Project Title	Field grown horticultural crops. A costed study in the use of selected green manures/biofumigants to control selected nematode pests and pythia and their influence on soil nutrition status.
Project number:	FV 273
Project leader:	Mr P Knight, VCS Ltd
Report:	Final report, March 2006
Key staff:	Dr Sue Hockland Dr. Philip Jennings Tony Prickett Tom Prior
Location of project:	CSL and two field sites on commercial farms in Norfolk.
Project coordinator:	Andrew Burgess, R. B. Organic Ltd, Stanley Farm, Great Drove, Yaxley, PE7 3TW
Date project commenced:	1 April 2005
Date completion due:	31 March 2006
Key words:	Biofumigant, biocidal crop, *Brassica juncea,* cultivations, fallow, free-living nematodes, green manure, mustard, pythia, soil nutrition.

The results and conclusions in this report are based on two trials conducted over a one-year period. The conditions under which the experiments were carried out and the results have been reported in detail and with accuracy. However, because of the biological nature of the work it must be borne in mind that different circumstances and conditions could produce different results. Therefore, care must be taken with interpretation of the results, especially if they are used as the basis for commercial product recommendations.

AUTHENTICATION

We declare that this work was done under our supervision according to the procedures described herein and that the report represents a true and accurate record of the results obtained.

[Name]
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CONTENTS

Grower Summary

Headlines

- Caliente Brand Mustard 119 replaced Nemat *Eruca sativa* as a biocidal crop in the trial.

- The Mustards increased the levels of plant-parasitic nematodes during the growing period and but reduced them after incorporation.

- However, there was no overall significant reduction of plant-parasitic nematodes by either Mustard 99 or Mustard 119 (each different blends of *Brassica juncea*) compared to fallow plots.

- There was no overall significant reduction of pythia by the biocidal crops compared to fallow plots.

- Overall, few significant differences were found between biocide crop areas and uncultivated fallow for K, Mg, P or pH during the project.

- The biocide crops appear to capture N and will thus serve to assist in its management and delay leaching.

- Both Caliente Brand Mustards 99 and 119 produced total ground cover canopy in three weeks and good weed suppression was observed, for the entire nine week life of the crops.

- The effect of the biocidal crops was not the same at each site, supporting evidence that the ability of such crops to reduce pest pressure and improve soil quality will vary with factors such as soil type, management techniques and weather conditions.

- Long-term studies of the regular use of biocidal crops are necessary to assess their full potential.

Background and expected deliverables

Certain pesticides such as Temik are often used prophylactically to control plant-parasitic nematodes, but whether such use is warranted has been the subject of recent HDC research (HDC Reports FV232, FV249) and debate (HDC Report FV 278). Whilst this product is due to be revoked on 31 December 2007, alternative chemical products may be used.

Intensive root crop rotations on light/medium soil types with irrigation are leading to higher levels of soil-borne fungal pathogens and novel methods of control are being sought.

Assured Produce Schemes are encouraging the use of sustainable pest management practices, such as the inclusion of poor or non-host crops (being investigated in The Netherlands (Korthals *et al.*, 2004) or green manures or biofumigants (collectively called 'biocidal crops) which are now being marketed in the UK. Generally speaking, green manures may serve several functions including improvement of soil conditions, whilst biofumigants have properties that are used specifically for the control of pathogens, although they may also, incidentally, improve soil structure. Both crops have potential as weed suppressants. However, there is a need for an independent assessment of the benefits and disadvantages of such crops, especially for the control of pests and diseases. Such work is being carried out worldwide, but there has been little investigation in UK conditions.

This project sought to investigate and quantify the effectiveness of two biocidal crops being sold as green manures and biofumigants, namely Caliente Brand Mustards 99 and 119 (hereafter called Mustard 99 and Mustard 119), in controlling plant-parasitic nematodes and pythia as well as their influence on the nutritional status of the soil. Mustard 99 is *Brassica juncea* ISCI 99, and is particularly high in glucosinolates. The particular blend of glucosinolates and enzymes will, in theory, affect the amount of isothiocyanates that are produced when the crop is chopped and incorporated and hence the level of kill of plant-parasitic nematodes and other pathogens. Mustard 119 is a blend of *Brassica juncea* and *Sinapsis alba,* with ISCI 20 being the predominant species in the blend, and was said to be the best all-round variety.

In such a short investigation the results can only suggest the consequences of using such crops and their role in developing an integrated crop management system that would offer a more sustainable option for the future control of pathogens in vegetable crops.

Summary of the project and main conclusions

- There were higher levels of plant-parasitic nematodes in the Mustard areas than the fallow areas by pre-incorporation (crop at full crop canopy, four weeks from first flower), despite the latter supporting a range of weeds that could act as nematode hosts

- Also at pre-incorporation, there was a significant increase in the number of stubby-root nematodes in Mustard 99 compared to the fallow plots, but this effect was not detected with the Mustard 119 crop.

- Whilst the biofumigant effect of the incorporated biocidal crops significantly reduced their higher levels of nematodes, it was not sufficient to reduce them below the levels found in the fallow plots six weeks post-incorporation, resulting in no differences between the treatments for total numbers of nematodes. The reduction in total nematode numbers was more noticeable at Knights than at Elveden.

- Overall there was no statistically significant difference between treatments for total pythia counts.

- The cultivation action on incorporation had itself no significant effect on nematode levels, although there was a small and just significant effect of cultivation on pythia in the Mustard 99 areas but not in the Mustard 119 areas.

- Nutrient values of soil from the cropping area were compared with soil from the uncultivated fallow plots for all sampling dates. Nitrogen was applied to all plots after drilling, making the most important comparison for N that relating to variations between pre-incorporation and six weeks post-incorporation.

- At pre-drilling there were no significant differences in nutritional values across the plots or through the profiles, except for K in the Mustard 119 area, where the mean level was higher in the uncultivated fallow.

- The levels of P, K, Mg or pH did not change between pre-drilling and pre-incorporation.

- Between pre-incorporation and six weeks after incorporation K levels in Mustard 99 plots increased by 7.8% compared with a 6.3% drop for uncultivated fallow. This represents a capture of K during cropping then subsequent release after the crop was incorporated. However, such an effect did not occur with Mustard 119. There were no statistically significant differences in pH with either Mustard 99 or Mustard 119.

- Over the whole sampling period, however, the only changes were a slight decrease in pH in the uncultivated fallow compared with Mustard 99 whilst in Mustard 119 there was an increase of P and K.

- Between pre-drilling and pre-incorporation N values at both depths varied. The change was greatest in uncultivated fallow, where the levels of N were higher. This higher level of N, in the uncultivated fallow, when compared with the cropped areas, reflects the biocidal crops ability to capture N.

- The difference in levels of N between the two profiles (0-30cm and 30-60cm) was the same in both the biocidal crops and the uncultivated fallow at pre-drilling and six weeks post-incorporation. At pre-incorporation, there were no differences with Mustard 99 but with Mustard 119 there was a slight difference caused by just significantly higher N in the cropped area compared to the fallow.

- Between pre-incorporation and six weeks after incorporation there was a significant increase of N in the shallow profile with both biocidal crops compared with a small loss in uncultivated fallow. In the deeper profile there was a greater difference between the increase of N in Mustard 99 and the small loss with the associated uncultivated fallow but with Mustard 119 there was no significant difference. Comparing real values of N, variations were found between sites; at Elveden there was a mean increased availability behind Mustards of 80kg N/Ha (indicating effective trapping and then release). The associated fallow showed a mean decrease or 61kgN/Ha (indicating loss by leaching). For the same period at Knights there was a mean increase of 35kgN/Ha behind Mustards (again showing these crops' ability to trap and release N). However, the fallow here also registered a small increased availability of 6kgN/Ha. These results suggest that environmental or site variations are important. There is a need for extending the sampling period post-incorporation to gain better understanding of the period of release (mineralisation) of N from green manures.

- Both Caliente Brand Mustards 99 and 119 produced total ground cover canopy in three weeks, resulting in good weed suppression compared to the fallow areas. This effect was also noticeable six weeks after incorporation.

- The results supported previous suggestions that individual biocide 'brands' may differ in their particular effects, each 'brand' being a blend of different cultivars in order to maximize particular effects.

- A range of factors, such as differences in management techniques and environmental factors, probably contributed to site differences in nematode control and N levels seen in this project. Soil type varied; both sites are glacial deposits, with fields at Elveden being a deep loamy sand over chalk but in places over deep sand and occasionally small areas of clay, whilst Knights Top Battle is a sandy loam (but not so deep) over chalk with pockets of deep sand. Thus the latter site has potentially the most moisture retentive soil. Such factors will affect the ability of biocidal crops to reduce pest pressure or improve soil quality.

- Overwintering a biocidal crop, or drilling and incorporating it close to drilling may provide benefits not seen here, providing cress tests indicate no phytotoxic effects are likely.

- Such a relatively small investigation can only give an indication of the effects of the selected biocidal crops on soil quality and pests and diseases of specific interest to carrot growers. Further work is needed to clarify the effects of biocidal crops in a sustainable rotation, and their contribution to a long-term improvement in both soil condition and pest and disease control.

Financial benefits

A relatively small investigation such as this will only provide an indication of the potential of the selected biocidal crops. However, the findings could result in more productive use of Defra grants. The costs associated with the use of mustard crops are set out below, but a full assessment of benefits is not possible as sampling did not continue to eventual cropping of the field sites.

Table 1. The cost of establishing and management of Mustard crops to include incorporation. Expressed as cost per Ha for commercial areas at contract/farmer rates (associated costs from A.B.C. Farm Machinery Costs Book).

Variables:	Comments	Cost
Seed	ISCI 99 @ 10Kg/Ha x £8.80	£88.00
	199 @ 15Kg/Ha x £6.00	£90.00
Fertilizer:	Nitrogen @140KgN/Ha x £0.53	£72.20
Total Variables:		£72.20
Operations:		
Plough/Press		£40.00/33.00
Combi Drill		£37.25/29.50
Fertilizer Spreading		£ 6.00/ 5.00
Roll		£14.00/10.00
Irrigate 30mm x £2.2		£66.00
Mulch		£16.00/12.00
Disc/Press		£31.00/26.50
Total cost		£371.45/343.20

The most likely cost to change is irrigation; the 30mm applied is based on experience from the project with most applied at time of incorporation.

Biocidal crops offer savings as part of a soil management/rotation enhancing policy.
Cultivations of fallow land x 3 @ £16.60/12.90 =£49.80/38.70
Fertilizer input to the following crop will also be reduced. A small increase in organic matter will help soil management (a requirement of Single Farm Payment) with possible reductions in levels of erosion, both water and wind.

Action points for growers

If growers are considering incorporating biocidal crops into a rotation they should note that

- Significant benefits of biocidal crops compared with uncultivated fallow for nematode and pythia control have not been seen in this project
- Biocidal crops may assist in the retention of N for the benefit of subsequent crops, thus may have a place in rotation
- Biocidal crops may offer a sustainable method of weed control between crops
- Overwintering a biocidal crop, or drilling and incorporating it close to drilling may provide benefits not seen here, providing cress tests indicate no phytotoxic effects are likely.

Acknowledgements

We are grateful for the assistance of the following companies for the use of their sites and assistance with ground work:

Elveden Farms Ltd, Estate Office, Elveden, Thetford, Norfolk, IP24 3TQ

Knights Farms Ltd, The Estate Office, Lower Farm, Narborough, Kings Lynn, Norfolk, PE32 1JB

We are also grateful to Tom Will and Emily Heading (Vegetable Consultancy Services), James Quill and all staff involved with extraction of nematodes and *Pythium* from soils (Central Science Laboratory) for their invaluable assistance with this project.

Lastly, for supplying the seed free of charge, our thanks go to Plant Solutions Limited, Pyports, Downside Bridge Road, Cobham, Surrey KT11 3EH

Science Section

Introduction

Certain pesticides such as Temik are often used prophylactically to control plant-parasitic nematodes, but whether such use is warranted has been the subject of recent HDC research (HDC Reports 232, 249) and debate (HDC Report FV 278). Whilst Temik is due to be revoked on 31 December 2007, alternative chemical products may be used.

A literature review prepared for the HDC in conjunction with the proposal for this project (Hockland, 2005; Appendix 1) concluded that chemicals derived from biofumigant crops offered an additional sustainable control tool to reduce pathogens and weeds. Intensive root crop rotations on light/medium soil types with irrigation are leading to higher levels of soil-borne fungal pathogens and thus novel methods of control are also being sought for diseases.

A range of biocidal crops is being marketed in the UK, but none offer blanket control of all pathogens and the effectiveness of many biocidal crops is difficult to predict. There has been no scientific or costed assessment of the field use of biofumigants in horticultural crops in the UK, thus lending support to this investigation. Concurrently, new formulations of biocidal plant products are being developed (such as a pelleted form), making their use more versatile, so growers also need to consider if they need the potential advantages of growing such crops as a green manure for improving soil structure or as a crop cover for weed control.

This project sought to investigate and quantify the effectiveness of two biocidal crops being sold as green manures and biofumigants, namely Caliente Brand Mustards 99 and 119 (hereafter called Mustard 99 and Mustard 119), in controlling plant-parasitic nematodes and pythia as well as their influence on the nutritional status of the soil. Mustard 99 is *Brassica juncea* ISCI 99, and is particularly high in glucosinolates. The particular blend of glucosinolates and enzymes will, in theory, affect the amount of isothiocyanates that are produced when the crop is chopped and incorporated and hence the level of kill of plant-parasitic nematodes and other pathogens. Mustard 119 is a blend of *Brassica juncea* and *Sinapsis alba,* with ISCI 20 being the predominant species in the blend, and was said to be the best all-round variety (Anon, 2004).

In such a short investigation the results can only suggest the consequences of using such crops and their role in developing an integrated crop management system that would offer a more sustainable option for the future control of pathogens in vegetable crops.

Materials and Methods

On 7 April 2005 soil sampling took place in Norfolk to determine those fields likely to offer the best combination of plant-parasitic nematodes and pythia for assessment purposes. The trials eventually took place on two sites, namely Elveden Waterloo and Knights Top Battle, and the sequence of events is set out in Table 2. On each site the trial followed a fully randomized replicated plot design, using four replicates of each treatment, which were 'Mustard 99', 'Mustard 119', and fallow, either with cultivation only at incorporation or with no cultivation at all. Soil samples for nematode, pythia and nutritional analysis were taken pre-drilling in June, pre-incorporation of the biocidal crops in August and six weeks post-incorporation in September.

Table 2. Sequence of events at Elveden Waterloo and Knights Top Battle, Norfolk

Date	**Task**	**Site**
week beginning 23.05.05	Sites ploughed and pressed	
24/25.05.05	Sites marked out	
01.06.05	First full plot sampling	Elveden (dry)
02.06.05		Knights (wet)
03.06.05	Drilling and rolling	Both (good moisture)
Pre- drilling	N application 140Kg N both sites	Knights
Post-drilling		Elveden
Immediately post drilling – heavy rain		both sites
09/10.06.05	Crop emergence	Both
w.c. 20.06.05	Crop 3 / 4 TL	Both
w.c. 27.06.05	Crop total ground cover	Both

Date	Task	Site
w.c. 04.07.05	Crop stem extension	Both
w.c. 11.07.05	Crop flowering commenced	Both
15.07.05	High level caterpillar & some aphid - Sprayed Hallmark	Knights
30.07.05	Irrigated 25mm	Elveden
03.08.05	Pre-incorporation plot sampling	Elveden
04.08.05		Knights
03.08.05	Crop chopped & incorporated; control plots requiring cultivation also done	Elveden
05.08.05	Crop chopped & incorporated; control plots requiring cultivation also done	Knights
06/07.08.05	Irrigated 20mm	Knights
06.09.05	Weed population & growth survey	Both
14.09.05	Final plot sampling (6 weeks post incorp)	Elveden
15.09.05		Knights

Soil sampling and site selection

Soil samples were taken using a 'cheese corer' type auger, taking at least 40 cores up to a depth of 30cm along a W-path across a field or plot. For Nitrogen samples a deeper core of soil was taken and a surface to 30cm section was separated from the 30-60cm section to provide two samples for analysis.

Extraction and recording of plant-parasitic nematode species

Soil samples were processed using the Whitehead Tray method and the numbers and genera of the free-living plant-parasitic species were recorded for each plot.

Isolation of pythia from soil

A sub-sample of the soils used for the determination of nematodes was used for the detection of *Pythium* species.

A 30g sub-sample was weighed from each main soil sample into 300 mL glass bottles and 250 mL of de-ionised water added. The soil/water solution was shaken and left to soak for one hour. Following the period of soaking the solution was shaken for a further two minutes using a Stuart flask shaker set at maximum.

All soil solutions were then diluted 1:10 using sterile de-ionised water and 0.1 mL of the neat and diluted soil solutions spread plated onto separate plates of the *Pythium/ Phytophthora* selective agar PARP (Jeffers and Martin, 1986; Cornmeal Agar (CMA)

17 g/L, Pimaricin 5 mg, sodium ampicillin 250 mg, Rifampicin 10 mg dissolved in 1ml dimethyl sulfoxide (DMSO), pentachloronitrobenzene (PCNB) 100 mg. All amendments were either suspended or dissolved in 10 ml of sterile distilled water and added to CMA after it had been autoclaved and cooled to 50°C in a water bath).

Plates were incubated at 20°C and after a period of 36-48 hours the number of colonies growing counted. Colonies were transferred onto Potato Dextrose Agar (PDA) and incubated at 20°C for 3 days. To allow differentiation between the colonies they were then sub-cultured onto CMA. Both CMA and PDA plates were returned to the 20°C incubator for a further 7 days. Colonies were assessed microscopically for production of spores and associated structures, in addition growth pattern and growth rate were recorded. For each group of 'presumptive pythia' the number of colonies were counted and the number of colony forming unit per gram of soil calculated.

To try and encourage spore production a number of the colonies isolated were also grown on pieces of grass (sterilised by boiling for 5 min) floating in a 50:50 mix of pond and de-ionised water.

Nutritional analysis

The basis of the analysis was as practiced by ASA, i.e. the Analysis of Agricultural Material (ADAS Reference Book 427). All soil samples were stored and transported in insulated containers.

Statistical analysis

Statistical analysis was by Analysis of Variance (anova) with contrasts, using Genstat 8. There were three treatments (Biocide, Cultivation, No Cultivation) with four replicates of each treatment at each of the two sites. There were two complete experiments conducted with each biocide crop at the same time, one with Mustard 99 and one with Mustard 119. In the analysis the sites were blocks and the two contrasts were Biocide versus Cultivation and Biocide versus No cultivation. The pythia and nematode counts for stunt and stubby nematodes were transformed to logarithms for the analyses (log(n+1) for (since these counts contained zeroes), which successfully normalised the data and stabilised the variances, thus meeting the requirements of anova. The initial values for the soil nutritional data in June were compared by anova (Genstat) to see if they differed between the Crop and No Cultivation plots. The difference between N at 30 and 60cm was compared between treatments at each time point. Further comparisons of the difference between the August and September soil analyses was by anova with Mustards 99 and 119 as the two treatments and the two sites as blocks. The Mustard 99 and Mustard 119 trials were analysed separately.

