Cover crops

With green manure/cover crops we use plants to improve and protect the soil. Green manures and cover crops have thus far been understood to be crops grown by themselves, with the primary aim of increasing soil fertility and which are then ploughed back into the soil when they are in the flowering stage and still green.

In CA and as smallholders, we use cover crops somewhat differently:

Relay cropping of winter cover crops: saia oats, fodder radish and vetch

Maize and cowpea intercrop

Collecting seed of winter cover crops

Firstly, rather than always being planted alone, cover crops are usually planted together with the main food crops and at about the same time (intercropped), or they are planted among the main food crops just before these crops are harvested (relay intercropping). Now farmers can improve their soil without dedicating extra land to growing these crops

Secondly, cover crops are cut or rolled down after their seed is harvested, so that we can use the seed as food for humans and animals and replant them

Thirdly, the cover crops are cut or rolled down and left on top of the soil as we do not disturb the soil through ploughing – the organic matter on the soil surface can protect the soil from sun, wind and rain and provide extra soil fertility.

Fourthly, we plant cover crops to control weeds, pests and diseases. Cover crops compete with weeds and very effectively prevent or suppress them from growing. Cover crops 'push' or 'pull' pests and diseases out of the fields and/or away from food crops, since they are either liked or disliked by them.

Advantages of planting cover crops (CCs)

1. **Increased organic matter and soil nutrients:** CCs are capable of adding as much as 50 metric tons/hectare (MT/ha) or more of organic matter (green weight) to the soil each year. This organic matter has various positive effects on the soil, such as recycling nutrients back into the soil, pumping nutrients up to the soil surface, and improving the soil's water-holding capacity. It can also increase the total amount of nutrients in the soil, improve its nutrient balance, increase the number of macro and microorganisms (very small animals in the soil, many of which also help a farmer's crops grow better), improve the acidity of soil (i.e.: buffer soil pH) and sequester carbon.

   Organic matter makes soil nutrients, including those supplied by chemical fertilizers, more accessible to crops. In the case of phosphorous, this is particularly important: in acidic soils, phosphorus may become four to five times more available to plants when surrounded by organic matter.

2. **Nitrogen fixation:** Legumes (plants that produce their seeds inside pods) are able to fix nitrogen (N) from the atmosphere into a plant-usable form that accumulates in plant tissues. Legumes can thereby add large quantities of nitrogen to farmers' soils. Most of the widely used legume CCs are capable of producing more than 50 kg N/ha; some a lot more.

3. **Weed and pest control:** CCs can also be an important factor in reducing the cost and the labour required for controlling weeds. Herbicide use is either reduced or eliminated, since many CC species are able to smother weeds. Some species of CC can be used in place of other chemicals. For example, mucuna (velvet bean) and lablab beans kill nematodes, while sunnhemp (*Crotalaria ochroleuca*) can be used to control pests that eat stored grain. Brassicas (plants in the cabbage family) have an allelopathic effect that inhibits the germination of small seeded weeds. Rye, wheat and hairy vetch also produce compounds that inhibit weeds.

4. **Soil cover and erosion control:** The soil cover provided by many CCs can be very important for soil conservation. The soil cover, or mulch, that is provided by a CC also greatly improves drought resistance. The residues add organic matter to the soil, which increases infiltration of water into the soil and increases the water-holding capacity of the soil, while run-off and erosion is reduced substantially. Cover crops protect soil aggregates from the impact of rain drops by reducing soil aggregate breakdown.

