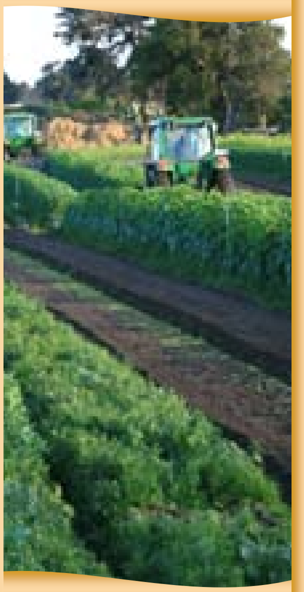
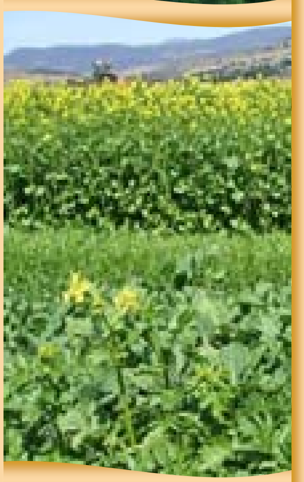
Managing Soilborne Diseases in Vegetables

Vegetable Disease Program IPM

Rotation with green manure and biofumigant crops shows disease control & yield benefits

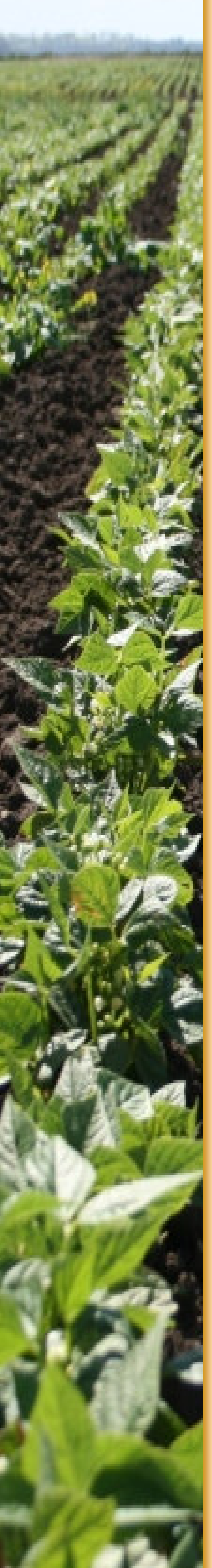
KEY MESSAGES

- Crop rotation strategies can reduce inoculum of soilborne pathogens by breaking the disease cycle, biofumigation activity (e.g. mustards) and/or improving soil health.
- Biofumigant crops with the highest levels of isothiocyanate (ITC) producing glucosinolate (GSL) compounds were more effective for pathogen control.
- In-field effects of *Brassica* biofumigant crops include excellent weed suppression, a reduction of root rots in green beans and lettuce drop and an increase in the fresh weight of spring onions.
- Biofumigant crops should be pulverised before incorporation into moist soil to ensure biofumigant compounds are released into the soil.
- Some green manure crops showed other soil benefits including increased organic matter, nitrogen and soil biological activity.

Victoria
The Place To Be

DEPARTMENT OF PRIMARY INDUSTRIES

biosciences research



Researchers at Vic DPI, Qld DEEDI and Peracto are finding that green manures and *Brassica* biofumigant crops provide many benefits within vegetable cropping systems. Information from trials including the agronomic characteristics of these crops, their biofumigant potential, effects on key soil health parameters and compatibility with current cropping systems is being used to develop new strategies for managing soil-borne diseases in vegetable production.

Identifying Biofumigant Crops with Anti-fungal Activity

Laboratory and glasshouse studies identified four *Brassica* biofumigant crops, Caliente 199™, Mustclean™, Gladiator™ and Nemfix™, with excellent activity against four major soil-borne pathogens of vegetables. Volatile compounds (ITCs), produced from precursor glucosinolates (GSLs) contained in freeze dried tissue of these biofumigants, were inhibitory and/or biocidal to *Sclerotinia minor*, *Fusarium oxysporum*, *Pythium dissotocum* and *Rhizoctonia solani* (Table 1).

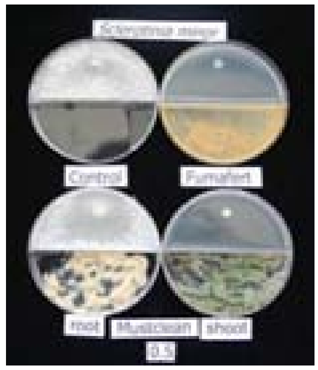


Figure 1. Petri dish assay used to determine biofumigant volatiles effect against soilborne pathogens

Table 1. Effect of biofumigant volatiles on growth of vegetable pathogens in culture, compared with Fumafert™, the standard control, and untreated controls.

