

The potential of biofumigation to control soil borne pests, pathogens and weeds

Problem

Soil borne pests and pathogens can bring major constraints to crop production and their suppression often relies on synthetic chemicals that can be ineffective and/or expensive. A crop protection approach with broad efficacy and applicable for a wide range of crops and agronomic situations is needed. A group of UK growers who have been using and developing biofumigation and two industry experts in the field have explored the practicalities of applying the technique. This abstract is based on their findings which were discussed in a workshop that formed the basis for the 'Agroecology in Focus' podcast (see 'Further Information').

Solution

Biofumigation involves incorporating brassicaceous cover crops into the soil; they produce a range of secondary metabolites including glucosinolates which can control pests. Brassicas also contain an enzyme called myrosinase. When combined with water and glucosinolates, this enzyme produces volatile compounds (isothiocyanates) which help limit the proliferation of certain pathogens (bacteria, fungi, nematodes) and weeds. However, the effects of crops grown as biofumigants can be variable, with the impacts of the biomass and glucosinolates depending on how the crops are managed and the soil conditions. It is therefore important to make appropriate practical changes at the farming system level.

Benefits

A reduction in soil borne pests and pathogens and weeds - due both to the release of natural toxic substances and the effect of the biofumigation cover crop. Incorporating brassicas biomass into the soil creates a compost effect. This substrate, when used by microorganisms, can deliver volatile compounds acting as biofumigants limiting pathogen and pest development. Growing deep-rooted brassica cover crops can also bring other benefits such as improving soil structure, drainage and nutrient capture and providing a refuge for auxiliaries. The isothiocyanates produced by the biofumigation process can also reduce weed burdens.

Practical recommendation

- **Site selection**-When deciding where to sow, it is important to consider the biofumigant crop as a brassica within your rotation - could it attract insects that could damage your crops, or could it attract insects away from your other crops? Also be aware of potential bird predation. The soil pH can affect the type of volatile organic compounds produced. Low pH soils (below 5) can produce conditions less conducive for biofumigation, make sure therefore that soils have a more neutral pH.
- **Crop type**-To maximise on glucosinolate, the choice of crop species and cultivar is important. Caliente (Indian mustard) (see Figure 1) has been found to be the most consistent in causing reductions in pests and pathogens.
- Oilseed radish has potential but produces less biomass. White mustard should not be considered because it does not produce the

Applicability box

Theme

Rotation, organic, cropping system, learning

Agronomic conditions

Plant into moist soil, above pH 5 and above 8°C.

Application time

Summer (June - August) is optimal (maximum UV, temperature and daylight)

Required time

10 - 14 weeks (growing time for biofumigant crop)

Period of impact

2 weeks

Equipment

Flail mower or strimmer for cutting. Rotavator or spade for incorporation

Best in

Arable or protected cropping



Figure 1: Caliente (Indian mustard). Photo: Matthew Back

right type of glucosinolates.

- **Biomass**-It is important to maximise the volume of material produced from the brassica plants (which need adequate water and nutrition). Aim at producing 50 tonnes of fresh weight, up to 10 tonnes of dry weight per hectare. In contrast to standard cover cropping, you are trying to maximise biomass and glucosinolate content (quantity and quality)
- **Nutrients**-Nitrogen (N) is important for biomass and sulphur (S) for glucosinolate content. Aim at 100kg per hectare (ha) of N and 25kg per ha of S. For organic systems, aim at utilising nutrients from previous crops such as peas or legumes to feed the biofumigatory green manure (mustards can be very good at mopping up and recirculating surface nutrients). If incorporating a 2-year break crop into your rotation (i.e. with legumes or clover), consider reducing it to 18 months and utilising the nutrition to feed the biofumigatory crop.
- **Sowing**-Sowing date for Caliente should be as early as possible (in an arable rotation, sowing in June - July has been found to produce the highest biomass and highest glucosinolate content - due to higher UV, temperatures and longer day length). Plant seeds into clean moist ground, so they can race ahead of and suppress weeds.
- **Incorporation**-Damaging the plant cells allows the glucosinolates and myrosinase to interact with one another - this can be done by flailing, cutting and bruising the tissue as much as possible. Early flowering is when there is a peak of glucosinolates in the plants so this is the best time to cut (with Caliente, this would typically be within 10 - 14 weeks into growing time). Flowers may be at different stages - cut when the majority are closest to early flower as possible (once seed pods are formed it is too late). Outside, applying a light roll over can be beneficial. This should ideally be done coming up to early flowering.
- The volatile organic compounds are lost quickly (within the first 5 hours) after chopping and incorporating the plant material, therefore it needs to be buried quickly. Ideally, incorporate straight after chopping. It is recommended to use a front mounted flail followed by a rear mounted rotavator, and to compress in a one pass system if possible. If growing in protected cropping, it is possible to trim plant material into small pieces, then rotavate it in. Do this a bit at a time, and then apply water. A mower could alternatively be used - pull the whole plant up, roll over it lightly with the mower, then work it in.
- When about to incorporate the plant biomass, make sure the soil is moist enough. It may be best to wait for rain before incorporating (but avoid soaking wet soil). The aim is to enable the release of as much of the volatile gases in the soil as quickly as possible. 75% field capacity is best for optimising the hydrolysis and the biofumigation. The soil temperature needs to be above 8°C for optimal movement of the volatile compounds.
- **Watering**-In protected cropping, consider covering (i.e. with polythene) to lock in the volatile gases and leaving it on for a few days to a week (most of the biofumigation happens in the first 24 - 48 hours). Make sure the soil moisture is good beforehand, watering on top also creates a bit of a cap. On a field scale, irrigate after incorporating - the equivalent of about half an inch. This will create the chemistry and seal it in.).
- **Crop management**-It is important to leave a gap between incorporating the biofumigant crop and planting a cash crop, in order to allow sufficient time to ventilate the soil. Allow a 2-week margin to be safe (even though isothiocyanates are lost within the first 5 hours, there are other volatile compounds that come later). Growing successive crops may lead to a greater suppression of certain soilborne pests and pathogens e.g. potato cyst nematodes.

N.B. The figures for biomass and nutrient recommendations come from research and relate to optimal production and biocidal activity.

Further information

Podcast

- Agroecology in Focus - Biofumigation <https://agricology.libsyn.com/agroecology-in-focus-biofumigation> (English)

Further readings

- Biofumigation (Dictionary of Agroecology) <https://dicoagroecologie.fr/en/encyclopedia/biofumigation/>
- Biofumigation: Practical Information, Advantages and Disadvantages <https://www.best4soil.eu/assets/fact-sheets/11.pdf>
- Biofumigation to suppress pests, weeds and diseases <https://www.fas.scot/downloads/technical-note-tn735-bio-fumigation-to-suppress-pests-weeds-and-diseases/>

Weblinks

- International Biofumigation Network <https://www.harper-adams.ac.uk/research/cipm/2/>

About this practice abstract and DiverIMPACTS

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Project website: www.diverimpacts.net

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