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**Review Article**

# SOIL MANAGEMENT OPTIONS FOR IMPROVING PHYSICAL ATMOSPHERE FOR SUSTAINABLE AGRICULTURE PRODUCTION: A REVIEW

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**Abstract-** Sustainability is the widely use to describes ability of a system. It depends to the large extent on the maintenance or improvement in the soil quality and health. Soil quality is conceptualized as the foremost linkage between the strategies of soil conservation management techniques and achievement of the major aims for sustainable agriculture. The sustainable agriculture systems unless for improving the soil quality indicator *viz*. physical characteristics. Soil quality is the ability of a situation soil to function, within natural or managed ecosystem boundaries, to sustain the plant and animal community to improvement water and air quality and support human health and surroundings. The major problem in crop production at higher level to meet the increasing demands for the food, fiber and fruit quality attributes for increasing population day by day. The restricted sources land and water resources are the input constituent of Indian farmings. The most favourable the genetic yield potential of a crop cannot be realized even when all the other requirements are fulfilled. In the soil for physical quality indicator are enhanced by different technologies like optimal uses of minimum or conservation tillage practices and organic and inorganic mulching could favorably modify the soil physical parameters like bulk density, porosity, aeration, soil moisture, temperature, soil aggregation, water retention properties and water transmission properties and soil processes like evaporation, infiltration, runoff and soil loss for better crop growth and yield. The balance /optimum dose of manure and fertilizer for increasing the soil fertility and buildup carbon for sustainable agriculture crop production. Hence there is need to improvement of sustainable soil health management through these eco-friendly shall lead to efficient use of inputs and help in sustaining farming systems for agricultural crop production at higher level to meet the demand in humans and animals community.

**Keywords**- Sustainable agriculture, soil physical quality, soil health and soil functions

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## Introduction

Sustainable farmings systems goals at meeting the needs of present generation without endangering the resource base for posterity. Unfortunately unsustainable productivity, yield was decrease, environmental pollution, decreasing soil organic matter storage, decreasing factor productivity under high intensity agriculture in the post green revolution era has been a matter of great concern today. In the sustaining, the productivity at higher level is therefore the key issue in Indian agriculture to meet the increasing demands of food and fiber for the growing population. Maintaining soil quality and health is indispensable for sustaining the agricultural productivity at higher level. Soil quality is the capacity of soil to function within ecosystem and land use margins, to sustain biological productivity, maintain the ecological quality and promote plant, animal and human health [1]. Soil quality includes three groups with the interactive attributes i.e. soil physical, chemical and biological quality, which must be restored at its optimum to sustain productivity at higher, levels in the long run. It is the high time to appreciate the fact that the unless of the soil physical surroundings is maintained at its optimum level, the genetic yield potential of a crop cannot be realized even when all the other requirements are fulfilled. The nature and extent of physical constraints are not stagnant. The mechanization farm operations, frequent tillage in intensive cropping systems, unscientific and indiscriminate use of inputs and decline in soil organic matter etc. are adding new problems to the existing area. The current scenario calls for appreciating the fact that the once degraded soils, it is not easy, if not impossible to restore the soil to its better quality for atmosphere condition. Persistent hard work are therefore acceptable to arrest further aggravation of soil degradation, to alleviate soil physical constraints and also to understand the respective causal processes for the sake of holistic, safe and resilient agricultural production system. Therefore must be to improve and maintain the soil physical environments at its optimum condition with minimal risks to environment.

## Management's options

### Improving Soil Physical atmosphere through Use of Mulching Practices

Mulch is a surface layer of material applied to the soil or it is any material used to cover the surface of cultivated soil to protect plant roots from heat, cold, or drought, to keep fruit clean, or to control weeds. Mulches are useful to make more attractive, high yielding horticultural crops. It is the artificial purpose of mulch, practiced to obtain beneficial changes in soil physical environment. Mulching improves physical conditions of soil, chemical environment and biological activities. Favorable modification of the soil hydrothermal regime, improvement of soil aggregation and retardation of erosion and soil loss, improve the physical condition of soil under mulch.