Results and Discussion

Results of soil samples taken for site selection are set out in Appendix 2. The Contract required that the results were reviewed in early autumn to assess whether the sampling regime should be repeated in the spring, before cropping. As the results from the nematode sampling inferred the biocidal crops had had no significant effect on nematode numbers and virtually no effect on levels of pythia, it was decided not to proceed with further sampling.

Results of nematode extractions

Details of the numbers found of each nematode group are set out in Appendix 3A, 3B and 3C.

Results of pythia isolations

The medium used was selective for both *Pythium* and *Phytophthora* species and the growth patterns of all the colonies isolated were consistent with these groups. The colonies isolated were labelled 'presumptive pythia', however some of these may have been *Phytophthora* species. Only group P2 of the 'presumptive pythia' was positively identified to species, this was *Pythium ultimum* (a well known pathogenic species).

Effects of Biocides on Nematodes and pythia

The results of the sampling for total nematode numbers, total pythia, root-lesion and stubby-root nematodes are represented in Figs 1 – 8.

Fig 1. Numbers of total plant-parasitic nematodes on each sampling date - Mustard 99

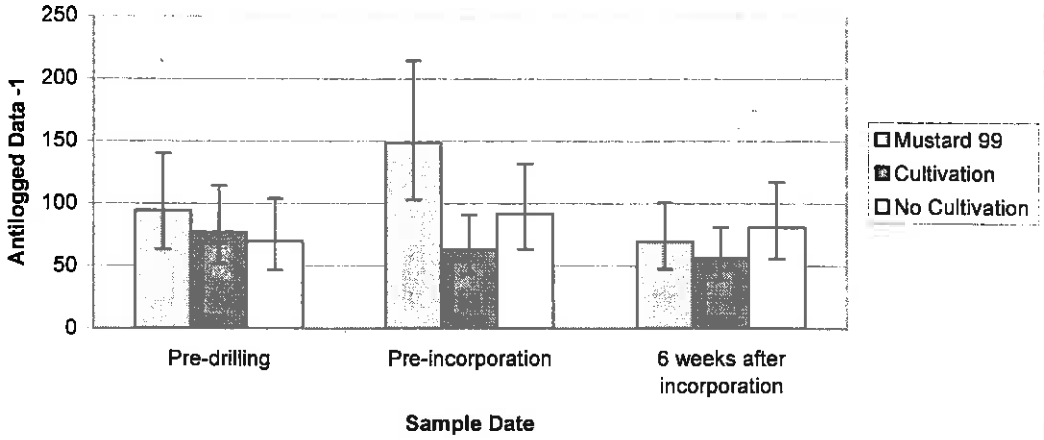
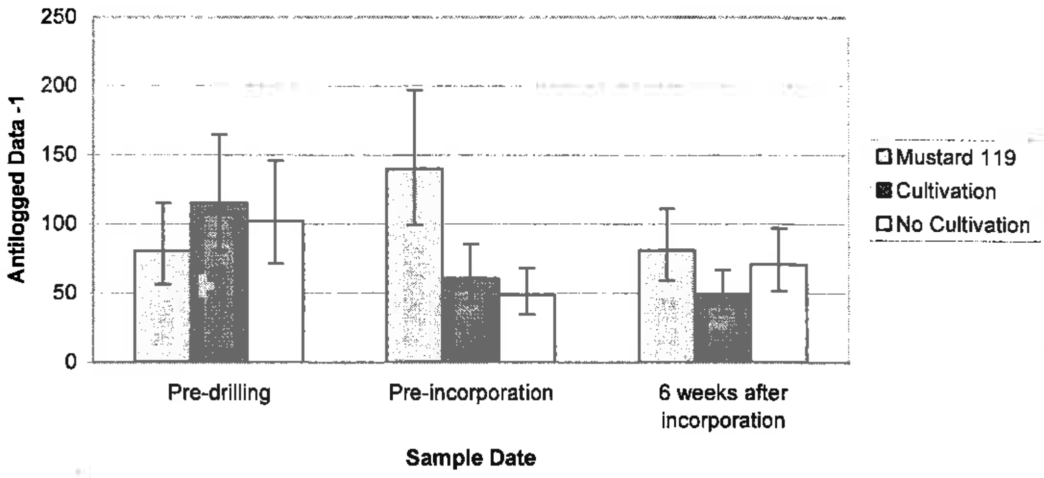


Fig 2. Numbers of total plant-parasitic nematodes on each sampling date - Mustard 119



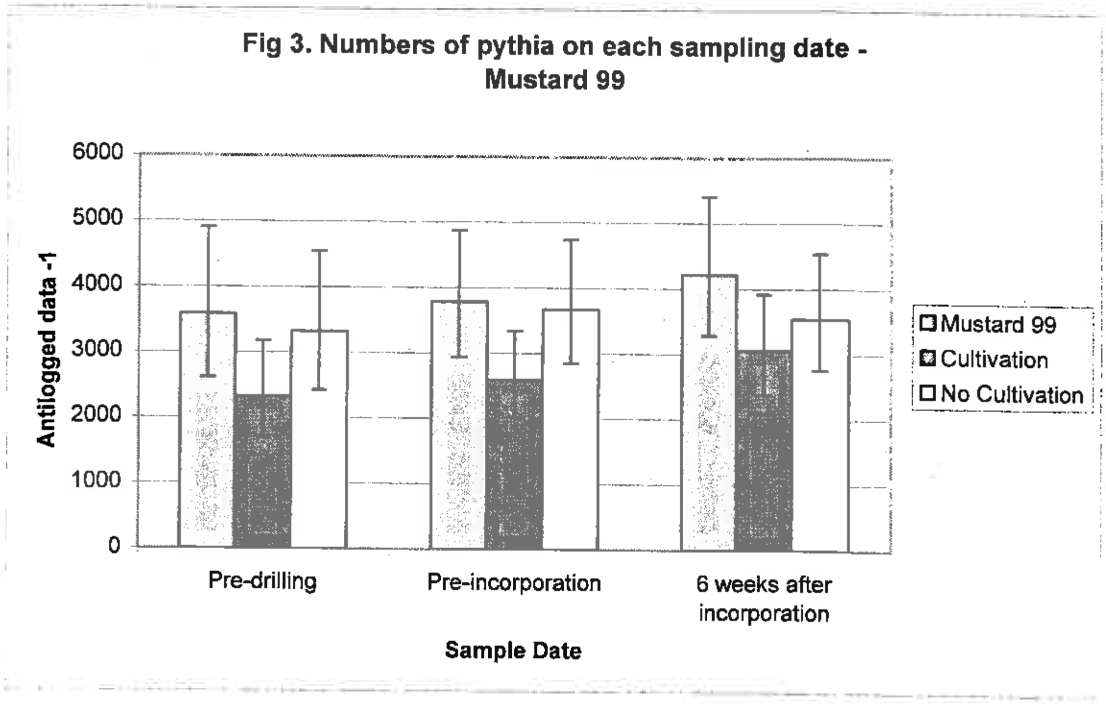


Fig 3. Numbers of pythia on each sampling date - Mustard 99
6000
5000
4000
3000
2000
1000
0
Antilogged data -1
Mustard 99
Cultivation
No Cultivation
Pre-drilling
Pre-incorporation
6 weeks after incorporation
Sample Date

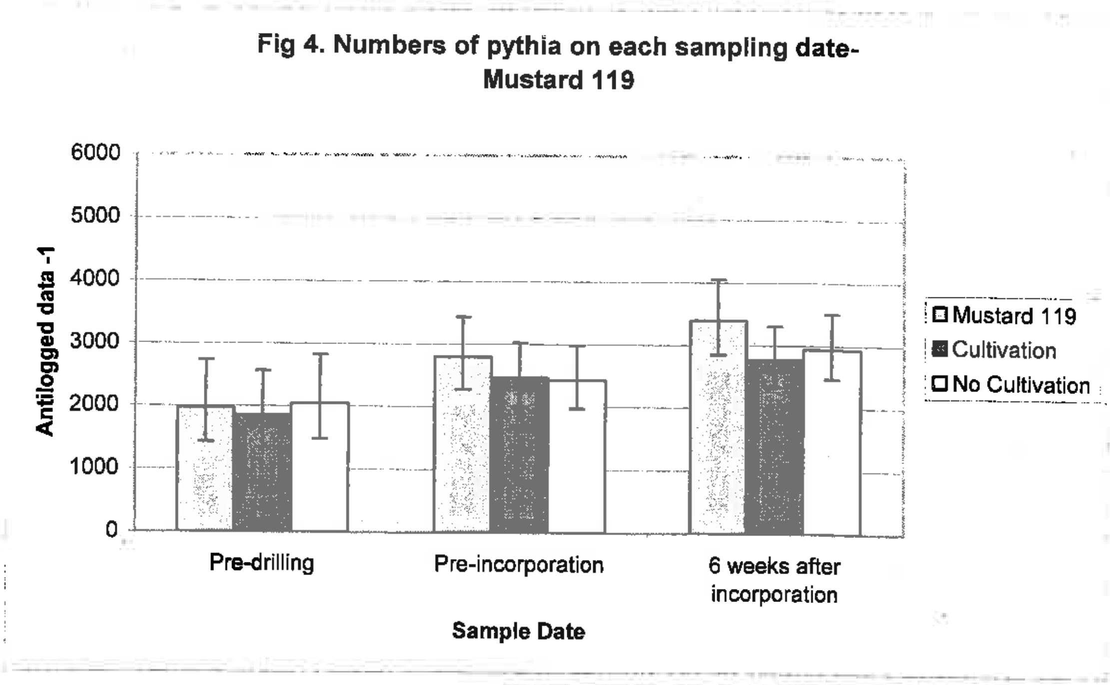


Fig 4. Numbers of pythia on each sampling date- Mustard 119
6000
5000
4000
3000
2000
1000
0
Antilogged data -1
Mustard 119
Cultivation
No Cultivation
Pre-drilling
Pre-incorporation
6 weeks after incorporation
Sample Date

Fig 5. Numbers of root-lesion nematodes on each sampling date - Mustard 99

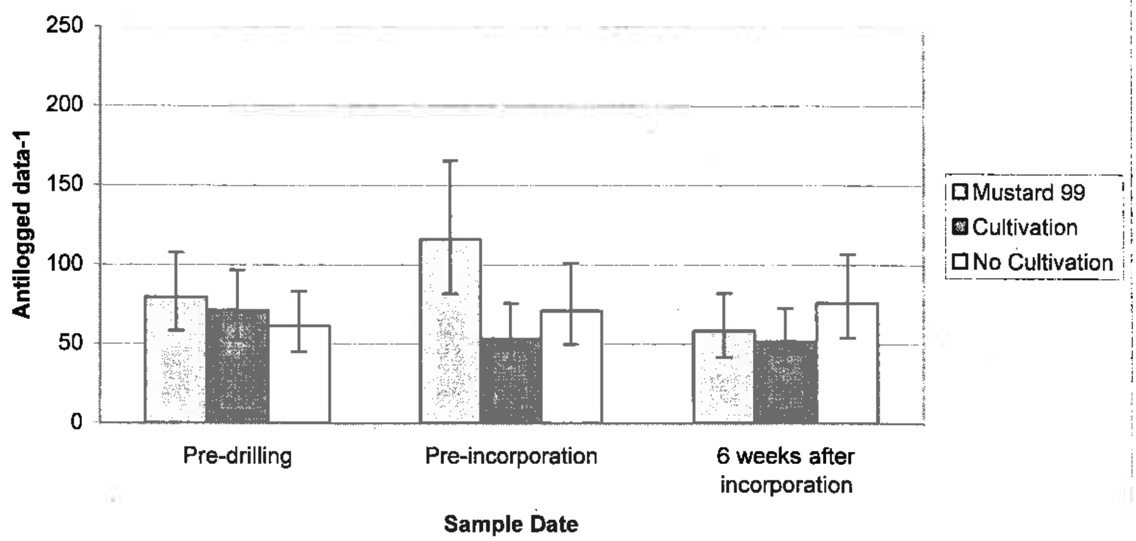


Fig 6. Numbers of root-lesion nematodes on each sampling date - Mustard 119

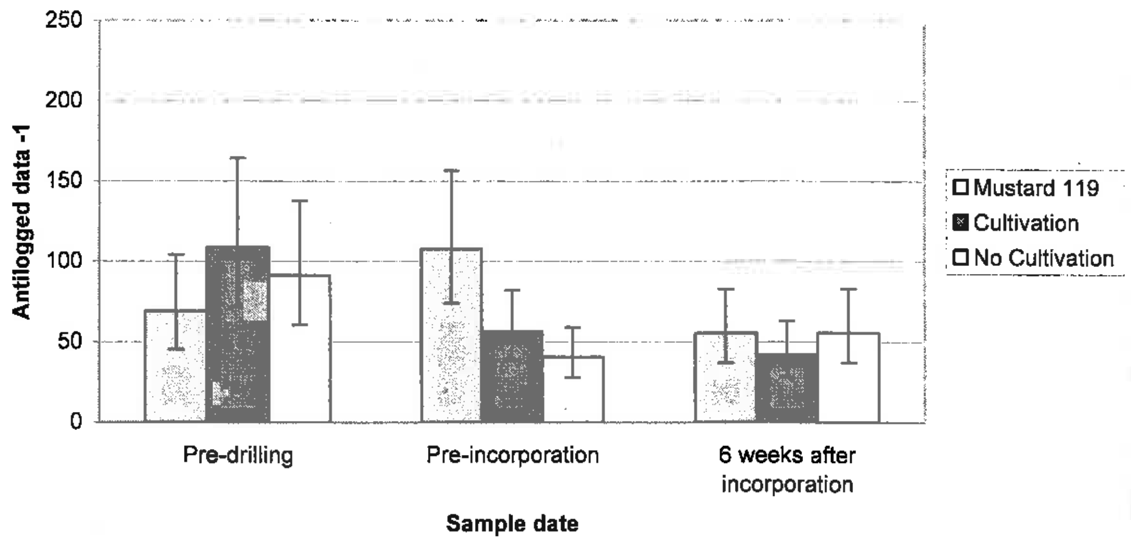


Fig 7. Numbers of stubby-root nematodes on each sampling date - Mustard 99

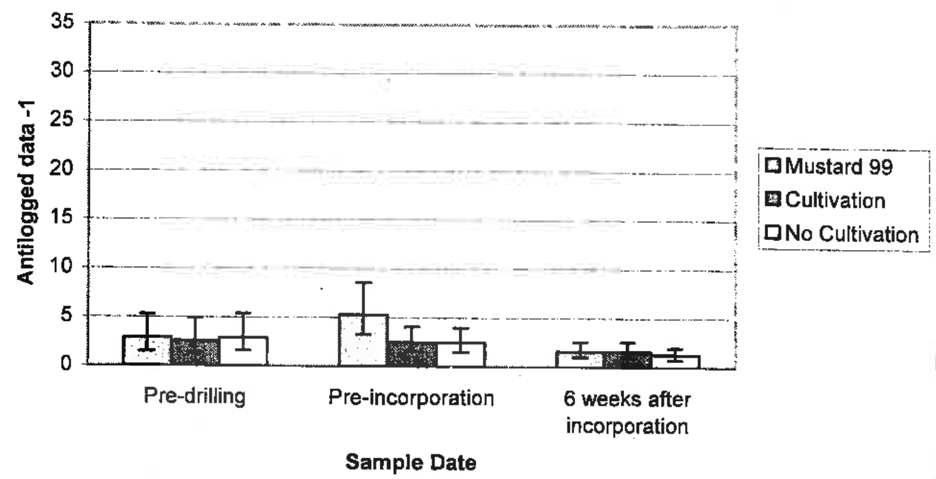
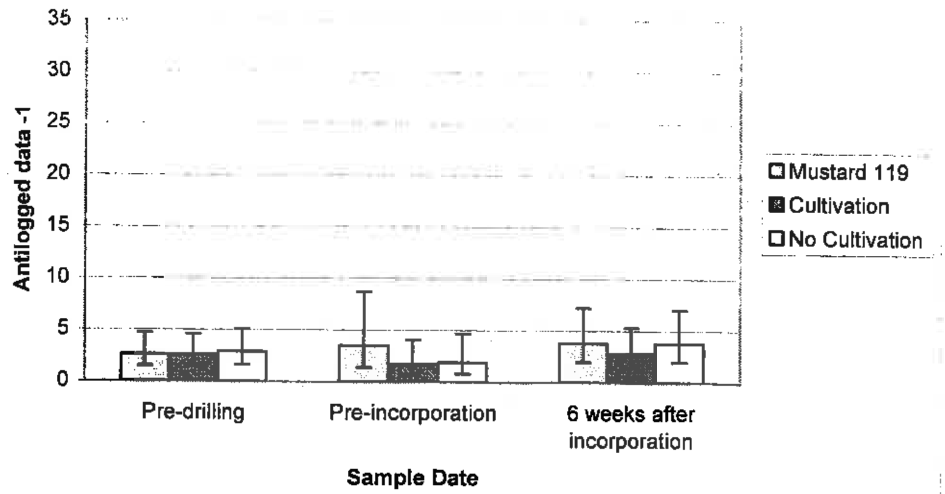


Fig 8. Numbers of stubby-root nematodes on each sampling date - Mustard 119



Pre-drilling soil samples produced no statistically significant differences between the three treatments (biocide, fallow with cultivation and fallow uncultivated) for either total nematodes (Figs 1-2.), total pythia (Figs 3-4.), root-lesion nematodes (Figs 5-6.), stubby nematodes (Figs 7-8.) or stunt nematodes, for either Mustard 99 or Mustard

119 (Appendix 4, Tables 1a and 1b). This was an ideal result on which to base subsequent sampling results.

Soil samples taken just before incorporation of the biocidal crops showed a significant difference between the biocide crop areas and fallow for total nematodes and root-lesion nematodes. This was due to there being significantly more nematodes in the Mustard 99 and Mustard 119 plots compared with the respective fallow (cultivated) plots and in the case of Mustard 119, in the fallow (uncultivated) plots. This was despite the fallow plots having a general cover of weeds that could also act as hosts for nematodes. There was a significant increase in the number of stubby-root nematodes in the Mustard 99 compared with the fallow plots, but this effect was not detected with Mustard 119 (see Appendix 4, Tables 1a and 1b).

Between pre-incorporation and six weeks post-incorporation there was a marked decrease in total nematode numbers with both biocide crops but not in the fallow plots (Appendix 4, Table 1c, Diff 2:3). Despite this, at six weeks post-incorporation there were no differences between the treatments for total numbers of nematodes or pythia. Changes in nematode numbers between pre-drilling and six weeks post-incorporation were compared between the treatments (referred to as Diff 1:3 in Appendix 4, Tables 1a and 1b). No significant differences were detected for any of the nematodes or pythia for either biocide crop (Appendix 4, Tables 1a and 1b). Thus despite the significant increase in nematode numbers in the biocide crop areas during cropping and the significant reduction of these levels after incorporation, there was no difference between nematode numbers in the biocide crop areas or the fallow areas at the end of the investigation.

