SoilWealth
NURTURING CROPS

Managing cover crop residues in vegetable production

Cover crops are great tools for soil management. Their benefits can include improving soil structure and health, reducing erosion and weeds, adding nitrogen and contributing to weed and disease control.

Managing the transition from cover crop to cash crop is a key factor in determining the successful integration of cover crops into your farm. With cover crops able to produce more than 100 tonnes of fresh plant material per hectare, the transition needs to be well managed to prevent problems in the following cash crop.

The aim of this factsheet is to outline key factors and the management options for the successful transition from cover to cash crop.

What are your cover crop goals?

Be clear on what the purpose of your cover crop and how it fits into your production system. This will help determine the right cover crop, and the timing and method of termination to manage the cover crop residues. For example, if you are growing baby leaf crops then complete breakdown of your cover crop will be important to prevent contaminated by cover crop residues at harvest. By contrast, if erosion and weed control is your goal retaining cover crop residues on the soil surface will require different management and cover crop choices.

Key factors in the management of cover crop residues

Managing the transition from cover to cash crop successfully requires the integration of the following aspects:

1. Cover crop chemistry (Carbon to nitrogen ratio),
2. How it is terminated, and
3. Tillage

Below, we discuss these three aspects and provide some rules of thumb to guide you in tailoring your cover crop to your farm.

Potential cover crop residue issues include:

- Cover crop residue contamination of cash crops such as baby leaf
- Crop establishment issues due to high cover-crop residues
- Disease carry over – e.g. Sclerotinia surviving on decaying cover-crop residues
- Cover crop residues providing food and shelter for crop pests such as snails and slugs
- Nutrient draw down resulting in nitrogen deficiencies in the cash crop

A 150 t/ha fresh weight biofumigation cover crop immediately prior to mulching and incorporation

This project has been funded by Horticulture Innovation Australia Limited using the vegetable levy and funds from the Australian Government.

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Cover crop chemistry – Carbon to Nitrogen ratio

The Carbon to Nitrogen (C:N) ratio of the cover crop will play a major part in determining how long the cover crop residues take to decompose. Soil organic matter typically has a C:N ratio of 10:1 (for every ten units of Carbon there is one unit of nitrogen).

The ideal plant C:N ratio for soil microbes is 24:1, which provides enough carbon for microbe maintenance and energy, and enough nitrogen for proteins. When the C:N ratio is above around 30:1 decomposition will slow and the microbes may need nitrogen from the soil to continue to breakdown the plant material. For example, most non-legume straw has C:N ratio higher than 50:1. Incorporation of this plant material into the soil will most likely result in nitrogen drawdown from the soil. This can occur if cover crops are left to maturity and allow to hay off.

The slow decomposition of cover crops can be beneficial if the goal is to protect the soil from erosion or weed control. Here, a good cover of slowly decomposing straw will reduce erosion. In this case, when the straw is not incorporated, then nitrogen draw down is less of an issue, as decomposition is slow.

For many vegetable crops the quick decomposition of cover crop residues is required. This can promoted by producing a lower C:N ratio residue through either choosing different species (Table 1), or by terminating the cover crop at different ages (Figure 1). You can use this information to help design the cover crop to do the main job you want, while managing the plant residues.

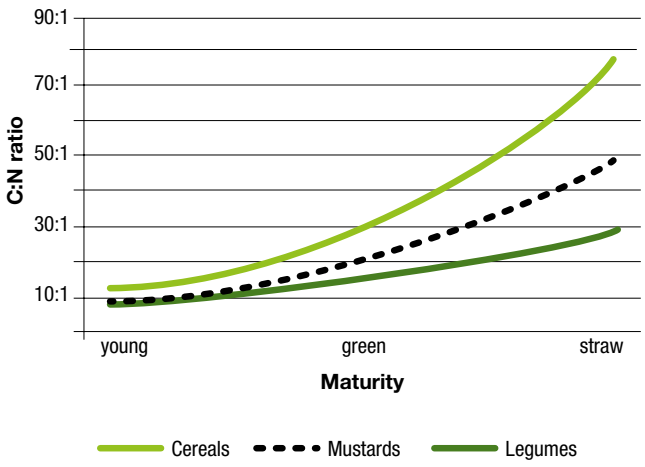

Figure 1. Maturity related changes in carbon to nitrogen ratio of three major cover crop groups.

