

Cover crops

for soil health and sustainable agriculture

Dhiraj Kumar*, Nishant Kumar Sinha, Jitendra Kumar, Rahul Mishra, Shilpi Verma, Somasundaram Jayaraman and Monoranjan Mohanty

ICAR-Indian Institute of Soil Science, Bhopal, Madhya Pradesh 462 038

Cover crops (CCs) either alone or in association with row crop rotation have long been considered as a favourable practice to conserve soil, water and nutrients apart from its role for ecological benefits. CCs are one of the viable options for sustainable agriculture through their beneficial effects on soil. However, several benefits of CCs depend largely on type of climatic conditions, selection of species, association with main crops, root system architecture, time of planting and its termination. Moreover, the species of CCs having fibrous root systems are found to have better soil by checking erosion and increasing adherence of soil particles. However, investigation is needed on effect of CCs on associated crops, its long term impact on soil quality, and benefits in terms of sub-surface soil layers etc. Nevertheless, there are number of positive effects of CCs on soil as well as overall ecology for achieving the goal of sustainable and regenerative agriculture.

Keywords: Cover crops, Environment, Resources, Soil health

COVER crops (CCs) include any leguminous or non-leguminous broad leaved plant species or any grasses that have been grown apart from the basic need of grains and fodder/forage production. Several studies demonstrate the beneficial effects of CCs on crop production and sustainability owing to their positive impact on improvement of soils chemical, physical and biological properties. However, the performance of CCs and their impact on soil fertility improvement and other associated benefits may differ as per the climatic conditions, type of CCs, soil types, elevation etc during the growing period of CCs. For example, the single CCs may have been utilised to serve specific goals, leguminous CCs have their beneficial effects in N fixation and thus improve soil fertility, fibrous root system CCs help in proper binding of soils, improve aggregation, reduce runoff, organic matter addition etc. Broad leaved leguminous CCs may add

more residues and non-leguminous ones have better penetration in compacted soil layers. This article reviews some of the beneficial effects of CCs and the challenges towards their promotion and suggests the way ahead.

The world population is increasing with an alarming pace and to meet the demand of food of this mammoth population, we need to grow more from less arable land. Moreover, the natural resources degradation accompanied with climate change has further worsened the condition. Thus, current practices need to be revised for increasing yield and reducing the environmental degradation. It is crucial to include cover crops (CCs) in the production system for sustainability in the cropping system. CCs are generally planted to cover the soil surface apart from being solely harvested. Nowadays commercial crop growing techniques lead to removal of crop residues from the field, thus

exposing the soil surface and making it fragile for erosion, excess heating, gaseous loss, surface runoff of soils and nutrients, leaching and complete removal of soil.

Inclusion of CCs in our production system not only protects the soil from any type of losses but adds to several ecological benefits in terms of higher carbon sequestration, weeds and pests suppression, nitrogen fixation, nutrient recycling, better biological conditions etc. for making our soils more and more resilient and improves their quality.

Beneficial effects of cover crops

Control of soil erosion: Cover crops have been known to conserve soil and water. If soil is kept barren, then it leads to severe loss of soil, water and nutrients which further degrade soils. But CCs could be used effectively for controlling soil erosion and thus conserving the environment. They also increase the water infiltration and thus improve soil moisture status that will directly

benefit the crops. Some of the CCs like oats (*Avena sativa*), rye grass (*Lolium perenne*), white mustard (*Sinapis alba*), cereal rye (*Secale cereale* L.) etc are known to have high fibrous root system that leads to better binding of soil particles and thus checks soil erosion (Table 1).

Weed and pest management: Weed is a major menace in crop cultivation. The damage caused due to weed infestation depends upon the environmental conditions, type of crop plants and cover of soil surface. CCs if dead, add residue and live CCs are found very effective for weed seed emergence suppression. They play important role for weed seed mortality. Generally, vigorous CC species like velvet bean (*Mucuna* spp.), cowpea (*Vigna unguiculata* L.), sudan grass (*S. sudanense*) etc which are adapted for hot climates can serve very effective for weed smothering in warmer climate (Table 1).