Analysis of the reduction effect of the Mustards for the two sites showed it present at the Knights site but not at Elveden, thus illustrating a site effect which has been reported previously (HDC report FV 249). Differences in management techniques and environmental factors such as soil type and weather, probably contributed to site differences seen in this project. Soil type varied; both sites are glacial deposits, with fields at Elveden being a deep loamy sand over chalk and in places over deep sand and occasionally small areas of clay, whilst Knights Top Battle is a sandy loam (but not so deep) over chalk with pockets of deep sand. Thus the latter site has potentially the most moisture retentive soil, with consequences for nematode and pathogen activity.

Overall, the level of pythia did not differ significantly between treatments over the life of the project, and there were no differences between treatments six weeks post-incorporation.

An analysis of the differences between the cultivated fallow and the uncultivated fallow produced no differences in nematode numbers; there was a small and just significant effect of cultivation on pythia in the Mustard 99 part of the trial but not in the Mustard 119 area. Cultivation may have an effect on weed control which may result in differences in soil moisture levels (undisturbed fallow land may have higher soil moisture levels than cultivated land).

This investigation only recorded information over a short period, but has shown that biocidal crops, before they are incorporated, may increase nematode numbers before they reduce them, with apparently no overall short-term benefit on control. In the USA, researchers have found a similar increase in free-living nematode species (Dale Gies, personal communication). Where they have seen meaningful reductions with Caliente Mustards for root-knot nematodes (*Meloidogyne* spp.), a group not recorded in this project and only of local importance in the UK.

It is possible that the Mustards were better hosts than the general weed hosts present. The variation observed in numbers of nematodes in the fallow plots may be due to a complex interaction of factors, such as the development (or not) of weed cover, with its provision of roots for nematode feeding and shade for the soil surface, and the effects of cultivation or not, which besides having a direct affect on the nematodes would also affect the moisture levels in the soil.

The two Mustard crops were each a different blend of *Brassica* plants, with different levels of glucosinolates and enzymes which were said to result in different benefits. However, the control of pathogens was disappointing overall in the period offered by this study but the reasons for this are not clear. Specific benefits promoted for selected crops may, in practice, be difficult to achieve, given the known variation with different soil types, management techniques and weather conditions. Incorporation was done as advised by the suppliers and efforts were made to provide the essential soil moisture to facilitate the release of isothiocyanates and produce an effective seal.

Soil nutrients

Nutrient values of soil from the cropping area were compared with soil from the uncultivated fallow plots for all sampling dates. Nitrogen (N) was applied to all plots after drilling so the most important comparison for N relates to variation between pre-incorporation and six weeks post-incorporation.

The initial values at pre-drilling were compared by anova (Genstat) to see if they differed between the biocide crops and uncultivated fallow plots (Appendix 5, Table 3). There were no statistically significant differences, including for N at both 30cm and 60cm depths, except for K in the Mustard 119 area, where the mean level was higher in the uncultivated fallow.

There were no significant differences in P, K, Mg or pH in the biocide areas or the uncultivated fallow when sampled at pre-incorporation or six weeks post-incorporation (Appendix 5). The only difference recorded for N was at pre-incorporation, caused by a just significantly higher N in the Mustard 119 area compared to the fallow. It was expected that the crops would facilitate the capture of N but this was not always the case here, and this may have been affected by environmental or site factors.

Despite there being no obvious differences between treatments at each sampling date there were some differences in nutrient levels (including N) *between* sampling dates and these were examined in more detail.

The levels of P, K or Mg, or pH did not change between pre-drilling and pre-incorporation for either the biocide crops or the fallow areas but overall levels of N did change during this period at both 30cm and 60cm depths, with the change being greater in uncultivated fallow soil (with higher levels of N) than in the biocide crops soil, reflecting the ability of the plants to capture N and therefore assist with its management and delay or reduce leaching (Appendix 5, Table 6). However, this effect was less pronounced at Knights, indicating an effect of environmental or other site factors (Figs 9-16).

Between pre-drilling and six weeks post incorporation the only change with Mustard 99 was a slight decrease in pH in the uncultivated fallow compared with the biocide. For the same period, the effect of Mustard 119 was an increase in P and K compared to uncultivated fallow plots.

Statistical analyses were performed for both the change in soil nutrients (including N) between pre-incorporation and six weeks post-incorporation and the proportionate change (Appendix 5). Examination of the residuals in the analyses of proportionate values showed no sign of non-normality and hence transformation was not necessary. There was a significant change in K with Mustard 99 (7.8% increase) and uncultivated fallow (6.3% drop). This probably represents a capture of K during cropping then a subsequent release after the crop was incorporated. However, such an effect did not occur with Mustard 119. There were no statistically significant differences in Mg or P but with Mustard 119 the percentage change in P (%23P) differed but not the actual change (diff23P). There were no statistically significant differences in pH with either Mustard 99 or Mustard 119.

For the same period, between pre-incorporation and six weeks after incorporation, there was a significant increase in N at 30cm depth with both Mustard 99 and Mustard 119 compared with a small loss in the fallow. This suggests that the incorporated crops helped to retain N whereas in the fallow areas N was leached out.

For N at 60cm depth there was a statistically significant difference with a large increase for Mustard 99 and a small loss in the fallow. This difference was more pronounced than at 30cm depth, probably because there had been a continual loss of N from the fallow areas but in the cropped areas six weeks after incorporation the N had probably only just started to leach from the surface layers. However, although there was also a large increase with Mustard 119, there was also a (smaller) increase in the uncultivated fallow, resulting in there being no statistically significant difference between Mustard 119 and uncultivated fallow.

Overall, the benefit of incorporating biocidal crops for soil nutrition, compared with leaving the land fallow was not apparent. The statistically significant results with N were heavily influenced by the results at Elveden; at the Knights site the differences in N between the biocide area and the fallow area were far less obvious (Figs 9-16). Thus the characteristics of a particular field (due to environmental factors or management techniques) may have an effect on nutrition as well as pathogen control.

Fig 9. Elveden Site - Mustard 99 v. No Crop
Nitrogen Levels at 30cm

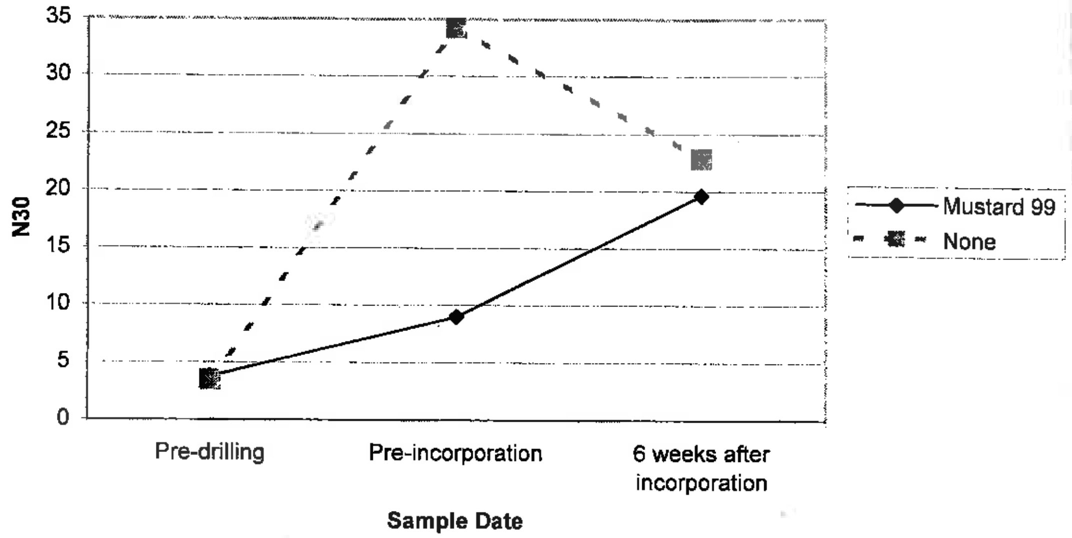


Fig 10. Knights Site - Mustard 99 v. No Crop
Nitrogen Levels at 30cm

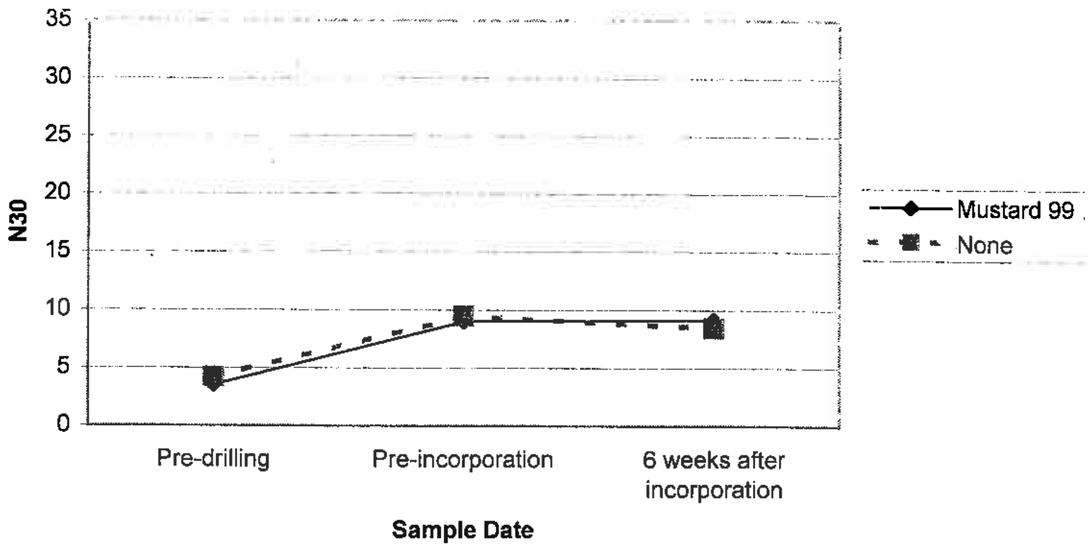


Fig 11. Elveden Site - Mustard 119 v. No Crop
Nitrogen Levels at 30 cm

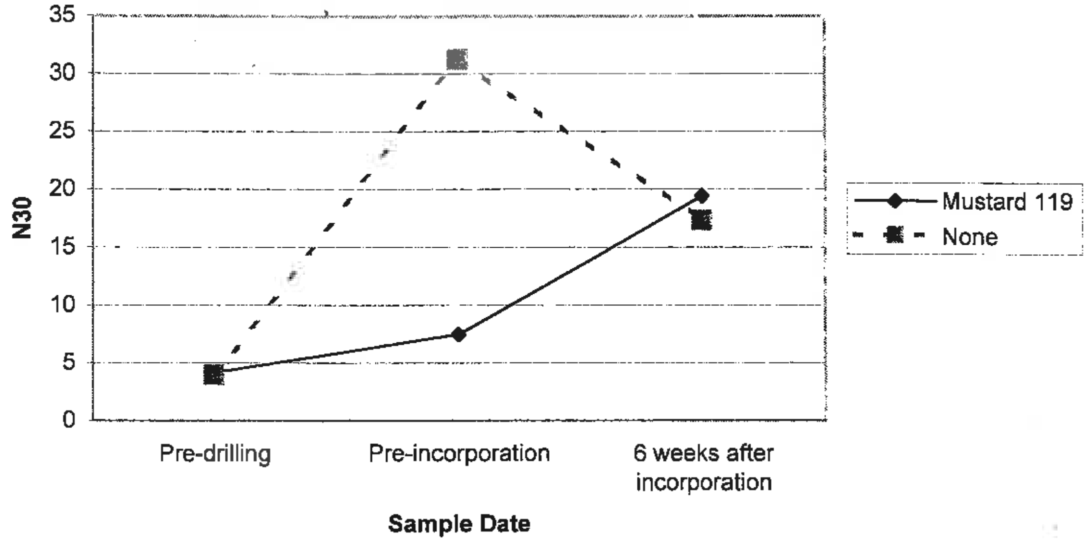
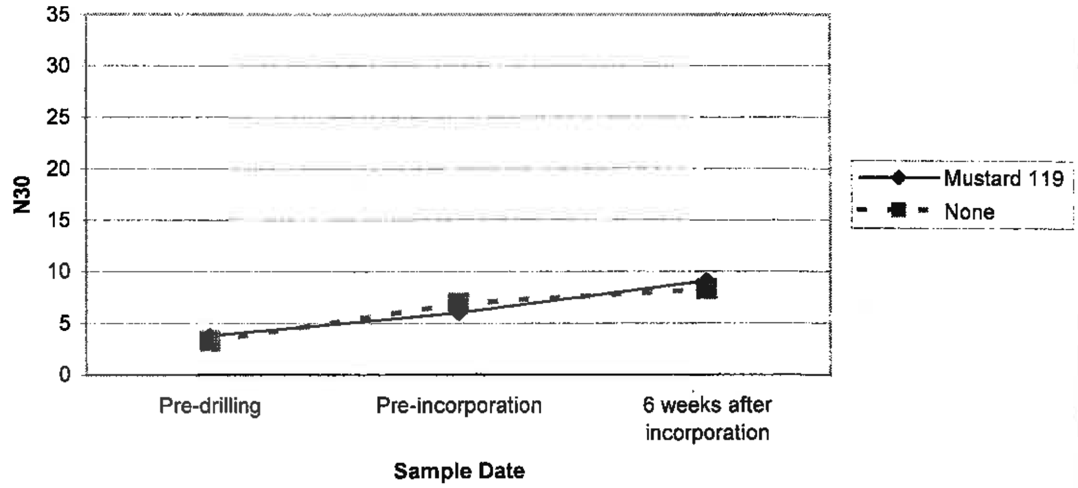


Fig 12. Knights Site - Mustard 119 v. No Crop
Nitrogen Levels at 30cm



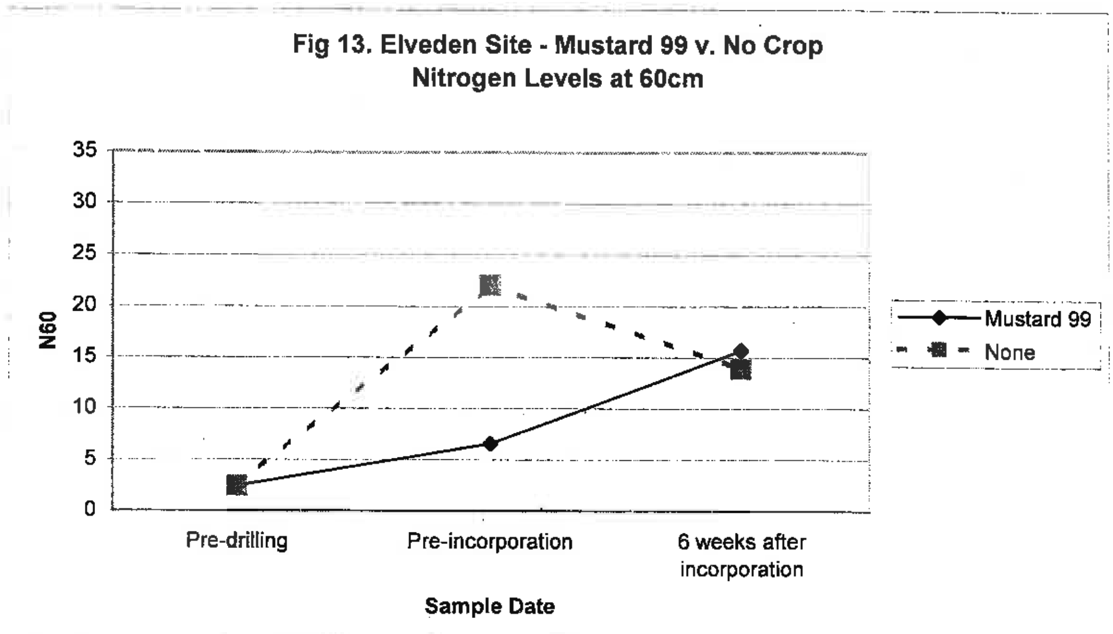


Fig 13. Elveden Site - Mustard 99 v. No Crop
Nitrogen Levels at 60cm
35
30
25
20
15
10
5
0
N60
Pre-drilling
Pre-incorporation
6 weeks after incorporation
Sample Date
Mustard 99
None