**Soil moisture retention**

The soil moisture retention through mulching is one of the main purposes. When the soil surface is covered with mulch materials helps to prevent weed growth, reduce evaporation and increase infiltration of rain water during growing season. The mulches provides several benefits to crop production through soil and water conservation, enhanced soil biological activity and improved soil properties. [2] found that the higher soil moisture in black polyethylene at 0-15 cm and 15-30 cm depth after 170 days of mulching at both soil depths. The higher soil moisture content below the mulches in various mulching treatment may be owing to reduction of water erosion, reduction in soil surface evaporation, suppression in extreme fluctuation of soil temperature, resulting more stored soil moisture [3]. Mulching being positively influences the soil moisture preservation by controlling evaporation from soil surface, improving infiltration and soil moisture retention and facilitating condensation of water at night due to temperature [4].

**Improving soil structure**

Mulching improves soil structural properties directly and indirectly by promoting the biological action. Organic mulching improves the total porosity of the soil, macro and micro porosity and mean weight diameter of dry and wet stable aggregates, which may be due to accumulation of organic matter upon disintegration by soil microorganisms. The mean weight diameter of water stable aggregates increases with increase in the mulch rate [5]. In general, the mulched condition, bulk density of the soil is lesser than that under unmulched condition. Bulk density decreases with increase in crop residue mulch rate. One of the reasons for decrease in bulk density with increase in mulch rates is high earthworm activity in mulched plots.

**Soil aeration**

Crop residue mulch improves in soil aeration by promoting free exchange of gases between soil and the atmosphere. These are the improvement of the structural stability, total porosity and macroporosity, decrease of surface crusting and by the improving the overall in the soil drainage. The mulch condition is higher than under unmulched condition by oxygen diffusion rate. The gaseous composition of soil air under mulch depends on the nature of the mulch material (C:N ratio), its rate of decomposition, the soil moisture regime and the climatic condition. Plastic mulch is practically impervious to carbon dioxide ($CO_2$), a gas that is of prime importance for photosynthesis. Very high levels of $CO_2$ manufacture takes place under the plastic, as the film does not agree to escape. It has to come through the holes made in the inorganic mulch for the plants and a “chimney effect” is created, consequential in localized concentrations of abundant $CO_2$ for the actively growing leaves that accelerate the growth of the crop.

**Improving soil fertility**

Organic mulches improves the soil fertility status of soil could be due to after decomposition when release organic material and plant nutrients to the soil and improve the physical, chemical and biological properties which in turn increases crop yield. Soils under the mulch condition are left overs loose and friable. Mulching increased soil moisture retention, organic matter contents leading to suitable environment for root penetration. The soil organic matter increased due to decomposition of applied mulch. [6] reported that the mulched treatments show significantly greater total uptake of nitrogen, phosphorus and potassium than corresponding unmulched ones. Higher organic carbon content of soil observed with sunhemp mulch (0.71%) followed by silkworm bed waste (0.68%) and paddy straw (0.66%) mulched plots. The least organic carbon content was recorded in no mulched plot (0.48%) [7].

**Controlling runoff and soil erosion**

Mulching always decreases soil erosion and often reduces the runoff rate and its amount. Mulch prevent the soil surface from raindrop impact and surface sealing, increases the infiltration rate and decreases the run-off velocity through physical resistance of water flow. In general, the loss in water through runoff decreases exponentially with increase in mulch rate [8]. For several types of soils, mulch does not substantially decrease runoff but drastically reduces soil erosion. The runoff water gets filtered through the mulch and is often clear with little sediment. Mulching decreases sediment concentration in runoff water through the protective effect of crop residues against raindrop. The adequate amount of crop residue mulch could mitigate the effect of degree of slope in reducing runoff and soil loss. Mulching is also effective in reducing soil erosion by wind and reducing the wind velocity on soil surface when the mulch is fixed to soil so that it does not get blown up by the wind. In the standing crop residues serve as barriers to wind and are more effective than flattened surface mulches in decreasing wind erosion. The success standing crop residues depends upon the plant density of the crop harvested and their size above the ground.