Treatment	Relative-GSL content[1]	Rate*	Pathogen			
			S. minor	*P. dissotocum.*	*F. oxysporum*	*R. solani*
Fumafert™	high	0.25	B	B	B	B
		0.50	B	B	B	B
Caliente 119™	high	0.25	I	I	I	B
		0.50	B	B	B	B
Mustclean™	mod	0.25	N	N	N	N
		0.50	N	I	N	N
BQ Mulch™	mod	0.25	I	I	I	N
		0.50	I	I	I	I
Gladiator™	low	0.25	N	-	-	-
		0.50	B	-	-	-
Nemfix™	high	0.25	B	-	-	-
		0.50	B	-	-	-

[1] 2-propenyl-GSL (sinigrin) in shoot tissue, e.g. Caliente 35-70 µMol/g DW. * Rate = grams tissue/ plate
B = biocidal; I = inhibitory; N = no effect; - = not yet tested
Mustclean was more inhibitory at > 0.50g/plate (data not shown)

Effect of Green Manure and Biofumigant Crops on Disease, Yield and Soil)

Field trials in Victoria and Tasmania demonstrated that using Mustclean™ and Caliente 199™ as green manure rotation crops significantly reduced lettuce drop and bean root diseases. For instance, the biofumigation effect of Mustclean™ reduced lettuce drop by 62% and bean root rots by 35%, compared with fallow or grass and cereal rotations. Caliente 199™ had the highest average concentration of shoot GSL (2-propenyl) across all Victorian field sites although the concentration recorded in tissue collected at Lindenow was low due to uneven plant growth (Table 2). At this site legume crops including faba bean and, to a lesser extent, vetch were also a good rotation choice providing similar levels of disease control to biofumigants. These preliminary results indicate potential disease control benefits which warrant further investigation over the long term. At another site, Caliente 199™ increased the fresh weight of spring onions by 16%. In addition, results showed that some of the green manure crops improved soil health by increasing organic matter, nitrogen and beneficial microbial activity.

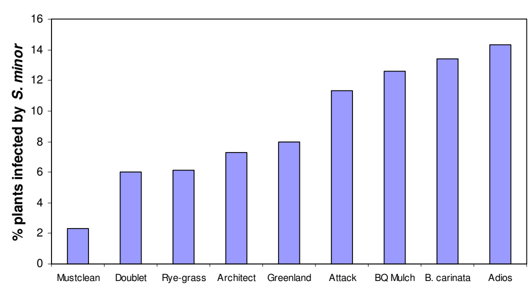


Figure 2. Effect of biofumigation with eight biofumigant plant varieties (rye-grass is the control) on lettuce drop caused by *S. minor* in Tasmania.