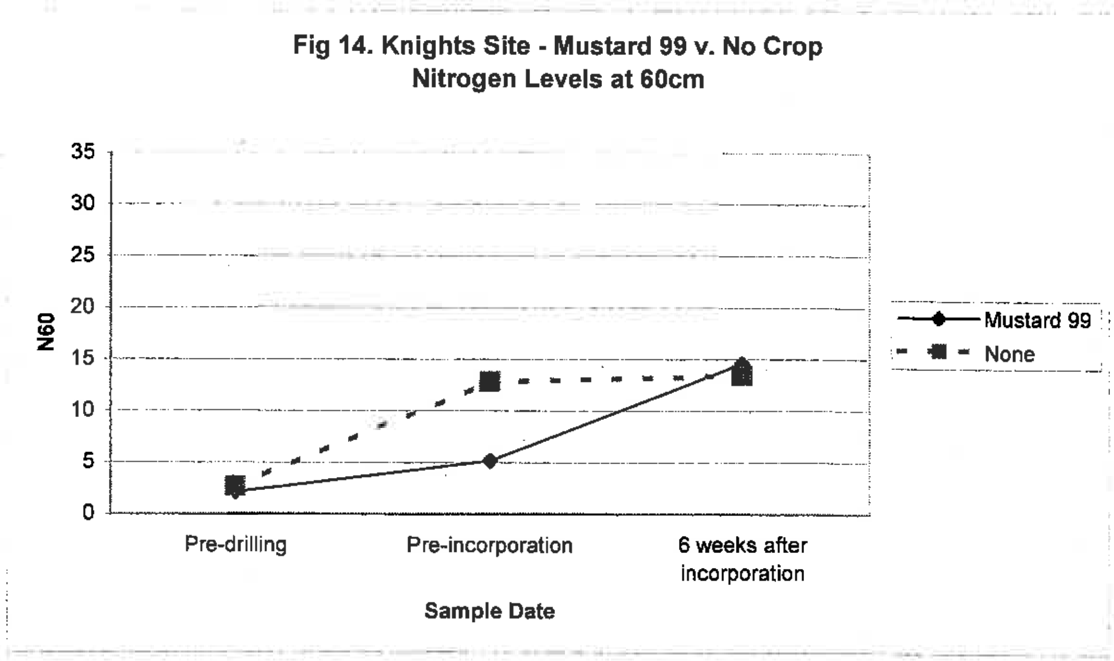
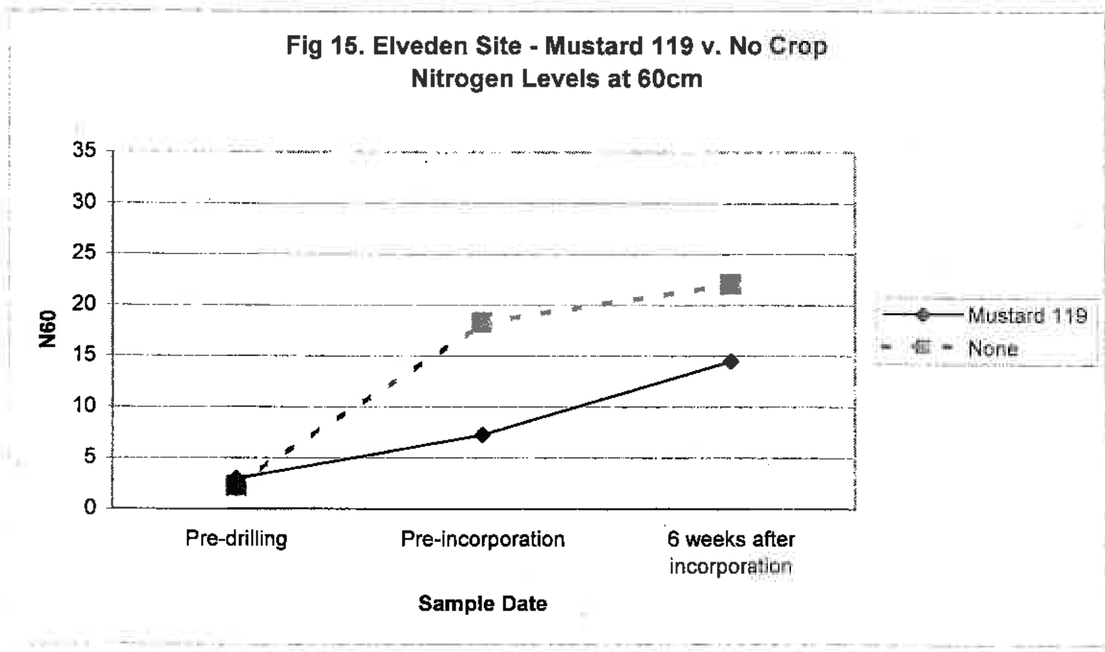
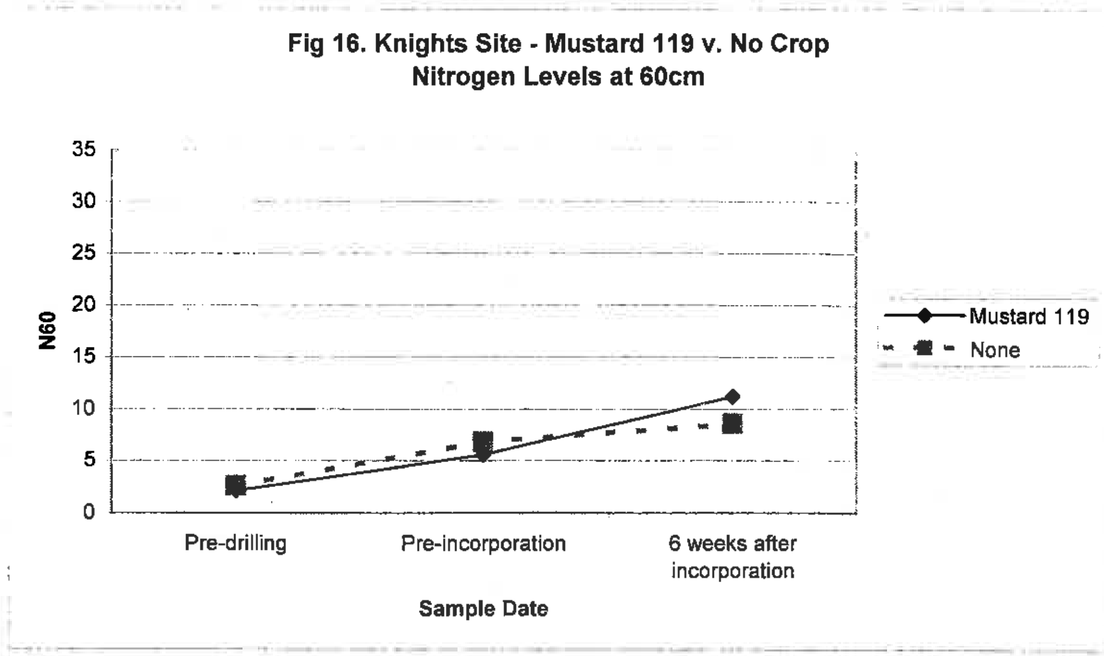


Fig 14. Knights Site - Mustard 99 v. No Crop
Nitrogen Levels at 60cm
35
30
25
20
15
10
5
0
N60
Pre-drilling
Pre-incorporation
6 weeks after incorporation
Sample Date
Mustard 99
None





Weed Suppression

Field observations recorded that both Mustard 99 and 119 produced total ground cover canopy in three weeks providing good suppression of weeds, including volunteer potatoes, compared to the fallow areas. They were also the dominant plants up to incorporation and post-incorporation weed suppression remained obvious until the last sampling; weed emergence after Mustards was delayed by seven days and growth was then slower both in terms of weed height and maturity during the six-week period. These crops therefore offer promise for weed suppression.

Conclusions

This project showed no significant benefits of an early summer planting and late summer incorporation of the selected biocidal crops compared with uncultivated fallow for nematode and *Pythia* control. However, the project produced some evidence that biocidal crops may assist in the retention of N for the benefit of subsequent cropping and may have a place in the management of N. They may also offer a sustainable method of weed suppression but any possible benefits are likely to be affected by the soil type of the site selected and other environmental factors.

Overwintering a biocidal crop, or drilling and incorporating it close to drilling may provide benefits not seen here, providing tests for phytotoxicity, using cress, indicate no adverse effects are likely. The development of biocidal pellets offers the potential for an improvement in pathogen control, especially for nematodes, as the biofumigants produced would have an effect on a population not increasing on good host root systems. However, this technology would not offer the benefits of Nitrogen management or weed suppression.

It should be acknowledged that such a relatively small investigation such as this can only give an indication to the effects of the selected biocidal crops on the chosen pests and diseases of specific interest to carrot or vegetable growers. Repeated use of these crops with associated records of their benefits may need to be done to illustrate their full potential; in Jersey, brassica crops (but not *B. juncea*) were grown between potato crops for four years but disease assessments generally showed an inconsistent effect. However, many growers are now using these brassicas rather than ryegrass or barley as a break crop and reporting an improvement in tuber quality (R. Collier, personal communication). Most recent work in California using mustard crops in six field trials in processing tomatoes over three years has failed to show benefits for disease control or yield, although environmental benefits, such as the reduction of N leaching seen in this project, may be achieved (Hartz *et al.*, 2005). Thus further work is needed to clarify the effects of biocidal crops in a sustainable rotation, and their contribution to a long-term improvement in both soil condition and pest and disease control. Such an approach would be in line with the productive use of Defra grants to support a sustainable cropping system for horticultural crops.

Technology transfer

The literature review of the biocidal crops Mustard (*Brassica juncea*) and Wild Rocket (*Eruca sativa*) (Appendix 1) has been circulated to interested parties by the HDC. The results of this project have been discussed at a growers' meeting held by the HDC. A short article in the HDC News might be useful for growers if considered to be cost effective.

References

Anon, 2004. Caliente Brand Mustard – For green manure and biofumigation. Plant Solutions Limited.

Hartz, T.K., Johnstone, P.R., Miyao, E.M. and Davis, R.M. (2005). Mustard cover crops are ineffective in suppressing soil-borne disease or improving processing tomato yield. *Horticultural Science*, 40, 7, 2016-2019.

Jeffers SN, Martin SB, 1986. Comparison of two media selective for *Phytophthora* and *Pythium* species. *Plant Disease* 70, 1038-1043.

Korthals, G.W., Visser, J.H.M. and Molendijk, L.P.G. (2004). Improvement of soil resistance using biotic and abiotic cultivation measures. *Gewasbescherming. Koninklijke Nederlandse Plantenziektenkundige Vereniging, Wageningen, Netherlands:* 2004, 35:1, 6-8.

LITERATURE REVIEW OF THE BIOCIDAL CROPS MUSTARD (*Brassica juncea*) AND WILD ROCKET (*Eruca sativa*)

Sue Hockland
Central Science Laboratory
March 2005

Contents **Page**

Growers' Summary

- plant-derived chemicals from biofumigant crops offer an additional, sustainable control tool to reduce pathogens and weeds
- a range of biocidal crops are being marketed in the UK, but none offer blanket control of all pathogens, including those of particular interest, *Brassica juncea ISCI 99* and *Eruca sativa NEMAT*
- The effectiveness of many biocidal crops is difficult to predict
- There has been no scientific assessment of the use of biofumigants in horticultural crops in the UK
- Field assessments are required to refine a biofumigation strategy
- Seeding rates are 10kg/ha for *ISCI 99* and 8kg/ha for *NEMAT*. Both will cost approximately £100 per ha. Establishment costs are estimated to be about £75 per ha.
- In the light of developing technology for formulations of biocidal plant products, growers need to consider the advantages of growing such crops solely as a green manure for soil structure or for crop cover for weed control
- The cost:benefit of using biocidal plants as pellets or as a meal will need to be assessed
- After many years research, biofumigants are now used routinely in the USA and parts of Europe

Introduction

In order to assess the potential of *Brassica juncea* (available in the UK as ISCI 99) and *Eruca sativa* (available in the UK as NEMAT), growers need to be aware of current research into the use of Brassicaceae crops generally as biofumigants. Many growers are familiar with manufactured products for soil sterilisation, used to reduce the incidence of pests (particularly plant-parasitic nematodes), diseases and weeds. The active ingredients in these commercial products include dazomet and metam-sodium, which both release methyl isothiocyanates. The isothiocyanates are a group of volatile compounds that are also produced when plant tissue is damaged and most researchers believe their role in nature is to provide protection against pests and pathogens. They are produced when plant cells are damaged and the glucosinolates they contain react with water and the enzyme myrosinase at neutral pH (also found in plant tissue). However, there are different types of glucosinolates which vary in their reactivity and the quantity of isothiocyanates released. *Brassicaceae* species contain high levels of these glucosinolates and so offer potential as biofumigants for a natural release of isothiocyanates when the plants are chopped and used as a green manure.

Whilst biofumigation is the term generally used to describe the exploitation of the myrosinase-glucosinolates system, it is also used to describe the use of other plant-derived chemicals for the control of pathogens. Nematode suppression has occurred following soil incorporation of cyanogenic sudangrass hybrids into soil before cropping with carrots (Widmer & Abawi, 1998), and has been shown to be correlated with the amount of free cyanide released into soil (Widmer & Abawi, 2002). Poultry manures also have potential to suppress nematodes whether through stimulation of antagonistic microbes (Kaplan *et al.,* 1992) or by production of ammonia (Rodriguez-Kabana, 1986). Lucerne soil amendments have also been reported to suppress nematodes (Mankau, 1968; Mankau & Minteer, 1962; Johnson *et al*., 1967) and have shown potential to reduce plant disease caused by soil-borne fungi (Asirifi *et al.,* 1994; Nam *et al.,* 1988; Okumura, 2000). Sulphur volatiles produced by *Allium* species also show good potential for pest and disease pathogens (Auger *et al.,* 2004). Amendments with high N contents are generally recognised as being more effective against nematodes than those with lower N contents (Mian & Rodriguez-Kabana, 1982).

Whilst biofumigation seems to be practical and involve little expenditure, efficacy is, in several cases, still far from that which can be obtained with the synthetic compound treatments (Lazzeri *et al.*, 2004). There is no 'blanket' activity against all pests, diseases and weeds by any biofumigant. For example, research in France into the effectiveness of a range of green manures against *Aphanomyces* root rot of pea has not, so far, found a successful candidate (Moussart *et al.*, 2004). Increased research and usage should highlight those crops which have consistently been effective against certain pests and diseases. However, whilst there has been some work on the identity of glucosinolates and their respective efficacy in Europe (Quinsac *et al.*, 2004; Sørensen *et al.*, 2004) the limited amount of research into the complicated reactions that occur in the soil during and after release of the isothiocyanates means that the effectiveness of many biocidal crops will remain difficult to predict.

The quality and quantity of glucosinolates present in cruciferous plants varies according to the genera, species, cultivar and their location in the plant, and thus gives different biofumigants different properties. This has given rise to blends being developed to provide maximum control for particular pest or disease situations. Trials have also been done to investigate the most glucosinolate-productive parts of these plants. For example, in-vitro work in Australia (Bianco *et al.*, 2001) illustrated how root material from a mixture of *Brassica napus* and *B. campestris* was more effective against *Rhizoctonia fragariae* than the shoots from this mixture, suggesting that it might be worthwhile macerating the whole plant, not just the foliage, when incorporating biofumigants into the soil. The mixture used in this in-vitro study also produced 8 times more and a greater variety of isothiocyanates than the use of *B. juncea*, a popular biofumigant crop, alone. However, this literature study has illustrated that results from many in-vitro tests are contradicted when assessed in field situations. It has taken many years' research in Washington State, U.S.A., to develop a blend of *Sinapis alba* and *Brassica juncea* to control major pathogens of potato, namely *Meloidogyne chitwoodi* (Columbia root-knot nematode) and *Verticillium dahliae* (potato early dying disease) and weeds (McGuire, 2004a).

Whilst there is increasing knowledge about the characteristics of individual biofumigants there are common traits to be evaluated when considering their use. For example, a key characteristic of the release of the isothiocyanates (either from the enzyme hydrolysis in biofumigants or manufactured chemicals) is that it occurs within a few hours. Indeed, research on biofumigant crops has estimated that degradation may be faster (20 minutes) or slightly slower (7 hours) but the rate of degradation seems to be related to the level and particular types of glucosinolates involved (Aires *et al.,* 2004). Persistence, or the length of time over which isothiocyanates are produced, might also be related to soil pH and moisture levels (Bianco *et al.,* 2001) as well as temperature.

Other factors to be considered, which also apply when using manufactured sterilants, include the production of a fine tilth of soil, a minimal presence of clods, prompt and efficient incorporation and a quick, efficient surface seal. In The Netherlands, where the use of biocidal plants in strawberry, asparagus and woody ornamentals is under investigation, the soil surface is lightly compacted and irrigated after the biofumigant or green manure crop has been incorporated and then covered with a plastic film for 6-10 weeks under warm conditions in the summer. The anaerobic conditions that develop form additional toxic fermentation products but details of the success in controlling pathogens and weeds are not available. In the case of biocidal plants, other factors, such as ensuring a good biomass is produced, and that the plants are not only finely chopped but pulverised and watered before incorporation, have been found to be key elements in achieving maximum isothiocyanate concentration in the soil (Matthiessen, 2004).

An important point that is often overlooked in green manure or biofumigant studies is whether the cultivation of the biocidal crop itself will serve only to increase levels of pathogens, compared to leaving the land fallow. Certainly, Walker (2004), using pot experiments to investigate the control of root-knot nematodes in carrots, found that some green manure cultivars of sorghum and rapeseed he tested resulted in higher densities of *M. javanica* in soil before planting compared to leaving soil fallow. There also appeared to be differences in the effect of particular green manure crops on different populations of the same species of nematode, thus illustrating the importance of selecting the right cultivar and recording the effects on nematodes at different sites. The susceptibility of some biofumigant cultivars to pest and disease infestation could be overcome by using the most promising candidates, such as lucerne, as a soil amendment in pellet form rather than as a green manure crop. Whilst this would increase costs, the reduced availability of other controls for pest and diseases could make their use a practical proposition. However, the loss of crop cover and biomass would reduce the influence of the crop for weed control and improving soil structure. Certainly the development and marketing of biocidal crops in pellet form is being considered by companies involved in their promotion. Thus whilst green manures may provide other benefits to the soil such as increased levels of organic matter, their use needs to be carefully considered.

Other negative effects of biocidal crops on subsequent cropping also need to be considered carefully. For example, a negative effect of the use of *Brassica napus* (or canola) on the growth of maize has sometimes been reported, and this has been attributed to an effect on vesicular-arbuscular mycorrhizal fungi, thus having a negative effect on uptake of low-mobile nutrients like phosphorous. Work by Pellerin *et al.*, (2004) however, failed to show that the biofumigant had a detrimental effect in this way. Recent research has shown different effects according to the biofumigant crop type on biocontrol agents such as *Trichoderma* spp., used against a range of plant diseases, so information regarding compatibility with such agents could be important (Galletti *et al.*, 2004). Walker (2004) found that carrot emergence was suppressed when amendments were applied 14 days before planting, but not if planting was delayed for at least four weeks.

Buried crop debris has been implicated as a contributory cause of fanging in carrots (Rubatzky *et al.*, 1999) but innovations such as the use of pellets, because of their small size, will be less likely to cause problems. As fanging is one of the symptoms used to measure nematode damage (though it can also be a symptom of disease and herbicide damage) care must be taken not to underestimate the effect of biocidal crops in reducing nematode levels.

Whilst many of the potential benefits have been highlighted and are indeed promoted in the commercial literature, there remains a lack of research into the efficacy and consequences of biofumigation. There are risks associated with the development of enhanced degradation (where the continual use of the same fumigant results in a shift in the soil micro-flora to populations that can break down the fumigant so rapidly that the fumigant is not available to destroy the target organisms) (Warton *et al.*, 2001), potential impacts on associated beneficial organisms and the fate of isothiocyanates and other compounds in the environment (Kirkegaard & Matthiessen, 2004). In addition and in contrast to commercial pesticides, biocidal plant tissues also contain other chemicals and contribute large amounts of organic carbon that may positively or negatively influence the toxicity of isothiocyanates. As yet not enough is known about the complex relationships that occur when using biocidal plants to comment on likely efficacy (Morra, 2004).

Research and development of biofumigants in the field is in its infancy in the UK. As more becomes known about the chemical processes involved in the production, release and effectiveness of isothiocyanates, so it becomes essential to obtain specific information on glucosinolate types, levels and profiles in plant tissues of important cruciferous crops and the benefits of using particular cultivars, and even particular parts of these cultivars i.e. the seeds, roots, foliage, etc. The choice of biocidal plant may also depend on the relative importance of its biofumigant action as well as its benefits in biomass production; the latter will thus not only serve to benefit soil structure but may also increase isothiocyanate production.

Although it is unlikely that biofumigation or the addition of amendments will provide a direct replacement for manufactured sterilants or methyl bromide, its integration with other cultural or chemical methods offers an alternative to improve the sustainability of horticulture in general (Bianco *et al.*, 2001). In this survey of the literature it was interesting to note that some of those involved in organic farming did not view biofumigants as an essential tool, except for use in severe pest and disease outbreaks, such as during the first years of conversion from other farming methods (Micheloni & Conte, 2004). An alternative philosophy, however, might be that frequent use of biofumigants might help to keep levels of pests and disease down, providing that this approach did not accelerate the biodegradation process.

Such is the confidence in the role that biofumigant crops can play as part of an integrated control programme for pathogen and weed control that there are several research centres developing cultivars specifically for this purpose, such as the Départ. Agronomie et Environnement, ENESAD, Dijon, France, which is working specifically on *B. juncea* genotypes (Merah *et al.,* 2004) and the *Brassicaceae* breeding group at the University of Idaho (Brown *et al.*, 2004), where breeding efforts have been directed towards two biofumigation systems, namely (1) green manure/incorporation cultivars that have high biomass accumulation and high concentrations of specific glucosinolates in the plant tissue, and (2) cultivars with high concentrations of specific glucosinolates in the seed meal, so that the meal can be used as a soil amendment. The latter might require less interruption in cropping schedules but possible phytotoxic effects of cropping close to incorporation need to be investigated.

