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Nongmaithem Shitaljit Singh

Research Scholar, M.Sc Soil
Science and Agriculture
Chemistry, School of Agriculture,
Lovely Professional University
Phagwara, Punjab, India

Pankaj Kumar Yadav

Research Scholar, M.Sc Soil
Science and Agriculture
Chemistry, School of Agriculture,
Lovely Professional University,
Phagwara, Punjab, India

Soil health and land use strategies for sustainable agriculture: A review

Nongmaithem Shitaljit Singh and Pankaj Kumar Yadav

Abstract

Soil health observation tends to focus more in biological components of the soil. In agro-ecosystem soil organic matter played an important role in enhancing the soil physical, chemical and biological properties. Climatic factors and environmental stress like tillage affects the soil health and soil quality of different land use system, it has also has been found out that the role of chemical fertilizers results major impacts on soil health and soil quality and the soil organic matter are used for resolving the soil condition. However, the role of agroforestry, integrated nutrient management system enhances the soil and maintained its sustainability. Farming practices like organic farming also helps in improving the soil condition improving the activities, diversity, and abundance of the microorganisms comparing to the conventional farming system and also helps in achieving a sustainable agriculture. This review has focus on achieving the good soil health and soil quality of different land use system and to achieve a sustainable agriculture.

Keywords: Soil health, soil microorganisms, climatic factor, sustainable agriculture

Introduction

Soil is a naturally occurring resource that comforts a variety of ecosystem goods and services to the benefit of mankind. Its contributions to the environment are very important that it preserve and enhance the natural ecosystem. Boosting of soil health and soil quality is necessary to be implemented in these today society and knowing interrelationship between soil health and soil quality is also most of the important factors. Sometimes soil health and soil quality is used as a synonymous terms but actually they are different. Soil health term is widely used by the farmers while the researchers also known as the soil scientist used more about the term soil quality.

The strength of particular soil to function within its capacity within natural or managed ecosystem boundaries for sustainable plant and animal productive maintain or enhance air and water and for the benefit of human mankind is defined as the soil quality whereas soil health is defined as the capacity of soil to enhance the air, water quality to sustain plant and animal productive within a boundaries and promote plants, animals and human health. Soil can also be known as a very limited and it is a living resource. Having good soil quality is well considered as a good soil health also high organic matter content and nutrients in soil usually considered as a healthy soil but it may not be considered as a healthy soil if it causes injuries to crops or supports large parasite population. Soil health observations tend to focus more on biological components of soil. Soil organic matter (SOM), Soil organic carbon (SOC), Soil Enzyme activity and soil microorganisms are observed as major indicators of soil fertility and productivity; they took an important role in determining soil biochemical properties. SOM plays a major role in the functioning of agro - ecosystem and cropping land fertility (Tiessen *et al.*, 1994) [27]. (observed that the carbon sequestration take part a significant role in increasing and stabilizing of rice production. Knowing the controls of SOM on the productivity and yield stability of the soil will make us to know the process of carbon inputs into soil under different orchard system. SOC helps us to store nutrients (N, P, K, Ca, Zn etc.), it also helps the soil to boost the biological processes and strengthens soil resilience. Likewise soil enzymes and soil microorganisms is an important factors that takes an important role in maintaining soil quality. In the agro-ecosystem, soil enzymatic activity is an indicator of the soil processes. Soil enzyme are taking part through catalyzing various reactions and metabolic process occurring in organic matter, metabolism, maintaining soil structure, nutrient cycling and producing the energy for both microorganism and plants(while applying organic fertilizers it affects the enzyme activities, different researchers has proved that application of organic

Corresponding Author:

Nongmaithem Shitaljit Singh

Research Scholar, M.Sc Soil
Science and Agriculture
Chemistry, School of Agriculture,
Lovely Professional University
Phagwara, Punjab, India

fertilizers increases the enzyme activities but the enzymes activities might change depending on their type of the organic fertilizers and the relative availability of the nutrients Soil microorganisms also plays an important role in regulating the soil health and soil quality, It also took part in recycling the C, N and other important nutrients. With this type of practices it may able to have sustainable agriculture.

