

Maintaining and Improving Soil Health



PROFESSIONAL ALLIANCE FOR CONSERVATION AGRICULTURE
Getting Agriculture to Work For the Farmer & Environment

Soil is a national and global asset and is one of our most important natural resource. Maintaining and improving the health of our soil resource is critical not only for ensuring our national food security needs but also to ensure sustained livelihoods of millions of farmers who produce and meet basic food production needs. It is also essential to sustain agriculture by encouraging effective functioning of our ecosystem that provides us a range of services like availability of clean water, recycling of nutrients, habitat for biodiversity, carbon sequestration etc.

Evidence has been mounting over past decades that health of vast majority of our soils is deteriorating on one account or another. The cause and extent of decline in the health of soils is varied, and therefore correct diagnosis of factors contributing to deteriorating soil health is important. This will help address appropriate corrective measures to manage critical natural resource for sustained agriculture, food and ecological security.

Symptoms of declining health of soils

The symptoms of declining health can be perceived in many ways. Farmers whose livelihood depends directly on the health of soils have concerns arising from the fact that they have to incur higher expenses on fertilizers while crop yields stagnate or even decline. It is not difficult for them to recall that earlier in most cases, while application of only nitrogenous fertilizer would suffice to obtain good yields, now not only higher doses of nitrogenous fertilizers but also phosphorus, potassium, sulfur and micronutrients based fertilizers needed to be applied to maintain crop yields. They ascribe weakening soil health to continuous use of chemical fertilizers and to little or very limited use of organic matter which served as the main source of nutrients before they started using chemical fertilizers. This was of course necessitated due to limited availability of cow-dung with large scale mechanization in intensively cultivated areas. One of the direct manifestations of this decline is the almost complete depletion of soil biota that is reflected through the living quality within a healthy and productive soil.



Good Soil

There are other ways in which farmers express how soils have changed. They feel that nowadays after a rainfall event or even when irrigation is applied, it takes longer for the soils to absorb water compared to earlier years - necessitating more frequent irrigation to maintain yield levels. Another symptom of deteriorated health of soils particularly in rainfed areas, cited by farmers relates to increasing proneness of soils to formation of surface crusts and soil sealing following a rainfall event, often requiring farmers to re-seed crops, thus increasing costs and resulting in reduced productivity.



Cracking on Soil Surface

As part of our ecosystem, soils perform many functions. To the agriculturist and farmers, crop productivity is the most important function. However, concerns of declining soil health are not only limited to farmers with an implication on the country's food security but also to our overall environmental and ecological security. Environmentalists are greatly concerned about increasing levels of pollution of our ground and surface water bodies, resulting from runoff and erosion from agricultural fields, and their adverse impact on biodiversity. Siltation of water bodies and drainage lines from erosion prone soils is a primary cause for their reduced capacity and need for regular desiltation incurring huge costs. Declining groundwater tables on one hand and high rates of runoff and erosion on the other are disrupting hydrological balance. Heightened concerns are also being expressed on high levels of green house gas emission (CO₂, Nitrous Oxides and Methane) from soils that are contributing to global warming. It is thus apparent that declining soil health is adversely impacting not only the farmers but also the entire society due to disruption in the entire range of processes and functions that the soil performs as a natural body. It is therefore important to understand and pinpoint the causes, such that remedial measures are taken to restore the health and their robust functioning.

Organic Matter - The Lifeline of Soils

There now appears a consensus based on evidence from several sources that the primary and fundamental contributing factor to decline in health of soils is the continuing depletion of organic matter content in soil over a period of time. Organic matter depletion directly impacts soil processes and functioning in many ways, and also makes the soil more vulnerable to accelerated deterioration by external factors. Organic matter is the main storehouse of nutrients in the soil and they perform the critical function of regulating supply of nutrients to growing plants.

Similarly organic matter is the food for the large diversity of living organisms in the soil that are responsible for decomposition of organic matter and nutrient recycling in the soil-plant-animal system. The products of organic matter decomposition are not only a storehouse of nutrients; they also impact the soil's environment for efficient performance of different functions. Thus organic matter is the key component that imparts the soil's stable structure by binding together primary soil particles (clay, silt, sand) in the form of stable aggregates. A stable soil structure, in turn, allows the soil to perform such critical functions as absorbing, retaining and regulating movement and supply of water to plants, thus contributing to functioning of overall

hydrological process including groundwater recharge. Stable soil structure is also important for exchange and renewal of soil's air from the atmosphere and soil aeration for healthy growth of roots and soil organisms. In recent years the role of soil both as a source and a sink for GHGs has been increasingly emphasized. While soil is the biggest storehouse of carbon in the form of organic matter, it is also a significant source of CO₂ emission. Similarly organic matter can effectively improve the efficiency of applied chemical fertilizers and limit emission of nitrous oxides. As indicated earlier, soils with improved level of organic matter are also less prone to degradation by action of rain water, such as erosion and runoff. Soil organic matter is therefore fundamental to improving and maintaining health of soils.