**Minimum evaporation and maintain of soil temperature**

Mulching reduces soil temperature in summer and raises it in winter. It prevents the extremes of temperatures. During summer, mulching conserves the soil moisture due to reduced evaporation. The cooling effect of soil promotes root development. In general, the effect of mulching on the temperature regime of the soil varies according to the capacity of the mulching material to reflect and transmit solar energy. Mulches results in greater water content and lower the evaporation. However, effects on soil temperature are highly variable. White mulches increase soil temperature. At night, condensation on the mulch absorbs the long wave radiation emitted by the soil thereby slowing cooling the soil [9]. The ability of clear mulches to produce soil temperatures high enough to control weeds, plant pathogens and nematodes forms the basis for the soil solarization process [10]. The dry soil are more heated more easily than a wet soil because the specific heat of water is nearly five times than dry soil. The high specific heat of water prevents the sudden changes in temperature of irrigated soil during winter [11]. Mulches lessen water evaporation from soil and help maintain stable soil temperature [12]. [13] Observed that the growing season the soil temperature in the farmland mulched by wheat straw was lower than under the control condition by 22.5$^0$C, while the accumulated soil temperature in the farmland mulched by film was higher than under the control condition by 159.5$^0$C.

**Improving infiltration rate**

An organic mulching materials improves the infiltration rate for the basis that it serves as a barrier for runoff, which allows more opportunity time for water to infiltrate into the soil profile. Mulch also intercepts the rainfall and protects the soil from erosion under the impacts of rain drops. It was protects the crust formation due to blockage of soil pores, which increases infiltration rate. Furthermore, organic mulches improve the macro porosity and stability of structural aggregates of soil and thereby improve the water transmission properties, which facilitate healthier infiltration and recharge of the soil profile [5]. Straw mulch purpose increases soil water storage and storage efficiency. The amount of water storage in the soil profile, the storage efficiency, total water use and water use efficiencies of rainfed crops increase with increase in the mulch rate [14]. The increase in infiltration rate that outcome from mulch is found to be more important in some situations than its effect on reduction in evaporation for conservation of water in the profile.

**Modification of soil thermal regime**

Mulch has a moderating influence on the soil thermal regime and the effect varies among the soils, climate, kind of mulch materials used and rate of application. It increases soil temperature during cooler weather and decreases it during hot spells. In general, mulch hasa damping effect on the amplitude of the diurnal fluctuations in soil temperature. Organic mulching increase soil temperature at night and early morning hours but it decreases the daytime temperature as compared to unmulched plots. Transparent polythene mulch raises the maximum soil temperature whereas organic mulches like pine needle and grass mulches lesser it. Black polythene mulch, however, does not alter the maximum soil temperature appreciably. The application of straw mulch can lower maximum soil temperature due to interception of the incoming solar radiation, high reflectivity and low heat conductivity, the magnitude of which depends upon soil wetness, incidental radiation, and rate of mulch application as well as period of the year [15]. The lesser maximum soil temperature by straw mulching during early stage of growth of sugarcane can significantly improve the yield.

**Improving Soil Physical atmosphere through optimum use of tillage practices**

Tillage practices change the primary state of soil to a fresh state, with changes in the physical, chemical and biological characteristics of soil in the atmosphere. These in spin, influence the crop growth and yield and the input use efficiency of crops. Tillage either loosens or compacts in the soil and changes its volume and mass association. Bulk density of soil is vary by tillage operation i.e. breakdown of soil particles by mechanical changes in soils [16]. A decrease in bulk density increases the total porosity of soil and the quantity of macropores. The changes in total porosity, pore size distribution and particle contact affect all (physical) state variables of soil, which in turn, induce behavioral changes in soil properties and processes, modifying the edaphic environment. Hence all physical parameters affecting seedling emergence and root growth, i.e. soil wetness, aeration, temperature and penetration resistance are affected by the tillage [17].