Table 1. Carbon to nitrogen ratios for a range of commonly grown cover crops at green and straw maturity.[1,2,3]

COVER CROP	C:N ratio
STRAW	
Cereal rye straw	82:1
Wheat straw	80:1
Oat straw	70:1
Corn residues	57:1
Bean residue	34:1
Pea straw	29:1
Lucerne hay	25:1
GREEN (VEGETATIVE)	
Cereal/mustard mix	45:1
Cereal rye	44:1
Sorghum	35:1
Sunflower	35:1
Lupin	30:1
Wheat/oats	25:1
Millet	25:1
Canola	24:1
Buckwheat	24:1
Annual ryegrass	20:1
Field peas	20:1
Cowpeas	20:1
Forage radish/mustards	15:1
Sunn hemp/soya bean/radish/oats	15:1
Tillage radish	14:1
Mung bean	13:1
Clovers	13:1
Lucerne	12:1
Hairy vetch	10:1
Sunn hemp	10:1

[1] Carbon to nitrogen ratios in cropping systems. USDA Natural Resources Conservation Service 2011.

[2] D Finney, C White & J Kaye (2016). Biomass production and Carbon/nitrogen ratio influence ecosystem services from cover crop mixtures. Agron J. 108:39-52.

[3] Cover Crop Chart (v. 2.1). USDA 2015.

Terminating your cover crop

Timing of cover crop termination can affect soil temperature, soil moisture, nutrient cycling, tillage and planting operations, and the effects of allelopathic compounds on the subsequent cash crop.

Because of the many factors involved, decisions about when to kill the cover crop should be based on your cash crop requirements, the goal for your cover crop and soil and weather conditions.

The benefits of terminating a cover crop early can include:

1. Speeds breakdown of residues, decreasing potential interference with planting operation and contamination of the following cash crop.
2. Allows cover crops to be grown in a shorter window.
3. Reduces risk of phytotoxic effects of residues on cash crops.
4. Reduces survival of disease inoculum and/or some pest build-up.
5. Increases N mineralisation from lower C:N ratio cover crops.
6. Can increase soil temperature and moisture in spring.
7. Avoids cover crop setting seed.

The benefits of terminating a cover crop late can include:

1. Greater plant biomass input into the soil, potentially increasing soil organic matter.
2. More residue (mulch) available for soil and water conservation.
3. Better weed control from allelopathic compounds and mulch effect.
4. Greater nitrogen contribution from legumes.
5. Better nitrogen recovery from depth.

Management can be flexible to optimise the benefits of a cover crop. For example, a winter cover crop can be terminated early under dry spring conditions to conserve soil moisture. But if the spring is wet then the cover crop can be used to dry down the soil before terminating the cover crop allowing the soil to be cultivated at the correct moisture content.

Below we outline the main termination methods.

Mulching of a high biomass cover crop using a flail mower to produce fine residues.

Herbicides

Non-selective herbicides are an inexpensive and quick method for terminating cover crops. For many cereals/grasses herbicides are the only method for achieving a complete kill of the cover crop, particularly if the cover crop is to be terminated early. Refer to your local agronomist for advice on appropriate herbicides.

Mulching and rotary mowers

Many growers use a flail mower to mulch their cover crops before incorporation. Flail mowers can cut large biomass cover crops close to the ground, cut the plant material into smaller pieces and distribute the residue reasonably evenly. By contrast, mowing with a rotary slasher will struggle with large biomass cover crops, cut the plant material into larger pieces and distribute the residue in clumps. Both flail and rotary mowers are more time and energy intense (i.e. more tractor time and fuel) than spraying off the cover crop.

The main benefits of mulching a cover crop is the rapid transition from cover to cash crop. The mulching of the cover crop and incorporation into the soil allows faster breakdown of the residues. For many vegetable crops this will be an advantage, but again, this will come down to the goal of the cover crop and the main benefits you are aiming to obtain.

The effectiveness of mowing in terminate cover crops varies (Table 2 & Table 3). Most winter annual broadleaf and cereal cover crops can be effectively

Roller-crimping a ryecorn cover crop and direct seeding in one pass. Photo courtesy of Rodale Institute

killed by mowing. Not surprisingly grass cover crops are not effectively killed by mowing. An increased kill is usually achieved by mowing at a later growth stage and by mowing closer to the ground. For example, the percentage kill of hairy vetch increases from 19% to 100% when mown at early bud vs. full bloom, respectively.

Roller crimper

Roller-crimpers can be used to terminate cover crops by breaking (crimping) the stems. Their effectiveness is dependent on the cover crop species and growth stage. Roller-crimpers work best with tall-growing cover crops. Generally, roller-crimping is not as effective as mowing, but for some cover crops complete kill can be achieved. Again, the growth stage is important in determining the level of kill. For example, the percentage kill following roller-crimping increased from 21% to 93% when cereal rye maturity increased[6].