CCs are found very effective for controlling pest thus, reducing the load of chemical pesticides and are also environment friendly. The CC residue acts as a deterrent for insect habitat in soil. CCs could be used as a trap crop in maize for controlling the infestation of corn earworm, tarnish bugs etc. Early season infestation of thrips in cotton is found to be reduced, due to CCs.

Organic matter addition: The soils which are under cultivation are found to be depleted of SOC compared to natural vegetation. The C sequestration rate in any cropping system is being dictated largely by type of management practices adopted due to difference in C input

Table 1. Cover crops and their beneficial effects

Cover crops	Beneficial effects
Winter Rye, Oats, Clover	Erosion control, nitrogen fixation, soil structure
Vetch, Clover, Peas, Bean	N fixation, erosion reduction, better pollination in main crops, soil organic C
Wheat, Buckwheat, Mustard, Barley	Nutrient capture, ground cover, erosion control, weed control
Sudan grass, Cowpea	Soil organic C, microbial proliferation, ground cover, weed smothering
Pigeon pea, Beans	C/N ratio, increases exchangeable K, increase soil organic carbon

and its mineralisation. Type of CCs, mainly their biomass potential and root system decides the level of C being added into the soil. Further, the root and shoots of CCs feed a lot of macro and micro-fauna in soil that in turn increase soil C level in soil.

The grassy species of CCs along with leguminous nature CCs have more potential of C capture in soil. Thus, CCs could serve as a potential tool for long term C sequestration and increase ecosystem resiliency against climate change.

Soil moisture retention: Well planned CCs increase the moisture availability in soil as they add lot of organic matter in soil. CCs directly conserve moisture from soil profile and indirectly maintain water holding capacity, improving infiltration characteristics through way of soil cover, root growth in deeper soil layers, decomposition, generally along with minimal disturbance of soil. Infact due to their excellent behaviour of water conservation, they can serve as win-win situation in rainfed agro-ecosystems.

Below ground biodiversity: CCs promote soil microbial activity through their root system exudates

that in turn feed soil microbes and reduce organic matter burn off and N mineralisation. Their root systems also encourage soil aggregation and promote variety of microbes depending upon the type of wastes.

Nutrient recycling: CCs due to their nature of N fixation, if leguminous or in association with microbes lead to addition of nitrogen in soil. This not only benefits the crops but also reduces the burden of fertilizer cost.

Further, on decay of CCs, there is enough addition of nutrients in soil thereby making soil more fertile. Infact incentives should be given for CCs to reduce the cost and environmental load due to fertilizers.

Phosphorus availability: In case of alkaline or calcareous soil, CCs make the availability of phosphorus from the locked up P. Further, CCs through their extensive root systems make associations with mycorrhizae that in turn increases the availability of phosphorus in soil. Mostly the subsequent crops take up phosphorus resulting from residue decomposition of CCs that leads to increase in P use efficiency.

Structure and strength of soil: CCs through their extensive root



Mustard crop under Aonla based agroforestry system



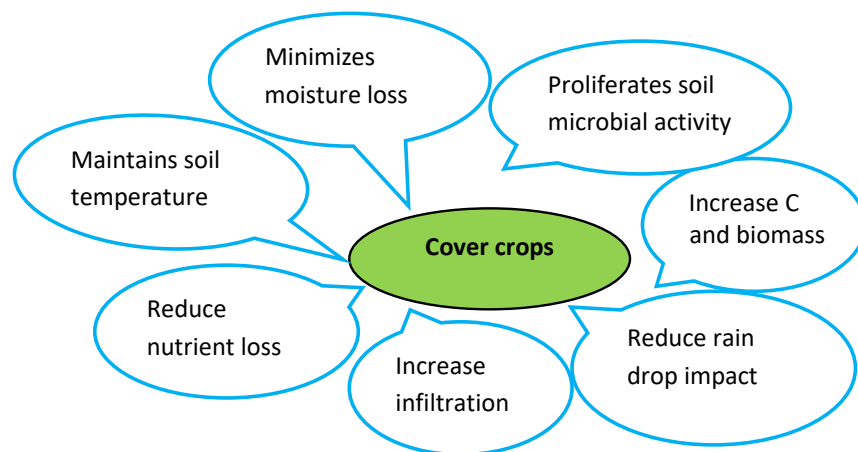
Performance of crop under no tillage system