**Bulk density and porosity**

Loose of soil particles reduce and its compaction increases the bulk density of the soils. Tillage change in soil by deep operation in sandy soil decreased the bulk density of tilled zone than by conventional tillage [17]. In the surface soil layer, no tillage generally increases the bulk density of soil. [18] found that the bulk density of soil and soil strength increased in the 0-100 mm layer of Pullman clay loam soil after 12 years of burden of no tillage compared with stubble mulch. The decrease in bulk density of soil and increase in total porosity of soil under no tillage than conventional tillage [19].Tillage increases the macro-porosity of soil while as compaction increases micro-porosity in the soil. It is reported that there was significant increase in the proportion of non-capillary pores under mould board plough and disc harrow compared to no tillage in a lateritic sandy loam soil. In difference to the conventional and conservation tillage system outcome in more continuous pore system for the cause that increase in the earthworm activity, old root channels and vertical cracks between peds. [20] observed that the significantly greater macro pores (>30 μm) in the top 30-70 mm soil layer after 10-year imposition of minimum tillage. The conventional tillage appreciably decreases the macro-aggregates with a significant redistribution of aggregates into micro-aggregates. The conventional tillage leads to formation of carbon depleted micro-aggregates at the cost of carbon rich macro-aggregates. Increased in the macro-aggregate by turnover under conventional tillage is the primary phenomenon for loss of organic matter [21].

**Aggregate stability**

Increase in wet stable aggregates size distribution and mean weight diameter under no till than conventional tillage [19]. In the upper layer of soil conservation tillage increases the soil strength. In the presence of slowly decomposing organic residues, biological exudates, and higher amount of particulate organic matter may explain the slower wetting of aggregates in these soils [22]. Partly decomposed organic materials in association with microbial processes may have formed mucilaginous films on aggregate surface, partially obstructing pores, retarding the advance of the wetting front. [23] Observed that particulate soil organic matter had hydrophobic characteristics and SOM derived from crop residues was more wetable than that derived forest or pasture residues. Loosening of soil by tillage also decreases cohesiveness and particle-to-particle contact and hence reduces soil strength in the tilled layer.

**Soil wetness**

Soil water content status vary its affect by tillage operations and the capacity of plants to consume it. The surface conditions of soils that preside over infiltration, runoff and evaporation of water, weed growth, root proliferation and crop establishment. The mechanical operation by shallow tillage after rain/irrigation by control of evaporation from the soil surface. [24] Observed that tillage not only helps conserve moisture but also in moving over the moisture in the seed zone. Reduce the bulk density increases the amount of water held at higher water potentials and reduces it at low water potentials, which in roll, influence its availability.

**Soil aeration**

Soil aeration increase by tillage operations by macro-pores in tilled layer, which can drainage out water rapidly after heavy rains or irrigation and able to restore adequate porosity free from water. The decrease in volume-water fraction increases the volume of water free pores, enhancing soil aeration. Tillage is likely to also affect the increase the oxygen diffusion rate (ODR). [25] Observed that the gas diffusion in untilled soil is 2-6 times less than in tilled soil layers.

**Soil temperature**

The changes in surface coarseness and plant excess cover, affect by tillage influence the thermal regimes. [26] reported that the change in bulk density alters the specific heat capacity of a soil, primarily by changing the relative amount of water and mineral matter per volume of soil. The compaction increases thermal conductivity of soil because of decreased porosity and increased in between the particles. The minimum tillage of the soil surface, lowers the soil temperature increase than conservation tillage. [27] found that the no tillage that left significant crop residue on the surface reduced the maximum soil temperature at 5 cm depth by 11$^oC$ and 9$^oC$ in two weeks old maize and soybean, respectively in Nigeria.

**Improving Soil Physical atmosphere through optimum use of manure and fertilizers**

Application of organic manures *viz.,* vermicompost, compost; farmyard manure and green manure improve soil physical properties through improvement of soil organic matter. The better plant biomass produced by fertilizer, results in increased return of organic material to soil in the form of well rotten roots, litter and crop residues. The mineral fertilizers indirectly influence soil organic matter content by improving crop productivity and thereby increasing the amount of organic matter returned to soil in various crop residues. [28] reported that the effect of mineral fertilizers may be therefore compared to that of straw incorporation. The soil organic matter content is increased as usual leads to decrease in bulk density, surface crusting and an increase in water holding capacity, macro-porosity, infiltration capacity, hydraulic conductivity and aggregation. These aspects are discussed below:

