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# Cover Crops under Conservation Agriculture

**Niraj Biswakarma[1], Koushik Bag[1]✉, Priti Tigga[1] and Sourav Sarkar[1]**

[1]ICAR-Indian Agricultural Research Institute (IARI), New Delhi 110 012, India

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✉
amikoushikbag@gmail.com

**ABSTRACT**
Cover cropping could be a viable alternative for achieving a permanent organic cover under conservation agriculture. Its inclusion in the cropping system not only increases crop yields but also delivers a wide range of ecosystem services such as atmospheric N fixation, organic matter & nitrogen (N) retention, reduced soil loss, weed suppression, and C-sequestration etc. Thus, selection of crops, planting time, seeding method, and termination are crucial for better crop establishment, greater profitability and agricultural sustainability. Keeping the above facts in view, this article aims to provide an overview of cover crops and their importance in conservation agriculture
**Keywords:** Conservation agriculture, Cover crops, Ecosystem service

Conservation agriculture ($C_A$) based production system sustainably increases crop productivity and preserves the soil quality (Verhulst *et al.*, 2010). It is based on three interlinked principles i.e. minimum tillage, permanent residue retention, and crop rotation. In India, $C_A$ practice has been the most successful resource-conserving technology ($R_{CT}$) covering an area of 1.5 million ha (Kassam *et al.*, 2019). However, in the rice-wheat cropping system, achieving the second principle, i.e., permanent soil cover is quite challenging under the actual farm situations as paddy crop residue is burnt in-situ for timely sowing of the succeeding winter crop (Erenstein, 2011) while the wheat crop residue is used for feeding livestock due to its higher nutritive value and palatability in Indo-Gangetic plains. Thus, an alternative practice like cover cropping is crucial to implement conservation agriculture in the true sense. Cover cropping is an age-old practice often used by farmers and is defined as the crop that is planted to cover the soil rather than to be harvested. It adds in living or residual crop biomass and provides several ecosystem services such as soil and water conservation, increasing soil carbon/nitrogen pools, enhanced biodiversity, and reduced interference of biotic and abiotic stresses, besides improving soil's physical, chemical, and biological properties. However, its establishment and termination require basic agronomic management, which are briefly discussed in this article.

## Ecosystem services provided by cover crops:

**Provisioning services**
- Genetic resource conservation
- Source of animal feed
- Biofuel production
- Source of propagating material
- Biochemical, natural medicine

**Supporting services**
- Fixing atmospheric N
- Recycling of organic matter
- Maintaining soil fertility
- Provisioning of habitat
- Increasing soil productivity

**Regulating services**
- Weed, insect and disease management
- Soil erosion control
- Decrease water pollution
- Soil moisture conservation
- Carbon sequestration

## Cover crop establishment:

### Crop selection

Crop species and varietal diversity have the potential to provide various ecosystem services (Beillouin *et al.*, 2021). The selection of the right crop for a given climate and soil determines the final output (i.e. higher biomass production and soil cover). The list of suitable

crop species for cover cropping is given below:

Table 1 Annual cover crop species used under $C_A$ practices

| **Non-leguminous crops** | | | |
|---|---|---|---|
| *Common name* | *Scientific names* | *Benefit obtained* | *Reference* |
| Oat | *Avena sativa* | Prevent soil erosion, increasing soil moisture, rate of infiltration, C-sequestration, nutrient scavenging, prevent Nitrate leaching, weed suppression, provide ground cover, mitigate climate change, and enhance microbial population *etc*. | Lal, (2004), Clark 2008, De Baets *et al.*, (2011), Kaspar *et al.*, (2012), Basche *et al.*, (2016), Masilionyte *et al.*, (2017) Kaye and Quemada (2017), Finney *et al.*, (2017) |
| Mustard | *Brassica species* | | |
| Buckwheat | *Fagopyrum esculentum* | | |
| Italian ryegrass | *Lolium perenne* | | |
| Common barley | *Hordeum vulgare* | | |
| Proso millet | *Panicum miliaceum* | | |
| Cereal rye | *Secale cereale* | | |
| Foxtail millet | *Setaria italica* | | |
| Triticale | *Triticosecale rimpaui* | | |
| **Leguminous crops** | | | |
| Peanut | *Arachis hypogaea* | Nitrogen fixation, control nitrate leaching, prevent soil erosion, increase organic matter, C-sequestration, mitigate climate change, helpful for insects and pollinators, enhance earthworm and microbial population *etc*. | Lal (2004), Tonitto *et al.*, (2006), Clark (2008), De Baets *et al.*, (2011), Kaye and Quemada (2017), Finney *et al.*, (2017) |
| Egyptian clover | *Trifolium alexandrinum* | | |
| Jack bean | *Canavalia ensiformis* | | |
| Chickpea | *Cicer arietinum* | | |
| Guar | *Cyamopsis tetragonoloba* | | |
| Soybean | *Glycine max* | | |
| White pea | *Lathyrus sativus* | | |
| Lentil | *Lens culinaris* | | |
| Sweet clover | *Melilotus officinalis* | | |