Soil health of Different land use system

A) Orchards

The field or land area which are planted with the fruit crops are known to be as orchards. India also takes an important role in producing fruits crops. Fruits like Mango, Fig, Papaya, Coconut, Banana, Orange, Kinnow, etc. are widely grown over Indian orchards. It is long term investment crop cultivation. Selecting proper site, planting system and the planting distance is much needed for the efficient yield productions (Dr. N. Kumar. 1997. Introduction to Horticulture). Cultivating orchards fruit crops make the soil less disturbance and prevents soil erosion which give affects to the soil health. Like the canopy appeared by the orchard crops protect the soil surface from direct sunlight heat so that it reduces rate of evaporation from the soil surface which prevents the soil quality and the soil health from the destruction. While Intercropping can also be practiced in this type of cultivation that it allows to boost the economic conditions of the farmers in shorter period. Orchards soils gets easily changed due to climatic factors and environmental stress (Pergola *et al.*, 2013) ^[1] with uses of more number of tillage frequently, intensive tree growing affects the stability of micro-aggregates which plays a major role in Soil Organic carbon (SOC) stabilization and also supports the carbon sequestration for long term and appearing more stability than the macro-aggregates (Culliney *et al.*, 2013; Celano *et al.*, 2011; Totsche *et al.*, 2018) ^[2-4]. Regarding the input of the inorganic fertilizers it may increases their yield for the current situation but it does not provide a good crop residue for the enhancement of the SOM (Palese *et al.*, 2015; Mininni *et al.*, 2018) ^[5-6]. Fertile soils have rich SOM which are built by the carbon that the living plants remove through atmosphere by the photosynthesis (FAO). With the use of more tillage frequently and heavy fertilizers soil releases carbon-dioxide. By the IPCC report, it has a conclusion that maximum cropland soils have lost their SOM content to the percentage about 20-60%. Increase of SOM content enhances soil ability to hold the water and also minimized happening of soil erosion, due to the these storage of water it can have the life of tree crops more sustaining when there happening of the drought condition (Sofa *et al.*, 2019) ^[10]. Living microorganisms also plays an important role towards soil health, Soil macro fauna can also acts as an important tools for indicating the soil status, sustainability and their environmental health (Paoletti *et al.*, 1998) ^[17]. Macro fauna like earthworms plays a role that benefit metabolism of the plants and production of crop, it causes increase in nitrogen fixing activities, availability of the macro and micronutrients and polysaccharides and it enhances biological synthesis of the plant growth regulators (Negassa *et al.*, 2018 Tomati *et*

al., 1995) ^[11-12]. In the orchard soils, earthworms are very sensitive to the available nutrient status and SOM content and they are abundant under sustainable land management system, where sufficient litter is usually available (Coleman *et al.*, 2007; Li *et al.* 2017) ^[13, 17]. Enhanced soil with the earthworm allows plants roots to grow deeper into the soils and it also maintain their aeration benefits to their development and it also helps in reducing the soil borne diseases. But in the limitation it has shown that the spontaneous or cultivated cover crops obtained in different sustainable orchards develops a helpful vegetation covers, resulting in a more humid soil environment that positively affects the activity of soil living organisms. High root density increases the soil macrospores and also for the soil macro fauna which is followed by the nutrient mineralization (Ruiz *et al.*, 2008; Moore *et al.*, 2005) ^[15, 16]. Sustainably managed orchards obtained large abundant fauna with density and the biomass content is much higher than the conventional managed system. Practices of the sustainable agriculture enhance the crop residue quality and have huge effects on the soil macro-fauna and soil health of the ecosystem (Ruiz *et al.*, 2008; Coleman *et al.*, 2007) ^[15, 13]. Use of Good Agricultural Gaps (GAPs) of “Smart agriculture” can also provide an important role in maintaining biodiversity and their ecological functions (Sofa *et al.*, 2010) ^[18]. Orchards soils attains a huge reservoir of the biodiversity, earthworms, termites, ants and beetles are macro fauna that occurred commonly in the orchard soils and help in the soil factors in developing the new habitats (Jones *et al.*, 1994; Buchholz *et al.*, 2017) ^[19, 20]. Earthworm is the vast macro fauna that we found commonly in the orchard that also helps in developing the soils structure and breakdown of the SOM (Castro Lopez *et al.*, 2019) ^[21]. In the avocado orchards soils it has been found out that the surface feeding earthworm horizontally and vertically disseminate microorganisms, pollen, spores and seeds with the digestion of the fungal spores the plant pathogen are reduces (Van Zwieten *et al.*, 2004) ^[22] and also in the same orchard field it has been found out that the earthworm play and important role in mixing the organic residues and fine mineral and increases the content of soil organic matter. In calcareous loam orchard (pears) soil it has been found out that the without the content of the earthworm it let the soil to be more compaction and changes in the SOM In the apple orchards it has been found out that with no- tillage, ridge till attains to have decrease of earthworm loss and biomass from the soil surface (Paoletti *et al.*, 1999) ^[24], with the use of conventional farming it has been found out that there is loss of earthworm present in the soil of the apple orchard in comparing with the organic farming (Paoletti *et al.*, 1999) ^[24]. Content of copper is needed in all organisms but if excess it effects and may become toxic that will bring the reduction of the biological activity and fertility of the soils (Van Zwieten *et al.*, 2004) ^[22]. One most important factor is that macro fauna effects in decomposing leaf litter is and increased rate of nitrogen mineralization and not from the excretion where results came out to be accumulate nitrates in soils in time to time where plants do not carry them up and thus favorable with the leaching (Vanlauwe *et al.*, 2012) ^[26].

Table 1: Comparison between different orchards

S. No	Crops	Place	N	P	K	pH	References	Remarks
1	Guava	Eastern India	220.0 kg/ha	21.3 kg/ha	355 kg/ha	4.71	(S.C. Swain <i>et al.</i> , 2016)	Acidic soil with N is low P is slightly low K is medium
2	Mango	Eastern Region, Jharkhand, India	254.0 kg/ha	31.0 kg/ha	341 kg/ha	4.68	(Sushanta Kumar <i>et al.</i> , 2016)	Acidic soil with N is low P is medium K is medium
3	Kinnow	Punjab, India	148.2 kg/ha	2.69 kg/ha	114.5 kg/ha	8.82	(Yogesh Khokhar <i>et al.</i> , 2012)	Alkaline soil with Low NPK
4	Litchi	Dehradun	205 kg/ha	6.678 kg/ha	2.39 kg/ha	5.3	Singh and Varu (2013)	Acidic soil with very Low NPK
5	Ber	China	191 kg/ha	1.36 kg/ha	7.23 kg/ha	8.44	(Xiaoja Wang <i>et al.</i> , 2022)	Alkaline soil with very low NPK