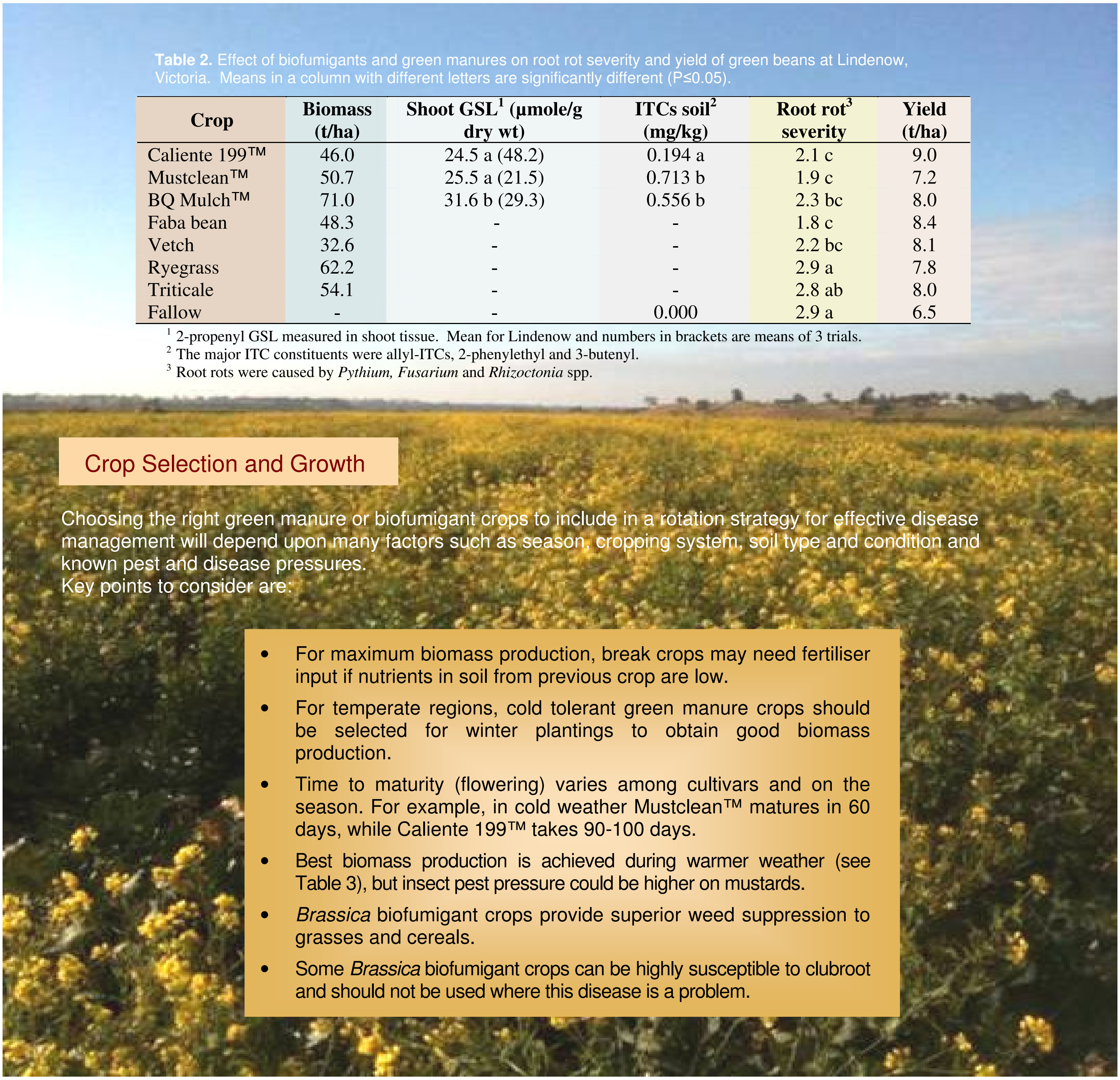


Table 2. Effect of biofumigants and green manures on root rot severity and yield of green beans at Lindenow, Victoria. Means in a column with different letters are significantly different (P≤0.05).

Crop	Biomass (t/ha)	Shoot GSL[1] (µmole/g dry wt)	ITCs soil[2] (mg/kg)	Root rot[3] severity	Yield (t/ha)
Caliente 199™	46.0	24.5 a (48.2)	0.194 a	2.1 c	9.0
Mustclean™	50.7	25.5 a (21.5)	0.713 b	1.9 c	7.2
BQ Mulch™	71.0	31.6 b (29.3)	0.556 b	2.3 bc	8.0
Faba bean	48.3	-	-	1.8 c	8.4
Vetch	32.6	-	-	2.2 bc	8.1
Ryegrass	62.2	-	-	2.9 a	7.8
Triticale	54.1	-	-	2.8 ab	8.0
Fallow	-	-	0.000	2.9 a	6.5

[1] 2-propenyl GSL measured in shoot tissue. Mean for Lindenow and numbers in brackets are means of 3 trials.
[2] The major ITC constituents were allyl-ITCs, 2-phenylethyl and 3-butenyl.
[3] Root rots were caused by *Pythium, Fusarium* and *Rhizoctonia* spp.

Crop Selection and Growth

Choosing the right green manure or biofumigant crops to include in a rotation strategy for effective disease management will depend upon many factors such as season, cropping system, soil type and condition and known pest and disease pressures.
Key points to consider are:

- For maximum biomass production, break crops may need fertiliser input if nutrients in soil from previous crop are low.
- For temperate regions, cold tolerant green manure crops should be selected for winter plantings to obtain good biomass production.
- Time to maturity (flowering) varies among cultivars and on the season. For example, in cold weather Mustclean™ matures in 60 days, while Caliente 199™ takes 90-100 days.
- Best biomass production is achieved during warmer weather (see Table 3), but insect pest pressure could be higher on mustards.
- *Brassica* biofumigant crops provide superior weed suppression to grasses and cereals.
- Some *Brassica* biofumigant crops can be highly susceptible to clubroot and should not be used where this disease is a problem.

Table 3. Sowing dates, time to maturity (incorporation) and biomass production of different biofumigant crops trialled in Victoria, Tasmania and Qld.