***Left:** Runoff in a field planted to maize only has washed away some of the younger and germinating plants*
***Right:** On the same field intercropping with a cc has reduced the runoff a lot and crops are doing well*

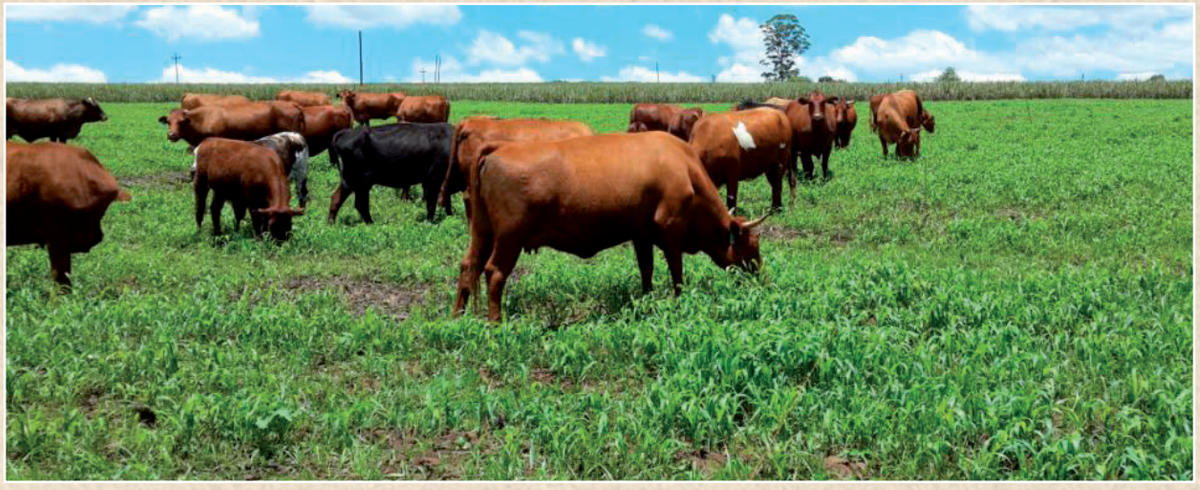
5. **Mycorrhizal Fungi:** Cover crops increase mycorrhizal fungus activity promoting a symbiotic relationship with the plants' roots for water and nutrient uptake. Plants provide the polysaccharides and the mycorrhizal fungus provide the protein to form a glycoprotein called glomalin which promotes soil aggregate stability (more macro-aggregates) and improved soil structure. Mycorrhizal fungus grows better in undisturbed soils. No-till and actively growing roots promote this reaction to occur. The majority of soil microbes are located next to growing roots with 10,000 times more microbes located in the rhizosphere next to the root than in bare soil.

   The soil microbial biomass and enzymatic activity increases with cover crop usage. Cover crops increase SOM, macroporosity, soil permeability, mean aggregate size, and aggregate stability (macro aggregates vs. micro-aggregates).

Roots, fungal hyphae and their secretions stabilize soil aggregates and promote good soil structure, thus preventing compaction and increasing soil water holding capacity and nutrient cycling

6. **Additional benefits:**

- CCs can provide food for humans and fodder for animals, including cattle and poultry.
- CCs can provide economic benefit through sale of fodder, hay and seed



Livestock grazing on a fodder rye and clover mixture of cover crops *(from: S Hodgson, 2014)*

- CCs can reduce pest attack and problems on staple crops including nematodes in growing crops and various pests in stored grain. CCs can be used as a trap crop for insects if the cover crop is killed before planting maize. Some green cover crops attract army worm, cutworms and slugs so the cover crop needs to be killed 3 to 4 weeks before planting maize.
- Letting cover crops grow and mature (flower) may allow populations of beneficial insects to increase.
- CCs can reduce incidence of diseases in crops, notably root rots and other fungal diseases.
- CCs can alleviate soil compaction through improved root sysems and soil structure.
- CCs increase the solar energy harvest (through photosynthesis) to increase carbon in the soil.

- CCs provide food for macro- and micro-organisms and other wildlife.
- CCs increase organic carbon, cation exchange capacity, aggregate stability and water infiltration.

