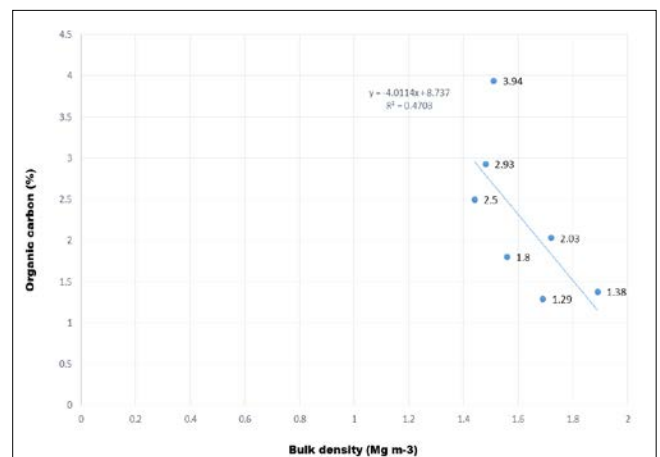


Fig 3: Liner relationship between soil organic carbon and bulk density

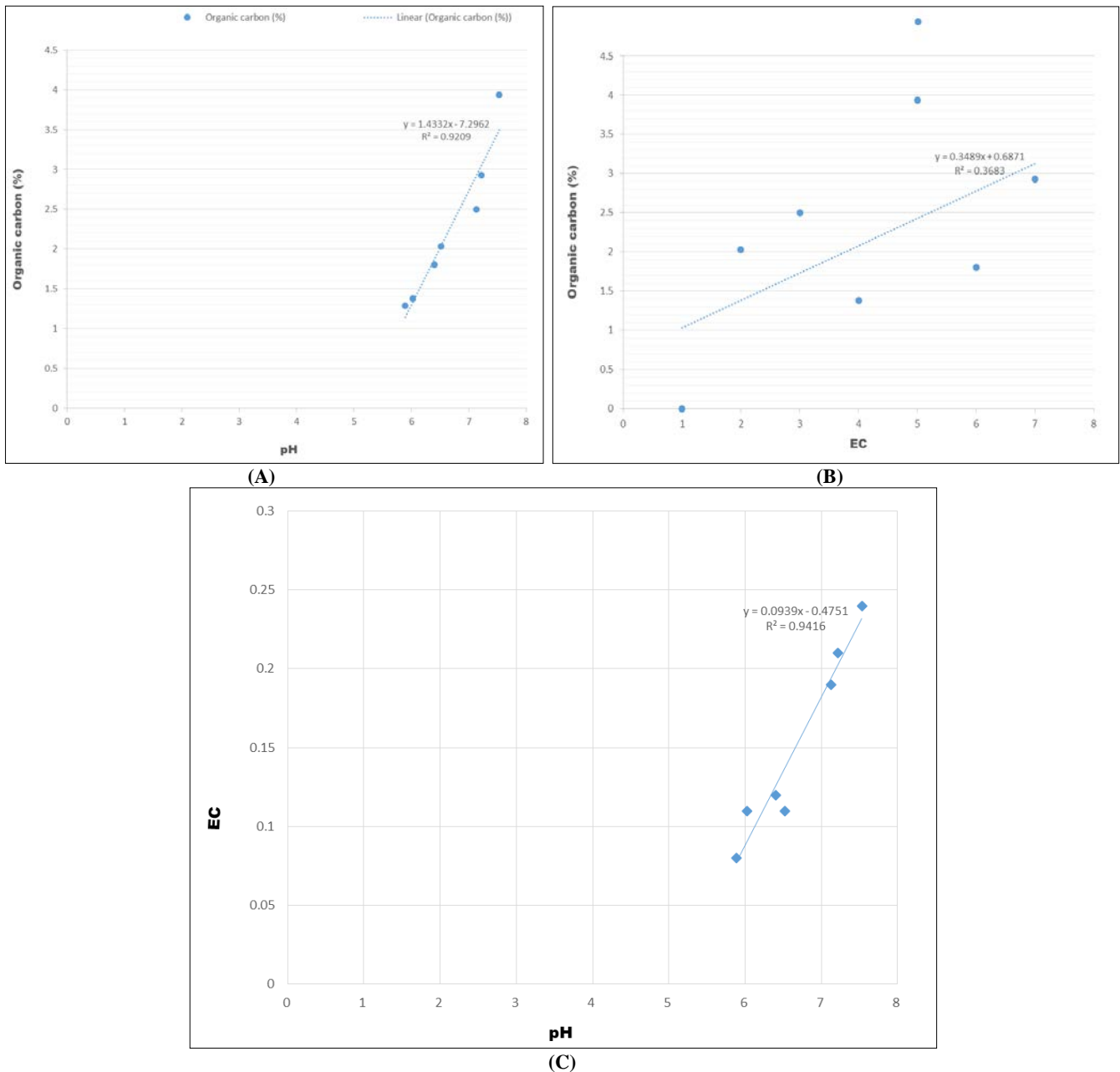


Fig 4: Relationship between organic carbon with pH, EC (A&B) & pH with EC (C)

From the study, the post - harvest soil properties like pH, EC, bulk density and soil organic carbon have significant relationship with each other. These findings were ably supported by negative correlation between organic carbon with bulk density ($r=0.0470^*$), positive correlation between organic carbon with pH ($r=0.920^*$) and EC ($r=0.368$), and positive correlation between pH and EC ($r= 0.941^*$). This shows that different cropping systems vary in their natural additives (NA) to soil based on the quantity and quality NA, the soil properties plays effective part in carbon accumulation capacity of certain cropping system. From the assessment it can concluded that maintenance and improvement in soil quality through cropping systems thereof is an important key to sustain productivity of the soils with different cropping systems. Soils with rice-pulse cropping system showed better physical conditions than that of soils under other cropping system. Therefore, to perform better soil functions and to achieve sustainability in the given ecosystem, the rice-pulse rotation could be a viable

option for the farmers by improving the carbon accumulation capacity of cropping system effectively.

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