SOIL CARBON SEQUESTRATION IN TEMPERATE CONDITIONS FOR SUSTAINING SERICULTURE

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ABSTRACT:- Plant sequester carbon from atmosphere via photosynthesis, proportion of which in turn is taken up by animals and returned back to soil through plant residue, animal fecal matter and decomposition. The carbon is primarily stored in the soil as Soil Organic Matter/Carbon (SOM/SOC) which is a complex mixture of organic matter both living and nonliving. The soil microbial biomass is the living portion of organic content in soil, maintenance of which facilitates retention of SOC and nutrient availability. Carbon emissions through agricultural activities add CO_2 to atmosphere, carbon sequestration in agricultural soils, through the use of proper management practices, can mitigate this trend. Agricultural activities have implications on soil organic carbon content both in short and long term. Enhancing soil carbon content results in soil quality improvement, reduces soil erosion and degradation, improves surface water quality, and increases soil productivity. Hence, carbon sequestration in soils means increased soil organic carbon through appropriate management provides a multitude of environmental benefits. The term of storage is determined by various factors such as climate, vegetation, soil texture, drainage and management of resources. It is essential to study the mechanisms and changes of SOC to better understand and mitigate climate change. The goals to sequester soil organic carbon is to create a win-win situation to improve soil productivity, reduce unnecessary inputs, and promote sustainability.

INTRODUCTION:

Soil is an indispensable basic natural resource for crop production. The fertility of a soil refers to the ability of a soil to ensure supply of nutrients essential for plant growth and development. Fertility is only one of a number of factors that determine the magnitude of crop yield. Low fertility is one of the major constraints to optimum crop growth and yield. The fertility of the soil can be managed by fertilization, but farmer must be aware of the nature and severity of the nutrient problem (s) in order to arrive at a decision regarding the kind and dose of fertilizers to be applied. Soil fertility depletion also occurs due to continuous cultivation of soil. A soil analysis will determine the level of nutrients found in a soil sample. The soil analysis report provides an approximation of the amount of fertilizer nutrients required to complement those in the soil. Applying the appropriate type and amount of needed fertilizer will give the agricultural a more reasonable chance to obtain the desired crop yield and to maintain the soil quality.

Soil quality (SQ) is the capacity of a specific kind of a soil to function, within natural and managed ecosystem boundaries, to sustain plant productivity but discriminate and imbalanced use of fertilizer deteriorates inherent capacity of the soil to supply plant nutrients. Soil organic carbon (SOC) is the most reliable, versatile and easily assessable indicator, encompassing the interactive effect of several factors. Retarding trend of crop yields at current levels of supervision indicates declining soil health (SH). Soil health can be defined as the ability of the soil to meet the requirement of the entire constituent's organisms of the environment for nourishment. Sustenance of soil health is concerned with fulfillment of needs of soil-ecosystem. Erosion, drought and desertification, irrigation induced salinity and sodicity, paradigm shift in land use, nutrient depletion and intensive cultivation are the causes of SH deterioration. SH is an indicator of good soil's physical, biological and chemical properties for maximum production. Soil, water and biodiversity are an integral part of sustainable production system in the era of resource degradation and heavy input depended agriculture. Soil organic matter (SOM) is the mainstay of SQ. Since balanced fertilization may meet crop productivity and maintain SOM, there is an urgent need to improve the soils by all available resources including recycling of crop residues, green manuring, composting, resource conserving technologies and other soil agro-techniques. Hence, the project focuses on different ways to sustain soil health status in temperate ecosystems.

Soils play significant roles in global carbon cycle. It is estimated that soils contribute about 55 to 878 billion tons (GT) of carbon to the total atmospheric CO_2 (Kimble et al. 2002). Total soil carbon comprises of soil organic and inorganic carbon, estimated to be approximately over 2250 GT in the top 1 meter depth of earth. The soil mixture comprises of plant and animal components at various stages of putrefaction, microbiologically from the breakdown products, and from living microorganisms. In temperate region the climatic factors are perfect to have long term storage. In the peak cold months the degradation activities in soil is minimal and hence supports long term storage of carbon stocks.