Disadvantages of planting CCs

1. **Opportunity cost of land:** Farmers normally will not plant something that only improves their soil if the land could instead be planted with either food crops or cash crops. Unless the CCs also produce food, the land used to grow CCs must have no other valuable use
2. **The slow results:** Soil improvement is a long-term process that may not be immediately noticeable to the farmer. Usually, concrete, visible results are not apparent until well into the second cropping cycle. This slow appearance of results – improved soils – that are often difficult for people to believe, further complicates the adoption of CCs.
3. **Dry season problems:** Often CCs must produce their organic matter at the end of the wet season, or must continue to grow during the dry season. Grazing animals, wild animals, termites, agricultural burning, bush/veld fires or several other problems may destroy organic matter or growing plants before the farmer can use them the following rainy season.
4. **Timing (also called "synchronization"):** The nutrients provided by the CCs, especially nitrogen, must be available to crops when they need them in order to raise productivity. CCs will boost farmers' productivity only if the nutrients are available to the crops at the right time. In many systems, the correct timing is either impossible or very difficult to achieve. Therefore, the efficiency of the systems is reduced.

Nutrient cycling and release with cover crops

Generally cover crops consist of mixtures of grasses and or grains and legumes to balance the need for inclusion of both carbon (C) and nitrogen (N) to build the soil. Both C and N are needed to form soil organic matter. Grass cover crops may contribute N as scavengers or legumes may fix additional N. Grasses contribute more carbon than legumes. The carbon to nitrogen ratio (C:N) determines how organic matter is decomposed, at which rate and which nutrients are released or held in more stable forms. At C:N ratios of less than 20, N is released. The average C:N ratio in the soil is around 10-12:1 indicating that N is available.

Nitrogen uptake depends on how much nitrogen is in the soil, the climate (temperature and water), cover crop species, seeding rate, planting and die back or killing date. Winter grass cover crops (such as saia oats and annual ryegrass) accumulate soil N in autumn and winter due to fast root growth. After the boot stage (when the stems start to thicken and lengthen), there is not much additional nitrogen uptake with grasses. Legumes accumulate nitrogen longer into the spring. Grasses and or brassica species absorb and recycle nitrogen if excess N occurs from manure or fertilizer. Legumes are used to supplement N for the next crop if more N is needed for fertilization.

The release of N depends on cover crop species, growth stage, management, and climate. For example:

- An early spring kill of grasses promotes a lower C:N ratio and a faster release of N.
- Legumes tend to have a lower C:N ratio but if either grasses or legumes are allowed to reach full maturity, N release is delayed.
- Slower N release occurs more in dry weather than in wet years due to decreased microbial activity needed to decompose residues and release N
- N uptake of cover crops varies from 57 to 296 kg N/ha. If 50% of N is recycled, cover crops may supply 25 to 132 kg N/ha to the next crop
- Late planted cover crops may not have as much vegetative growth but may impact soil and water quality through reduced soil erosion.

Types of cover crops

Mostly mixtures of grasses, legumes and brassicas (cabbage family) are used. The general rule is to plant as many different types of cover crops together as possible. The most efficient organic matter building process is through a diverse range of cover crops that help to maintain a diverse microbial community.

When five or more species or types are planted together, such as grasses, cereals, brassicas, legumes and chenopods (a family of plants that includes spinach, beetroot, amaranthus and lamb's quarters or chenopodium), synergistic effects start to be noticed. More phenolic compounds are produced in the plants and microorganisms. These compounds have a role to play in the fixation of nitrogen and also in building resistance to insect and disease attack.

We can choose the combination of cover crop mixes depending on the season, the rainfall and the requirements of the soil in our situation. For smallholder farmers we would be looking mostly for mixes with good grazing and food potential.

***Top:** Amaranthus species are good cover crops and also provide food as indigenous greens*

***Below:** Chenopodium or lambs quarters similarly is a highly nutritious vegetable*

Examples of commonly used cover crops

Annual cover crops that are used as rotations with summer and winter grain crops are the most common. Cover crops need to be good fodder for livestock as well as having soil building and soil health improvement properties. In the South African conditions they need to be tolerant to bad quality soils that are often acidic or sandy and to heat and drought stress.

