Cover Crops

Cover crops are typically defined as crops used to protect agricultural soils and improve soil productivity. They are generally non-cash crops and rarely harvested. A cover crop may be used:

1) as a green manure "plow-down" crop incorporated into the soil to increase soil organic matter, stimulate soil biological activity or improve soil physical characteristics;
2) to protect the soil from wind and water erosion;
3) to recycles valuable nutrients that are present but not readily available to cash crops;
4) to catch or conserve nutrients that may be lost through leaching;
5) to interrupt pest and disease cycles and/or suppress weeds; and
6) as supplemental feed for livestock or to provide an additional food source for pollinators (honey bees and leafcutter bees) and other beneficial insects.

The very nature of cover crop benefits, as well as the fact that they have both short-term and long-term effects, means that it is often difficult to assign a monetary value to them. Ultimately, the insertion of cover crops into a crop rotation should increase the overall sustainability of the farm.

Benefits of Using Cover Crops

ADD ORGANIC MATTER TO THE SOIL

Historically, farmers have relied on green manure crops to add organic matter to their soil. Once incorporated, green manures break down into various types of organic matter. Mature and fibrous crop materials are characterized by a relatively high carbon:nitrogen (C:N) ratio, and generally consist of complex lignin compounds that do not readily decompose. This slow decomposition generates long-lived or stable organic matter frequently referred to as "humus". Often, only a very small portion of crop residues are transformed into this stable organic matter. Producers who are looking to increase soil organic matter content should consider cover crops that produce large amounts of mature, fibrous materials. It is best to avoid nitrogen fixing legumes and crops that produce young "succulent" materials (see Table 1.)

Fall plowing of grain stubble and annual rye grass

Table 1. C:N Ratios of Various Organic Soil Amendments and Cover Crops

Soil Amendment	C:N Ratio	Outcome of soil incorporated organic amendments
Sawdust	150-400:1	Formation of "long-lived" or "stable" organic matter (humus like) ↑
Straw	40-80:1	
Autumn leaves	40-80:1	
Corn stalks	60:1	
Solid manure (no bedding)	16:1	
Fresh Ryegrass	25:1	
Alfalfa hay	15-20:1	
Produce waste	11-25:1	
Grass clippings	9-25:1	↓ Biological Stimulation
Poultry manure	5-10:1	

STIMULATE SOIL BIOLOGICAL ACTIVITY

Young, fresh crop materials (including legumes) contain readily available compounds which serve as food for soil micro-organisms. When worked into the soil, they may produce very little, if any, stable organic matter. They may, however, significantly stimulate soil biological activity which in turn leads to enhanced mineralization (release of nutrients from decomposing organic matter for plant uptake). Soil biological activity will also make certain nutrients more readily available for crop uptake.

The properties of the cover crop residues are therefore very important as they have a direct influence on the outcome of organic matter decomposition (humification and mineralization) and other plant nutrition dynamics. Young and succulent green manure crops with a low C:N ratio will feed soil micro-organisms, while a mature, fibrous green manure crop such as cereal straw will form stable organic matter but provide little stimulation of soil biological activity (see Table 1). A good ground cover will not only protect the soil surface but will also favourably impact upon micro-organism development in the area located near the roots (rhizosphere). Roots from living crops release compounds that sustain and stimulate soil biological activity. Consequently, a late seeded fall cover crop that does not provide much biomass for incorporation may still stimulate soil life.

IMPROVE SOIL STRUCTURE

Soils with a high organic matter content and intense biological activity generally have excellent soil structure. In fact, soil organic matter and biological activity promote good soil aggregation, improved soil stability and improved soil porosity. These, in turn, lead to improved water retention and erosion protection. In addition, field equipment will not compact soils that are well structured quite as easily as they would soils that are not.

Soil macro-organisms (such as earthworms) and micro-organisms play an important role in improving the soil's physical characteristics by digging tunnels, decomposing or digesting organic matter and secreting "glue-like" compounds that improve soil aggregation. Many crops, including root vegetables, benefit greatly in terms of higher yields and quality from improved soil structure.

Soil structuring winter rye

Fall seeded oilseed radish and oats

In addition, most forage crops (clovers and grasses) and small grains are excellent soil conditioners because their vigourous, shallow and fibrous root systems are able to loosen the soil and improve soil tilth. Perennial pasture and hay/haylage mixtures, annual ryegrasses and winter rye are good examples of such crops.