One Italian company, Cerealtoscana (www.cerealtoscana.it), is promoting the use of biocidal plants under the brand 'Sovesci Bluformula'. It has worked with the Research Institute for Industrial Crops of (or Instituto Sperimentale Colture Industriali - ISCI) Bologna, to develop a selection of green manures, namely three cultivars of *Brassica juncea* (namely ISCI 20, 61 and 99) and one cultivar of *Eruca sativa* (NEMAT). These are now available in the UK via Plant Solutions Limited (www.plantsolutionsltd.com). The crops ISCI 99 and NEMAT have been selected for the joint VCS/CSL proposal to investigate the potential of such plants to reduce pests, diseases and weeds and improve soil nutrition.

The use of many different *Brassica* cultivars for biofumigation is cited in the literature because of their well-known properties of the production of glucosinolates (e.g. *Brassica napus* and *Brassica campestris* (Bianco *et al*., 2001). However, the cultivars currently being offered commercially in the UK include *B. juncea* and *E. sativa* and it is the use of these that have been particularly investigated in this review.

Many of the papers referred herein have not been published in English, and in the time available it has not been possible to obtain complete translations but wherever possible English summaries have been obtained. In addition, there is much information available only as locally produced reports or Conference proceedings, which are also not immediately available to examine in detail.

Brassica juncea (ISCI 99)

B. juncea is grown in several countries for oil production (e.g. Canada, China, India) and in Burgundy, France where it forms the basis for the famous 'Dijon' mustard used as a table condiment (Lionneton *et al.,* 2004). *B. juncea*, sometimes known as 'Indian' or 'Brown' mustard, has been highlighted in several research projects as one cultivar having particularly high levels of glucosinolates. In particular it contains the glucosinolate sinigrin (which interestingly, is also responsible for the flavour of Dijon mustard), and work with this group has shown that organic matter and glucosinolate yield is highly dependent on plant type and cultivation time.

Researchers have investigated *B. juncea* but it is not always clear in the literature which cultivar has been used, thus some comments refer to the characteristics of the species in general, although it is clear that cultivars of the same species can have very different properties. *B. juncea* Czern et Coss, for example, has been shown to significantly suppress multiplication of the root-knot nematode *Meloidogyne incognita* on tomato roots and thus increase the crop yield (D'Addabbo *et al.,* 2004), but it would be unsafe to assume that the same effect would be achieved by all other cultivars of this species.

Work in Italy has included the use of the cultivar ISCI 20 (Lazzeri et al., 2003a). It is claimed to be a robust producer of glucosinolates, is adaptable to many soil types and climates and is easy to manage in the field. It is reported to produce up to 138 tonnes dry matter (DM) per ha, which may contain more than 1.6% Nitrogen. Reported variations in DM production are said to be due to differences in cultivation, including a failure to sow at the optimal time. Strawberry crops succeeding *B. juncea* in the rotation have shown no adverse reaction to glucosinolates and are said to have given results comparable those following sterilisation with methyl bromide, but no details are available. ISCI 20 is also being investigated by Applied Plant Research Flower Bulbs, Lisse, in The Netherlands as a control for plant-parasitic nematodes and soil borne fungal diseases (van Bruggen, 2004; van Os, 2004). Results for nematodes were not available, but the cultivar did produce a reduction in the incidence of *Rhizoctonia solani* on lily, resulting in a significant increase in bulb yield compared to other green manure crops. Variable results were obtained in similar work with tulip.

In France, trials have investigated an unknown cultivar of *B. juncea* amongst a range of potential biofumigants in the control of soil-borne pathogens in vegetable crops. Whilst, unfortunately, the specific effectiveness of *B. juncea* was not revealed, a general conclusion was that the biofumigants tested were effective against *Rhizoctonia solani* and *R. solani*, but not against *Phytophthora cactorum* (Villeneuve, *et al.,* 2004). The activity against this disease is another example of how in-vitro studies seem to provide little indication as to the effectiveness of biofumigant crops in practice; laboratory work by Dunne *et al* (2003) suggested that *B. juncea* was very effective against *P. cactorum*. However, the laboratory work had demonstrated that there was also significant variation in the sensitivity of the *Phytophthora* species to the suppressive effects of the biofumigants. Experience gained during the trials work found that success was dependent on many factors, including the plant species used, the quantity of fresh organic matter ploughed in, the soil temperature during the period of coverage with plastic (with lower efficacy at lower temperatures) and the type of plastic used (important in their ability to reduce vapourisation rates, maintain temperature and modify the soil atmosphere).

There are several instances of conflicting information being published concerning the effectiveness of this group of green manure crops against pathogens. In laboratory work using pure isothiocyanates, it was predicted that *B. juncea* would be one of a group of *Brassica* plants containing high concentrations of propenyl isothiocyanates most likely to control *Fusarium oxysporum* isolates obtained from forest tree nurseries in Idaho and Washington (Smolinska *et al.,* 2003). However, at a USDA Forest Service Nursery in Idaho, seedling production was not improved by incorporating brassica green manure crops, compared to the use of dazomet or fallowing, and in some cases large increases of potentially pathogenic *Fusarium* spp. were recorded (James *et al.*, 2004). Soil *Pythium* levels were reduced when plastic tarpaulins were used to reduce losses of decomposition products, but this did not result in improved seedling production. The laboratory work had noted that only a fraction of the isothiocyanate potentially available from the glucosinolate within the tissues is actually released and available for pathogen inhibition; this combined with other factors that are necessary to maximise the fumigation effects illustrates the care and preparation necessary when investigating the use of biofumigants.

In Washington State, USA, *B. juncea* and *Sinapis alba* were incorporated into soils in the autumn and planted with potatoes the following spring. No information is available for the effects of *B. juncea* only, but the green manures were considered an effective replacement for manufactured soil fumigants (McGuire, 2004b).

Work in the USA has recently evaluated the herbicidal properties of seed meal of *Brassica* plants in glasshouse tests, including that produced from *B. juncea* under the name 'Pacific Gold'. The results varied according to cultivar, with 'Pacific Gold' having good herbicidal activity on wild oat seeds, but less activity compared to other Brassicaceae on wild mustard and pigweed. It did significantly reduce weed biomass overall. In subsequent field trials in strawberry crops 'Pacific Gold' did not perform as well as other seed meals, but in common with others was responsible for high phytotoxicity on first year strawberry transplants. However, yields from the crops were not significantly lower than those from the standard chemical treatment. Further research will determine efficacy rates and the timing of incorporation for maximum effect and productivity (Brown *et al.*, 2004). No phytotoxicity was reported when a crop of *B. juncea* was incorporated into soil to be cropped some 2-3 months before planting with strawberries (Lazzeri *et al.*, 2003b). In this trial weed control was not necessary, yields of strawberries were not compromised, but the effect on pests and diseases was unclear.

In Southern California, the incorporation of the formulation 'Pacific Gold' or the plant mulch was investigated for nematode, disease and weed control, but it is not clear whether the two types of amendment were used separately or jointly (Daugovish *et al.*, 2004). A reduction of 92% in nematode numbers was achieved, but the growth of sclerotia of *Sclerotinia minor* (leaf drop of lettuce) was not affected except when used in combination with plastic covers, when a 75% reduction in sclerotial growth compared to the control was achieved. Such work highlights the requirement for a good seal to maximise the effect of the biofumigation. Colony development of *Phytophthora cactorum* (crown rot of strawberries) from biofumigated plots was inhibited by 90% or more, but intensive growth of *Pythium* spp. was also observed, leading to suggestions that the lack of growth of *P. cactorum* may not have been due to biofumigation but perhaps more likely a change in the microbiological environment that favoured the development of *Pythium* spp.

'Pacific Gold' seed meal resulted in 100% mortality of vine weevil larvae when incorporated into compost for potting, but resulted in phytotoxic effects on certain nursery tree species in the glasshouse or field. Also in the USA, glasshouse tests have been evaluating the effectiveness of *B. juncea* as chopped residues for weed control, but the results were very variable. Although in laboratory work germination of all weed species was completely inhibited, in the field trials there was no such inhibition in weed seed emergence. This again illustrates that whilst it is important to collect data from laboratory work where the effect of the biofumigants can be studied, it is also important to investigate their effects in the field to provide more lines of enquiry.

Some work has been done on the environmental effects of *B. juncea.* In Italy this has concentrated on investigating laboratory findings that glucosinolates and their hydrolysis products inhibit soil nitrifying bacteria communities, but in the field contradictory results have been obtained, requiring further work to determine the fertiliser value of this green manure crop (Marchetti *et al.,* 2004).

Eruca sativa cv. NEMAT

Compared to the work that has been done on *B. juncea,* relatively little information is available specifically for *E. sativa* cv. Nemat, perhaps because it has shown more selective action against pathogens in trials. The genus is part of the *Brassicaceae* and *E. sativa* is more commonly known as garden or salad Rocket, whilst the common name given to the one under investigation here is 'wild Rocket'. The main class of glucosinolates produced by this crop appears to be those containing glucoerucin, in contrast to the sinigrin found mainly in *Brassica* plants.

There is a lack of scientific data for the effect of this crop on nematodes. Hydrated, defatted seed meal (the product remaining after oil has been extracted) of *E. sativa* was tested for its efficacy in controlling *Sclerotinia* species (Marciano *et al.,* 2004). In common with other seed meals it greatly reduced the viability of sclerotia of *S. minor*, but did not affect those of *S. sclerotiorum.* It did have some effect on the antagonistic activity of biocontrol fungi, whereas other seed meals did not, so overall it did not rate highly in selections for disease control. Confirmation of this selective action raises an important point when choosing a biofumigant crop – if biofumigants have selective action then integrating them into control programmes will require specialist advice.

No phytotoxic symptoms were seen in strawberries planted after a crop of *E. sativa* had been incorporated into the soil prior to planting (Lazzeri *et al.,* 2003b). The overwintering crop cover so provided eliminated the need for weed control, and yields of strawberries were better than in untreated plots, but the effect on pests and diseases was unclear.

In Italy laboratory tests using a seed meal formulation of the product resulted in high mortality of wireworms, but insecticidal activity ceased after 2-3 days illustrating typical problems in persistence with brassicas that could cause practical problems (Furlan *et al.,* 2004).

Some work has been done on the fertilising effect of the defatted meal of this crop in soil. The meal is rich in organic nitrogen (4-7% N), phosphorous (2-3% P) and sulphur (2-3% S). All these elements have to be mineralised to be available to plants. Meal was found to have potential as a good organic fertiliser (Cavani *et al.*, 2004).

Conclusions

With reform of the Common Agricultural Policy in the EU the basis upon which farm economics operates has been changed quite radically. Whilst the use of plants as whole crop biofumigants may become an economic option there is a need to ensure that truly repeatable results in terms of performance are shown by biofumigants (Askew, 2004).

The promotional literature produced by the commercial companies now marketing biocidal plants tends to present a simplistic picture of their use but evidence for consistent results with pest, disease or weed control is somewhat lacking. For instance, this relatively brief search and report on the available literature concerning *B. juncea* (ISCI 99) and *E. sativa* (Nemat) could obscure the fact that both crops may have a similar effect on levels of plant-parasitic nematodes in the soil. However, both companies have taken an active interest in research projects and in practical trials to gain further knowledge of the effectiveness of these crops in reducing pathogens and weeds. Their accumulated field experience must be utilised to the full when planning to use biocidal crops.

Future challenges for researchers are to identify ways of maximising the release of isothiocyanates from incorporated biofumigants into soil. This might include breeding for higher levels of glucosinolates, improved agronomic practices and understanding the interaction of biofumigation with the soil environment.

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References

Aires, A., Carvalho, R., Iori, R. and Rosa, E. (2004). Influence of myrosinase activity on glucosinolate degradation and the consequences in the control of soil-borne pathogens and pests. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 56.

Asirifi K.N., Morgan, W.C. and Parbery, D.G. (1994). Suppression of *Sclerotinia* soft rot of lettuce with organic soil amendments. *Australian Journal of Experimental Agriculture* 34, 131-136.

Askew, M.F. (2004). Economic aspect of biofumigation in EU. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p.1.

Auger, J., Charpentire, M., Arnault, I., Divo, S. and Reverchon, S. (2004). Fungicidal potential of *Allium* sulfur volatiles for soil fumigation. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 59.

Bianco, V., Mattner, S.W., Nicholls, J.W., Allen, D., Porter, I.J. and Shanks, A.L. (2001). Factors that influence the ability of biofumigants to suppress fungal pathogens of strawberries. *Proceedings of the Second Australasian Soilborne Diseases Symposium, Lorne, March 2001.*

Brown, J., Hamilton, M. and Brown, D.A. (2004). Using Brassicaeae seed meal as an alternative to highly toxic soil fumigants in strawberry production. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 14.

Brown, D.A., Brown, J., Seip, L. and Baker, N. (2004). Developing designer *Brassicaceae* crops for biofumigation. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 43.

Cavani, L., Ramieri, N.A., Ciavatta, C. and Gessa, C.E. (2004). Nitrogen mineralisation of defatted meals from plant seeds containing glucosinolates in soil. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 51.

D'Addabbo, T., De Mastro, G., Sasanelli, N., Di Stefano, A. and Omidbaigi, R. (2004). Suppressive action of different cruciferous crops on the root-knot nematode *Meloidogyne incognita.* In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 66.

Daugovish, O., Downer, J., Becker, O. and Browne, G. (2004). Mustard-derived biofumigation research in Southern California. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 37.

Dunne, C.P., Dell, B. and St. J. Hardy, G.E. (2003). The effect of biofumigants on the vegetative growth of five *Phytophthora* species in vitro. *Acta Horticulturae. International Society for Horticultural Scienec (ISHS), Leuven, Belgium, 2003.* 602, 45-51.

Furlan, L., Bonetto, C., Patalano, G. and Lazzeri, L. (2004). Potential of biocidal meals to control wireworm populations. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 24.

Galletti, S., Burzi, P.L., Cerato, C., Marinello, S. and Lazzeri, L. (2004). Colonisation of Brassicaceae rhyzosphere by selected *Trichoderma* spp. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 62.

James, R.L., Knudsen, G.R. and Morra, M.J. (2004). Preplant soil treatment effects on production of Douglas-fir seedlings at the USDA Forest Service Nursery, Coeur d'Alene, Idaho. *Forest Health Protection Report – Northern Region, USDA Forest Service. Northern Region, USDA Forest Service, Missoula, USA: 2004.* 04-10, 14.

Johnson, L.F., Chambers, A.Y. and Reed, H.E. (1967). Reduction of root-knot of tomatoes with crop residue amendments in field experiments. *Plant Disease Reporter* 51, 219-222.

Kaplan, M. Noe, J.P. and Hartel, P.G. (1992). The role of microbes associated with chicken litter in suppression of *Meloidogyne arenaria. Journal of Nematology* 24, 522-527.

Kirkegaard, J. and Matthiessen, J. (2004). Developing and refining the biofumigation concept. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 2.

Lazzeri, L., Leoni, O., Malaguti, L. and Cinti, S. (2004). Plants, techniques and products for optimising biofumigation in full field. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 13.

Lazzeri, L., Malaguti, L., Cinti, S. and Baruzzi, G. (2003a). Biocidal plants for green manure in the rotation. *Colture Protette. Gruppo Calderini Edagricole Srl, Bologna, Italy*: 2003. 32, 1, 53-56.

Lazzeri, L., Baruzzi, G., Malaguti, L. and Antoniacci, L. (2003b). Replacing methyl bromide in annual strawberry production with glucosinolate-containing green manure crops. *Pesticide Management Science* 59, 983-990.

Lionneton, E., Aubert, G., Ochatt, S. and Merah, O. (2004). A candidate gene approach identified loci involved in biosynthesis in brown mustard (*Brassica juncea*). In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 46.

Mankau, R. (1968). Reduction of root-knot disease with organic amendmentsunder semifield conditions. *Plant Disease Reporter* 52, 315-319.

Mankau, R. and Minteer, R.J. (1962). Reduction of soil populations of the citrus nematode by the addition of organic materials. *Plant Disease Reporter* 46, 375-378.

Marchetti, R., Lazzeri, L. and Malaguti, L. (2004). Soil carbon and nitrogen content in biofumigated crops. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 47.

Marciano, P., Odorizzi, S., Malaguti, L. and Lazzeri, L. (2004). Effect of volatiles produced by hydrolysis of Brassicaceae seed meals towards *Sclerotinia* spp. and antagonistic fungi. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 60.

Matthiessen, J. (2004). The importance of plant maceration and water in achieving high ITC levels in soil. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 12.

McGuire, A.M. (2004a). Mustard green manure use in Washington State, USA. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 77.

McGuire, A.M. (2004b). Mustard green manures replace metam sodium in potato cropping system. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 35.

Merah, O., Guinet, T., Tittonel, E.D. and Alcaraz, G. (2004). Genetic diversity for glucosinolates, oil and agronomical traits in a large collection of *Brassica juncea.* In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 45.

Mian, I.H. and Rodriguez-Kabana, R. (1982). Survey of nematicidal properties of some organic materials available as amendments for control of *Meloidogyne arenaria. Nematropica* 12, 235-246.

Micheloni, C. and Conte, L. (2004). To which extent organic farming needs biofumigation. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 57.

Morra, M.J. (2004). Controlling soil-borne plant pests using glucosinolate-containing tissues. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 6.

Moussart, A., Even, M.N., Lemarchand, E., Tivoli, B. and Reau, R. (2004). Effect of green manure crops on *Aphanomyces* root rot of pea. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 72.

Nam, C.G., Jee, H.J. and Kim, C.H. (1988). Stuudies on biological control of *Phytophthora* blight of red pepper. II. Enhancement of antagonistic activity by soil amendment with organic materials. *Korean Journal of Plant Protection* 4, 313-318.

Okumura, M. (2000). Soil microbial properties in various rotation systems and ecological control of *Fusarium* root rot of kidney beans in the Tokachi district. Report of Hokkaido Prefectural Agricultural Experiment Stations No. 97, 102pp.

Pellerin, S., Mollier, A., Plenchette, C., Morel, C., Thunot, S. and Reau, R. (2004). Does incorporation of *Brassica napus* L. residues in soils affect mycorrhizal colonisation of roots and P uptake by maize (*Zea mays* L.). In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 54.

Quinsac, A., Dechambre, J., Krouti, M., Sausse, C., Reau, R., Wagner, D. and Garric, B. (2004). Screening of diverse field-grown Brassicaceae cultivars according to their biofumigation potentials. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 8.

Rodriguez-Kabana R. (1986). Organic and inorganic nitrogen amendments to soil as nematode suppressants. *Journal of Nematology* 18, 129-135.

Rubatzky V.E., Quiros C.F. and Simon P.W. (1999). *Carrots and Related Vegetable Umbelliferae.* CABI, Wallingford, U.K., 294 pp.

Smolinska, U., Morra, M.J., Knudsen, G.R. and James, R.L. (2003). Isothiocyanates produced by Brassicaceae species as inhibitors of *Fusarium oxysporum. Plant Disease* April 2003.