**Improving soil aggregate stability**

Soil aggregation is the most important process of carbon sequestration and useful strategy to mitigate the increase in concentration of atmospheric carbon dioxide. Soil aggregates of different sizes are joined and held together by different organic and inorganic binding agents. The organic matter is the main binding agent responsible for the water stability of soil aggregates with the formation of clay humus complex in the surface soils. [29] reported that the soil aggregate stability was positively correlated with the soil organic carbon content. So it is estimated that the addition of materials rich in organic carbon such as manure or sludge leads to an improvement of the soil aggregation [30]. The purpose of long-term fertilizer studies to have shown an increase in the number and size of water stable aggregates. The addition of inorganic fertilizers can have physico-chemical effects on soils, which influence soil particle and aggregate stability. Phosphatic fertilizers and phosphoric acid could also favour of soil aggregation with the formation of Al or Ca phosphate binding agents. Where fertilizer $NH^{4+}$ accumulates in the soil in high concentrations, it behaves like $Na^+$ and causes dispersion of clay colloids.

**Soil bulk density and porosity**

Application of long-term organic manures generally decrease the bulk density of the soil due to higher organic matter content, better soil aggregation and a consequent increase in volume of pores, soil aeration and increased root growth. [31] reported that the addition of large quantity of organic manure or wastes reduces the bulk density of the soil due to a dilution effect caused by mixing and addition of organic material with the denser mineral fraction of the soil. The organic matter concentration and bulk density of soil amended with inorganic fertilizer and farmyard manure normally shows a negative linear relationship [30]. Addition of organic manure leads to an increase in total pore volume of the soil, besides vary in pore size distribution with fertilization. [32] reported that the organic matter addition through sludge and compost increases the percentage of transmission (50-500 μm) and storage (0.5-50 μm) pores while reduces the percentages of fissure (>500 μm).

**Water retention**

Water retention by soils is restricted primarily by: (i) the number of pores and pore-size distribution of soils and (ii) the specific surface area of soils. Therefore, it is increased soil aggregation with supply of organic manures, total pore space is improved. A decreased in bulk density, the pore-size distribution and is altered the relative number of micro-pores increases, especially for coarse textured soils. Organic manure application improves water retention properties of soil through its effect on pore size distribution. The soil structure and improves soil water retention more at lower suctions due to increase in micro-pores and inter-aggregate pores caused by enhanced soil organic matter content and higher activity of soil fauna e.g. earthworms and termites. The higher in the tensions close to the wilting point (1.5 MPa) nearly all pores are filled with soil air, surface area and the thickness of water films on soil particle surfaces establish moisture retention.

**Improving hydraulic conductivity**

The added of organic manure and mineral fertilizer outcome better aggregate stability, increase in effective pore volume and increase in continuity of pores due to enhanced root growth and formation of biopores, increased faunal activity and earthworm population and burrows. [33] reported that the soil permeability is the function of effective pore volume, increased pore volume has a direct influence on the saturated hydraulic conductivity of the soil. The mixture of organic and inorganic fertilizers to soil increased the hydraulic conductivity of soil under vertisol in soybean and wheat cropping system [30].

**Increasing infiltration rate**

The infiltration through the soil surface depends on surface features and the hydraulic conductivity of the soil in the underlying soil mass. The application of organic manures normally improves the initial and steady state infiltration rate due to increase in water stability of soil aggregates, reduction in crust formation and consequent increase in hydraulic conductivity [34].

**Conclusion**

Maintenance or enhancement of soil quality is a common criterion when assessing long-term sustainability of physical quality indicator in the soils. However, the task of establishing a specific criterion for soil quality is challenging because functions and subsequent values provided by atmosphere are changeable and rely on the interplay of soil physical properties and processes, which often differ significantly across spatial and temporal scales. Selection of a standard set of specific soil properties as indicators of soil quality can be complex and may vary among surroundings areas. These properties such as organic matter content, soil structure, aggregation, bulk density, porosity, soil aeration, hydraulic conductivity, minimum evaporation, maintaining soil temperature and moisture retention. Some of these soil properties may be relevant to several soil functions simultaneously and will have varying levels of influence, which can be weighted accordingly in soil quality index models. Ability to meet this challenge will play a key role in formative the sustainability of soil health management. Hence, there is need for eco-friendly site-specific technologies *viz*., efficient use of organic manures and fertilizers, minimum/optimum tillage and mulching can improve the soil physical surroundings, which in turn will lead to efficient use of inputs and help in sustaining agricultural production at higher level.

**Conflict of Interest: None declared**

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