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# Strategies to sequest the carbon through smart agriculture practice

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**Abstract**
Agriculture in India has started from ancient time by our ancestor but in past few decades, some erratic change attracted the attention of global researcher though some warm issues at global level *viz* climate change, global warming, greenhouse gases (GHGs) food security. The level of carbon di oxide ($CO_2$) gases in atmosphere is continuously increased with the decade of 1980. Carbon sequestration on agricultural fields is feasible with a range of soil management approach and can be considerable with improved planning. Carbon sequestration of emitted carbon emissions is now essential to mitigate or unlikely to stabilize our altering atmosphere. There are many management strategies for removing carbon from the environment and fixing it into the soil. These mitigation strategies of $CO_2$ vary with different location as well as soil types. It is become a issue for researcher that duration and amount of carbon sequestration by agricultural fields is what up to the level but precise management practice can able to lower down the carbon di oxide level up to certain level.

**Keywords:** Atmosphere; Agriculture Practices; Carbon Sequestration; Climate Change; $CO_2$

## Introduction

Agriculture is now facing a kind of threat from different alarming issues. A drastic change in gaseous composition of earth's atmosphere has sought attention of researcher (Lal, 2004; Paustian *et al.,* 2016) [15, 4]. The present day agriculture is facing a problem of continuous decline in soil nutrients reserve and decrease in organic matter content of soil. Hence keeping in mind the fertility status of soil as well as increasing level of GHGs in atmosphere it is basic need to develop the Carbon sequestration based smart practice. Soils have the capacity to fix carbon from the atmosphere with proper management (Lal, 2008) [16].

## Carbon Cycles in nature

The Carbon cycle is integral part of soil system and it can't be overlooked. At present the atmosphere and ocean have very high carbon while agriculture soils have lost carbon at an alarming rate due to conversion of native grasslands and forests to cultivated lands, development and agricultural practices that decrease soil organic carbon content? Oceans and aquatic system are estimated 38,000 giga tons (Gt) and vegetation is the very less of the pools at an estimated 650 Gt while soil is about four times more of the vegetation pool with an estimated 2500 Gt, making it the largest terrestrial pool of carbon (Batjes, 1996) [2].

## Soil C content

The fertility status of soil is now going down with the scarcity of macro as well as micro nutrients. Soil scientists classify carbon into general groups or pools depend on how long the carbon remains in the soil, a figure often referred to as "mean residence time". The most commonly used model of these pools includes three different groupings: the fast or labile pool, the slow pool, and the stable pool (Jenkinson and Rayners, 1977) [14] among them fast pool is soil carbon that remove and added to the atmosphere sometime within a few days to a few years and Carbon in this pool is typically composed of recently incorporated plant residues and simple carbon compounds that are exuded by roots. This labile pool is the one most readily used by soil microbes, meaning it generates a great deal of $CO_2$. The slow pool is composed of more processed plant residues, microbial byproducts of the fast pool, and carbon molecules that are protected from microbes by physical or biochemical soil processes (Lal 2004; 2010) [15].

**Carbon stock in Soils**

Carbon and nitrogen are major components of soil organic matter (SOM). Organic matter is important for many soil properties, including structure formation and maintenance, water holding capacity, cation exchange capacity, and for the supply of nutrients to the soil ecosystem. Since the size of the carbon pool is generally static, soil carbon is effectively enhanced in the labile and slow pools by enhancing the net amount of carbon that goes down the soil in each year relative to the lost. Agricultural scientist can highly influence this dynamic in following ways:

1. Decreasing the level of soil disturbance (i.e. zero tillage) to increase the physical protection of soil carbon in pools.
2. Enhancing the quantity and quality of plant and animal residues to soils.
3. Improving soil fauna diversity and abundance.
4. Maintaining continuous by live mulch cover on soils year-round.

