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.

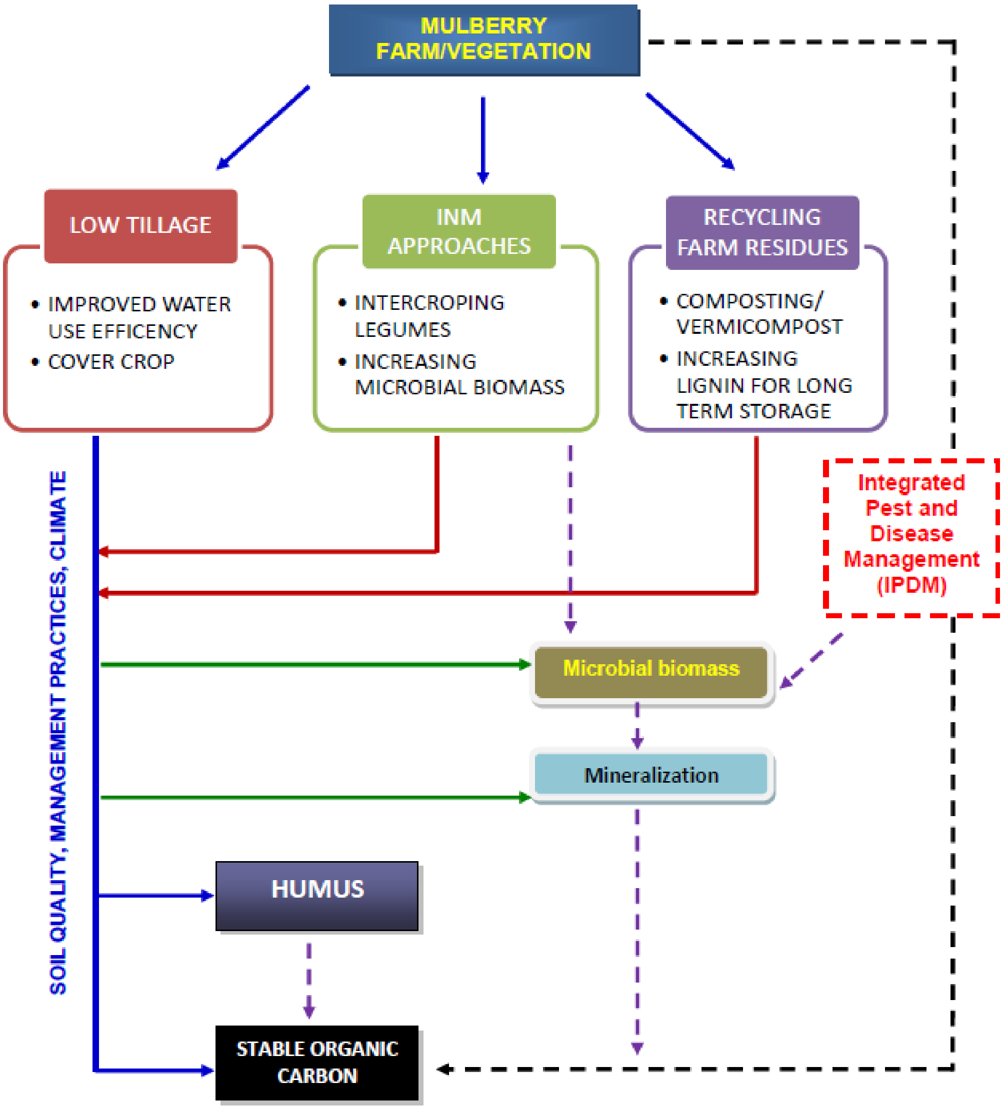
Fig. E: Furrow type of irrigation system to minimize carbon loss to environment.

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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