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COVER CROPS AND MULCHING IN INDIA

This summary document provides an overview of the state of cover crops and mulching in India. And also covers a literature review of impact studies conducted on cover crops and mulching in India. **It is a part of the larger CEEW study,** *Sustainable Agriculture in India 2021: What We Know and How to Scale Up.*

Sustainable Agriculture in India 2021: What We Know and How to Scale Up, is a handbook on the prevalence, practices and state of affairs of the 16 most promising sustainable agriculture practices in the country. It presents the economic, social and environmental impacts of these practices with recommendations on their potential to scale-up sustainable agriculture in India.

The study is available at: https://www.ceew.in/publications/sustainable-agriculture-india-2021

Image: IStock

Cover crops are crops planted to cover the soil, rather than to be harvested. They can be rotated along with other crops or intercropped and also when regular crops are not being grown, with the aim of controlling erosion and adding organic matter to the soil, supplying nitrogen, controlling weeds, and fighting insects/pests. Cover crops can be grown with plantation crops or rotated with cash crops and they can be annual, biennial, or perennial, as well as leguminous or non-leguminous. Few of the cover crops (pulses) can be grown as a short duration catch crops to shield the farmers economically during times of drought.

Mulching is the practice of covering the soil surface with organic materials (plant residues, straw, hay, groundnut hulls, leaf and compost, peat, wood products, sawdust, and animal manure), or synthetic materials (paper, polyethylene, wax-coated papers, aluminium, steel foils, and asphalt spray emulsions, etc.) with an aim to conserve soil moisture, avoid runoff and increase soil productivity.[1,2] Trash farming, where the crop residues are cut, chopped, and mixed into the ground, is also a form of mulching.[3]

Image: IStock

Cover crops and mulching's linkages to FAO's agroecological elements

In principle, these practices adheres to and promotes many agroecological elements as defined by the FAO

Elements	Description of agroecological linkages
Diversity	Cover crops provide multiple benefits as growing a variety of crops increases biodiversity in an agroecosystem and improves microbial biodiversity in the soil.
Co-creation and sharing of knowledge	Farmers need to select cover crops that can provide multiple agroecosystem services. This requires knowledge about crop combinations. This knowledge is often passed from generation to generation, and also shared amongst communities.
Synergies	The variety of crop species provided by cover crops helps create significant synergies above and below the soil, suppressing weeds, building soil health and retaining moisture.
Efficiency	Cover crops and mulching allow for efficient water use of water and possibly reduce the use of external inputs like fertilisers. On a no-till farm, cover crops and mulch increase water infiltration, conserving moisture while reducing excess evaporation.
Recycling	Cover crops absorb and recycle soil nutrients and mulch is often created by recycling materials.[4]
Resilience	Cover crops slow down the intensity of rainfall before it contacts the soil surface, preventing soil erosion and surface run-off. It provides a cover to base crops, making them more resilient. Mulching also reduces evaporation, checks weeds, and protects the crops against external weather impact. Both have vital roles against the backdrop of climate change.
Human and social values	Cover crops and mulching help maximise farming livelihoods while improving the sustainability of the farm. They have both immediate and long-term benefits.

A brief context in India

Traditionally, **cover crops** were mainly grown as green manure crops, animal feed, or sustenance against droughts in rainfed areas. Nowadays, they find prominence in no-tillage (reduced tillage) farming systems in conservation agriculture. In rainfed areas of eastern India, farmers mostly either leave the land fallow or cultivate short duration pulses as a second crop after rice, which act as a cover crop.

Mulching is done to conserve moisture in rainfed areas and reduce the irrigation frequency in the northern plains. Plastic film (polythene, polyvinyl) is widely used as mulch because of its water conservation and weed suppression benefits, but it is costly and difficult to manage under large-scale field conditions for low-value crops.[5] Its use is unsustainable in the long-term, as the plastic residues are retained in the terrestrial environment and seep into the aquatic habitats too. Thus, only organic mulch is referred to in the chapter from this point onward.

Cover crops are mentioned as a one of the management strategy in organic farming systems and related documents.[6] They are also one of the fundamental principles advocated under conventional agricultural methods, which advises that the soil needs to be covered (at least 30 per cent) with cover crops.