Legumes

Common cover crop options for legumes:

Warm season	Cool season
• Dolichos (*Lablab purpurea*) • Sunnhemp (*Crotalaria juncea*) • Cowpea (*Vigna unguiculata*) • Lucerne (*Medicago sativa*) • Velvet beans (*Mucuna pruriens*) • Soybean (*Glycine max*) • Mung bean *(Vigna radiata)*	• Hairy vetch (*Vicia villosa*) • Burmedic (*Medicago polymorpha*) • Red clover (*Trifolium pratense*) • Forage pea/field pea (*Pisum sativum*)

Dolichos beans (*Lablab purpureus*)
Lablab is remarkably adaptable to wide areas under diverse climatic conditions and soil types with pH varying from 4.4 to 7.8. Being a legume, it can fix atmospheric nitrogen to the extent of around 170 kg/ha besides leaving enough crop residues to enrich the soils with organic matter. It is a drought tolerant crop and grows well in dry lands with limited rainfall. The crop prefers relatively cool seasons (temperature ranging from 14-28°C) with the sowing done in July-August. It is an extremely good high protein animal fodder for the dry season and is highly preferred by cattle. It seeds throughout the dry season and will not provide seed under heavy grazing conditions. *(Truter et al 2015) (http://www.lablablab.org/html/general-information.html).*

***Right:** Lablab grows prolifically and seeds late in the season going into winter. It provides full ground cover while maize is dying back*

Sunnhemp (*Crotalaria juncea*)
This is a tropical legume that has huge potential as a cover crop. It is planted in the warm season and is an annual that produces large quantities of biomass. It is a good fodder for livestock and grows in low fertility sandy soils. It has a suppression effect on plant parasitic nematodes and fixes around 120kg/ha of nitrogen. *www.biomassproducer.com.au*

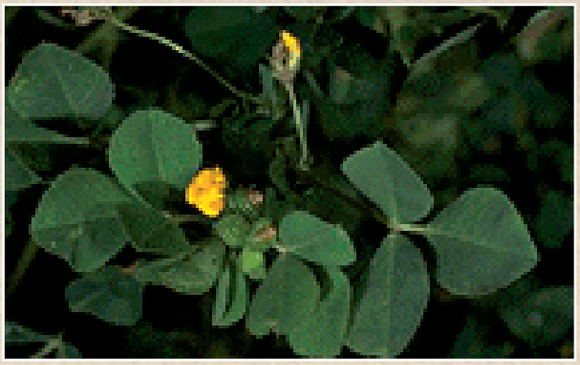
***Left:** Sunnhemp grows tall and straight and seeds quickly producing high biomass and protein rich fodder*

Lucerne/Alfalfa (*Medicago sativa*)
This is a perennial flowering plant in the pea family and is grown as an important livestock fodder crop. It is also considered a good crop for promoting the presence of beneficial insects such as predatory and parasitic wasps. It is hardy and drought tolerant. This deep rooted crop breaks up hard soils and recycles nutrients bringing trace elements to the soil surface. It can be cut and hay can be produced, or grazed directly. It is planted in spring. It fixes between 180-250kg/ha of nitrogen. *www.agricol.co.za*

***Above:** Lucerne can be cut and fed to livestock 2-3 times per season. It produces a very high value hay*

Bur Medic (*Medicago polymorpha*) is a legume that is closely related to alfalfa/ lucerne. They fix around 120kgN/ha. They are true annuals flowering, setting seed and dying within one growing season (60 to 100 days). They germinate and grow quickly and can tolerate a wide range of soil pH. They can be used for fodder. *http://ucanr.org/sites/asi/db/covercrops.cfm*