### *Seeding methods*

Cover crop seeding is an important operation, and using equipment that offers accurate seeding may ensure better seed germination and optimum crop stand. The different methods of cover crop establishment are described below:

**Broadcasting by air** - This technique is suitable for larger seeded crops viz. wheat and rye as compared to smaller seeded crops. The seeds are broadcasted from seed mounted device fitted on an aircraft. However, it has several drawbacks like over seeding, higher seed rate, and lower seed germination (Wilson *et al.*, 2013).

**Broadcasting by ground** - This method is most common among the farmers. The cover crop seeds are broadcasted manually or using spinners, drop tubes or air pressure. This technique makes sure that the seeding is appropriate for complete and even ground cover. Cover crops have varying spreading characteristics, which are governed by seed weight as the seeds having heavier weight cover a larger area in a short period as compared to the lighter seeds.

**Drilling** – This method is more appropriate for crop establishment under conservation agricultural ($C_A$) practices. The seeds are directly drilled by opening a narrow slit of soil using a zero-till seed drill mounted with a seed metering device. This technique ensures good placement and seed-to-soil contact, thereby giving a better crop stand than the conventional practices.

## Method of planting

### *Planting after economic crop harvest*

In India, cover crops are sown after the harvest of the main crop by no-till seed drill or broadcasting. However, for harnessing the maximum benefit, the former is recommended over the latter under $C_A$ practices. The sowing operation of any crop depends on the prevailing climatic condition, and one can establish a cover crop just after the harvest in a region

with a milder climate. In North-western India, the choice of a cover crop to fit between main summer crops is limited by the short growing season and severe cold during winter (Mondal *et al.*, 2015). Thus, the winter rye is probably the most reliable cover crop in this region whereas in warmer areas, early-maturing vegetable crops are suitable during the late spring or early summer.

Fig 1. Cover cropping under conservation agriculture (*Source:* Clark 2008)

### *Intercrops and living mulches*

Growing crop between the rows of the main crop offers potential advantages such as erosion control, higher water-infiltration capacity, soil organic matter addition, nitrogen buildup through biological N fixation, and reduced weeds infestation (Gebru, 2015). Contrarily, intercrops may compete with the main crop for above and below ground growth factors. Therefore, to lessen the competition two techniques are usually recommended, (i) delaying seeding of intercrops until the main crop establishment and (ii) providing a wider spacing between the main and intercrop rows.

## Cover crop termination

Cover crops are an essential part of many conservation tillage systems. The cover crop termination is location and situation-specific, which depends on many agronomic factors (Keene *et al.*, 2017). However, a thumb rule is to terminate the crop, 2 to 4 weeks before the anticipated main crop planting time. Cover crop termination can be achieved through mechanical, chemical, or combination of both under $C_A$ practices.

### *Mechanical method*

Rollers crimpers, a front or rear-mounted implement are used in conservation agriculture to terminate cover crops. Roller crimpers are found effective in the termination of annual cover crops when performed at the right growth stage (Ashford and Reeves, 2003). There are several general recommendations for terminating a cover crop with a roller-crimper. They are (i) terminate cover crops when the plants are mature, (ii) mixture of grasses and climbing legume in the cover crop system, and (iii) be aware of potential issues associated with allowing cover crops to become mature like nitrogen immobilization for the economic crop, the dry seedbed for commercial crop sowing and the need for no-till equipment at planting.

### *Chemical method*

Chemical termination using herbicide is more popular since it is more convenient and cost-effective than the mechanical method. Herbicides like 2, 4-D ester, and glyphosate are the most common among others and seem to fit best for the terminating cover crops (Davis, 2010). However, chemical termination is not allowed in the organic production system and it also lodges tall plants and complicates planting. The success of chemical cover crop termination depends on several factors like herbicide selection, herbicide crop rotation restrictions, adjuvant or additives, active cover crop growth, termination before flowering and weather conditions.

Fig 2. Termination of cover crop using mechanical and chemical methods (*Source:* Davis 2010)

## Conclusion

Cover crops enhance plant growth by adding soil organic matter, improving the bio-availability of plant nutrients, and reducing soil erosion and weed competition. By following the above-discussed crop establishment strategies, farmers could maximize the benefits of cover crops in terms of higher crop yield, reduced cost of cultivation, and enhanced soil health. In nutshell, implementing proper management decisions is highly essential for growing cover crops, to make the $C_A$ production system more feasible, attractive, and sustainable in the long run.

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