SOIL ORGANIC CARBON:

Soil organic carbon is considered to be one of the largest carbon reservoirs of the terrestrial ecosystems and also plays an important role in the global carbon cycle (Alexander *et al.,* 2015) Forests act as one of the largest carbon sinks and helps to control atmospheric CO2 concentrations. Forest soil have a considerable amount of carbon (C), approximately half of earth's terrestrial carbon i.e (1146×10^{15} g), and out of which, about two- thirds is retained in soil pools . Temperate forests ecosystems contain a significant amount of soil organic carbon (C), both globally and regionally. Mountainous cold-temperate areas have high SOC content but large spatial variability, due to variable climate and vegetation (Harper and Tibbett 2013). This spatial variability has made it difficult to predict the spatial distribution of SOC in forest soils. Various studies have reported the influence of topography, climatic conditions, soil composition, litter quality and its decomposition rate and species composition or vegetation type on the spatial distribution of SOC. Soil organic carbon is usually calculated to a depth of 0-30 cm since most of which is present in top layers and most of the plant root activity is concentrated in this horizon. Thus the quantity of SOC in the 0-30 cm layer is about twice the amount of carbon in atmospheric carbon dioxide (CO2) and three times that in global above ground vegetation. A small change in soil carbon results in a large change in atmospheric concentration.

Carbon Sequestration:

Carbon sequestration refers to long term preservation of carbon in sea, soil, flora (especially forests), and other geological systems. Oceans are the primary reservoir for most of the Earth's carbon; on land the soils have 75% of the carbon pool.

The quantum of carbon in the atmosphere in terms of CO_2 has rose upto 30 % in the past 150 years, which seems to have positive correlation with increasing global temperature. The recent inclination is to fix this CO_2 in some immobilized form on earth or ocean for sustainable production.

Sequestration of Carbon in soil:

Plant sequester carbon from atmosphere via photosynthesis, proportion of which in turn is taken up by animals and returned back to soil through plant residue, animal faecal matter and decomposition. The carbon is primarily stored in the soil as Soil Organic Matter/Carbon (SOM/SOC) which is a complex mixture of organic matter both living and nonliving. The soil microbial biomass is the living portion of organic content in soil, maintenance of which facilitates retention of SOC and nutrient availability.

The term of storage is determined by various factors such as climate, vegetation, soil texture, drainage and management of resources.

Approaches for carbon sequestration includes following:

- **Conservation tillage** minimizes or eliminates manipulation of the soil for crop production. It includes the practice of mulch tillage.
- **Cover cropping** is the use of crops such as clover and small grains for protection and soil improvement between periods of regular crop production.
- **Mulching of plant residues**, leaves, pruned twigs etc.
- **Increasing soil microbial** load by use of biofertilizers, mulching, green manuring etc.
- **Intercropping with legumes**, to reduced carbon emission, there is also an environmental benefit in using legume crops resulting from increased plant residue input and increased soil organic carbon content.
- **Reducing chemical inputs with increased organic inputs** are necessary to increase soil organic carbon stocks (FYM, Compost, IPDM etc.).

Improved strategies adopted in temperate conditions for soil carbon sequestration:

S .No.	Traditional methods	Improved management practices followed
1.	Conventional tillage and clean cultivation	Conservation tillage , mulch farming and crop cover to possible extent
2.	Residue Removal	Residue returned as surface mulch
3.	Intensive use of chemical inputs, Low input subsistence farming	Sustenance of soil health via Integrated nutrient management and INM

4.	Surface flood irrigation	Furrow or sub irrigation
5.	Indiscriminate use of pesticides	Integrated pest management
6.	Bare /idle land	Increasing the acreage under mulberry by planting more trees.