Some crops, such as oilseed radish, sweet clover, and alfalfa can be used as "biological subsoilers". Used strategically, their deep tap roots can break-up plough pans and compacted soil horizons. In combination with mechanical sub-soiling, deep tilling and improved soil drainage, such cover crops can provide superior soil loosening effects.

RECYCLE, PRESERVE AND ADD NUTRIENTS

Deep rooted cover crops have the ability to extract nutrients from the deep soil horizons and bring them to the surface, near the root zones of subsequent cash crops. Some cover crops are also known for their ability to extract nutrients that are not readily available to other plants. An example of this is the uptake of soil phosphorus by buckwheat and oats.

Fall cover crops are generally seeded after the main cash crop to catch and retain nutrients that may otherwise be leached out of the cropping system, for example brassica crops such as oilseed radish. In Atlantic Canada, this type of catch crop can sometimes be planted after early potatoes, cereals or vegetables in order to capture available nutrients that were not taken up by the cash crop. Catch crops can also be used prior to, or shortly after, manure and compost applications. Fall cover crops that protect against water and wind erosion can reduce topsoil and phosphorus losses.

Legumes such as clover, alfalfa, vetches and peas that can fix atmospheric nitrogen, are also able to supply nitrogen to subsequent crops. When sources of manure or compost are not readily available, legume crops can be inserted into a crop rotation to supply nitrogen to the following cash crops. Full or partial incorporation of such cover crops should be done in late fall

when the soil temperatures are relatively cool or in the spring, prior to the establishment of the cash crop. This timing avoids excessive mineralization at a time when nitrogen could be leached out of the system.

Fall seeded oats

Common vetch

Cover crops may provide significant benefits in relatively productive soils. For soils that are naturally poor, however, the cover crop can only marginally enrich the soil. In naturally low fertility soils, it may be necessary to add nutrients through the use of soil amendments such as manure, compost, rock powder or synthetic fertilizers.

INTERRUPT PEST & DISEASE LIFE CYCLES

The use of cover crops in well-planned crop rotations can help to interrupt the life cycle of many fungal, bacterial, insect or nematode pests. To interrupt pest life cycles, it is important to select cover crops of a different family than that of the future cash crop so that they do not harbour pests that can negatively impact the cash crop that will follow. Cover crops may also attract beneficial organisms that prey upon or parasitize pest species. Some cultivars of brassica crops (mustards) and pearl millet have been reported to suppress harmful nematode populations.

In a row-crop situation, living mulches and inter-planting practices can also reduce insect pressures by making the cash crop more difficult to find. A diversified environment tends to reduce the risk of specific pest out-breaks.

PROVIDE WEED CONTROL

Several cover crops are considered “smother” crops because they are used to control or suppress weeds. Crops that give the best results are those that are quick to germinate, provide rapid ground cover and form thick canopies. Buckwheat, some of the spring cereals and fall rye are good examples of smother crops. These crops compete with the weeds for water, sunlight, space, rooting zone and nutrients (e.g. nitrogen). Some smother crops such as Japanese millet, sorghum Sudan hybrids and annual rye-grass establish very slowly at first, but tend to compete with weeds very well later in the season. It is often recommended to clip or mow these early in the season to stimulate their regrowth and eliminate annual weeds which could go to seed.

Smother crops are often more effective when they are integrated into a broader weed management approach. For example, smother crops are generally more effective in controlling perennial weeds such as quack grass when combined with a short fallow period.

Some crops, such as cereal rye, hairy vetch, and oats are reported to have allelopathic properties. These crops produce compounds when they are growing or decomposing that inhibit germination, especially of weeds that have small seeds.

In vegetable production systems, living mulches are also used to suppress weeds. Low-growing clovers and ryegrass are sometimes used for this purpose. The living mulch can also be planted prior to or after the vegetable crop. It is important to note that the use of living mulches may be risky in some situations because these can compete with the vegetable crop and cause significant yield loss. The characteristics of the living mulch must complement those of the cash crop to be grown.

Selecting a Cover Crop

Since cover crops have different functions, it is important to determine what the crop is expected to do. Is the intent to add organic matter to the soil? To add nitrogen to the cropping system? To stimulate soil biological activity? To protect the soil during the winter months?

It is much easier to select cover crops when the crop rotation or cash crops have already been determined. There are simply fewer choices available. A long crop rotation may allow room for full season cover crops which build soil organic matter, whereas a short or “tight” rotation may limit the choice to short season crops, fall cover crops or inter-planted crops.