system make soil much more friable and smooth and makes the availability of moisture optimum for plant survival. This way, they reduce the soil compaction and increase infiltration. The aggregation also gets improved resulting in better soil structure and good tilth for any agricultural operation. The resilience of the soil under CCs improves remarkably to withstand any stress.

Bioremediation: Bioremediation of contaminated sites could be successfully done through introduction of CCs. Heavy metal uptake, salinity reclamation and pesticide residue reduction could be handled in a bio-friendly way through CCs. Species of Vetiver, Cynodon, Lantana, Medicago etc could be used very effectively for bioremediation. Infact, there should be some ideal characteristics for bioremediation by CCs, i.e. they should have high root proliferation to go deeper into the soil, very high biomass potential, tolerate high levels of metal/pesticides loads, thrive in variety of climatic situations, fast growing, and most effectively should be repulsive by herbivores or non-palatable to avoid contamination in animals and humans.

Nitrogen cycling: Mainly the leguminous cover crops like clover, vetch add significant nitrogen into the soil through their mutualistic relationship with *rhizobia* bacteria. These microbes capture N from air and convert it into available forms to plants. Further, the scavenger CCs like radish, rye could scavenge N from deeper layers and make it available for next crops. This way they play crucial role for trapping free N that would otherwise contaminate the ground water or nearby areas through leaching, surface runoff etc.

Economical benefit: CCs could uplift the profit of farmers through their effects on both cost saving of agricultural inputs and ecological benefits. The important cost saving strategies through CCs include cutting the rate of fertilizer application as they add sufficient amount of nutrients into the soil,



Benefits of cover crops

reducing the need of pesticides and herbicides, conserving soil moisture, reducing erosion, encouraging beneficial soil microbes, creating inhospitable environment for diseases and pests, water quality improvement, heavy metal load reduction thus, safeguarding health concerns.

Challenges of cover crops

There are certain issues pertaining to cultivation of CCs such as there is no proper knowledge among the growers for proper time of planting, killing CCs and their suitability. The initial cost of growing CCs may be higher but its impact comes afterwards. Mainly the non-leguminous CCs have the chances of emerging again provided they are properly killed. Otherwise, these CCs may compete for space, light and nutrients. There are chances of CCs to act as an alternate host for offseason insect and pathogens. Also, there are limited marketing facilities for CCs.

Way forward

Cover crops have been seen as an integral part of sustainable agriculture encompassing conservation of natural resources in first place. Despite the immense benefits of using CCs, the knowledge and skill related to CCs is still lacking. There is a need of giving skill and expertise to the farmers to aware them regarding the huge potential of CCs. The package of practices involved for growing CCs and its applicability in diverse agro-

climatic scenarios and cropping system at both national and global level needs to be imparted not only to growers but also to all the stakeholders involved for their widespread dissemination.

SUMMARY

Soil health improvement follows the basic principles of covering the soil, crops having fibrous root system, better soil biodiversity and less disturbance of soil etc. Researchers suggest even the modest use of CCs will make a huge difference for soil health. Especially, their beneficial effects on nutrient contribution may allow some reduced reliance on synthetic fertilizers. There is growing evidence that soil having CCs has more soil organic matter, better physical condition, enhanced belowground biodiversity, improved water retention, infiltration, reduced runoff etc. However, their potential is not understood completely in different climatic zones and under diverse cropping systems. Therefore, there is a critical need to properly utilize CCs in order to get their full benefits and future research must focus their effect on crop growth, yield dynamics, nutrient dynamics, system productivity as well as profitability. Thus, CCs could serve as a win-win situation for improving production system output and environmental sustainability.

*Corresponding author's e-mail: dhiraj.iasi@gmail.com