Temperate Region and Carbon sequestration:

Temperate climatic conditions of Kashmir are well suited for mulberry sericulture activities. The sericulture in the region mainly thrives on bivoltine sericulture. The host plants are utilized at their maximum potential as feed for the developing silkworm larva. There is sink for nutrients in plants, which creates a demand from soil for replenishment. In traditional system it creates depletion of essential nutrients from soil leading to poor productive system. The colder ecosystem paves way for adopting soil carbon sequestration strategies. Various strategies adopted for soil carbon assimilation in host plant field are depicted in Fig.1.

Figure 1: Strategies to conserve and increase organic carbon stock in soil:

Fig. A: Cover crop in mulberry plantation for moisture retention in soil.

Fig. B: Intercropping of leguminous plants for sustenance of soil health and increasing SOC.

Figs. C&D: Mulching of farm residues in soil to increase lignin content for long term storage.

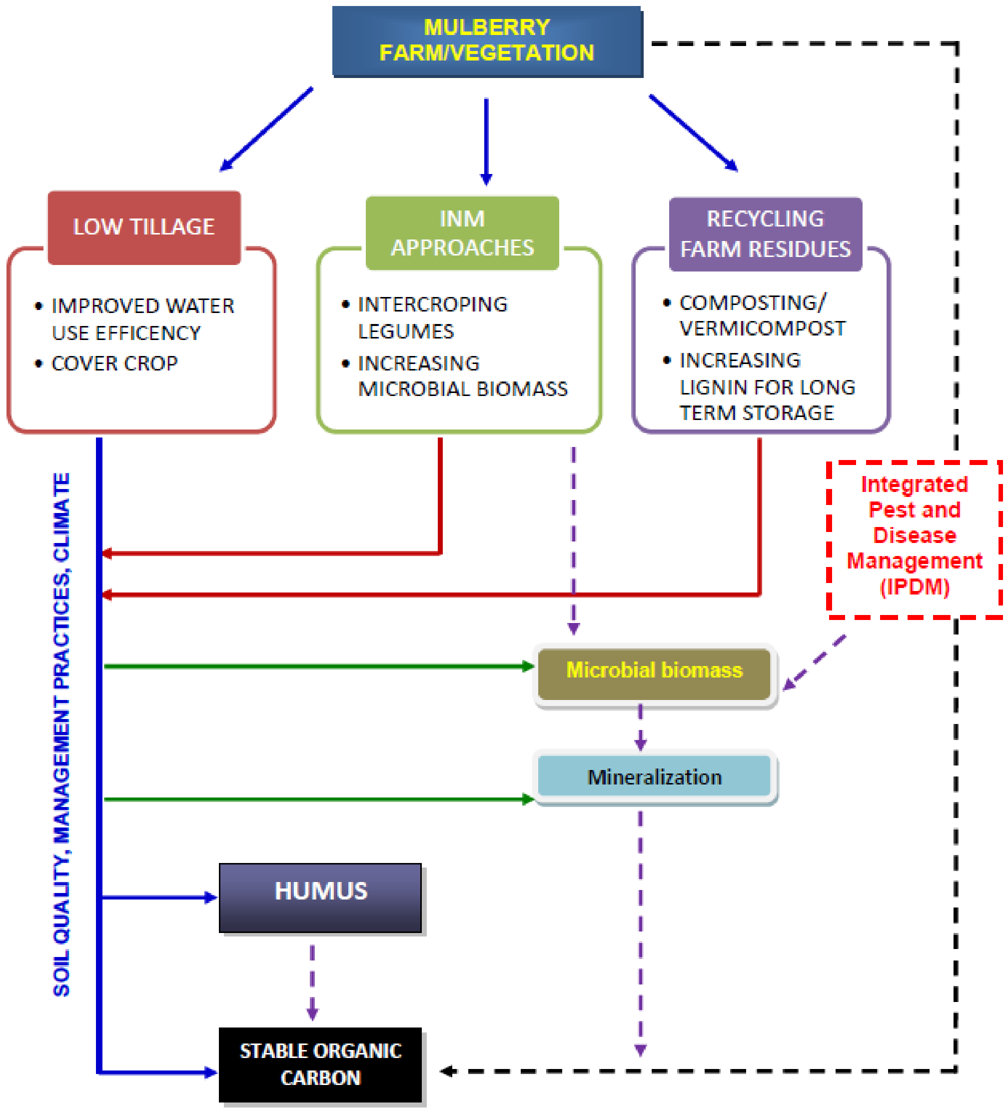
Fig. E: Furrow type of irrigation system to minimize carbon loss to environment.