B) Agriculture

Agriculture is a vast systems and practices of different farming process benefitting human as well as animals. It plays an important role in an Indian economy, providing more than 50% of employment towards the people of India. Regions like Punjab, Haryana, and Uttar Pradesh etc. are the best agricultural states having good amount of productions of food. Rice is the staple food of India and Wheat is the second most important agricultural crops grown in India. Production of good yield and good quality depend upon the availability of nutrients. Lack of nutrients, deficiencies etc. make the farmers to use huge amount of chemical fertilizer, pesticides which causes harmful effects directly or indirectly to human health and which also affects the soil health. Consuming this toxic materials regularly make humans to bring serious illness like different types of cancer. Proper management factors are needed to save from this effects and for the change practicing of organic farming towards entire globe is must needed. It is the right time to start for the future of our environment sustainability. According to the FAO, Soil fertility is defined as the ability of the soil to provide essential plants nutrients and soil water in required amounts and proportions for the plant growth and reproduction in the absence of the toxic substances which may inhibit the plant growth. Providing the essential nutrients for the growth of the plants, supports a well diverse and active biotic communities, exhibiting a typical soil structure and allows for the undisturbed decomposition is called fertile soils Evaluation of the land allocates the land uses and it is the first step taken up for the development of sustainable land management. In some countries with the low population uses land evaluation for identifying the fertile soil for the agricultural productivity whereas on the factors of countries with huge population it was use for identifying the deficiency factors in agriculture that could be improved particularly by manuring. Integrated Nutrient Management (INM) took an important role in having sustainable management of SOC pool and its changes and had good positive soil ecosystem [Vanlauwe *et al.*, 2012] [26]. For sustaining the soil fertility and agronomic productivity enhancement of the SOC is an important factor [Tiessen *et al.*, 1994] [27]. The soil of the West Africa, losses soil organic carbon due to depletion of the natural resources like the cropland in other different countries [Lal *et al.*, 2004] [28]. Therefore there are four basic principles of Conservation agriculture they are a) Keeping up of crop residue mulch b) incorporating cover crops in the rotation cycle c) access of Integrated Nutrient Management d) Reduces of Soil mechanical disturbances (Lal *et al.*, 2015) [37]. 30% of the world's nitrogen fertilizers was consumed by the China (Li *et al.*, 2009) [30] and they are able to provide food of the world

22% populations in 6.8% of the world cropland area but the country has huge suffer on the soil health and environmental health due to Nitrogen use efficiency, outcome of the leaching of N into surface and groundwater and even volatilization of N in to the atmosphere.

C) Forest

Forest soil are highly rich in organic matter due to the large decomposition of plants leafs that are fallen under their surface area. They contain high organic matter comparing to the agricultural land. In tropical forest there is a positive co-relationship between soil microbial biomass and the plant litter. Due to presence of high organic matter rate of decomposition is also increasing. Decomposition and transformation of litter also took part an important role to the cycles of carbon and nitrogen in soil Arbuscular mycorrhizal fungi (AMF) and Glomatin related soil protein (GRSP) is also used as an Biological indicator of soil quality. Arbuscular mycorrhizal Fungi (AMF) took an important role in recovering forest soil of Brazilian tropical forest. Thus forest reduces the risk of soil erosion, rich in organic carbon, exchangeable cations, available nutrients and microbial activities improves the soil quality and soil health of the land use system. Forest ecosystem is the largest terrestrial carbon pool (Pan *et al.*, 2011) [31] with the availability of Carbon percentage of about 80% of all terrestrial above ground and with the presence of more than 70% of Soil Organic carbon (Jandl *et al.*, 2006) [32]. While in the tropical forest also huge number of Carbon stored in or above the ground surface (FAO, 2011) [33]. Forest soils attains nearly about half of the total organic carbon of the terrestrial ecosystem (Mayer *et al.*, 2020) [35]. Climate change impacts the ecosystem of the tropical forests, environmental health and the soil health also with the carbon status, it has an effect due to increase in population, fertility of the soil and the reduction of food which leads to an increase in land degradation (Bini *et al.*, 2009; Lal *et al.*, 2015) [36, 37]. With the practices of forest management it improves the Soil ecosystem and carbon pools of the forest soils. Forest and grassland systems appeared higher concentrations and more soil organic carbon stocks than cultivated rice land and jhum land. Due to cause of climate change and Land degradation it affects the sustainable agriculture and the forest environment over world-wide (Bini *et al.*, 2009; Lal *et al.*, 2015; Pimente *et al.*, 2013) [36-37, 39]. Sustainable soil management through Carbon sequestration is major soil components for restoring the soil health and sustaining soil health (Lal *et al.*, 2015 Lal *et al.*, 2012) [37-38]. Forest land management is an important factor for boosting of carbon and soil health. In Central China, afforestation done in a large area of land increases the soil carbon and nitrogen

storage in macro-aggregates (>2000µm) (Dou *et al.*, 2016) ^[40]. It has also been found out that, the percentage of carbon concentration in particulate organic matter decreases in second rotation (Koutika *et al.*, 2019) ^[41] and has shown the interrelationship among them.