Cultivar	Site	Common and scientific name[1]	Sown	Incorporated[2]	Biomass t/ha[2]
Mustclean™	Vic	Indian mustard (*B. juncea*)	March	May	87
Mustclean™	Tas	Indian mustard (*B. juncea*)	May	October	30
Mustclean™	Tas	Indian mustard (*B. juncea*)	October	December	77
BQ Mulch™	Vic	Rape/turnip *B. napus/campestris*	March	July	118
BQ Mulch™	Tas	Rape/turnip *B. napus/campestris*	May	October	62
BQ Mulch™	Tas	Rape/turnip *B. napus/campestris*	October	December	65
BQ Mulch™	Qld	Rape/turnip *B. napus/campestris*	February	April	-
BQ Mulch™	Qld	Rape/turnip *B. napus/campestris*	December	January	-
Caliente 199™	Vic	Indian mustard (*B. juncea*)	March	July	95
Architekt™	Tas	White mustard (*Sinapsis alba*)	October	December	50
Adios™	Tas	Oilseed radish (*Raphanus sativus*)	May	October	83
Adios™	Tas	Oilseed radish (*Raphanus sativus*)	October	December	102

[1] Architekt™ and Abraham™ were highly susceptible to frost damage. Other biofumigant varieties evaluated in Tasmania were white mustard (Abraham™ and Attack™), forage rape (Greenland™), oilseed radish (Arena™ and Doublet™) and Ethiopian mustard (*B. carinata*).
[2] Mustards incorporated at flowering. Variation in biomass levels is due to sowing time and soil types.
- Not assessed

Cultivation and Incorporation

The ideal time to incorporate *Brassica* biofumigant crops is at flowering, before any seed is formed. This is the stage when glucosinolate concentration is at its peak, and also prevents these plants from becoming weeds.

For the best effect, the crop should be completely macerated before incorporation into moist soil to release the isothiocyanate (ITC) compounds. These compounds are highly volatile, so the soil surface should be sealed by rolling or irrigation after incorporation to minimise their escape from the soil.

Contact:
Caroline Donald (VIC DPI, 03 9210 9299)
Oscar Villalta (VIC DPI, 03 9210 9269)
Hoong Pung (Peracto P/L, 03 6423 2044)

Practical methods to optimise the disease control effect of *Brassica* biofumigants include:

- Pulverising plant tissue using a flail mower with hammer blades before incorporation into moist soils.
- Sealing the soil surface with a roller attached to the back of the rotary hoe and/or with irrigation.
- Incorporate tissue into moist soil to initiate the breakdown of glucosinolates into ITCs compounds which are biocidal to soilborne pathogens.

Other novel disease management strategies being developed as part of this program

Grafting

In the Northern Territory, field trials using snake beans grafted onto a Fusarium resistant Iron cowpea root stock have reduced the incidence of Fusarium wilt by as much as 98%. The feasibility of adapting this technique to other vegetable crops is being investigated.
Contact Barry Condè (NTDR) 08 8999 2265

Figure 3. Alternating rows of healthy (grafted) and unhealthy, Fusarium wilt affected (non-grafted) snake beans

Disruption of Fungal Resting Structures

Melanised fungal structures called sclerotia enable many fungal pathogens to survive for long periods in soil. Fundamental research has identified the pathway by which *Sclerotinia* produces melanin. Chemical disruption of this pathway resulting in inhibition of sclerotial development and/or melanisation has been demonstrated. Work is continuing to identify genes involved in sclerotial formation. These may provide targets for sustainable control of *Sclerotinia* and other soil-borne plant pathogens.
Contact Kim Plummer (La Trobe University, 03 9479 2223)

Fungal Derived Volatiles

Australian native plants have been found to be excellent sources of endophytic fungi that produce volatile antimicrobial metabolites. A total of 18 endophytes (from one genus) demonstrated strong antimicrobial activity against key soil-borne pathogens of vegetable crops *in vitro.* Mycofumigation produced results equivalent in pot trials to the commercially available fumigant Basamid®, reducing inoculum of *R. solani* by >99%.

Table 4. A comparison of the effects of mycofumigation with Isolate 1.1 and the commercial fumigant Basamid® on populations# of *Pythium* spp. and *Rhizoctonia solani* (AG 2.1) in soil.

Treatment	*Pythium* spp. DNA (pg / g soil)	*Rhizoctonia solani* (AG 2.1) DNA (pg / g soil)
Untreated	179	10,581
Isolate 1.1	65	4
Basamid®	4	0
P Value	0.004	<0.001
LSD (5%)	131.5	5571.3

 # - pathogen populations in soil quantified by amount of DNA present

Plant Derived Compounds

Inhibitory and biocidal activity and soil-borne disease control potential of thyme, clove bud and origanum has been demonstrated using *in vitro* and pot bioassays. Further work is required to optimise in-field application rates and methods.
Contact Caroline Donald (VIC DPI, 03 9210 9299)