Decline in the Organic Matter Content of Soils - Reasons

It is important to understand factors contributing to decline in soil organic matter content so that effective strategies can be pursued to reverse the decline and improve its content in soils. One factor that is obvious is that over the past few decades with increasing dependence on chemical fertilizers to meet nutrient needs of intensive crop production systems, and with increasing mechanization; the availability and recycling of farm manure and wastes by farmers has declined drastically and they now use very little organic matter if at all. This is one of the main reasons for gradual decline in soil organic matter content, among others such as burning of crop residue or using crop residue as household or industrial fuel depriving the soil from organic inputs.



Degraded Soils

A well established scientific fact which has not been much appreciated widely is the adverse impact that ploughing and tillage practices have on accelerated oxidation of soil's organic matter content. Tillage practices are energy intensive and expose large surfaces of soil to the oxidative forces. Tillage has been practiced by farmers over centuries and availability of modern machines has further led to intensified tillage practices and the process is considered indispensable to preparation of seed bed and seeding, control of weeds and for capturing rainwater, particularly in the context of rainfed agriculture. Ample scientific evidence however has accumulated over past few decades to convince and conclude that in most situations tillage practices can be dispensed with and alternative technologies and practices adopted to ensure sustained productivity helping conserve soil carbon at the same time.

With total emphasis on achieving increased productivity of a few selected crops during the Green Revolution era, practices like adopting crop rotation that have been traditionally recognized as being extremely important to sustained productivity have been ignored in favor of mono-cropping systems. Growing a variety crops in a temporal and spatial sequence helps maintain and improve health of soils in many ways. Crop rotations help in build-up of useful organisms within the soil while restricting incidence of pests. Crop rotations also help tap and recycle nutrients from different depths. It would thus appear from the above explanation that any strategy aimed at improving soil organic matter content and health needs to be multi-pronged considering the range of factors that have contributed to declining soil health.

Conservation Agriculture - The Way to Improving Soil Health

Over the past couple of decades, the concept of Conservation Agriculture (CA) has emerged globally as a response to issues of declining soil health offering means to minimize soil degradation, and to recoup soil health for sustaining agriculture. The concept is rooted in three scientifically sound and proven principles according to which:

- The soil should be disturbed to the minimum (e.g. by adopting zero tillage) as a part of agricultural operations that go into crop production
- A live or dead plant material (e.g. crop residue) cover must be maintained on the soil surface all the time as far as possible
- There is need to promote diversified cropping in the temporal and spatial contexts by adopting crop rotations including inter cropping, agro-forestry practices etc.



Confluence of CA Principles

Sufficient evidence has accumulated from different parts of the world to show that when practices based on above principles are developed, refined, and promoted in the context of a specific farming system or a region; they can bring about a reversal in the processes causing soil degradation and set in place processes that bring about improvements in soil health in an integrated manner. These practices contribute to gradual improvement in the chemical, physical, and biological properties of soils that contribute to efficient and effective functioning of soil processes leading to efficient crop production.

It is true that practices like tillage and ploughing have come to be considered synonymous with farming, and are seen as being indispensable to create a good seed bed, removal of weeds, retention of rain water, etc. However efforts by scientists have now convinced farmers that seeding, good germination and crop stands, and control of weeds can be achieved by using appropriate seeding equipment and weed control measures. As a result, several hundred thousand farmers are now seeding wheat crop in standing residue of previous crop without ploughing their land in northern states of India, thus saving on costs on account of fuel, labor, and farm machinery. While wheat crop has been the larger recipient of this approach, other crops too have had success stories. CA practices hold promise of reversing the processes contributing to soil degradation, leading to a path of more sustainable agriculture, relevant to both irrigated and rainfed regions. CA practices are being adapted and promoted globally and millions of hectares are being farmed adopting CA principles. Conservation Agriculture has thus emerged as an effective way to maintain and improve soil health and sustain agriculture productivity.

About the Education Series

The Conservation Agriculture Education Series is part of our effort to contribute to capacity building in conservation agriculture efforts being undertaken by PACA. It will deal with chosen subjects from a conceptual and application perspective. It's handy size and easy to read format with a pictorial approach will help reach it to many farmers as we hope to make these available in local languages. Efforts have been made to make information available in a manner suiting conditions in India and progressively PACA hopes to cover other topics of importance.

About PACA

Professional Alliance for Conservation Agriculture (PACA) is a platform that has emerged from concerns surrounding agriculture, given its increasing importance and diminishing interest in today's world. Recent discussions surrounding food security, diversion of croplands for other applications, impact on climate change, and diminishing returns to farmers are all adding to heightening worry for farmers and policy makers alike. PACA will endeavour to be an agent of change working within the agriculture system, to contribute to improved food security for benefit of humans and environment. It will take a professional approach through a collaborative mechanism to address needs in a participative manner based on sound scientific and social principles.

PACA is promoted by Centre for Advancement of Sustainable Agriculture (CASA) and Society for Strategy Technology & Delivery for Development (SocietySTADD) as a platform to motivate concerned stakeholders involved with agriculture who wish to address the deteriorating situation. It hopes to function as a catalyst to incubate an alliance of concerned and well meaning professionals for the cause of agriculture.



Professional Alliance for Conservation Agriculture

1st Floor, NASC Complex, DPS Marg, Pusa, New Delhi - 110 012 INDIA

Tel.: +91-11-45132119 / +91-98101-12773

Website: www.conserveagri.org

Email: info@conserveagri.org