Sørensen, J.C., Sørensen, S. and Sørensen, H. (2004). Metabolism of glucosinolates and formation of glucosinolate-derived products with potential value as biocides and biofumigants. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 10.

van Bruggen, A.S., de Boer, F.A., van Os, G.J. and Lazzeri, L. (2004). Effects of biofumigation crops on nematodes in flower bulbs. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 58.

van Os, G.J., Bijman, V., de Boer, M., Breeuwsma, S., van der Bent, J. and Lazzeri, L. (2004). Biofumigation against soilborne fungal diseases in flower bulbs. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 20.

Villeneuve, F., Raynal-Lacroix, C., Lempire, C. and Maignien, G. (2004). Possibility of using biofumigation in vegetable crops for controlling soil borne pathogens. In: Biofumigation: A possible alternative to methyl bromide? *Proceedings of the First International Symposium 'Biofumigation: A possible alternative to methyl bromide'. Research Institute for Industrial Crops (ISCI Bologna).* p. 81.

Walker, G.E. (2004). Effects of *Meloidogyne javanica* and organic amendments, inorganic fertilisers and nematicides on carrot growth and nematode abundance. *Nematologica Mediterranea* 32, 181-188.

Warton, B., Matthiessen, J.N. and Roper, M.M. (2001). Enhanced biodegradation of metham sodium soil fumigant – occurrence, influences and implications. *Proc. 2nd Soil-borne Diseases Conference, Lorne, Victoria.* p. 83-84.

Widmer, T.L. and Abawi, G.S. (2002). Relationship between levels of cyanide in sudangrass hybrids incorporated into soil and suppression of *Meloidogyne hapla. Journal of Nematology* 34, 16-22.

Widmer, T.L. and Abawi, G.S. (1998). Marketable yields of carrots in *Meloidogyne hapla* infested soils as affected by a green manure of Sudan grass. (Abstr.) *Journal of Nematology* 30, 522.

Results of pathogen analyses for soil samples from prospective trial sites

Field	**Total Pythium cfu/g soil**	**Nematodes Root-lesion**	**Stubby-root**	**Needle**	**Heterodera cysts (juveniles)**	**Stunts**	**Spirals**
Site E: Chestnuts Court	1,230	56	0	0	5(3)	2	0
Site E: Waterloo	1,485	90	5	0	5	0	0
Site K: Honey Pot 1	11,100	5	6	0	(13)	13	5
Site K: Top Battles	9,360	173	6	1	(1)	11	0

Nematode data
Elveden Estates Waterloo

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20508848	A11	8th June 2005	Root-Lesion	70
			Stubby Root	11
			Cyst Male	1
20508849	A12	8th June 2005	Root-Lesion	42
			Stubby Root	5
			Stunt	1
20508850	A13	8th June 2005	Root-Lesion	85
			Stunt	5
20508851	A14	8th June 2005	Root-Lesion	55
			Stunt	14
			Stubby Root	1
			Cyst Juvenile	1
20508852	A21	8th June 2005	Root-Lesion	66
			Stubby Root	17
			Stunt	1
20508853	A22	8th June 2005	Root-Lesion	50
			Stunt	9
			Stubby Root	1
20508854	A23	8th June 2005	Root-Lesion	18
			Stunt	4
			Stubby Root	4
20508855	A24	8th June 2005	Root-Lesion	101
			Stubby Root	6
			Stunt	3
20508856	A31	8th June 2005	Root-Lesion	83
			Stubby Root	4
			Stunt	2
20508857	A32	8th June 2005	Root-Lesion	63
			Stunt	5
			Stubby Root	2
20508858	A33	8th June 2005	Root-Lesion	68
			Stunt	10
			Cyst Male	1
20508859	A34	8th June 2005	Root-Lesion	86
			Stubby Root	12
20508860	A41	8th June 2005	Root-Lesion	78
			Stubby Root	2
			Stunt	2
20508861	A42	8th June 2005	Root-Lesion	146
20508862	A43	8th June 2005	Root-Lesion	96
			Stubby Root	10
20508863	A44	8th June 2005	Root-Lesion	54
			Stubby Root	34
20508864	A51	8th June 2005	Root-Lesion	90
			Stubby Root	1
20508865	A52	8th June 2005	Root-Lesion	77
			Stubby Root	10
20508866	A53	8th June 2005	Root-Lesion	97
			Stunt	10
			Stubby Root	7
20508867	A54	8th June 2005	Root-Lesion	83
			Stubby Root	6

			Stunt	1
20508868	A61	8th June 2005	Root-Lesion	87
			Stubby Root	8
			Stunt	1
20508869	A62	8th June 2005	Root-Lesion	133
			Stunt	3
			Stubby Root	3
20508870	A63	8th June 2005	Root-Lesion	72
			Stubby Root	13
			Stunt	2
20508871	A64	8th June 2005	Root-Lesion	83
			Stubby Root	3
			Stunt	2

Nematode data
Knights Top Battle

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20508873	B11	8th June 2005	Root-lesion	91
			Stunts	11
			Cyst Juvenile	1
20508874	B12	8th June 2005	Root-lesion	73
			Cyst Juvenile	18
			Stunts	10
			Stubby Root	1
20508875	B13	8th June 2005	Root-lesion	91
			Stunts	14
			Cyst Juvenile	8
			Stubby Root	3
20508876	B14	8th June 2005	Root-lesion	187
			Cyst Juvenile	9
			Stubby Root	3
			Stunts	3
20508877	B21	8th June 2005	Root-lesion	73
			Stunts	2
20508878	B22	8th June 2005	Root-lesion	65
			Stunts	2
			Cyst Juvenile	1
20508879	B23	8th June 2005	Root-lesion	108
			Cyst Juvenile	5
			Stubby Root	3
			Stunts	2
20508880	B24	8th June 2005	Root-lesion	64
			Stunts	1
20508881	B31	8th June 2005	Root-lesion	69
			Stunts	2
			Cyst Juvenile	1
20508882	B32	8th June 2005	Root-lesion	103
			Stubby Root	2
			Stunts	1
20508883	B33	8th June 2005	Root-lesion	44
			Stubby Root	1
20508884	B34	8th June 2005	Root-lesion	69
			Stunts	3
			Stubby Root	1
			Cyst Juvenile	1
20508885	B41	8th June 2005	Root-lesion	49
			Stunts	11
			Stubby Root	1
			Cyst Juvenile	1
20508886	B42	8th June 2005	Root-lesion	25
			Stunts	8
			Cyst Juvenile	1
20508887	B43	8th June 2005	Root-lesion	72
			Stunts	2
20508888	B44	8th June 2005	Root-lesion	98
			Stunts	2
			Cyst Juvenile	1
20508889	B51	8th June 2005	Root-lesion	24
			Stunts	9
20508890	B52	8th June 2005	Root-lesion	108

			Stunts	14
			Stubby Root	3
20508891	B53	8th June 2005	Root-lesion	139
			Stunts	7
20508892	B54	8th June 2005	Root-lesion	237
			Stunts	4
20508893	B61	8th June 2005	Root-lesion	93
20508894	B62	8th June 2005	Root-lesion	73
			Stunts	4
20508895	B63	8th June 2005	Root-lesion	176
			Stunts	5
20508896	B64	8th June 2005	Root-lesion	234
			Stunts	2

Nematode data
Elveden Estates Waterloo

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20512965	A11	9th August 2005	Root-Lesion	129
			Stubby Root	34
20512966	A12	9th August 2005	Root-Lesion	153
			Stunts	32
			Stubby Root	13
			Ring	1
20512967	A13	9th August 2005	Root-Lesion	98
			Stunts	18
			Stubby Root	11
20512968	A14	9th August 2005	Root-Lesion	86
			Stunts	45
			Stubby Root	3
20512969	A21	9th August 2005	Root-Lesion	91
			Stubby Root	21
			Stunts	4
20512970	A22	9th August 2005	Root-Lesion	145
			Stunts	22
			Stubby Root	2
20512971	A23	9th August 2005	Root-Lesion	31
			Stubby Root	3
20512972	A24	9th August 2005	Root-Lesion	111
			Stubby Root	4
20512973	A31	9th August 2005	Root-Lesion	109
			Stubby Root	15
			Stunts	2
20512974	A32	9th August 2005	Root-Lesion	39
			Stunts	5
			Stubby Root	2
20512975	A33	9th August 2005	Root-Lesion	55
			Stunts	11
			Stubby Root	3
20512976	A34	9th August 2005	Root-Lesion	42
			Stubby Root	8
20512977	A41	9th August 2005	Root-Lesion	113
			Stunts	9
20512978	A42	9th August 2005	Root-Lesion	72
			Stubby Root	6
20512979	A43	9th August 2005	Root-Lesion	142
			Stubby Root	26
20512980	A44	9th August 2005	Root-Lesion	118
			Stubby Root	32
20512981	A51	9th August 2005	Root-Lesion	54
			Stubby Root	2
20512982	A52	9th August 2005	Root-Lesion	61
			Stubby Root	2
20512983	A53	9th August 2005	Root-Lesion	45
			Stubby Root	6
			Stunts	8
20512984	A54	9th August 2005	Root-Lesion	60
			Stubby Root	2
20512985	A61	9th August 2005	Root-Lesion	43
			Stubby Root	4

20512986	A62	9th August 2005	Root-Lesion	74
			Stunts	8
20512987	A63	9th August 2005	Root-Lesion	138
			Stubby Root	10
			Stunts	10
20512988	A64	9th August 2005	Root-Lesion	39

Nematode data
Knights Top Battle

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20512990	B11	9th August 2005	Root-lesion	136
			Cyst Juveniles	11
			Stunts	2
			Stubby Root	1
20512991	B12	9th August 2005	Root-lesion	111
			Cyst Juveniles	27
			Stunts	2
			Stubby Root	1
20512992	B13	9th August 2005	Root-lesion	92
			Stunts	18
			Cyst Juveniles	16
			Stubby Root	6
20512993	B14	9th August 2005	Root-lesion	143
			Stunts	8
			Cyst Juveniles	2
20512994	B21	9th August 2005	Root-lesion	79
			Stunts	4
20512995	B22	9th August 2005	Root-lesion	35
			Cyst Juveniles	19
20512996	B23	9th August 2005	Root-lesion	81
			Cyst Juveniles	134
			Stunts	1
20512997	B24	9th August 2005	Root-lesion	63
			Cyst Juveniles	3
20512998	B31	9th August 2005	Root-lesion	18
			Stunts	4
20512999	B32	9th August 2005	Root-lesion	60
			Stunts	10
20513000	B33	9th August 2005	Root-lesion	56
			Cyst Juveniles	4
			Stunts	4
20513001	B34	9th August 2005	Root-lesion	109
			Cyst Juveniles	17
20513002	B41	9th August 2005	Root-lesion	54
			Stunts	81
			Cyst Juveniles	1
20513003	B42	9th August 2005	Root-lesion	125
			Stunts	54
			Stubby Root	3
			Cyst Juveniles	1
20513004	B43	9th August 2005	Root-lesion	142
			Stunts	25
			Cyst Juveniles	6
20513005	B44	9th August 2005	Root-lesion	138
			Stunts	4
20513006	B51	9th August 2005	Root-lesion	9
			Stunts	6
20513007	B52	9th August 2005	Root-lesion	28
			Stunts	3
20513008	B53	9th August 2005	Root-lesion	47
			Stunts	23
20513009	B54	9th August 2005	Root-lesion	69

			Stunts	4
20513010	B61	9th August 2005	Root-lesion	40
			Stunts	1
20513011	B62	9th August 2005	Root-lesion	31
			Stunts	2
			Cyst Juveniles	1
20513012	B63	9th August 2005	Root-lesion	72
			Stunts	7
			Cyst Juveniles	3
20513013	B64	9th August 2005	Root-lesion	66
			Cyst Juveniles	2

Nematode data Elveden Estates Waterloo

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20516409	A11	21st September 2005	Root-lesion	43
			Stubby Root	10
20516410	A12	21st September 2005	Root-lesion	71
			Stunt	12
20516411	A13	21st September 2005	Root-lesion	155
			Stunt	30
20516412	A14	21st September 2005	Root-lesion	41
			Stubby Root	3
			Stunt	4
20516413	A21	21st September 2005	Root-lesion	106
			Stunt	1
20516414	A22	21st September 2005	Root-lesion	99
			Stunt	24
			Stubby Root	2
20516415	A23	21st September 2005	Root-lesion	54
			Stunt	1
20516416	A24	21st September 2005	Root-lesion	79
			Stunt	4
20516417	A31	21st September 2005	Root-lesion	44
			Stunt	3
20516418	A32	21st September 2005	Root-lesion	82
			Stunt	1
20516419	A33	21st September 2005	Root-lesion	63
			Stunt	2
			Pin	1
20516420	A34	21st September 2005	Root-lesion	28
			Stubby Root	1
20516421	A41	21st September 2005	Root-lesion	65
			Stubby Root	4
20516422	A42	21st September 2005	Root-lesion	103
			Stunt	3
20516423	A43	21st September 2005	Root-lesion	80
			Stubby Root	9
20516424	A44	21st September 2005	Root-lesion	76
			Stubby Root	8
20516425	A51	21st September 2005	Root-lesion	70
			Stubby Root	2
20516426	A52	21st September 2005	Root-lesion	84
			Stubby Root	9
20516427	A53	21st September 2005	Root-lesion	58
			Stubby Root	4
20516428	A54	21st September 2005	Root-lesion	16
			Stubby Root	10
			Stunt	1
20516429	A61	21st September 2005	Root-lesion	74
			Stubby Root	8
20516430	A62	21st September 2005	Root-lesion	40
			Stubby Root	2
			Stunt	2
20516431	A63	21st September 2005	Root-lesion	20
			Stunt	2
20516432	A64	21st September 2005	Root-lesion	34
			Stunt	4

Nematode data — Knights Top Battle

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20516434	B11	21st September 2005	Root-lesion	54
			Stunt	4
			Cyst Juvenile	1
20516435	B12	21st September 2005	Root-lesion	35
			Stunt	4
			Cyst Juvenile	1
20516436	B13	21st September 2005	Root-lesion	62
			Stunt	40
20516437	B14	21st September 2005	Root-lesion	58
20516438	B21	21st September 2005	Root-lesion	75
20516439	B22	21st September 2005	Root-lesion	28
20516440	B23	21st September 2005	Root-lesion	107
			Cyst Juvenile	14
			Stunt	5
20516441	B24	21st September 2005	Root-lesion	108
			Stubby Root	1
			Cyst Juvenile	2
20516442	B31	21st September 2005	Root-lesion	28
			Stubby Root	1
20516443	B32	21st September 2005	Root-lesion	47
			Cyst Juvenile	3
			Stunt	3
20516444	B33	21st September 2005	Root-lesion	68
			Cyst Juvenile	27
			Stunt	2
20516445	B34	21st September 2005	Root-lesion	85
			Stubby Root	2
20516446	B41	21st September 2005	Stunt	52
			Root-lesion	34
			Stubby Root	4
20516447	B42	21st September 2005	Stunt	50
			Root-lesion	39
			Stubby Root	3
20516448	B43	21st September 2005	Root-lesion	51
			Stunt	45
			Cyst Juvenile	2
20516449	B44	21st September 2005	Root-lesion	32
			Stunt	5
			Stubby Root	4
			Cyst Juvenile	1
20516450	B51	21st September 2005	Root-lesion	46
			Stubby Root	5
			Stunt	5
			Cyst Juvenile	2
20516451	B52	21st September 2005	Root-lesion	53
			Stunt	16
			Stubby Root	1
20516452	B53	21st September 2005	Root-lesion	37
			Stunt	22
			Cyst Juvenile	15
			Stubby Root	1
20516453	B54	21st September 2005	Root-lesion	184

CSL Reference Number	Plot number	Sampling Stage (Date)	Common Name	Number per 200g
20516454	B61	21st September 2005	Root-lesion	37
			Stunt	4
			Stubby Root	1
20516455	B62	21st September 2005	Root-lesion	59
			Cyst Juvenile	12
			Stunt	8
			Stubby Root	2
20516456	B63	21st September 2005	Root-lesion	36
			Stubby Root	7
			Stunt	5
			Cyst Juvenile	1
20516457	B64	21st September 2005	Root-lesion	61
			Stubby Root	2
			Cyst Juvenile	1

Statistical Analysis for Effect of Biocidal Plants on Numbers of Nematodes and *Pythia*

Statistical analysis was by Analysis of Variance (anova) with contrasts, using Genstat 8. There were 3 treatments (Biocide, Cultivation, No cultivation) with 4 replicates of each treatment at each of 2 sites (Elveden, Knights). There were 2 complete experiments conducted at the same time, one with Mustard 99 as the Biocide and one with Mustard 119*. In the analysis the sites were blocks and the two contrasts were Biocide versus Cultivation and Biocide versus No cultivation. The pythium and nematode counts were transformed to logarithms for the analyses (log(n+1) for stunt and stubby nematodes since these counts contained zeroes), which successfully normalised the data and stabilised the variances, thus meeting the requirements of anova.

At pre-drilling (Count 1) no statistically significant differences were found between the three treatments (biocide, cultivation and no cultivation) for either total pythium, total nematodes, lesion nematodes, stubby nematodes or stunt nematodes, for either Mustard 99 or Mustard 119 (see Tables 1a and 1b).

At pre-incorporation (Count 2) there was a significant difference between treatments for total nematodes and lesion nematodes, due to there being more nematodes in the Mustard 99 and Mustard 119 plots than in the respective Cultivated plots and also, in the case of Mustard 119, in the Uncultivated plots. There were also more stubby nematodes in the Mustard 99 plots, but this difference was not detected with Mustard 119.

At six weeks post-incorporation (Count 3) no differences were detected - all the differences seen at Count 2 had disappeared.

Changes in nematode numbers between Counts 1 and 3 were compared between the treatments (referred to as Diff 1:3 in the Tables) to see if they changed similarly. The values analysed were log(Count1) - log(Count3) which is equivalent to Count1/Count3. No significant differences were detected for pythium or any of the nematodes for either biocides (Tables 1a,b).

Changes in numbers between Counts 2 and 3 were similarly compared between treatments (referred to as Diff 2:3, Table 1c.). Overall, there was a marked drop in total nematode numbers from Count 2 to Count 3 with both Biocides which was not mirrored in the other two treatments. Analyses of the two sites individually confirmed this effect for Knights but not for Elveden. For a simple visualisation see Table 3e for t-tests on the combined sites (don't quote these since the previous approach is better).

The results of the analyses are sumarised in appended Table 1 (log means and probabilities), Table 2 (antilogs of the means and their confidence intervals), and Table 3 (Means and standard errors for each treatment at each site, log and antilog.). Slightly edited (shortened) Genstat output is appended – note cross-reference numbering between the contents of Tables and the output.

Table 1a. Means (log10) and probabilities of differences between treatments for total Pythium, total nematodes and lesion nematodes.