Buckwheat being mowed with a brush-hog (photo provided by Mountaindale Farm, New Brunswick)

Specialized inter-planter (photo provided by the New Brunswick Soil and Crop Improvement Association)

Some cover crops will require specific seeding, mowing or tillage equipment. Before deciding upon a cover crop it is important to make sure that the appropriate equipment is available. Seed availability and cost are factors that must also be accounted for. It may be more feasible to use expensive cover crops when it is possible to establish them for a long period of time. It may not be possible to justify higher cover crop seed costs, however, when a limited growing period is available. Before establishing a large area of a new cover crop, producers should first experiment

with the crop to become familiar with how it performs on a smaller scale. There may be advantages to planting mixtures of cover crops:

1) to maximize biomass production;
2) to offer structural support to crops that climb;
3) to include crops that emerge and establish quickly, thus suppressing weed development;
4) to include crops that are adapted to different growing conditions; and
5) to include crops that have complementary root patterns.

It is advisable to adjust your seeding rates when seeding cover crop mixtures. For more information about cover crops used in Atlantic Canada, refer to sections A and B of the selection chart below (Table 2).

Table 2A. Cover Crop Selection Chart for Atlantic Canada
(adapted from Jobin, P. and Douville, Y. *Engrais verts et les cultures intercalaires*)

Cover Crop	Full season	Short season	Fall season	Winter killed	Nitrogen fixing*	Biomass production
Buckwheat	0	+++	+	Yes+++	No	++
Clovers						
• Crimson (annual)	+++	++	++	Yes+++	+++	++
• Persian (annual)	+++	++	++	Yes+++	+++	++
• Red	+++	+	++	No	++	+++
• Sweet white blossom (annual)	+++	+	+	Yes	++	++
• Sweet yellow blossom (biennial)	+++	+	+	No	++	+++
• White clover (Grazing & Ladino)	+++	+	+	No	++	++
Fall rye (cereal)	+	n/a	+++	No	No	+ / +++
Field peas	++	++	+	Yes+++	++	++
Japanese millet	+++	++	0	Yes+++	No	+++
Oats	++	+++	+++	Yes+++	No	++
Oilseed radish (other cruciferous crops)	0	+++	+++	Yes+++	No	++
Phacelia	+++	0	0	Yes+++	No	+
Ryegrass (annual forage)						
• Westerwolds type	+++	++	++	Yes+++	No	+++
• Italian “grazing” type	+++	++	++	Yes++	No	+++
Sorghum Sudan hybrid	+++	++	0	Yes+++	No	+++
Permanent forage mix (i.e. Triple mix)	+++	+	+	No	++	++
Vetches						
• Common	++	++	++	Yes+++	++	++
• Hairy	++	++	++	Yes++	+++	++
• Chickling	++	++	++	Yes++	+++	++

Very good (+++), Good (++), Poor (+), Not recommended (0), Not applicable (n/a).

Table 2B. Cover Crop Selection Chart for Atlantic Canada
(adapted from Jobin, P. and Douville, Y. *Engrais verts et les cultures intercalaires*)

Cover Crop	Days to 1st mowing ** (regrowth)	Seeding rate, kg/ha ***	2008 seed cost, $/kg ($/ha)	Weed suppression	Latest seeding date ****
Buckwheat	>28(0)	60	1.40 (84)	+++	Aug 15
Clovers					
• Crimson (annual)	>60 (++)	18 (10)	3.70 (67)	++	Aug 10
• Persian (annual)	>60 (++)	5-7 (3)	6.10 (37)	++	Aug 10
• Red	>60 (++)	8-10 (6)	3.30 (30)	++	Aug 10
• Sweet white blossom (annual)	>60 (++)	15 (5)	2.80 (40)	+	Late spring
• Sweet yellow blossom (biennial)	>60 (++)	15 (5)	2.80 (40)	+	Late spring
• White clover (Grazing & Ladino)	>60 (++)	6 (3)	9.40 (56)	+/0	Late spring
Fall rye (cereal)	n/a	120	0.79 (95)	+++	Sept 15
Field peas	>45 (+/0)	150 (100)	1.00 (150)	++	Aug 10
Japanese millet	>60 (+++)	30	2.30 (69)	+++	Aug 1
Oats	>45 (+)	120 (80)	0.55 (66)	++	Sept 5
Oilseed radish (other cruciferous crops)	>35 (0)	12	4.70 (56)	++	Sept 1
Phacelia	>60	8	not available	+/0	Late spring
Ryegrass (annual forage)					
• Westerwolds type	>45 (+++)	15 – 30, but variety specific	2.00 (46)	+++	Aug 10
• Italian “grazing” type	>60 (+++)		2.00 (46)	+++	Aug 10
Sorghum Sudan hybrid	>60 (+++)	15	1.68 (25)	+++	Aug 1
Permanent forage mix (i.e. Triple mix)	>60 (++)	15	2.60 (38)	++	Late spring
Vetches					
• Common	>50 (+/0)	45	2.90 (130)	++	Aug 10
• Hairy	>50 (+/0)	30	4.76 (143)	++	Aug 10
• Chickling	>50 (+/0)	60	2.40 (144)	++	Aug 10