D) Wasteland

In India, farming land continuous on degradation and it is quietly converted into wastelands. National Wastelands Development Board (NWDB) defined wasteland as “that land which are degraded and with no use due to different limitations. Also wasteland is defined as the areas that are unutilized and produces biological activities less than 20%. Comparing to the matured plants young plants are more sensitive to salt. During growing period applying fresh water is recommended for ensuring germination of plants (Yuan *et al.*, 2011) ^[68] Physiological drought causes with increase in concentration of salt in the soil and the species which are chosen should be resistant of high salt concentration (Yadav, 1978) ^[69]. It is the place that are unfit for the cultivation, grazing and other economic uses due to water logging and the major issue like soil erosion. As per the reports almost 17% of Total geographical area of India is waste land. States like Rajasthan tops the highest wasteland area in India (as per the details of 2019). According to the research paper “Soil quality under forest compared to the other land- uses in acid soil of North western Himalaya, India” by S. Pal, P. Panwar, D.R. Bhardwaj we have found that in waste land area the Cation exchange capacity (CEC) is very less as compared to the other land use system, less nitrogen availability, less available phosphorous, less available potassium and coming to the micro-nutrient contain in the soil, waste land soil gets less as compared to the other land use system. Biological properties like microbial biomass carbon, microbial biomass nitrogen, microbial biomass phosphorous is also less are compared with the other land use system. Overgrazing along with the deforestation causes degradation among different Indian states which has made the increase of wasteland are more than 20% (Source: Wasteland atlas of India by national remote sensing agency, NRSA). Due to higher availability of livestock population it has made overgrazing which led to the decrease in infiltration rate, increasing the runoff and soil erosion. Thus many researchers has been suggested that afforestation and reforestation to be done for the reclamation of wasteland areas. Fly ash is used on reclaiming the wasteland (sodic soil, acidic soil mine soil) as fly ash acts as many functional properties of gypsum and lime (Shainberg *et al.*, 1989; Kumar D *et al.*, 2003; Mitra BN *et al.*, 2005) ^[65-67] and this fly ash is also hardly recommended for sustaining and reclamation of wasteland. An Arbuscular mycorrhizal fungus improves soil health and they have a capability in reinstatement of wasteland and increase the soil fertility. The technique of Auger hole reclaimed of a very small fraction of the total area and it also aims the roots to go deep into the soil and helps in mitigation of adverse effect on high alkali in the surface area of the soil. When the present roots goes deeper they found a favorable environment and also with the good moisture availability in a very short period with this result it helps the tree for better growth and increases the roots growth. With the help of technique scientifically the wastelands are reclaimed and restored, also with practice of agroforestry or afforestation the wasteland are reclaimed. Agroforestry is a mostly used and best way for the restoration and reclamation

of wasteland as they have a many beneficial role in the environment. Agroforestry helps in higher productivity with no effects to the environment, it increases the soil quality and it also enhances the nutrient availability Agroforestry involvements through production of fodder by the permanent vegetation *viz.*, silvopasture and hortipasture systems plays a very important role in reclamation and restoration of degraded lands.

E) Jhum

It is an old and traditional method of cultivation which is commonly practice in the North eastern part of India. The framers cultivated the crops in steep slopes in a systematic way, before cultivation the surrounding land of the cultivating area are cleared by cutting down the trees and forest. Then the leftover are properly dried by the sun and burning was done, the remaining ash is used as a fertilizers and the sowing can be started immediately before raining. Therefore, long term practice of Jhum cultivation made the forest area reducing in most of the states (Canopy density >40%). The burning process which has done before the cultivation has brought serious effect in soil health, it makes the soil organic matter turns into ashes, it makes the soil surface increased in pH and cations and it decreases the carbon and nitrogen contain in the soil. Due to high oxidation losses the organic carbon decreased in the soil which has made the soil leads to soil erosion, at the time of cropping high nutrient losses was there due to runoff and percolation. In the north east India, the shifting cultivation they practiced was mostly operated by using the organic fertilizers. In this region used of Chemical fertilizers are in lesser amount on comparing to the other places and this has made the soil to maintain soil health. Proper management of watershed is needed in this region to attain soil health for the sustainable organic food production. Nowadays, the shifting cultivation are said to be stop by the many researchers as it causes serious damages to the natural soil system which accelerates deforestation that brought natural disaster over the people. According to the (Geist *et al.*, 2001) ^[21], Jhum or traditional shifting cultivation is quite different from shifting cultivation. It says that all shifting cultivation is not Jhum cultivation. Jhum are processed by different group of people with wide variation according to their culture and relationship with ecosystem. In Jhum, it removes the forest by burning and contributes carbon into the atmosphere, it is considered to be effect to climate change (Brady N.C *et al.*, 1996; Rastogi *et al.*, 2002) ^[72-73] and it comes under increasing pressure. It is known as the practice of the early period and these practices effects the natural resources. (Warner *et al.*, 1991; Brunn *et al.*, 2009) ^[74-75], the practices are well known as a major factor for change in ecosystem and loss of biodiversity. The practices were known for economically and energetically efficient on comparing to the other form of agriculture (terrace or valley cultivation) in heavy rainfall areas of the hill tracts (Ramakrishnan *et al.*, 1992) ^[77]. Jhum is also is well known for contributing towards the loss of forest (deforestation and degradation) (Kleinman *et al.*, 1995; Myers *et al.*, 1992) ^[78-79]. In jhum cultivation practices in Nagaland it has found out that it uses common salth in upland planted rice for the control of broad leaf weeds as post- emergence spray. This process was not recommend method for controlling weed but it work in alien weeds example *Ageratum conyzoides* L. and *Parthenium hysterophorus* L. was easily controlling by applying 15-20%

of common salt. The weed management which is done by adding common salt attained healthy soil and more productions of vigorous crops. (Rakesh kumar, Dibyender Chatterjee Bidyat C deka & SV Ngachan)