**Soil as live body**

Soil microorganisms are having an important role in the carbon sequestration (Six *et al*., 2006) [33]. Mesovores (soil-dwelling insects, worms, and nematodes) are responsible for converting larger segments of plant residues into smaller types that can be decomposed by smaller organisms such as fungi and bacteria (Grandy and Wickings, 2010) [12]. Soil fungi play a crucial role in soil carbon sequestration by enhancing the amount of carbon distributed. The AMF (Arbuscular Mychorrizal Fungi) form mutualistic consortium with plant roots, supplying plants with soil nutrients while plants provide to AMF simple sugars (Govindarajulu *et al*., 2005) [11]. As plants feed AMF, their biomass increases the amount of carbon the process of photosynthesis provides to the soil (Rillig *et al*., 2001) [30]. AMF also produce an adhesive protein called glomalin that helps to bind soil aggregates together, assisting to protect soil carbon (Rillig, 2004) [31].

**Fertilizers & Soil Carbon**

The fertilizers use in agriculture has dramatically enhanced global crops productivity by supplying crops with readily available nitrogen, an element essential to plant growth but from an ecological perspective, this shift in management represents a positive change in the nutrient status in soil ecosystems with a potential to dif fer soil carbon dynamics. Studies have shown that progressive nitrogen addition to soils in both natural and agricultural fields decrease soil microbial activity (Ramirez *et al*., 2012; Frey *et al*., 2014) [28, 10]. These findings are not beneficial since we might suppose that hug increase in available plant nutrients would in fact increase the activity, but it may be related to change in crop communities and their correlation with soil fauna. Plants to that apply chemical fertilizer do not use as extensive root systems to absorb for nutrients, reducing their ability by root outflow that increase soil microbial biomass. Many experiments have also been found that soil $CO_2$ respiration is reduced in progressive fertilized systems, and that convert highly recalcitrant soil carbon is subtracted to a great extent. Other research have also been found, however, that progressive fertilizer application increase the turnover of the labile soil carbon pool (Neff *et al*., 2002), compounds that are often recently plants origin and are essential to increasing soil carbon over time. Thus, the ultimate effect of regular nitrogen application on soils is complicated so fertilization may simultaneously protect one soil carbon pool while minimizing the capacity of soils to increase others. This shift in dynamics is further complicated by the fact that fertilization can increase the total amount of plant biomass produced in agricultural cropping systems, which supplies hug amount of carbon to soils.

**Agricultural practices and Carbon Sequestration**

Scientific and technical knowledge in studying the types of agricultural systems or cropping systems enhanced soil carbon and has generated more no. of experiments on different systems and on carbon dynamics in agricultural systems in different ways. Many agricultural systems have run as having the potential to enhanced soil carbon, although important details about the permanence of the carbon sequester should be carefully considered.

**Conventional and Conservation tilling system**

Among the mostly studied agricultural management approaches that can enhance soil carbon in soil for long spell are no-till systems. No-till or zero till is a system approach technique that generally relies on specialized cultivation equipment, chemical herbicides, and genetically modified planting or seeding material to eliminate or minimize the need for tillage equipment. Since soils in this system remain undisturbed, soil aggregates remain unbroken and physically protect soil carbon. Several findings have demonstrated that no-till can rapidly enhance carbon in soil, especially at the upper soil horizons (West and Post, 2002) [40]. However, in order to maintain inputs in soil carbon, it is important to regular manage soils with zero-till system. Grandy and Robertson (2006) [13] observe that tilling a zero tilled soil quickly returned all the previously storage carbon pool by breaking aggregates and exposing carbon to microbial attack. Similarly, in no-till or zero-till conservation agriculture tillage implements less aggressively utilizes than the traditionally improved mouldboard plough and requires less tillage passes each season such that more residues are left on the soil surface and break down of soil aggregates is reduced. This technology also generally depends on chemical herbicides and genetically modified planting material to reduce weed pressure. The large number of experiments on carbon sequestration in zero-till and conservation tillage systems have generated more no. of ideas that both these techniques can increase soil carbon (Powlson *et al*., 2014) [27] and both highlight that the majority of studies on no-till and conservation tillage primarily showed differences in carbon content at the soil surface, while ignoring lower depths of soil where more intensive tillage systems, such as mouldboard ploughing, may actually be replace carbon. It is also clear that since the carbon stored in these systems is largely due to physical protection, maintaining the shallow tillage depth is important to confirming that carbon remains sequestered. Furthermore, the heavy use of herbicides and fertilizers can adversely affect water quality, and the continuous use of glyphosate has produced a number of glyphosate-resistant weeds that which require intensive tillage to control (Duke and Powles, 2008) [8].

