CONTROLLING SOILBORNE DISEASES AND PESTS WITH BIOFUMIGANTS

The soil ecosystem directly impacts crop yield and quality. In recent years, there has been growing interest in sustainable farming practices that improve soil's biological, chemical and physical characteristics. Biofumigation is one of these sustainable practices.

UNDERSTANDING BIOFUMIGANTS

The emerging tool of biofumigation can help reduce reliance on chemical fumigants. Biofumigation involves the cultivation of specialised cover crops. Brassica biofumigant crops release naturally occurring sulphur compounds, especially as they break down. These are harmful to various soilborne pathogens.

Some of these pathogens can persist in soil for extended periods, even when a suitable host is absent. Biofumigation therefore offers a natural method for managing soilborne pathogens as well as some pests and weeds

The problem with soilborne diseases

Dormant stages of some soilborne pathogens can remain inactive in the soil for many years. It is only when conditions become favourable that they multiply and cause symptoms in plants. For example, the onion disease white rot (*Sclerotium cepivorum* pathogen), can endure in the soil for over 20 years, while the potato disease Verticillium wilt (*Verticillium dahliae*) can survive in the soil for up to seven years.

The primary challenge in disease management is to reduce pathogen loads in the soil while preserving or enhancing soil health. Good soil health is the first step in bolstering crop resilience. An integrated approach that incorporates biofumigant cover crops can provide an effective way to manage soilborne diseases.

Which species are useful as biofumigants?

Brassica species, such as mustard, radish, and rocket, have demonstrated their capability to suppress soilborne diseases like basal rot (*Sclerotium rolfsii*), onion white rot (*Sclerotium cepivorum*), charcoal rot (*Macrophomina phaseolina*), and white mould (*Sclerotinia sclerotiorum*).

Common varieties of biofumigants available in Australia include:

- *Brassica juncea* (Indian mustards)
- *Brassica carintata* (Ethiopian mustards)
- *Brassica napus*
- White (*Sinapis alba*) and black mustards (*Brassica nigra*)
- Radish (*Raphanus sativus*), which has the added bonus of producing large roots, up to 80cm-100cm, improving the physical characteristics and providing water channels
- Rocket *(Eruca Sativa*)

Brassica juncea (Source: Hakgala, Sri Lanka. ID:1295029 Not Kew Copyright. Only licensed for display purposes in POWO)

Brassica napus (Source: Wikipedia)

Sinapsis alba (Source: Wikipedia)

SELECTING AND GROWING BIOFUMIGANT CROPS

Choose targeted and locally suited biofumigants[1]

The choice of biofumigant crops plays a pivotal role in the success of integrating them into potato crop rotations. Mustards, radishes, and other brassica species are common selections, each with its unique advantages.

Identifying which soilborne diseases are present at concerning levels is the first critical step. Once they have been identified, biofumigant cover crops can be selected that target that disease, and are suitable for local conditions.

Grow and treat as a cash crop

Proper planting and cultivation practices are essential to maximise biofumigant potential, including timely seeding, appropriate spacing, and careful management. Biofumigant cover crops should be managed like a cash crop, as that is really what they are.

The growth stage at which biofumigant crops are incorporated into the soil influences their effectiveness, emphasising the critical importance of timing for achieving desired results.

When brassica biofumigant crops are pulverised they release two essential chemical groups; glucosinolates and myrosinases. These compounds react to form isothiocyanates (ITCs). The result is production of a gas that effectively suppresses soilborne diseases.

As ITCs are highly volatile, swift and thorough incorporation of the biofumigant material into the soil is crucial. Otherwise, their effectiveness rapidly declines. Faster incorporation therefore yields better outcomes in disease control and soil health improvement.

IMPORTANT STEPS

1. Grow to 25% flowering
2. Mulch into small fragments
3. Incorporate
4. Irrigate or roll to seal biofumigant gases

BENEFITS FOR POTATO GROWERS

Potato growers can reap numerous benefits from incorporating biofumigants. As well as helping manage soilborne diseases, the addition of significant volumes of organic matter can improve soil health. This enhances microbial activity and nutrient cycling. Increased crop yields and improved quality are often reported.

Additionally, biofumigants are effective in reducing nematode populations,

This article is based on content from PotatoLink webinar: Biofumigants and cover crops for disease and nematode management, by John Duff (DAF).

Watch the full webinar here, including a presentation from Dr Mieke Daneel (ARC, South Africa) on nematodes.

Other resources

Guide to: Brassica Biofumigant Cover Crops: Managing soilborne diseases in vegetable production systems.

This resource was developed with funding from the vegetable levy, through project VG16068 - Optimising cover cropping for the Australian Vegetable Industry

1. Biofumigants may not always be successful at controlling soilborne diseases; growers should research the species they plan to grow to see if it hosts other problem diseases as well. Consider the whole system and rotations with other crops. Brassica biofumigants may not be a suitable fit if growing other brassica crops.

CASE STUDY

MANAGING VERTICILLIUM DAHLIAE IN POTATO FARMING

In a recent webinar, John Duff from the Department of Agriculture and Fisheries, Queensland (DAF), presented a case study from a potato grower in the Lockyer Valley who was facing a serious challenge with *Verticillium dahliae* (commonly known as Verticillium wilt) in their fields.

This soilborne pathogen was causing a significant reduction in tuber size with subsequent yield loss, as well as premature plant death. The grower had attempted crop rotations with cereals, such as sorghum and corn, but these strategies were not effective in reducing disease incidence. Moreover, as the pathogen can survive in the soil for up to seven years, extended crop rotations were impractical.