***Right:** Medics are used very successfully in dryland conditions with poor quality soils*



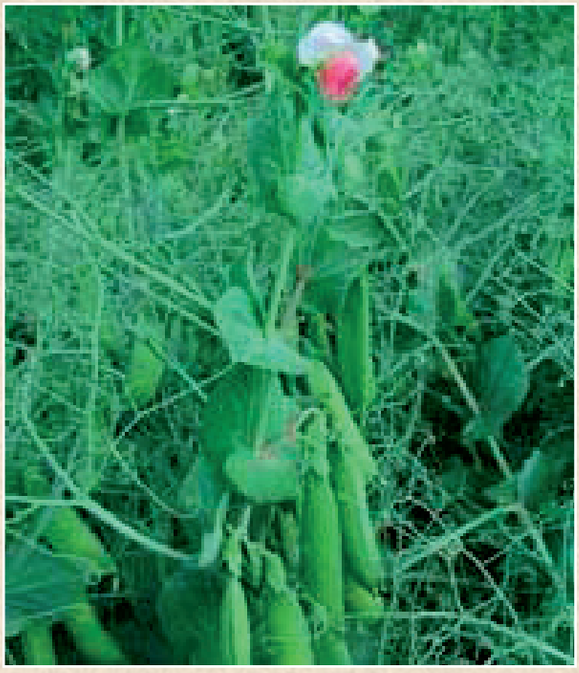
Hairy Vetch (*Vicia villosa*)
These legumes are planted in autumn and although a bit slow to establish are drought and cold tolerant once growing. They can grow in a wide range of different soil types and different pH and also do well in sandy soil. They show good N fixation at around 140kg/ha of N.

https://commons.wikimedia.org/wiki/File:Hairy-Vetch_(4709732410).gif

***Left:** Hairy vetch is one of the most rewarding cover crops. The small leaves and high biomass means fast decomposition and a significant increase in organic matter in the soil*

Red Clover (*Trifolium pratense*)
This is sown as a cool season cover crop and is shade tolerant if sown into a maize crop towards the end of the season. It fixes around 140kg/ha of Nitrogen and can be grazed in winter. *http://www.plantcovercrops.com*

***Right:** Clovers do well on highly clay and acidic soils where other cover crops may struggle. They are well adapted to cool wet conditions*



Forage pea (*Pisum sativum*)
These are winter legumes and good fodder crops for livestock. They are not very drought tolerant and require non acidic soil for optimum growth.

***Left:** The forage peas are a little slow to germinate and cannot tolerate very hard soils and dry conditions.*

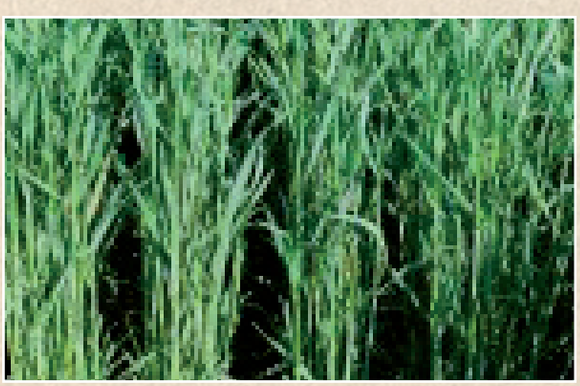
Grasses, cereals and brassicas

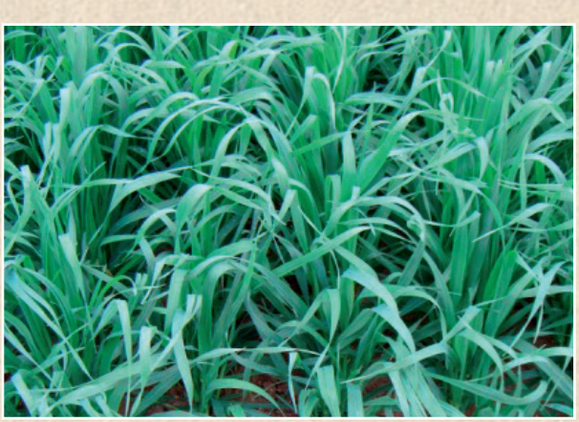
Common cover crop options for grasses, cereals and brassicas include the following:

Warm season	Cool season
• Babala/ pearl millet (*Pennisitum glaucum*) • Forage sorghum (*Sorghum bicolor*) • Sunflower • Buckwheat • Teff	• Black/saia oats (*Avena strigosa*) • Fodder rye (*Secale cereale*) • Fodder radish (*Raphanus Sativus Olieformis*) • Other bassicas including: kale, rape, turnips and mustard • Barley • White oats • Stooling rye

Cereal/ fodder rye (*Secale cereale*)
This is sown in autumn and forms dense stands and a large root mass. It is quite drought and cold tolerant and good for problem soils such as rocky or sandy soils.
http://www.kingsagriseeds.com/cool-season-annuals