Very good (+++), Good (++), Poor (+), Not recommended (0), Not applicable (n/a).

* **Nitrogen fixing legume crops** must be inoculated with rhizobium bacteria at planting. Legume crops require specific strains of fresh or well preserved inoculants. Inoculation is particularly important if the legume crop was never grown previously on the site.

** **Days to first mowing:** Minimum period of time to establish a beneficial cover crop. It often is the time when the cover crop should be clipped so that it does not produce viable seeds which could become a weed problem. This first mowing will also allow the control of annual weeds before they set their own seeds. In some instances, crop mowing will also stimulate the growth of the cover crop. Full season cover crops may require multiple mowings (e.g. annual ryegrass, Japanese millet and sorghum Sudan grass). In general, cover crops that are mowed during their vegetative stage (before bloom) will offer better regrowth. However, some crops if mowed at a later stage of maturity will not regrow.

*** **Seeding rate:** Since seeding rates can vary between varieties, check with your seed suppliers. When seeded in mixtures with other crops or when inter-planted (under seeded), a lower rate is recommended (rate given in brackets). The seeding rates listed are generally sufficient when seed beds are well prepared and drill seeders are used. Higher seeding rates may be required when seed is broadcasted or when seeding is carried out late in the season.

**** **Latest seeding date:** Since many factors influence the latest seeding date, the information in this table is a guide only. The dates listed should provide enough time for the crop to establish and provide a beneficial effect in the year of establishment (i.e. ground cover, biomass production, nitrogen fixation and soil biological stimulation).

Adding a Cover Crop to a Crop Rotation

There are many ways to insert cover crops into a crop rotation. They can be established in a pure stand or in a mixture with other crops or as a full season crop to maximize its beneficial properties. A cover crop can be used for a short period of time in the spring before the cash crop or later in the fall after a main crop has been harvested. In cases where crop rotations are very tight, it is often easier to insert a fall cover crop after the harvest of a cash crop, provided there is enough time for it to establish before early fall frosts.

Sometimes cover crops can be inter-planted with or into the cash crop. In this case, special seeding equipment may be required. The cover crop must be suited for inter-planting and not compete with the cash crop. To avoid significant competition, an inter-planted cover crop or living mulch may be seeded when the cash crop or row crop is being cultivated for the last time.

In Atlantic Canada, it is a common practice to underseed grain crops with forages such as red clover, annual ryegrass or a mixture of grasses and legumes such as “triple mix”. This is a good method to establish perennial forages and also an excellent way to insert legumes into the rotation, allow for good fall ground cover, offer competition to weeds that may otherwise out-compete the cash crop and provide better support for fall equipment traffic.

Potential Problems

The use of cover crops is not without some potential problems. Many annual cover crops must be mowed before they produce viable seeds which could become a weed. Some cover crops have allelopathic properties that can have detrimental effects on the cash crops that follow. Large amounts of cover crop residues can cause significant problems during seeding of the next crop. Precision seeders are particularly sensitive to seed bed conditions with excessive crop residues. Nitrogen can be tied up during decomposition of incorporated fibrous plant material to the detriment of the cash crop. Poorly selected cover crops can attract, stimulate or harbour pests that can negatively impact the following cash crop.

Additional Information

Jobin, P. and Douville, Y. **Engrais verts et les cultures intercalaires**. Centre de développement d'agrobiologie, Sainte-Elizabeth-de-Warwick, Québec. 20 pages.

Kroeck, S. **Crop rotation and cover cropping on the organic farm - organic principles and practices handbook series**. Northeast Organic Farming Association. 88 pages.

Sarrantonia, M. 1994. **Northeast cover crop handbook**. Rodale Institute. 103 pages.

Wallace, J. and Scott, J. 2008. **Under cover – a guide to using cover crops in the Maritimes**. 2nd edition. Nova Scotia Organic Growers Association and Atlantic Canadian Organic Regional Network. 71 pages.