	Mustard 99 Total pythium	Means (logs) Cult	**Mustard 99**	NoCult	e.s.e df=20	Anova Treats p		Contrast Must 99 vCult p		Contrast Must 99 vNoCult p	
1.1.1	Count 1	3.366	3.554	3.521	0.065	0.120		0.055		0.721	
1.1.2	Count 2	3.414	3.578	3.565	0.053	0.073		0.039	*	0.861	
1.1.3	Count 3	3.485	3.625	3.549	0.052	0.186		0.071		0.310	
1.1.4	Diff 1:3	0.119	0.071	0.028	0.081	0.729		0.677		0.710	

	Mustard 119 Total pythium	Means (logs) Cult	NoCult	**Mustard 119**	e.s.e df=20	Anova Treats p		Contrast Must 119 vCult p		Contrast Must 119 vNoCult p	
1.2.1	Count 1	3.268	3.310	3.296	0.068	0.905		0.770		0.889	
1.2.2	Count 2	3.391	3.385	3.446	0.043	0.552		0.378		0.326	
1.2.3	Count 3	3.443	3.468	3.531	0.037	0.235		0.102		0.238	
1.2.4	Diff 1:3	0.175	0.159	0.235	0.068	0.712		0.541		0.439	

	Mustard 99 Total nematodes	Means (logs) Cult	**Mustard 99**	NoCult	e.s.e df=20	Anova Treats p		Contrast Must 99 vCult p		Contrast Must 99 vNoCult p	
2.1.1	Count 1	1.886	1.974	1.844	0.083	0.300		0.302		0.132	
2.1.2	Count 2	1.799	2.172	1.961	0.076	0.009	**	0.003	**	0.066	
2.1.3	Count 3	1.748	1.842	1.907	0.077	0.365		0.401		0.561	
2.1.4	Diff 1:3	-0.138	-0.132	0.063	0.096	0.265		0.966		0.166	
	Lesion nematodes										
2.1.5	Count 1	1.852	1.899	1.787	0.064	0.471		0.611		0.227	
2.1.6	Count 2	1.726	2.065	1.851	0.074	0.014	*	0.004	**	0.054	
2.1.7	Count 3	1.711	1.765	1.879	0.071	0.254		0.594		0.268	
2.1.8	Diff 1:3	-0.142	-0.134	0.093	0.089	0.130		0.950		0.085	

	Mustard 119 Total nematodes	Means (logs) Cult	NoCult	**Mustard 119**	e.s.e df=20	Anova Treats p		Contrast Must 119 vCult p		Contrast Must 119 vNoCult p	
2.2.1	Count 1	2.062	2.009	1.906	0.074	0.340		0.153		0.338	
2.2.2	Count 2	1.783	1.686	2.146	0.071	<0.001	***	0.002	**	<0.001	***
2.2.3	Count 3	1.688	1.850	1.909	0.066	0.072		0.028		0.533	
2.2.4	Diff 1:3	-0.373	-0.159	0.003	0.083	0.016	*	0.005	**	0.184	
	Lesion nematodes										
2.2.5	Count 1	2.036	1.960	1.838	0.086	0.296		0.121		0.331	
2.2.6	Count 2	1.750	1.608	2.032	0.078	0.003	**	0.019	*	<0.001	***
2.2.7	Count 3	1.623	1.745	1.743	0.083	0.509		0.321		0.990	
2.2.8	Diff 1:3	-0.413	-0.215	-0.095	0.093	0.074		0.025	*	0.373	

Table 1b. Means (log10) and probabilities of differences between treatments for stubby and stunt nematodes.

	Mustard 99	Means (logs)			e.s.e	Anova		Contrast Must 99 vCult		Contrast Must 99 vNoCult	
	Stubby nematodes	Cult	**Mustard 99**	NoCult	df=20	Treats. p		p		p	
3.1.1	Count 1	0.421	0.458	0.463	0.129	0.969		0.842		0.979	
3.1.2	Count 2	0.405	0.727	0.390	0.100	0.045	*	0.034	*	0.027	*
3.1.3	Count 3	0.195	0.205	0.097	0.102	0.714		0.940		0.461	
3.1.4	Diff 1:3	-0.227	-0.253	-0.366	0.159	0.807		0.909		0.620	
	Stunt nematodes										
3.1.5	Count 1	0.460	0.769	0.542	0.128	0.232		0.102		0.223	
3.1.6	Count 2	0.600	0.960	0.380	0.254	0.099		0.172		0.035	*
3.1.7	Count 3	0.248	0.789	0.435	0.167	0.090		0.032	*	0.148	
3.1.8	Diff 1:3	-0.212	0.020	-0.107	0.151	0.561		0.289		0.557	

	Mustard 119	Means (logs)			e.s.e	Anova	Contrast Must 119 vCult	Contrast Must 119 vNoCult	
	Stubby nematodes	Cult	NoCult	**Mustard 119**	df=20	Treats p	p	p	
3.2.1	Count 1	0.413	0.462	0.420	0.119	0.953	0.965	0.810	
3.2.2	Count 2	0.218	0.285	0.550	0.187	0.197	0.091	0.171	
3.2.3	Count 3	0.449	0.575	0.582	0.131	0.725	0.481	0.970	
3.2.4	Diff 1:3	0.036	0.113	0.161	0.140	0.816	0.532	0.810	
	Stunt nematodes								
3.2.5	Count 1	0.476	0.640	0.433	0.117	0.435	0.796	0.226	
3.2.6	Count 2	0.520	0.560	0.850	0.180	0.393	0.214	0.275	
3.2.7	Count 3	0.511	0.459	0.809	0.161	0.275	0.205	0.140	
3.2.8	Diff 1:3	0.034	-0.181	0.376	0.153	0.055	0.130	0.018	*

Table 1c. Means (log10) and probabilities of differences between log nematode pre-incorporation (Count 2) and six weeks after incorporation (Count 3).

Diff 2:3	Mustard 99	Mean diffs (logs) Cult	Mustard 99	NoCult	e.s.e df=20	Anova Treats p		Contrast Must 99 vCult p		Contrast Must 99 vNoCult p	
	Both sites										
4.1.1	Total nems.	-0.051	-0.329	-0.055	0.0795	0.034	*	0.022	*	0.024	*
4.1.2	Lesion	-0.016	-0.300	0.029	0.075	0.011	*	0.014	*	0.006	**
4.1.3	Stunt	-0.349	-0.167	0.052	0.1629	0.243		0.438		0.354	
4.1.4	Stubby	-0.210	-0.522	-0.293	0.1417	0.295		0.135		0.266	
	Elveden				df=9						
4.2.1	Total nems.	-0.107	-0.288	-0.025	0.1308	0.387		0.355		0.189	
4.2.2	Lesion	-0.047	-0.233	-0.002	0.1355	0.47		0.357		0.257	
4.2.3	Stunt	-0.24	-0.29	0.16	0.225	0.347		0.878		0.192	
4.2.4	Stubby	-0.73	-0.68	-0.66	0.241	0.976		0.882		0.952	
	Knights				df=9						
4.3.1	Total nems.	0.005	-0.371	-0.084	0.0986	0.058		0.024	*	0.07	
4.3.2	Lesion	0.016	-0.366	0.059	0.0725	0.005	**	0.005	**	0.002	**
4.3.3	Stunt	-0.46	-0.04	-0.06	0.244	0.426		0.26		0.975	
4.3.4	Stubby	0.314	-0.362	0.075	0.1282	0.014	*	0.005	**	0.039	*

Diff 2:3	Mustard 119	Mean diffs (logs) Cult	NoCult	Mustard 119	e.s.e df=20	Anova Treatments p		Contrast Must 119 vCult p		Contrast Must 119 vNoCult p	
	Both sites										
4.4.1	Total nems.	-0.095	0.164	-0.237	0.1019	0.035	*	0.088		0.012	*
4.4.2	Lesion	-0.127	0.137	-0.289	0.118	0.057		0.129		0.019	*
4.4.3	Stunt	-0.01	-0.1	-0.04	0.174	0.928		0.71		0.795	
4.4.4	Stubby	0.231	0.29	0.032	0.1673	0.531		0.806		0.288	
	Elveden				df=9						
4.5.1	Total nems.	-0.224	-0.015	-0.161	0.1624	0.661		0.387		0.543	
4.5.2	Lesion	-0.23	-0.05	-0.13	0.174	0.772		0.485		0.758	
4.5.3	Stunt	-0.09	-0.16	-0.1	0.299	0.981		0.858		0.883	
4.5.4	Stubby	-0.08	0.24	-0.29	0.295	0.483		0.473		0.243	
	Knights				df=9						
4.6.1	Total nems.	0.034	0.343	-0.313	0.1078	0.006	**	0.074		0.002	**
4.6.2	Lesion	-0.022	0.327	-0.447	0.1304	0.008	**	0.091		0.002	**
4.6.3	Stunt	0.07	-0.04	0.03	0.21	0.937		0.727		0.832	
4.6.4	Stubby	0.54	0.345	0.349	0.1663	0.654		0.43		0.985	

Table 2a. Antilogs of the means and 95% confidence intervals for total Pythium, total nematodes and lesion nematodes.

Total pythium

	Mustard 99			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	3581.0	2615.6	4902.5	2322.7	1696.6	3180.0	3318.9	2424.3	4543.8
2	3784.4	2938.1	4874.5	2594.2	2014.0	3341.4	3672.8	2851.5	4730.8
3	4217.0	3286.5	5410.8	3054.9	2380.9	3919.8	3540.0	2758.9	4542.1

	Mustard 119			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	1977.0	1428.2	2736.7	1853.5	1339.0	2565.8	2041.7	1475.0	2826.3
2	2792.5	2273.6	3429.9	2460.4	2003.2	3021.9	2426.6	1975.7	2980.4
3	3396.3	2850.1	4047.0	2773.3	2327.4	3304.7	2937.6	2465.3	3500.6

Total nematodes

	Mustard 99			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	94.2	63.3	140.3	76.9	51.7	114.5	69.8	46.9	104.0
2	148.6	103.0	214.5	63.0	43.6	90.9	91.4	63.3	131.9
3	69.5	47.9	100.7	56.0	38.6	81.1	80.7	55.7	117.0

Lesion nematodes

	Mustard 99			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	79.3	58.4	107.6	71.1	52.4	96.6	61.2	45.1	83.2
2	116.1	81.5	165.6	53.2	37.3	75.8	71.0	49.8	101.1
3	58.2	41.4	81.9	51.4	36.5	72.3	75.7	53.8	106.5

Total nematodes

	Mustard 119			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	80.5	56.3	115.1	115.3	80.7	164.9	102.1	71.4	145.9
2	140.0	99.4	197.0	60.7	43.1	85.4	48.5	34.5	68.3
3	81.1	59.1	111.2	48.8	35.5	66.9	70.8	51.6	97.1

Lesion nematodes

	Mustard 119			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	68.9	45.5	104.1	108.6	71.8	164.3	91.2	60.3	137.9
2	107.6	74.0	156.5	56.2	38.7	81.8	40.6	27.9	59.0
3	55.3	37.1	82.6	42.0	28.1	62.7	55.6	37.2	83.0

Table 2b. Antilogs of the means and 95% confidence intervals for stubby and stunt nematodes.

Stubby nematodes									
	Mustard 99			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	2.9	1.5	5.3	2.6	1.4	4.9	2.9	1.6	5.4
2	5.3	3.3	8.6	2.5	1.6	4.1	2.5	1.5	4.0
3	1.6	1.0	2.6	1.6	1.0	2.6	1.3	0.8	2.0
Stunt nematodes									
	Mustard 99			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	5.9	3.2	10.9	2.9	1.6	5.3	3.5	1.9	6.4
2	9.1	2.7	30.9	4.0	1.2	13.5	2.4	0.7	8.1
3	6.2	2.8	13.7	1.8	0.8	3.9	2.7	1.2	6.1

Stubby nematodes									
	Mustard 119			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	2.6	1.5	4.7	2.6	1.5	4.6	2.9	1.6	5.1
2	3.5	1.4	8.7	1.7	0.7	4.1	1.9	0.8	4.7
3	3.8	2.0	7.2	2.8	1.5	5.3	3.8	2.0	7.0
Stunt nematodes									
	Mustard 119			**Cult**			**NoCult**		
Count	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim	Mean	95% low lim	95% high lim
1	2.7	1.5	4.8	3.0	1.7	5.3	4.4	2.5	7.7
2	7.1	3.0	16.8	3.3	1.4	7.9	3.6	1.5	8.6
3	6.4	3.0	14.0	3.2	1.5	7.0	2.9	1.3	6.2

Table 3a. Mustard 99 trial: Means and standard errors of the log number of nematodes for each treatment at each site.

Total pythium

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	3.371	3.355	3.405	3.141	3.243	3.226	3.230	3.478	3.277
	SE	0.049	0.076	0.066	0.093	0.039	0.043	0.101	0.039	0.091
Knights	Mean	3.737	3.801	3.845	3.591	3.584	3.744	3.812	3.651	3.820
	SE	0.141	0.109	0.070	0.043	0.043	0.103	0.101	0.091	0.071

Total nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	1.850	2.185	1.898	1.921	1.825	1.718	1.790	1.971	1.946
	SE	0.060	0.044	0.134	0.032	0.099	0.099	0.136	0.152	0.078
Knights	Mean	2.098	2.158	1.786	1.851	1.774	1.778	1.898	1.951	1.867
	SE	0.070	0.014	0.084	0.076	0.158	0.120	0.059	0.133	0.148

Lesion nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	1.785	2.055	1.822	1.871	1.748	1.701	1.695	1.914	1.913
	SE	0.066	0.057	0.134	0.033	0.102	0.101	0.159	0.147	0.066
Knights	Mean	2.013	2.074	1.708	1.833	1.705	1.720	1.879	1.787	1.846
	SE	0.089	0.044	0.056	0.075	0.163	0.105	0.053	0.085	0.138

Stubby nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	0.540	1.093	0.411	0.573	0.809	0.075	0.775	0.780	0.119
	SE	0.241	0.193	0.254	0.232	0.166	0.075	0.197	0.193	0.119
Knights	Mean	0.376	0.362	0.000	0.270	0.000	0.314	0.151	0.000	0.075
	SE	0.144	0.176	0.000	0.099	0.000	0.113	0.151	0.000	0.075

Stunt nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	0.564	1.115	0.826	0.574	0.584	0.345	0.651	0.515	0.675
	SE	0.259	0.380	0.319	0.223	0.230	0.131	0.144	0.327	0.259
Knights	Mean	0.975	0.797	0.753	0.345	0.610	0.151	0.433	0.250	0.195
	SE	0.127	0.196	0.331	0.131	0.219	0.151	0.044	0.166	0.195

Means and standard errors of log values
Total pythium, total nematodes and lesion nematodes are log10(value) since there were no zeroes
Stubby and stunt nematodes are log10(value+1) since there were zeroes

Table 3b. Mustard 119 trial: Means and standard errors of the log number of nematodes for each treatment at each site.

Total pythium

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	3.143	3.302	3.458	2.987	3.150	3.306	3.164	3.218	3.385
	SE	0.102	0.030	0.061	0.174	0.084	0.035	0.085	0.036	0.064
Knights	Mean	3.449	3.589	3.604	3.548	3.632	3.580	3.456	3.552	3.552
	SE	0.042	0.077	0.073	0.015	0.045	0.034	0.061	0.062	0.027

Total nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	2.012	2.095	1.934	2.002	1.844	1.620	1.977	1.778	1.762
	SE	0.056	0.073	0.038	0.048	0.137	0.117	0.027	0.012	0.116
Knights	Mean	1.799	2.197	1.883	2.121	1.723	1.757	2.040	1.594	1.937
	SE	0.099	0.032	0.087	0.116	0.090	0.063	0.184	0.163	0.112

Lesion nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	1.943	2.034	1.902	1.960	1.808	1.576	1.937	1.737	1.684
	SE	0.090	0.063	0.042	0.057	0.126	0.117	0.022	0.030	0.163
Knights	Mean	1.734	2.030	1.584	2.112	1.693	1.670	1.983	1.478	1.805
	SE	0.128	0.100	0.045	0.118	0.088	0.062	0.213	0.192	0.157

Stubby nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	0.766	0.949	0.663	0.826	0.435	0.358	0.773	0.569	0.804
	SE	0.336	0.350	0.231	0.135	0.261	0.228	0.163	0.092	0.133
Knights	Mean	0.075	0.151	0.500	0.000	0.000	0.540	0.151	0.000	0.345
	SE	0.075	0.151	0.168	0.000	0.000	0.128	0.150	0.000	0.161

Stunt nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	0.119	0.250	0.151	0.464	0.499	0.413	0.336	0.239	0.075
	SE	0.119	0.250	0.151	0.062	0.289	0.147	0.246	0.239	0.075
Knights	Mean	0.747	1.442	1.468	0.489	0.540	0.608	0.945	0.882	0.843
	SE	0.158	0.268	0.230	0.175	0.128	0.210	0.100	0.174	0.307

Means and standard errors of log values

Total pythium, total nematodes and lesion nematodes are log10(value) since there were no zeroes

Stubby and stunt nematodes are log10(value+1) since there were zeroes

Table 3c. Mustard 99 trial: Antilogs of the Mean log number of nematodes for each treatment at each site, and of the Mean±SE.

Total pythium

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	2349.6	2264.6	2541.0	1383.6	1749.8	1682.7	1698.2	3006.1	1892.3
	Mean+SE	2630.3	2697.7	2958.0	1714.0	1914.3	1857.8	2142.9	3288.5	2333.5
	Mean-SE	2098.9	1901.1	2182.7	1116.9	1599.6	1524.1	1345.9	2747.9	1534.6
Knights	Mean	5457.6	6324.1	6998.4	3899.4	3837.1	5546.3	6486.3	4477.1	6606.9
	Mean+SE	7550.9	8128.3	8222.4	4305.3	4236.4	7030.7	8184.6	5520.8	7780.4
	Mean-SE	3944.6	4920.4	5956.6	3531.8	3475.4	4375.2	5140.4	3630.8	5610.5

Total nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	70.8	153.1	79.1	83.4	66.8	52.2	61.7	93.5	88.3
	Mean+SE	81.3	169.4	107.6	89.7	83.9	65.6	84.3	132.7	105.7
	Mean-SE	61.7	138.4	58.1	77.4	53.2	41.6	45.1	65.9	73.8
Knights	Mean	125.3	143.9	61.1	71.0	59.4	60.0	79.1	89.3	73.6
	Mean+SE	147.2	148.6	74.1	84.5	85.5	79.1	90.6	121.3	103.5
	Mean-SE	106.7	139.3	50.4	59.6	41.3	45.5	69.0	65.8	52.4

Lesion nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	61.0	113.5	66.4	74.3	56.0	50.2	49.5	82.0	81.8
	Mean+SE	71.0	129.4	90.4	80.2	70.8	63.4	71.4	115.1	95.3
	Mean-SE	52.4	99.5	48.8	68.9	44.3	39.8	34.4	58.5	70.3
Knights	Mean	103.0	118.6	51.1	68.1	50.7	52.5	75.7	61.2	70.1
	Mean+SE	126.5	131.2	58.1	80.9	73.8	66.8	85.5	74.5	96.4
	Mean-SE	83.9	107.2	44.9	57.3	34.8	41.2	67.0	50.4	51.1

Stubby nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	2.5	11.4	1.6	2.7	5.4	0.2	5.0	5.0	0.3
	Mean+SE	5.0	18.3	3.6	5.4	8.4	0.4	8.4	8.4	0.7
	Mean-SE	1.0	6.9	0.4	1.2	3.4	0.0	2.8	2.9	0.0
Knights	Mean	1.4	1.3	0.0	0.9	0.0	1.1	0.4	0.0	0.2
	Mean+SE	2.3	2.4	0.0	1.3	0.0	1.7	1.0	0.0	0.4
	Mean-SE	0.7	0.5	0.0	0.5	0.0	0.6	0.0	0.0	0.0

Stunt nematodes

		Mustard 991	Mustard 992	Mustard 993	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult3
Elveden	Mean	2.7	12.0	5.7	2.8	2.8	1.2	3.5	2.3	3.7
	Mean+SE	5.7	30.3	13.0	5.3	5.5	2.0	5.2	6.0	7.6
	Mean-SE	1.0	4.4	2.2	1.2	1.3	0.6	2.2	0.5	1.6
Knights	Mean	8.4	5.3	4.7	1.2	3.1	0.4	1.7	0.8	0.6
	Mean+SE	11.7	8.8	11.1	2.0	5.7	1.0	2.0	1.6	1.4
	Mean-SE	6.0	3.0	1.6	0.6	1.5	0.0	1.4	0.2	0.0

Antilogs:
10^value for log10(value).
(10^value)-1 for log10(value+1) Note that this is an approximation

Table 3d. Mustard 119 trial: Antilogs of the Mean log number of nematodes for each treatment at each site, and of the Mean±SE.