ICAR advises farmers to mulch during droughts or delayed monsoons.[7] Retaining the straw as a surface mulch instead of burning it is promoted under the *National Policy for Management of Crop Residues (NPMCR)* for in-situ management of crop residues.[8] While even the Rainfed Area development under

NMSA has provision for 50 per cent assistance of the cost limited to INR 4000/hectare (USD 55/hectare) for in-situ soil conservation bunding, mulching purposes. Even the *Sub Mission on Agricultural Mechanisation* (SMAM) has provisions for financial assistance to mulchers.

Cover crops and mulching: acreage, geographies, and cultivation details

How much area in India is under cover crops and mulching? Stakeholders consulted at the ICAR-Indian Institute of Farming Systems Research (Modipuram) estimate the area under cover crops to be around 1.94 million hectares, while mulching covers around 20 million hectares.

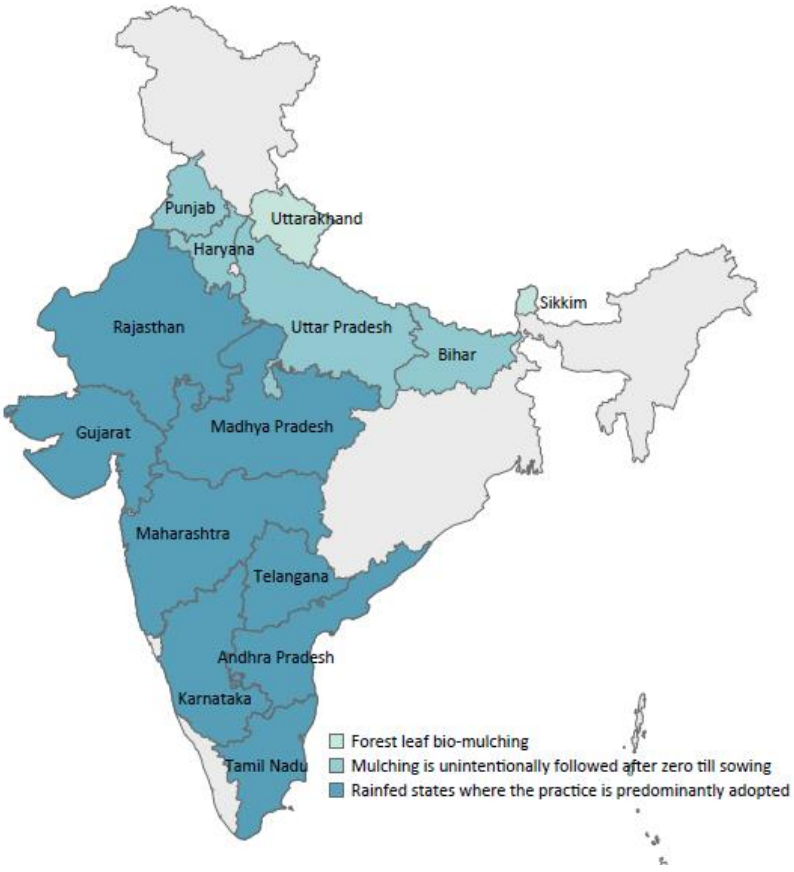
At what farm size is cover crops and mulching practised? Cover crops are followed by all types of farmers. Most of the large landowning farmers have enough land for subsistence and lesser cattle implies more of crop residues available for mulching purposes. While majority of the smallholder farmers tend to own cattle, and end up utilising the crop residues as cattle feed, which leaves them with no residues for mulching as communicated by a stakeholder in ICAR-NRRI. However, a few of the small-scale farmers use organic mulch, while inorganic mulch, including plastic and petroleum products (asphalt sprays, resins) are mostly used in commercial crop production, with polyethylene film mulch preferred.

How many farmers in India are practising cover crops and mulching? Around 1-2 million farmers are estimated to be practising cover crops; while mulching has been adopted by less than 5 million farmers as per the estimate of the stakeholders consulted at the ICAR-IIFSR.

Where in India is cover crops and mulching prevalent? Cover cropping is practised essentially in almost every state while mulching is practised mostly in rainfed regions (Karnataka, Andhra Pradesh, Maharashtra, for conserving moisture. However, even farmers in Punjab, Haryana, Bihar, and Uttar Pradesh mulch (unintentionally) following zero-till sowing practices (according to NRRI stakeholders).