**Organic residue with Zero-Till**

Since organic agriculture systems are restricted to use herbicides or synthetic fertilizers for weed management and cultivation of crops, although minimizing tillage in this system is not easy than in their traditional practices. Conservation tillage implements that done shallow ploughing and don’t be open soil like a traditional mouldboard plough by which less disturbance of soil, but the necessity to do multiple ploughing with secondary tillage implements to control weeds can give the benefits of conservation agriculture equipment's and lead to carbon emission. Many of scientists tested this system to deal with significant issues of weed dyanamics and regrowth of mulch crops that affect crop productivity (Mirsky *et al*., 2012) [19]. Key method to mixing the cover crop effectively is cutting it at the correct growth stage (Davis, 2010) [6]. Organic zero-till may also affect plant nutrient availability, as the high amount of plant biomass is need which can promote soil microbes to rapidly uptake soil nitrogen, converting it unavailable to plants (Parr *et al*., 2014) [26].

**Mulching and Crop Rotations**

Conservation tillage used to protecting soil from erosion by intensive tillage and other techniques remunerate for the emission of carbon due to more tillage operations by enhancing carbon inputs from plants. The use of seasonal green vegetation, crop rotations, and vegetative mulch crops that utilize semi perennial crops, such as alfalfa, greengram, cowpea were long used in agriculture but become less beneficial due to more widely use of chemical fertilizers and pesticides. Such practices have also provided benefits for weed control and increase in soil fertility, and some evidence suggests that they can also help to carbon sequestration in soil for medium duration. In long-term cropping systems experiments at the Kellogg Biological Station at Michigan State University, scientists found that over a 12-year period in organic management technique that practice to magnify rotational diversity and abundant use of crops for mulching led to a significant increase in soil carbon, although, heavy tillage for weed control (Syswerda *et al*., 2011) [36]. These results might be illustrated with a net positive distinction in carbon gains versus carbon emissions as $CO_2$, as well as increased soil biological properties. In a recent time, researchers found that more intensive crop rotations comparatively have high soil carbon and soil microbial biomass than lesser diverse systems, especially when cover crops were followed in the rotation (McDaniel *et al*., 2014) [17]. Tiemann *et al*. (2015) [37] further observed that rotational variations has important impacts on soil carbon pool by promoting the ability of soil microbial spp. to rapidly decomposition of plant residues and protect them by combining in aggregates. The incorporation of legume crops in a rotation also raises a greater diversity of carbon biomass in the soil, some of which may be greatly resistant to microbial decomposition (Wickings *et al*., 2012) [41]. The increase a diversity of crops, might be confirm that thickness of carbonic biomass in the soil increases with soil carbon sequestration potential increases. Increasing crop diversity is a system based strategy that is relatively easy to practice in a technical manner that it only requires producers to plant mulch crops or follows a high consistent rotation of crops (Davis *et al*., 2012) [7].

**Alternate Grazing**

Recent experiments on grazing system and rearing of animals, particularly cattle, have taken considerable attention for its carbon sequestration potential. When managed efficiently, herds of grazing animals can increase annual forage biomass production and redistribute carbon throughout pasture areas in the highly decomposed form of organic manures, leading to rapid increase in soil carbon stock. In addition, this practice of production does not need tillage, mean soil aggregates are not degraded and their carbon remains protected from human disturbance. The efficiency of rotational grazing may be increased by the addition of compost amendments to pasture lands (Ryals *et al*., 2014) [32]. These practices suggest that even very less addition of organic matter can highly improve the productivity of degraded waste lands and increase their carbon sequestration capacity (Conant *et al*., 2001) [4]. More intensive experiment on the complete carbon cycle of grazing operations, including some measurement of emissions in the form of methane from cows will be essential to properly evaluate the efficacy of this approach for soil carbon sequestration, but earlier results are promising.