F) Grassland

It is the one of the most important and largest areas among the four types of vegetation, it covers about one - fifth area of the earth surface. In India grassland attains about 18% of the area and it reduces day by day due to the conversion of grassland into agricultural lands by the farmers which has given a serious effect in the natural ecosystem. Grasslands play an important role in soil nutrient cycling and they also provide the food for the herbivores animals, it also protects soil from wind and water erosion and maintains soil fertility. Grasslands helps in binding the soil by their fibrous roots and also helps in soil reclamation, it also act as an good habitat for the microorganism According to the research paper given by S. Pal, P. Panwar, DR. Bhardwaj grassland(2.16%) attains high organic carbon next to forest (3.01%). High amount of exchangeable Ca and Mg are found over the grassland areas. Nitrogen contains in the grassland areas is high next to the forest areas. Due to the presence of high organic matter it makes the soil more fertile and thus increasing the soil health and soil quality. More than 70% of native grasslands were converted into agricultural land or to the other land uses globally (Ramankutty, Evan, Monfreda, & Foley, 2008) ^[82]. Comparison between native grasslands and long term cultivation, long term have less soil organic matter (SOM) between 30 and 60% (Kucharik *et al.*, 2001; ^[83] changed soil microbial communities enhanced loss of nutrients and cycling process (Burke, Lauenroth, & Coffin, 1995a) ^[84], reduced nutrient holding capacity (Kemp & Dodds, 2001) ^[85], soil are in compact (Murphy, Foster, Ramspott, & Price, 2004) It has suggested that the conversion of cropland to perennial grasslands helps in mitigation global climate change via soil C sequestration (Paustian *et al.*, 2016) ^[86].

G) Agroforestry

In this land use system it comes under trees, crops and animals. Young 1989, Nair 2011 has given that the aim of agroforestry is for the improvement of the soil quality. Their functions were not only for the good of soil quality but also provide good services to the other ecosystem. In these land use system there is presence of high soil organic carbon on comparing to the single cropping system. Soil organic carbon took part an important role in decomposition and in changing of organic matter in the soil. The leaf fallen over the ground in the area decomposed and it helps in improving crop yields. Agroforestry helps in improving soil living activities and leads to improvement of soil physical and chemical properties

and it attains soil fertility and sustainable agriculture. Due to availability of trees in agroforestry, it was improving soil fertility and nutrient availability status in soil which led soil microbes to increase and helps in maintaining soil health. In this generation agroforestry is one of the most important land use system, its contribution to the agriculture will make the soil health and soil quality improved and further it also helps in restoring and sustaining the soil health. Agroforestry is must applied for the future generation and for ecofriendly towards the environment. It has been found out in the upper part- and down part of the ground the Carbon content and their supply in oil palm and cacao at the land use of agroforestry systems in Brazil (Ramos *et al.*, 2018) ^[88]. High carbon content in upper portion of ground, (Noumi *et al.*, 2018) ^[92] has compared the world carbon content of Eucalyptus afforested plots with traditional Savannah in Cameroon. They have found out that the tree Eucalyptus has high carbon content than natural Savannahs which is the oldest (Yengwe *et al.*, 2018) ^[89] they have calculated the nutritious potential of *Faidherbia albida* which are performing intercrop in Zambia with the maize crop. They got a solution that litter intake from *F. albida* can be supplied more than 18 kg N ha⁻¹ year⁻¹ and the microbial activities were increased, populations and huge number of availabilities. (Kaur *et al.*, 2018) ^[90] gave a solution that agroforestry trees are helping in remediation of the chemically treated farmlands in India, they have measured the acceptance of cadmium and cadmium accumulation potential in *Eucalyptus tereticornis*, *L. leucocephala*, *Melia azedarach* and *Dalbergia sissoo* and observed that all the trees are relatively tolerant to Cd content, with the highest tolerance shown for *M. azedarach*, the trees are decreasing in cadmium content by 41-52%, with *M. azedarach* and *L. leucocephala* it is widely used for phytoremediation and the AMF (Arbuscular Mycorrhizal fungi) availability can be increased by agroforestry practices (Shukla *et al.*, 2018) ^[91], which has shown out the effect of dark on the efficiency of bio inoculants collected from rhizobacteria, phosphate solubilizing bacteria and Arbuscular mycorrhizal fungi. They observed that the yields of all the research plants were in low in the dark than in the full light, but the strength of the bio inoculants was comparatively in full sun and under shade for *Glycine max*, *Phaseolus mungo*, and *Cicer arietinum* and more beneficial for *Vigna radiata* and *Pisum sativum*. Where, they have found out less nodulation with less sun light than in full sun. Agroforestry is well known as a sustainable land management system, it has shown the proved of its role in improving soil quality and soil health. The above mentioned that agroforestry plays an important role in improving soil health and soil quality and contributes soil sustainability.