While mulching is common even in hilly states of Uttarakhand and Sikkim especially in ginger. Overall, mulching practices have increased in the north

Figure 1. Mulching is mostly followed in rainfed regions to deal with evaporative losses from crops and conserve moisture



Source: Authors compilation from literature and stakeholder consultations

Indian states due to the zero tillage practises followed, and organic mulch (farmyard manure) is widespread in Himachal Pradesh (figure 1).

Which are the major crops cultivated under cover crops and mulching in India? Commonly grown cover crops include legumes (cowpea,berseem, mustard) and non-legumes (rye, wheat, oat, barley, sorghum, pearl millet, maize, fodder).[9] In rainfed areas, rice is followed by cover crops of green gram, black gram, lentil, horse gram, lathyrus, pea and groundnut. In the irrigated rice-wheat belt of northern India, green gram is sown as a cover crop after wheat (Stakeholders, NRRI). Non-leguminous cover crops have assumed importance in states like Punjab, where crop residues are not enough to compensate for soil organic matter.[10]

Mulching is practised successfully in a wide variety of cereals, plantation, but more so in horticultural crops (fruit orchards, flower, vegetables, nurseries and forest) where lesser frequent cultivation is required for growing the crops. Most widely used mulches are crop residues and other plant products (straw, cloves, leaves, corn, and sawdust) as they are cheap and readily available.[11]

Impact of cover crops and mulching

This section considers the economic, social, and environmental impacts of cover crops and mulching.

ECONOMIC IMPACT

1. Yields

There is little research into the long-term impact of **cover crops** on crop yields. A couple of papers have thrown insights from the specific experiments conducted which makes it difficult to generalise across landscapes and circumstances. Nonetheless, few of the experiments done in the rainfed regions show that the incorporation of cover crops is a cost-effective measure that can be adopted by small and marginal farmers in semi-arid regions to improve crop yield.[12] Further, specific combinations of cover crops (legume Sesbania, organic nutrient management and vermicompost) have shown initial reduction in rice yields compared to inorganic fertilisers. But the crop productivity gradually improved by the third year, when it became almost comparable to the control due to residual benefits. In the irrigated state of Punjab, the yield of baby corn following cover crop treatments was higher than controlled plots without cover crops.[13]

There is considerable literature on the impact of **mulching** on different crop yields. Though the impact seems to vary according to crop type, mulch material and the micro-environment created by the mulch, in general mulching is known to boost yields by 50-60 per cent in rainfed conditions.[14] However, to optimise benefits, organic mulch needs to be applied immediately after germination of the crop at a rate of 5 tonnes per hectare.[15] Mulching is primarily known to increase horticulture crop production in water-scarce regions. Drip irrigation systems are often used alongside mulching to manipulate crop environments to increase yield and quality.[16] It is important to note that the choice of the mulch used depends upon the local factors (weather, soil, crops grown) and a wrong choice can affect the crop yields by increasing soil acidity and even pest attack.[17]

Few experiments indicate that mulch when added to crops (rice, sorghum) increases the grain yield from around 6 to 15 per cent.[18] Among the mulch materials higher yields were recorded with organic mulches and green manuring treatments on maize.[19] Yet another study found organic straw mulch to perform better with yields of horticultural crops than the control treatments. However, there are also challenges posed by organic mulches as it is known to increase the acidity of the soil which can affect the crop productivity.

2. Income

Cover crops is considered to be economical because it serves as a long-term investment for farmers due to its many merits for soil health. It can also give farmers additional income as forage or cash crops in plantations. It also lowers the amount of inorganic fertilisers required thus reducing input costs. Like yield, the cost-effectiveness of cover crops depends on the soil type, weather, location, and management practices.[20]

Economic assessments of the effects on income and net returns of cover crops are scarce in the literature, other than a few experiments. One field experiment in a rainfed area showed an increase in net returns of eight per cent in paddy grain when cover crops were incorporated with organic nutrient management and vermicompost. More importantly, the combination reduced the need to apply inorganic fertilisers and thereby led to savings for farmers.[21] On the other hand, cover cropping does incur costs when farmers have to buy seeds, and there are labour costs for managing crops. In no-till systems in conservation agriculture, specialised equipment is needed to handle the larger quantities of crop residues on the field, which is a barrier to small and marginal farmers.[22] The understanding of the impact of the practice on economic benefits is limited; thus, more research is needed involving field studies that look at monetary benefits from several types of cover crops.