APPROACH

1. **Soil testing:** John and colleagues collected numerous soil samples for comprehensive soil analysis, including a Predicta Pt test. The testing focused on a wide range of soil-borne diseases, with a particular emphasis on the detection of active DNA levels of *Verticillium dahliae*.
2. **Test interpretation:** The soil tests revealed DNA levels well above the problematic threshold, often reaching hundreds or even thousands of picograms per gram of soil DNA. It was evident that the high pathogen load in the soil was a significant contributor to crop losses. In addition to *Verticillium dahliae*, other pathogens were identified, including black dot and nematodes.
3. **Biofumigant selection:** Based on the soil analysis, two biofumigant crops - BQ mulch® (*Brassica carinata* 75% and *B. nigra* 25%) and Caliente™ (*B. juncea*), both known for their high glucosinolate content, were recommended.
4. **Planting and incorporation:** To maximise the biofumigation effect, the grower decided to plant the biofumigant crops in both the spring and late summer/ autumn. A minimum of 2 week gap was recommended between plantings and also the subsequent potato crop. John emphasises that it is vital to incorporate the biofumigant cover crop as quickly as possible on the same day.

Verticillium dahliae (Source: Ontario Crop IPM)

RESULTS

Pre cover crop results showed very high levels of *Verticillium dahliae* causing lots of problems for the grower (Table 1).

The biofumigants were very

Table 1. Soil sampling results for *Verticillium dahliae* (verticillium wilt) pgDNA/g sample (Source: J. Duff, DAF)

Date/ sample	2 Sept 2019 (pre cover crop)	21 Dec 2019	26 Feb 2020	20 May 2020	15 April 2021
1	351	Incorporate BQ mulch	8	Incorporate caliente	1
2	152		14		0
3	82		9		7
4	107		9		13
5	122		15		6
6	274		20		no data
7	364		23		13

NB. Predicta Pt recommendations for levels of DNA: *Verticillium dahliae* pdDNA/g sample; <4 considered low, 4-20 moderate, >20 high

Table 2a. Soil sampling results for *Colletotrichum coccodes* pgDNA/g sample - Area 1 (Source: J. Duff, DAF)

Date/ sample	2 Sept 2019 (pre cover crop)	21 Dec 2019	26 Feb 2020	20 May 2020	15 April 2021
1	661	Incorporate BQ mulch	123	Incorporate caliente	96
2	512		272		91
3	1128		202		136
4	441		193		96
5	513		194		165
6	368		220		no data
7	282		213		122

successful, disease load plummeting after the first incorporation. One year later *Verticillium dahliae* levels were still low, and only now, three years later, are they slowly increasing (results not shown). Going forward, the grower plans to include a biofumigant in his crop rotation to manage the issue.

Although the grower was not concerned about black dot, results showed elevated levels of inoculum in the soil. While the selected biofumigant crops were not so impactful against black dot as *Verticillium dahliae*, DNA load decreased dramatically (Table 2).

Because this grower's paddocks are sandier than elsewhere in the Lockyer Valley, he did have a nematode problem (note: the Predicta Pt test cannot distinguish between species of nematodes).

After one application of biofumigants, numbers almost disappeared. Even one year later after growing potatoes in the same soil, nematodes are still almost non-existent (Table 3a and 3b).

BIOFUMIGANT CROP MANAGEMENT

The biggest challenges faced by the grower were foliar diseases on the biofumigant crops, such as downy mildew, and the presence of aphids. These challenges required continual management, including regular monitoring for pests and diseases.

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Table 2b Soil sampling results for *Colletotrichum coccodes* pgDNA/g sample – Area 2 (Source: J. Duff, DAF)

Date/ sample	2 Sept 2019 (pre cover crop)	21 Dec 2019	23 March 2020	27 May 2020	10 Sept 2020
1	492	Incorporate caliente	70	Incorporate caliente	69
2	563		93		129
3	517		123		70
4	518		87		144
5	586		205		186
6	487		200		173
7	421		166		264
8	493		194		214
9	387		177		173
10	558		200		286

NB. Predicta Pt recommendations for levels of DNA: *Colletotrichum coccodes* (black dot) pdDNA/g sample - <4 considered low, 4-40 moderate, >40 high

Table 3a. Soil sampling results for *M. javanica/incognita/arenaria* pgDNA/g sample – Area 1 (Source: J. Duff, DAF)

Date/ sample	2 Sept 2019 (pre cover crop)	21 Dec 2019	26 Feb 2020	20 May 2020	15 April 2021
1	261	Incorporate BQ mulch	1	Incorporate caliente	0
2	173		3		0
3	103		0		0
4	133		1		2
5	25		6		0
6	23		0		no data
7	11		0		0

Table 3b. Soil sampling results for *M. javanica/incognita/arenaria* pgDNA/g sample – area 2 (Source: J. Duff, DAF)

Date/ sample	2 Sept 2019 (pre cover crop)	21 Dec 2019	23 March 2020	27 May 2020	10 Sept 2020
1	184	Incorporate caliente	0	Incorporate caliente	2
2	36		0		0
3	232		0		0
4	76		0		0
5	50		2		0
6	73		0		0
7	194		0		0
8	199		0		0
9	68		2		0
10	15		0		0

NB. Predicta Pt recommendations for levels of DNA: *rootknot nemoatodes* pdDNA/g sample - <5 considered low, 5-50 moderate, >50 high