Table2: practices done for the improvement of soil health and productivity

Technique	Cropping system	Place	Impacts	Reference
Mulching	Rice-wheat	India	It increases water use efficiency, and yield of wheat, weed control; It enhances the SOC pool, microbial biomass C, and microflora; it improve soil microbial count and soil biological quality	Singh <i>et al.</i> , (2008) Pal and Jat (2004) Jat <i>et al.</i> , (2004, 2009)
Waste water	Sugarcane Grain crops	Colombia India	It has better soils physiological parameters It has Lower microbial biomass C and has higher respiration rate	Madera <i>et al.</i> , (2009) Masto <i>et al.</i> , (2009)
Saline / brackish water	Fodder	India	It reduces the yield and increase in Na ⁺ uptake	Yadav <i>et al.</i> , (2003, 2007)

Soil health and climatic change

Major impact of soil health is quietly relatable with climatic change in our environment. Soil act as an major source of releasing gaseous like carbon dioxide (CO₂) and harmful gaseous such as CH₄, N₂O also known as greenhouse gases due to excess heating over the earth surface, the releasing gases are trap by the earth atmosphere and led the earth increases the temperature which has brought to Global warming. In other factors the ozone layer are depleting day by day which let the passes of harmful UV rays and cause serious effect to the living organisms and also severe impacts towards the different ecosystem services.

In soil, the microorganisms which are present act as a major consumers and contributor of greenhouse gases. They took an important role in contributing carbon in the soil from the atmosphere. Production of the yield of the crops is hardly dependent over the climatic condition. When the temperature of the atmosphere increases, the soil temperature is continuously increasing which has brought the increase of the solution chemical reactions rate and diffusion controlled reaction. It accelerates decomposition reaction, releasing the carbon dioxide from the soil and decrease in C: N ratio contain in soil. Due to increasing in soil temperature, the soil texture are affected as the microorganism contain in the soil are brought to dead which affects to the density of the soil and causes a serious factors like soil erosion. It can also have an effect on the porosity of the soil which has let the soil to have like surface runoff. Bulk density of the soil is increasing due to the dead of the microorganism by the high temperature which also contributes over soil erosion. It has also been found that soil temperature is an important factor where warmer soil used to accelerate soil processes, increasing the growth of microbial activities, fast rate of nutrient releases, increasing nitrification rate and it due to climate change land degradation is the major related issue that have people faced. As long as the climatic changes were there over our life, the future generation of our ecosystem might get extinct. However, proper measure is needed in this present generation to overcome this impact of climatic change. It has been found out that with the increase in temperature, high and low cause of rainfall, increases the concentration of CO₂ and theses interaction has brought by the climate change has made the physical soil condition changes which might happen like salinization, water availability decreasing and also changes in the carbon and nitrogen dynamics, nutrient storage in the soil and also reduction of the soil biodiversity Soil texture is a relative proportion of sand, silt and clay, it has direct impact of climate change. The four potential climate scenarios (Arid, Semi-arid, Sub-humid and Humid) have a great impact on important soil processes as the texture differentiation in the soil profile. With decrease of soil organic matter leads to decrease of soil aggregates stability, infiltration rates and increases compaction, runoff also happen due to erosion. The water availability for important soil processes and their plant growth are governed by the soil properties including field capacity, porosity, micro-pores flow, lower limit of plant available water and texture For the assess of management impacts plant available water is used as an soil health test. Decrease rate of organic carbon from due to increased decomposition by the elevated temperature might brought to an increase in bulk density and hence making soil more prone to compaction *viz.* land management activities and climate change stresses from variable and high intensity

rainfall and drought events Soil pH is an important indicators of Soil health, Soil pH take role in knowing the soil health in the assessment of the land use change and agriculture practices while these factors of climate change will affect organic matter status, Carbon and nutrient cycling, available water in plants and plant productivity, which in turn will affect soil pH Electrical conductivity (EC) are used as a chemical indicator for the information of soil biological quality in response to crop management practices It increases the electrical conductivity when there is a change in increasing the temperature and decreasing precipitation under climate changes Different Land use system and management practices leads to build up of SOM and will help in absorbing CO₂ from the atmosphere, thus mitigating global warming. With the increase of water storage, SOM plays an important role in the mitigating the flood impacts following extreme rainfall events, while storing of water in the conditions of droughts would led increase in soil resilience and the above portion has shown the interrelationship among soil health and the climatic change.

Table 3: Practices done for the enhancement of soil organic pool and for the improvement of soil health, mitigation of the climate change

Soil type	Management done	Place	Reference
Black soils (Mollisols)	Proper management of manures, rotation of the crops and straw are properly managed	China	Lui <i>et al.</i> , (2003)
Inceptisols	Organic amendments, crop residue are properly managed	India	Mandal <i>et al.</i> , (2007)
Inceptisols	Practices of conservation agriculture and straw management	United kingdom	Hazarika <i>et al.</i> , (2009)
Alluvial (Yangtze planis)	Manures, crop residue are properly managed and tillage conservation are practice	China	Rui and Zhang (2020)

Soil health and Sustainable agriculture

Sustainable agriculture is process of maintaining the farm system without giving effect to the environment directly or indirectly for the benefit of human life and for the future generation. In this system, it focuses mainly in increasing the content of soil organic matter in the soil and reduces land degradation like soil erosion. In this process, it increases the production of crop yields by reducing the climate change impact and used to preserve the agroecosystem which is one of the important goals of sustainable agriculture.