A few studies compare the economics of various **mulches**[23,24,25] which indicate a high net return on maize and wheat over conventional plots for most of the mulching materials. Straw mulch is known to give the highest net return, while dust mulching reported a higher benefit-cost (B:C) ratio than straw and no mulching in summer mung bean. Using oak leaves as bio-mulch in organic ginger resulted in higher net returns of 61 per cent compared to no mulching.[26] In the eastern dry zone of Karnataka, in-situ green manuring of sun hemp helped obtain higher net returns and B:C ratios than other green manuring and organic mulch treatments.[27]

SOCIAL IMPACT

1. Human health

In principle, cover crops indirectly impact human health through the reduction in fertiliser use and harmful pollution. However, there are no in-depth evaluative studies on this or on the overall health impacts which is a key information gap. This is also the case for mulching where no significant studies were found.

2. Gender

The lack of research on the gender impact of cover cropping is another significant information gap. On mulching, one study suggests a prominent role for women in ginger cultivation in a village in Meghalaya's Ri-Bhoi district. Almost 95 per cent of the women were involved in bio-mulching ginger, though both men and women were involved in decision making.[28]

More long-term studies are required to understand the impact of these practices on a significant level.

ENVIRONMENTAL IMPACTS

1. Soil and nutrients

In general, the literature confirms that **cover crops** build soil health over the long term by controlling erosion and suppressing weeds/insect pests, stabilising the root system, and increasing soil organic matter. Species with fibrous root systems (rye, ryegrass, oats) show high potential for controlling soil erosion, while those with thick roots (e.g., white mustard and fodder radish) are less effective.[29] Cover crops like forage legumes have deep root penetration that leads to a host of benefits, including conserving soil, rehabilitation of degraded areas (*Stylosanthes)*, cycling minerals up from deeper layers, and enhancing soil organic matter.[30]

On-farm experiments suggest that cover crops in particular enhanced available nitrogen and built-up soil nutrients. Leguminous plants used as cover crops convert residual nitrogen to proteins. Thus, cover crops can decrease the nitrogen requirements of the next crop, and they also prevent nitrate leaching. Usually, deep-rooted cover crops assist the upward movement of potassium and calcium to the root zone. They also compete for nutrients (nitrates) after harvesting the cash crops, which alters the nutrient soil status and suppresses weeds by inhibiting their growth.[31]

The benefits of **mulching** for soil health are also extensively documented, and include erosion control, and regulating soil temperature, along with moisture retention and weed suppression. Organic mulches are known to reduce the soil temperature by almost 1-6 degrees Celsius at 10 cm depth. Grass mulch applied at 6t/ha reduced the mean maximum soil temperature and evapotranspiration.[32] Other than temperature control, mulching improves soil structure, and when applied at an early stage, it reduces the need to use herbicides due to reduced weed growth.

The nutrient content also varies among different mulch materials: sawdust (wood shavings) is poor in nutritive value but materials like hardwood bark clippings contain more nutrients than softwood. In contrast, organic mulches (compost) return organic matter and plant nutrients to the soil, thus acting as the best mulch material.

2. Water

Along with soil protection, one of the principal functions of **cover crops** is to enhance water infiltration, decrease evaporation, and remove excess water. They also improve the bulk density and water retention capacity of various soils. The root growth of cover crops enhances soil macrofauna habitat, facilitating soil

pores and increasing water infiltration, which otherwise would drain off. However, there are disadvantages. One of the critical issues is the competition between cover crops (used as a mulch or a companion crop) and cash crops for water and nutrients. This is leading to less adoption of these practices in conservation agriculture.[33] Cover crops incorporated in a crop rotation can consume water needed by the next crop, particularly in rainfed areas. One gap in the literature is systematic studies of the impact of the practice on water-use efficiency; this topic deserves more attention.