Fig. F: Application of FYM to increase SOC content in soil.

Fig. G: Application of biofertilizers to reduce chemical inputs and enhance soil quality.

Fig. H: Increasing the acreage under mulberry by planting more trees.

A MODEL OF SOIL CARBON SEQUESTRATION UNDER TEMPERATE CONDITIONS:



DISCUSSION:

Mulberry is found under varied agro-climatic conditions in India. Research has shown that the yield of mulberry can be increased by following improved package and practices under irrigated conditions (Dandin *et al.,* 2003). In temperate region package and practices for mulberry tree cultivation has been given by Ahsan *et al.* (1990); Dhar and Khan (2004). Effect of nitrogen on growth and yield of mulberry has been studied by Fotadar and Chakraborthy, (1987). Response of mulberry saplings towards biofertilizers has been studied by Mir *et al.* (2004). Evaluation of various mulberry genotypes under rainfed conditions in Kashmir has been carried out by Mir *et al* (2003;2011). Methods of soil sampling and testing for mulberry cultivation and management of various nutrient deficiencies in mulberry plant in temperate climatic conditions has given by Srinivasulu *et al.* (2010) and Rathore et al. (2010).

The importance of chemical fertilizers and farmyard manure in mulberry cultivation is being well documented (Ray *et al.,* 1973; Bongale, 1995; Kasiviswanathan and Sitarama Iyengar, 1996). Sarkar (2000) has reported that the recommended dose of manure and fertilizer plays an important role in yield and quality of mulberry leaf the adoption of same is not seen at the farmer's level resulting in low yield and productivity). In temperate conditions adaptation of recommended management practices in agricultural lands for enhancing soil fertility has been suggested by Bangroo *et al.* (2011). Siddaramappa (2004) had reported that indiscriminate use of chemical fertilizers adversely affects soil chemical properties and micro-flora associated with mulberry, so to achieve optimum yield proper management of water and nutrient is needed. Jaishankar and Dandin (2009) had shown the importance of integrated nutrient management (INM) in soil fertility management at different farming levels in relation to various inputs used by farmers at different intervals.

Importance of availability and interaction of nutrients and need for assessing the availability of micronutrients and their relations with soil chemical properties has been emphasized (Krishnamoorthy, 1987; Kumaresan and Manickam, 1987; Ramesh *et al.,* 1994). Varied performances of silkworm cocoon crops associated with nutrient deficencis of leaves have also been observed (Bongale, 1995; Bongale *et al.,* 1996). Fertility evaluation and fertilizers recommendations for mulberry garden soils have been given by Bongale (1993). Soil fertility status and correlation between various fertility parameters have been studied by; Singh and Dwivedi (1996); Bongale and Lingaiah (1998). Use of nano fertilizers for slow release of nutrients is the recent trend in the industry (Nivedita and Subrata Roy, 2011). Reports are also available on relation between soil fertility and leaf quality parameters (Bongale *et al.,* 1993; Rupa *et al.,* 1993; Sujathamma and Dandin, 2000). The importance of organic fertilizer input in sustaining the soil health has been shown by Masilamani *et al.* (2007); Ramakrishna Naika *et al.* (2011). Mir *et al.* (2011) has shown the importance of FYM in increasing the rooting ability of temperate mulberry varieties and ways for improving mulberry wealth in Kashmir.

The importance of soil micro-flora in plant growth promoting activities have been shown by Ramesh and Kabbalageri (2006); Ram Rao *et al.* (2007); Saraswat and Kamble (2010) . In temperate conditions the efficacy of using *Rhizobium* and AM fungi has been done by Bhat *et al.* (2010).It can be inferred that the temperate ecosystem present alluring prospects for long term sequestration of organic carbon in soil.

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