***Right:** The grain can also be kept as food for livestock and humans and is comparatively high in protein*





Black oats (*Avena strigosa*)
This is a good cool season cover crop and is a valuable fodder crop for livestock, with good nutrition quality and high protein content. It is quite hardy, can tolerate low pH soils and improves soil aggregation and soil structure. It also mobilises C alcium (Ca) in the soil.
http://www.kingsagriseeds.com/cool-season-annuals

***Left:** Black oats forms one of the standard cover crop mixes as it has a strongly boosting effect on soil health and soil microbial life*

Babala/pearl millet (*Pennisitum glaucum*)
This is a quick growing summer annual used for grazing and silage. It has a well developed root system and good drought tolerance. It can tolerate low soil fertility, and high temperature. It performs well in soils with high salinity or low pH. Because of its tolerance to difficult growing conditions, it can be grown in areas where other cereal crops, such as maize or wheat, would not survive. In many parts of the world including Africa and India it is staple food eaten as a porridge or fermented into a local beer. Flatbreads, cakes and biscuits are also common.
www.en.wikipedia.org www.great-secret-of-lifecom

***Above:** Pearl millet is a good food for both livestock and humans*

Forage sorghum (*Sorghum bicolour*)
This sorghum type grows very tall and produces a large amount of vegetative growth. It is drought and heat tolerant and produces good animal fodder. It is also known as sweet sorghum.
www.youtube.com

***Right:** Forage sorghum is a very good cattle fodder and also known as sweet reed in more local cultures, it is eaten like sugarcane*

Fodder radish (*Raphanus Sativus Olieformis*)
It is a fast growing cool season cover crop which is immune to many brassica diseases, such as clubroot. It has a weed suppression effect and is a good grazing crop for livestock. It is cold tolerant and has positive effects on soil health and soil structure. It grows large very quickly and has a large nitrogen uptake of around 20kg/ha. It has a positive effect on acidic soils and fixes Aluminium (Al).
http://msue.anr.msu.edu/news/cover_crop_grazing_with_sheep_lessons_learned_from_recent_msu_extension_dem, www.cdiowa.org

***Left:** Fodder radish and oats mixture and the large root that cracks open and aerates soil as well as being a particularly sought after fodder for cattle*

Seed inoculation

Inoculation may be defined as the process of adding effective bacteria to the host plant seed before planting. The purpose of inoculation is to make sure that there is enough of the correct type of bacteria that multiply in the roots of a legume plant forming nodules where these bacteria fix atmospheric nitrogen for the nutrition of the plant. These inoculants can be bought and added to legume seeds prior to planting Inoculants are specific to each type of legume.
www.groworganic.com.

More recently inoculants containing beneficial fungi such as mycorrhizae have also been developed. These assist in general soil health and plant growth.

Cover crop mixes

The general rule is to mix cereals/ grasses, legumes and brassicas into the mixture. Any combination of these can wok well- depending on the local conditions and preferences. Remember to try and use as many different types and species as possible.

Warm season cover crop mixes

A good mixture is the following:

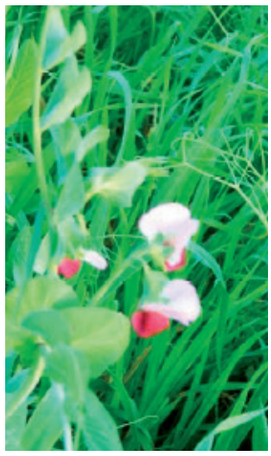
- Dolichos (Lab-Lab beans)
- Fodder sorghum
- and Sunnhemp.

***Right:** A trial plot with the summer mix of cover crops*
(from: H Smith, 2014)

Cool season cover crop mixes

Various combinations of black oats, fodder rye, vetch, fodder radish and fodder peas are possible.

***Right:** A plot with fodder pea, oats and rye grass;*
***Far Right:** A mix of hairy vetch, fodder peas and fodder rye.*
(From S Hodgson SACCS, 2014)



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