In this present generation, farmers used to depend upon use of chemical fertilizers and pesticides in high amount of rate and due to this it has been affected to the health of soil which led the soil happened like degradation and even in the other agroecosystem including human health. In the sustainable agriculture, soil biota plays and important role in decomposition, nutrient transporter and absorber. The soil rich in microorganisms attains good soil texture, good aeration and have good amount of required moisture content. Some examples like arbuscular mycorrhizal fungi (AMF), active bacteria and beneficial nematodes, they are highly related with the production of the crop yields, fruit quality, nutrients and soil water storage maintaining the soil health and soil quality of the soil, there function in soil acts as an organic. They play an important role in maintaining the plant health and soil fertility.

In sustainable agriculture maintaining good environmental

health, social equity and having good economic profitability is the most important factors. In having a good sustainable agriculture, practicing of organic farming was more likely to be considered towards farmer. Organic farming plays an important role in improving soil health by increasing the numbers of biota. The microorganisms present in the soil acts as an active indicators of soil health and soil quality. On finding out the chemical parameters of soil health, knowing pH, Salt concentration and available nutrient took and important role. In the previous days, the function on application of cultivating soil fungal biodiversity for the betterment of soil quality and increasing the productivity of agricultural ecosystems has been developed as a very seriously development towards the production of the plants. Micro-organisms took part in decomposing organic matter and gave nutrients for the growth of plants. Their role is very important for the shelter of plants against pathogen microorganisms the biological agents, which helps in encouraging the soil health. In healthy soil, the pest and the insects population is low and they are in less active. Soils with less human interferences like the natural forest has low bulk densities Micro aggregates are more stable and less affected by soil use and management system also they are also take role in stabilizing the soil organic carbon While the content of available water act as an determining factor of the microbial activities in the soil, the soil physical attributes affecting availability of the water and aeration in the soil will also affect the soil microbial activity, since due to the inverse correlation between water availability and microbial activities It has been identifying and screened some (183) biological indicators for checking the soils (Ritz *et al.*, 2009) [42]. Knowing the soil health component is necessary and commonly use in national and global agricultural checking systems and thus for the development of the sustainable agriculture. Organic farming is also increasing as the most sustainable agricultural system in the present situation because it does not improves only the physical, biological, and environmental resources like soil nutrient mineralization, microbial activity, availability and diversity, and groundwater quality with lower nitrate concentration, but it also improves the yield and product quality as proved in wheat, potato, watermelon, and strawberry (Fernandes *et al.*, 2012; Schrama *et al.*, 2018) [43-44] A study carried out in 12 years with rice (*Oryza sativa*) and corn (*Zea mays*) crops has shown that organic systems by using compost and peat sources has higher microbial population and enzyme activities as compared to conventional farming practices. The bacterial soil population and the microbial diversity in organic system with compared to the conventional banana (*Musa acuminata*) plantations where having a significantly higher in organic systems more than the conventional (Chou *et al.*, 2017) [46]. Practicing cultivation of vegetable crops such as tomato (*Solanum lycopersicum*), snap bean (*Phaseolus vulgaris*) and lettuce (*Lactuca sativa*) under organic methods and conventional culture methods for three years has a result that organic farming using compost had increased soil carbon dioxide respiration and enzyme activities (fluorescein diacetate hydrolysis, phosphatase, and arylsulphatase activities) in comparison with the conventional practices fertilizer (NPK) (Iovieno *et al.*, 2009) [47] Practicing organic farming is a good available source of macro-nutrients. Here we have, in a long-term (18 years) use of chemical and the organic fertilizers, Nitrogen storage is more in organically treated soil in the top

soil than the chemically treated soil (Gong *et al.*, 2011). Another case study in the place (21 years) of organic and chemically treated farming, nutrient input (N, P, K) in the organic soil was 34 to 51% lower than in the conventional practices, whereas Ca²⁺ and Mg²⁺ were (30-50%) in high [137]. While practice of organic farming is having less production than conventional farming, organic yield can have the same productivity after cropping for 10-13 years of practice (Mäder *et al.*, 2002) [49]. But still we will say that practicing organic farming is the best system for the improving the soil quality, but it may not be consider as the best option for farmers (short-term) when yield is the important part (Leskovar *et al.*, 2018) [50] also found that use of the tillage reduce soil macro- and micro-aggregate stability. A study was taken under 10 years on tillage practices on tomato planting soil, it has found out that the total number of nematode (soil microorganisms) comes under conventional tillage (moldboard plow) was 52% lower than of conservation strip tillage