The benefits of **mulching** for conserving water and controlling erosion are well documented. Crop residue mulch directly influences the infiltration of rainwater into the soil and evaporation from the ground. The approach reduces surface run-off and holds rainwater on the soil surface, giving it more time to seep into the soil. Straw mulch especially is shown to increase soil moisture by 55 per cent compared to conventional systems or no mulch. Similarly, wheat residue mulch indicated a significant increase in the average available soil moisture stored up to a depth of 1.5 m.[34] However, in periods of excess rainfall, mulching may not be effective to control erosion; and, residue production in drylands is often inadequate to result in sustainable water conservation.[35]

3. Energy

Very limited papers were found on the impact of cover crops on energy. One experiment conducted found that an organic nutrient management treatment that incorporated cover crops (in situ Sesbania green manure) with vermicompost reduced energy input (by 39 per cent) and enhanced energy efficiency (by 57 per cent) compared to applying inorganic fertilisers.[36]

A few publications mention the influence of mulching on energy use. One looks at the plant microclimate and energy balance; however, it does not probe further into the subject.[37] Another study mentions the varying ability of mulching to affect the soil temperature, which depends on the capacity of the mulch material to reflect and transmit solar energy.[38]

4. Emissions

Only a few studies look at the potential of cover cropping to increase soil organic carbon (SOC), though it does play an essential role in carbon sequestration and nutrient cycling.

Studies suggest that growing cover crops improves soil organic matter in rainfed zones, especially autumn and spring crops grown as cover crops.[39] Under a minimum tillage scenario, maize plus cowpea intercropping and a follow-up cover crop (Toria mustard and horse gram) showed a significant increase in SOC due to residue applications to the soil.[40] Legumes as cover crops also reduce carbon and nitrogen losses from cropping systems, while the ability of legumes to fix atmospheric N in their root nodules reduces the fertilisers needed for the next crop, thus optimising fertiliser use and reducing N_2O emissions.[41]

One experiment finds that inorganic mulches can increase soil microbial biomass carbon [42]and in-situ green manuring can increase the carbon content of soil.[43]

However, long-term empirical evidence of carbon sequestration or emissions is lacking.

5. Biodiversity

The evidence mostly suggests that cover crops and mulching increase the microbial biodiversity in the soil;[44] however, there are few in-depth studies. Again, there is a lack of systematic literature on the impact of cover crops and mulching on biodiversity implying more research in the subject.

Impact evidence

State of available research discussing the impact of cover crops and mulching on various outcomes.

Cover crops

Evidence Type	Yield	Income	Health	Gender	Soil and nutrients	Water	Energy	GHG emissions	Bio-diversity
Journals	2	2	0	0	5	1	1	2	0
Reports	0	0	0	2	1	0	0	0	0
Articles/ case-studies	0	0	0	0	0	0	0	0	0
Others **	3	0	0	0	0	0	0	0	0
Total	**5**	**2**	**0**	**2**	**6**	**1**	**1**	**2**	**0**

** Thesis, guidelines, conference papers, etc

Source: Authors' compilation

Mulching

Evidence Type	Yield	Income	Health	Gender	Soil and nutrients	Water	Energy	GHG emissions	Bio-diversity
Journals	26	5	0	1	35	11	2	2	2
Reports	0	1	0	0	0	0	0	0	0
Articles/ case-studies	0	1	0	0	0	0	0	0	0
Others **	0	0	0	0	0	0	0	0	0
Total	**26**	**7**	**0**	**1**	**35**	**11**	**2**	**2**	**2**

** Thesis, guidelines, conference papers, etc

Source: Authors' compilation

Note – The evidence is from the first 75 results examined in Google Scholar Advanced search and the first 30 results from Google Advanced Search. Only those papers which clearly established the evidence for different indicators were selected.

Stakeholder mapping

The following institutions are involved in the research and promotion of cover crops and mulching; a few were consulted for this research:

Government and research instituions	NGOs/Civil society organisations
Department of Agriculture, Cooperation & Farmers Welfare (DAC&FW)	BAIF Development Research Foundation
ICAR-Indian Institute of Farming Systems Research (IIFSR), Modipuram	PRADAN
ICAR - ICAR-National Rice Research Institute (NRRI, CRRI)	Centre For Dignity
ICAR-Central Research Institute for Dryland Agriculture (CRIDA)	Samaj Pragati Sahayog (SPS)
ICAR-Central Arid Zone Research Institute (CAZRI)	Jamnalal Kaniram Bajaj Trust

Source: Authors compilation

Note – The stakeholders list is indicative and not exhaustive

Endnotes

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