**Cropping Systems**

The mostly cropping systems are dominated by annual crops that depend on rotations of tillage and sowing of seed to ensure maximum productivity. By comparison, perennial crops that are able to survive in several seasons require fewer disturbances (Meena, 2013) [20]. Multiple cropping systems have been newly proposed as systems that could sequester soil carbon well, and since perennial crops often depend on highly deep roots systems to ensure longevity, they probably produce high underground biomass (Cox *et al*., 2006) [5]. Advance efforts to develop perennial plants in the Soviet Union were somewhat successfully done in deserted (Wagoner, 1990) [38]. The necessary field experiments to demonstrate the carbon sequestration ability of these crops are still to less, but perennial crops are conceptually favourable more. By contrasting, agro forestry systems that use tree plants and are designed to impersonate forest systems but are maximum underutilized and under research studies. Albrecht and Kandji (2003) [1] stated that the carbon sequestration potential of agro forestry systems is potentially remarkable based on a review of the agro forestry research.

**Co-Benefits**

In furthermore to reducing carbon emissions, increasing soil carbon stock can have intense effects on soil quality and agro ecosystem output. Soil carbon plays principle role in maintaining soil nutrient composition (Bronick and Lal, 2005) [3], improving soil water holding capacity (Rawls *et al*., 2003) [29], encourage diverse soil microbial communities (Wilson *et al*., 2009) [42], and increase productivity for crops. These improvements to soil carbon are important to improving agriculture as a whole. While uncertainties may persist about the potential of agricultural soils to act as carbon pool, the more number of benefits should remain an encouragement to change agricultural practices to enhance soil carbon in situ.

**Reduction GHGs Emissions in Agriculture**

One side from total soil carbon sequestration potential of agro system, there are many other important deliberations in evaluating agricultural fields for their climate mitigation ability and feasibility. While carbon dioxide is the largest agent of climate change, and has been the main target of mitigation attempts and other greenhouse gases (GHGs) that assemble significant contributions to climate change. Among these gases, methane ($CH_4$) and nitrous oxide ($N_2O$), are mainly emitted from agricultural soils and should be included in studies of agricultural climate reduction potential (Meena *et al*., 2013) [21]. Agricultural practices are contributes for about 70% of $N_2O$ emissions and 42% of $CH_4$ emissions globally (World Bank, 2015b) [44]. These greenhouses gases have significantly more atmospheric life than $CO_2$. Although neither of these gases can be reduces directly by plants and sequestered in soils as $CO_2$ so, it is necessary to reduce the emission of these GHGs when examine different agricultural methods for their capacity to sequester carbon. $N_2O$ emissions is more when soils become anaerobic with water, (i.e. low oxygen) soil conditions in which bacteria are forced to take nitrate instead of oxygen as a electron acceptor in metabolic reactions, release $N_2O$ (Firestone and Davidson, 1989) [9], mean agricultural practices that tend to saturate soil with nitrate produce higher $N_2O$ emissions. Optimizing the supply of nitrogen to crops and confirming that excess fertilizer is not used in crops can significantly lower down the potential for $N_2O$ production (Millar *et al*., 2010) [18]. The primary sources of methane emissions in agriculture are enteric fermentation in which cattle digest feed in their rumens with the help of symbiotic microbes, including methanogens so new research has developed a feed supplement that reduces methane production in the cow's gut, inhibiting methane production up to 30% (Mulhollem, 2015) [24]. Methane emissions are more in the cultivation of paddy, which is mostly flooded during production. Flooding soils reduces field's oxygen level, increasing soil methanogens activities, which utilize $CO_2$ in the place of oxygen as a final electron acceptor for metabolic reactions (Meena, *et al*., 2015) [22]. Researchers have recently released a genetically modified variety of rice that releases less carbon into the soil via its roots, thereby lower down the amount of $CO_2$ that methanogens would utilize and DSR approach can be decrease methane emissions in rice fields (Wassmann *et al*., 1993) [39]. Some of these changes could be easily implemented, rapidly reducing agriculture's footprint and shifting agriculture's carbon balance in a more favourable condition.

## Conclusions
Soil carbon sequestration includes transferring atmospheric carbon into the soil via plant metabolism and maintaining these soil-based carbon pools protected as efficiently as possible from microbial decomposition that will emit the carbon back to the atmosphere. The agricultural management techniques that give a restoring soils and sequestering a very important portion of atmospheric carbon. The need for efficient techniques is increasingly urgent and soil carbon sequestration via; agriculture needs for more attention from policymakers, climate polluters, farmers, and scientists. These management approaches that enhance carbon sequestration also improve soil aggregation, water holding, soil fertility and food security. These important co-benefits should serve as motivation for increased action.

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