The main advantages of roller-crimper termination are that herbicides use can be reduced or eliminated, a persistent coarse residue is created giving good erosion and weed control, and residues are rolled down parallel to rows making it more practical to sowing or transplanting through the residues if no-till systems are used.

Tillage

The termination and tillage method need to work together to deliver your cover-crops goals and benefit your following cash crop. There is an array of tillage implements, which can be used to incorporate cover crop residues. These range from "softer" tillage option such as spaders, discs and power-harrows, through to more

Table 2. The effectiveness of mowing and rolling on the level of kill of some summer cover crops.[4,5]

COVER CROP			LEVEL OF KILLED	
SPECIES		MATURITY	MOWN	ROLLED
Broadleaf				
Cowpea	*Vigna unguiculata*	green	High	Low
Lablab	*Lablab purpureus*	green	High	Low
Soybean	*Glycine max cv Young*	green	High	High
Buckwheat	*Fagopyrum esculentum*	Early straw	High	High
Grasses				
Pearl millet	*Pennisetum glaucum*	Early straw	Low	Low
German foxtail millet	*Setaria italica*	Early straw	High	High
Japanese millet	*Echinochloa frumentacea*	Straw	High	High
Sudan grass	*Sorghum sudanense*	Early straw	Low	Low
Sorghum-sundangrass	*Sorghum bicolor X sudanese*	Straw	Low	Low

Supercolter lightly working in cover crop residues after discing.

aggressive rotary hoes. The condition of the cover crop residue will play a major part in determining what tillage method is required. For example, tall biomass cover crops terminated using a roller-crimper will be difficult to incorporate into the soil.

Tillage may occur soon after cover crop termination. This will speed up the breakdown of the cover crop residue by mixing the residues with the soil microbes, providing a more stable water and temperature environment in the soil, and potentially able to break down the residues into smaller pieces. Depending on your cover crop goal,

Cover crops will respond to tillage differently due to different cover crop chemistry (Table 1). Mustard and ryegrass stubble following the same discing and supercolter tillage.

Table 3. The effectiveness of mowing and rolling on the level of kill of some winter cover crops.[4,5]

COVER CROP			LEVEL OF KILLED	
SPECIES		MATURITY	MOWN	ROLLED
Broadleaf				
Austrian field pea	*Pisum sativum*	green	High	nd
Hairy vetch	*Vica villosa*	green	High	High
Red clover	*Trifolium pratense*	green	Low	nd
Grasses				
Wheat	*Triticum aestivum*	Early straw	High	nd
Ryegrass	*Lolium muliflorum*	green	Low	nd
Oats	*Avena sativa*	Early straw	Medium	nd
Cereal Rye	*Secale cereale*	Early straw	High	High

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Oats and vetch cover crop being mulched with a flail mower.

Oats and vetch cover crop after herbicide termination and mulching.

speeding up the breakdown of cover crop residues, and release of nutrients, may be desirable.

To conserve existing soil organic matter and help the cover crops add to this, the minimum amount of tillage should be used, which then allows the cash crop to be successfully established but doesn't overwork the soil. Exactly what level of tillage is needed may be determined by the conditions on your farm – soil type, cover-crop biomass and condition following termination, time before cash crop establishment and requirements of the cash crop itself.

Using cover crops in no-till vegetable production requires careful consideration of cash crop establishment. No-till planters will need modification, such as coulters, to cope with the surface residues. Row cleaners can be used to in heavy cover crop residue to sweep the residue away from the opening disks of the planter units. Removing this residue reduces the chance of pushing residue into the seed furrow (hairpinning).

Strip tillage is another softer tillage option, which can be used following cover crops. Strip-tillage equipment can manage surface residue and undertake tillage in the rows where the cash crop is to be planted with minimal disturbance of cover crop residue and the soil.

No-till pumpkin established after a mulched oats and vetch cover crop.

[4] N Creamer & S Dabnet 2002. Killing cover crops mechanically: Review of recent literature and assessment of new research results. Am. J. Altern. Agri. 17:32-40.

[5] G Rogers, S Little & L Williams. 2001. Development of a sustainable integrated permanent bed system for vegetable crop production including sub-surface irrigation extension. Final Report for VG98050

[5] S. Mirsky, W Curran, D Mortensen, M Ryan & D Shumway. 2009. Control of cerea rye with a roller/crimper as influenced by cover crop phenology. Agron. J 101-1589-1596.