Sustaining Soil health for the better production in agriculture

Maintaining soil health is an important factor and it is a compulsory to have in these present generations for the production of the good yield of the crops which will help the human life. According to the farmers having good soil health is more considered and the scientist considered more for the soil quality. Having sustainable agriculture like organic farming improves more soil quality and soil health. They provides higher amount of soil microorganisms in the soil which help in forming the good soil aggregates, having good aeration, water content and preventing from the causes like soil erosion. Soil pH, cation exchange capacity (CEC), organic matter and the nutrients content are the main chemical indicators used in assessment of soil health, especially when considering the soil capacity in support for the high yielding crops. Increasing microorganisms decreases the pathogen and the diseases in that area as the available foods are all taken by them. Factors like Tillage, burning the remaining of the plants etc. are disturbing the soil environment killing the microorganisms content in the soil, increase in Bulk density of the soil, and weakness of the soil strength which had brought serious effects like causes of soil erosion. Use of highly toxic chemical fertilizers cause's serious impacts to the soil environment which can also brought the causes of serious health effects towards human health. In sustaining the soil health used of these chemical fertilizers should be reduce for the future generations. Some factors like soil cover can be maintained properly as they reduce the erosion, it conserves moistures, it helps in reducing the temperature, and it deactivates the weed growth and provides the habitat of the microorganisms. In the state like Punjab, health of the soil totally in a worst condition due to the use of high amount of chemical fertilizers for the long term processes and the only way to save the soil is giving the organic farming practices which will increases health of the soil with the increase of soil biota. As the farmers continues to use this toxic materials the chemical fertilizers, after some decades the scientist have said that the soil condition of the particular places will face serious problem that can have the phase of beyond the recycle phase which will get huge impact on the natural ecosystem and the living organism in these planet might get extinct. In order to have the good soil health and soil quality, sustaining soil

health is important and for the betterment of future generations. Soil biodiversity impacts are given by the intensive human use, change in climate, and practice of overgrazing, declining of soil organic matter present, occurrence of pollution, soil erosion, and land degradation (Orgiazzi *et al.*, 2016) ^[53]. While, knowing the effects and causes to soil biodiversity, it is necessary for the sustainability of the agriculture. The functional capabilities of microorganisms to nutrient acquisition, through mobilization, fixation, recycling, decomposition of organic matter, land degradation, and remediation in the soil helps in connecting microbial activities with soil health and sustainability of agriculture (Sahu *et al.*, 2019) ^[54]. The development and productivity of commercial microbial inoculants such as AMF, bio-fertilizers, and microbe-based decomposers gives the farmers the energy to reduce the chemically farm practices and adopted the integrated nutrient and pest management practices for the development of sustainable agriculture (Sahu *et al.*, 2012) ^[56]. Use of bio fertilizers improves plant nutrient content by providing plants nutrients directly, prompting root growth as well as sustaining the symbiotic relationships between them. (Vessey *et al.*, 2003) ^[55] Some of the well-known eco- friendly bio fertilizers for sustainable agriculture are Azotobacter, blue green algae, Rhizobium, and Azospirillum (Sahu *et al.*, 2012) ^[56]. It is said that conventional agricultural practices might reduce AMF density while organic low- input system would be viable to increase AMF activity and it took a major contributions to the development of the sustainable agriculture (Basu *et al.*, 2018; Panwar *et al.*, 2008) ^[57-58] Nematodes is also well known as biological indicators for soil quality assessment, they provide a good habitat for biodiversity and take part in the process of nutrient recycling (Stone *et al.*, 2016) ^[59]. The above mention the role of soil health in intensive crop production systems and identified factors to consider when assessing soil health components in sustainable agricultural systems Soil health considers soil biota component such as microorganism availability, diversity, activities, and community to be in stable form. Assessment of soil health indicators is necessary for the enhancement of our understanding on how production strategies and environmental factors impact the physical, biological, and chemical stability and change of the soil-rhizosphere-plant systems and their impact to short or long term sustainability.

Conclusion

In the conclusion the review examined that soil health of the different land use system mostly depends on their presence of their living microorganisms. Soil microorganisms play an important role in enhancing the soil health and soil quality. Presence of higher amount of soil micro and macro fauna leads to have a good soil health physically, chemically and biologically. Having good soil quality is well known to be attained good soil health. Soil enzyme plays an important role in indication of the soil fertility and soil productivity. It was observed that Soil organic carbon sequestration takes part an important role in enhancing and stabilizing of the yield production. The activities of the enzyme depend on the organic fertilizers applied; it changes due to organic fertilizers applied. While the changing of soil is also quietly depends on climatic factors and the environmental condition. The microorganisms like Earthworms play an important role in increasing the soil organic matter. Practicing conventional

farming tends to reduce soil living organisms which directly impact the soil health and its sustainability. Integrated nutrient management practices are also counted as the farming practices to be adopted to achieve a sustainable agriculture along with high productivity of the yield. Use of bio fertilizers keeps the soil in enhancing the soil health, quality and its sustainability. Forest soil has found that it has the largest terrestrial carbon pool. Agroforestry took an important role in enhancing the soil health and it also makes the ecosystem to have a sustainable agriculture system. While increasing the soil temperature it also causes the degradation of the land like soil erosion, decomposition of the living microorganisms. Soil organic matter takes an important role in reducing the flood occurrence by increasing the soil water absorbing capacity. It has a conclusion that maximum cropland soils have lost their soil organic matter content to the percentage about 20-60%. Practicing organic farming also tends to increase the soil health by the help of soil microorganisms which leads to a sustainable agriculture. Assessing soil health is an important indicators and it is necessary for the enhancement of the environmental factors and to get a sustainable eco-friendly environment and good soil health.

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