Total pythium

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult
Elveden	Mean	1390.0	2004.5	2870.8	970.5	1412.5	2023.0	1458.8	1652.0	2426.
	Mean+SE	1757.9	2147.8	3303.7	1448.8	1714.0	2192.8	1774.2	1794.7	2811.
	Mean-SE	1099.0	1870.7	2494.6	650.1	1164.1	1866.4	1199.5	1520.5	2094.
Knights	Mean	2811.9	3881.5	4017.9	3531.8	4285.5	3801.9	2857.6	3564.5	3564.
	Mean+SE	3097.4	4634.5	4753.4	3655.9	4753.4	4111.5	3288.5	4111.5	3793.
	Mean-SE	2552.7	3250.9	3396.3	3411.9	3863.7	3515.6	2483.1	3090.3	3349.

Total nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult
Elveden	Mean	102.8	124.5	85.9	100.5	69.8	41.7	94.8	60.0	57.8
	Mean+SE	116.9	147.2	93.8	112.2	95.7	54.6	100.9	61.7	75.5
	Mean-SE	90.4	105.2	78.7	89.9	50.9	31.8	89.1	58.3	44.3
Knights	Mean	63.0	157.4	76.4	132.1	52.8	57.1	109.6	39.3	86.5
	Mean+SE	79.1	169.4	93.3	172.6	65.0	66.1	167.5	57.1	111.9
	Mean-SE	50.1	146.2	62.5	101.2	43.0	49.4	71.8	27.0	66.8

Lesion nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult
Elveden	Mean	87.7	108.1	79.8	91.2	64.3	37.7	86.5	54.6	48.3
	Mean+SE	107.9	125.0	87.9	104.0	85.9	49.3	91.0	58.5	70.3
	Mean-SE	71.3	93.5	72.4	80.0	48.1	28.8	82.2	50.9	33.2
Knights	Mean	54.2	107.2	38.4	129.4	49.3	46.8	96.2	30.1	63.8
	Mean+SE	72.8	134.9	42.6	169.8	60.4	54.0	157.0	46.8	91.6
	Mean-SE	40.4	85.1	34.6	98.6	40.3	40.6	58.9	19.3	44.5

Stubby nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult
Elveden	Mean	4.8	7.9	3.6	5.7	1.7	1.3	4.9	2.7	5.4
	Mean+SE	11.6	18.9	6.8	8.1	4.0	2.9	7.6	3.6	7.7
	Mean-SE	1.7	3.0	1.7	3.9	0.5	0.3	3.1	2.0	3.7
Knights	Mean	0.2	0.4	2.2	0.0	0.0	2.5	0.4	0.0	1.2
	Mean+SE	0.4	1.0	3.7	0.0	0.0	3.7	1.0	0.0	2.2
	Mean-SE	0.0	0.0	1.1	0.0	0.0	1.6	0.0	0.0	0.5

Stunt nematodes

		Mustard 1191	Mustard 1192	Mustard 1193	Cult1	Cult2	Cult3	NoCult1	NoCult2	NoCult
Elveden	Mean	0.3	0.8	0.4	1.9	2.2	1.6	1.2	0.7	0.2
	Mean+SE	0.7	2.2	1.0	2.4	5.1	2.6	2.8	2.0	0.4
	Mean-SE	0.0	0.0	0.0	1.5	0.6	0.8	0.2	0.0	0.0
Knights	Mean	4.6	26.7	28.4	2.1	2.5	3.1	7.8	6.6	6.0
	Mean+SE	7.0	50.3	48.9	3.6	3.7	5.6	10.1	10.4	13.1
	Mean-SE	2.9	13.9	16.3	1.1	1.6	1.5	6.0	4.1	2.4

Antilogs:
10^value for log10(value).
(10^value)-1 for log10(value+1) Note that this is an approximation

Table 3e. T-tests on the differences between counts 1 and 3 and between 2 and 3 for log Total nematodes, (sites lumped together).

Trial	Diff	Treat	N	Mean difference	S.E.	t value	df	p	
Mustard 99	1:3	NoCult	8	0.06281	0.08507	0.74	7	0.484	
	1:3	Cult	8	-0.1378	0.1017	-1.36	7	0.217	
	1:3	Mustard 99	8	-0.1319	0.1306	-1.27	7	0.2	
Mustard 99	2:3	NoCult	8	-0.05454	0.06646	-0.82	7	0.439	
	2:3	Cult	8	-0.05112	0.08151	-0.63	7	0.550	
	2:3	Mustard 99	8	-0.3295	0.08377	-3.93	7	0.006	**
Mustard 119	1:3	NoCult	8	-0.1592	0.08157	-1.95	7	0.092	
	1:3	Cult	8	-0.3734	0.08358	-4.47	7	0.003	**
	1:3	Mustard 99	8	0.00312	0.08496	0.04	7	0.972	
Mustard 119	2:3	NoCult	8	0.1639	0.1025	1.60	7	0.154	
	2:3	Cult	8	-0.09483	0.1327	-0.71	7	0.498	
	2:3	Mustard 99	8	-0.2370	0.06428	-3.96	7	0.008	**

Edited Genstat output

1. Analysis of Pythium results

Analysis of Variance with contrasts, Genstat 8.
Three treatments: Biocide, Cultivation, No cultivation.
Four replicates each block.
Two blocks: Elveden, Knights
Contrasts: Biocide v Cultivation, Biocide v No cultivation

1.1. Mustard 99

1.1.1. Total pythium count 1 (transformed to log10).

```
139  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth1

Analysis of variance
====================
Variate: logTotPyth1
Source of variation      d.f.      s.s.       m.s.     v.r.  F pr.
Site stratum                1   1.30458    1.30458    38.10
Site.*Units* stratum
Treat                       2   0.16162    0.08081     2.36  0.120 ns
  Must99vCult               1   0.14195    0.14195     4.14  0.055 ns
  Must99vNocult             1   0.00448    0.00448     0.13  0.721 ns
Residual                   20   0.68491    0.03425
Total                      23   2.15111

Tables of contrasts
===================
Variate: logTotPyth1
Must99vCult        0.188,   s.e. 0.0925,   ss.div. 4.00
Must99vNocult      0.033,   s.e. 0.0925,   ss.div. 4.00

Tables of means
===============
Variate: logTotPyth1
Grand mean  3.480
    Treat       Cult  Mustard99    NoCult
               3.366     3.554    3.521

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0654

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
```

```
s.e.d.              0.0925

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1930
```

1.1.2. Total pythium count 2 (transformed to log10).

```
145  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth2

Analysis of variance
====================
Variate: logTotPyth2
Source of variation      d.f.       s.s.        m.s.     v.r.  F pr.
Site stratum                1    0.61648     0.61648    27.75
Site.*Units* stratum
Treat                       2    0.13316     0.06658     3.00  0.073 ns
  Must99vCult               1     0.10784     0.10784     4.85  0.039 *
  Must99vNocult             1     0.00070     0.00070     0.03  0.861 ns
Residual                   20    0.44429     0.02221
Total                      23    1.19394

Tables of contrasts
===================
Variate: logTotPyth2
Must99vCult       0.164,  s.e. 0.0745,  ss.div. 4.00
Must99vNocult     0.013,  s.e. 0.0745,  ss.div. 4.00

Tables of means
===============
Variate: logTotPyth2
Grand mean  3.519
    Treat      Cult  Mustard99   NoCult
              3.414    3.578    3.565

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0527

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.0745

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1555
```

1.1.3. Total pythium count 3 (transformed to log10).

```
151  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth3

Analysis of variance
====================
Variate: logTotPyth3
Source of variation        d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum                  1    1.50388    1.50388    69.78
Site.*Units* stratum
Treat                         2    0.07883    0.03942     1.83  0.186 ns
  Must99vCult                 1    0.07862    0.07862     3.65  0.071 ns
  Must99vNocult               1    0.02336    0.02336     1.08  0.310 ns
Residual                     20    0.43102    0.02155
Total                        23    2.01373

Tables of contrasts
===================
Variate: logTotPyth3
Must99vCult       0.140,  s.e. 0.0734,  ss.div. 4.00
Must99vNocult     0.076,  s.e. 0.0734,  ss.div. 4.00

Tables of means
===============
Variate: logTotPyth3
Grand mean  3.553
    Treat       Cult  Mustard99   NoCult
               3.485     3.625     3.549

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0519

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.0734

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1531
```

1.1.4. Difference between Total pythium counts 1 and 3 (log minus log).

```
157  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogPyth13

Analysis of variance
====================
Variate: DifflogPyth13
```

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Site stratum	1	0.00708	0.00708	0.14	
Site.*Units* stratum					
Treat	2	0.03327	0.01664	0.32	0.729 ns
Must99vCult	1	0.00929	0.00929	0.18	0.677 ns
Must99vNocult	1	0.00739	0.00739	0.14	0.710 ns
Residual	20	1.03738	0.05187		
Total	23	1.07773			

Tables of contrasts
===================

Variate: DifflogPyth13

Must99vCult -0.05, s.e. 0.114, ss.div. 4.00

Must99vNocult 0.04, s.e. 0.114, ss.div. 4.00

Tables of means
===============

Variate: DifflogPyth13

Grand mean 0.072

Treat	Cult	Mustard99	NoCult
	0.119	0.071	0.028

Standard errors of means

Table	Treat
rep.	8
d.f.	20
e.s.e.	0.0805

Standard errors of differences of means

Table	Treat
rep.	8
d.f.	20
s.e.d.	0.1139

Least significant differences of means (5% level)

Table	Treat
rep.	8
d.f.	20
l.s.d.	0.2375

1.2. Mustard 119

1.2.1. Total pythium count 1 (transformed to log10).

132 ANOVA [PRINT=aovtable,information,means,contrast; FACT=32; FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth1

Analysis of variance
====================

Variate: logTotPyth1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Site stratum	1	0.89625	0.89625	24.47	
Site.*Units* stratum					
Treat	2	0.00733	0.00366	0.10	0.905 ns
Must119 vCult	1	0.00322	0.00322	0.09	0.770 ns
Must119vNocult	1	0.00073	0.00073	0.02	0.889 ns
Residual	20	0.73265	0.03663		
Total	23	1.63622			

```
Tables of contrasts
===================
Variate: logTotPyth1
Must119vCult       0.028,   s.e. 0.0957,   ss.div. 4.00
Must119Nocult     -0.014,   s.e. 0.0957,   ss.div. 4.00


Tables of means
===============
Variate: logTotPyth1
Grand mean  3.291
    Treat      Cult    NoCult   Mustard119
              3.268    3.310    3.296

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0677

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.0957

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1996
```

1.2.2. Total pythium count 2 (transformed to log10).

```
114  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth2

Analysis of variance
====================
Variate: logTotPyth2
Source of variation      d.f.       s.s.        m.s.     v.r.  F pr.
Site stratum                1    0.81153     0.81153    55.43
Site.*Units* stratum
Treat                       2    0.01793     0.00896     0.61  0.552 ns
  Must119vCult              1    0.01188     0.01188     0.81  0.378 ns
  Must119vNocult            1    0.01485     0.01485     1.01  0.326 ns
Residual                   20    0.29282     0.01464
Total                      23    1.12228

Tables of contrasts
===================
Variate: logTotPyth2
Must119vCult       0.055,   s.e. 0.0605,   ss.div. 4.00
Must119vNocult     0.061,   s.e. 0.0605,   ss.div. 4.00
```

```
Tables of means
===============

Variate: logTotPyth2
Grand mean  3.407
    Treat      Cult    NoCult    Mustard119
              3.391     3.385     3.446

Standard errors of means
------------------------

Table                   Treat
rep.                        8
d.f.                       20
e.s.e.                 0.0428

Standard errors of differences of means
---------------------------------------

Table                   Treat
rep.                        8
d.f.                       20
s.e.d.                 0.0605

Least significant differences of means (5% level)
-------------------------------------------------

Table                   Treat
rep.                        8
d.f.                       20
l.s.d.                 0.1262
```

1.2.3. Total pythium count 3 (transformed to log10).

```
120  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotPyth3

Analysis of variance
====================

Variate: logTotPyth3
Source of variation        d.f.       s.s.        m.s.     v.r.  F pr.
Site stratum                  1    0.22972     0.22972    21.60
Site.*Units* stratum
Treat                         2    0.03315     0.01657     1.56  0.235 ns
  Must119vCult                1    0.03133     0.03133     2.95  0.102 ns
  Must119vNocult              1    0.01574     0.01574     1.48  0.238 ns
Residual                     20    0.21273     0.01064
Total                        23    0.47560

Tables of contrasts
===================

Variate: logTotPyth3
Must119vCult      0.088,   s.e. 0.0516,   ss.div. 4.00
Must119vNocult    0.063,   s.e. 0.0516,   ss.div. 4.00


Tables of means
===============

Variate: logTotPyth3
Grand mean  3.481
    Treat      Cult    NoCult    Mustard119
              3.443     3.468     3.531
```

```
Standard errors of means
------------------------

Table                    Treat
rep.                         8
d.f.                        20
e.s.e.                  0.0365


Standard errors of differences of means
---------------------------------------

Table                    Treat
rep.                         8
d.f.                        20
s.e.d.                  0.0516


Least significant differences of means (5% level)
-------------------------------------------------

Table                    Treat
rep.                         8
d.f.                        20
l.s.d.                  0.1076
```

1.2.4. Difference between Total pythium counts 1 and 3 (log minus log).

```
126  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogPyth13

Analysis of variance
====================
Variate: DifflogPyth13
Source of variation      d.f.        s.s.        m.s.      v.r.  F pr.
Site stratum                1     0.21847     0.21847      5.85
Site.*Units* stratum
Treat                       2     0.02584     0.01292      0.35  0.712 ns
  Must119vCult              1     0.01445     0.01445      0.39  0.541 ns
  Must119vNocult            1     0.02326     0.02326      0.62  0.439 ns
Residual                   20     0.74697     0.03735
Total                      23     0.99128

Tables of contrasts
===================
Variate: DifflogPyth13
Must119vCult       0.060,  s.e. 0.0966,  ss.div. 4.00
Must119vNocult     0.076,  s.e. 0.0966,  ss.div. 4.00

Tables of means
===============
Variate: DifflogPyth13
Grand mean  0.189
    Treat      Cult   NoCult   Mustard119
              0.175    0.159    0.235

Standard errors of means
------------------------
Table                    Treat
rep.                         8
d.f.                        20
```

```
e.s.e.              0.0683

Standard errors of differences of means
---------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
s.e.d.                  0.0966

Least significant differences of means (5% level)
-------------------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
l.s.d.                  0.2016
```

2. Analysis of Nematode results

Analysis of Variance with contrasts, Genstat 8.
Three treatments: Biocide, Cultivation, No cultivation.
Four replicates each block.
Two blocks: Elveden, Knights
Contrasts: Biocide v Cultivation, Biocide v No cultivation

2.1. Mustard 99

2.1.1. Total nematode count 1 (transformed to log10).

```
261  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem1

Analysis of variance
====================
Variate: logTotNem1
Source of variation        d.f.        s.s.        m.s.     v.r.   F pr.
Site stratum                  1     0.05472     0.05472     1.99
Site.*Units* stratum
Treat                         2     0.07048     0.03524     1.28   0.300 ns
  Must99vCult                 1     0.03092     0.03092     1.12   0.302 ns
  Must99vNoCult               1     0.06768     0.06768     2.46   0.132 ns
Residual                     20     0.55015     0.02751
Total                        23     0.67534

Tables of contrasts
===================
Variate: logTotNem1
Must99vCult       0.088,   s.e. 0.0829,   ss.div. 4.00
Must99vNoCult     0.130,   s.e. 0.0829,   ss.div. 4.00

Tables of means
===============
Variate: logTotNem1
Grand mean   1.901
    Treat      Cult  Mustard99   NoCult
              1.886     1.974    1.844

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.              0.0586

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.0829
```

```
Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1730
```

2.1.2. Total nematode count 2 (transformed to log10).

```
267  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem2

Analysis of variance
====================
Variate: logTotNem2
Source of variation      d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum                1    0.00658    0.00658     0.14
Site.*Units* stratum
Treat                       2    0.55723    0.27861     5.97  0.009 **
  Must99vCult               1    0.55410    0.55410    11.87  0.003 **
  Must99vNoCult             1    0.17693    0.17693     3.79  0.066 ns
Residual                   20    0.93343    0.04667
Total                      23    1.49724

Tables of contrasts
===================
Variate: logTotNem2
Must99vCult        0.37,  s.e. 0.108,  ss.div. 4.00
Must99vNoCult      0.21,  s.e. 0.108,  ss.div. 4.00

Tables of means
===============
Variate: logTotNem2
Grand mean  1.977
    Treat      Cult  Mustard99   NoCult
              1.799    2.172     1.961

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0764

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1080

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.2253
```

2.1.3. Total nematode count 3 (transformed to log10).

```
273  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem3

Analysis of variance
====================
Variate: logTotNem3
Source of variation      d.f.       s.s.        m.s.      v.r.   F pr.
Site stratum                1     0.01148     0.01148     0.24
Site.*Units* stratum
Treat                       2     0.10156     0.05078     1.06   0.365 ns
  Must99vCult               1     0.03521     0.03521     0.74   0.401 ns
  Must99vNoCult             1     0.01670     0.01670     0.35   0.561 ns
Residual                   20     0.95700     0.04785
Total                      23     1.07003

Tables of contrasts
===================
Variate: logTotNem3
Must99vCult       0.09,  s.e. 0.109,  ss.div. 4.00
Must99vNoCult    -0.06,  s.e. 0.109,  ss.div. 4.00

Tables of means
===============
Variate: logTotNem3
Grand mean  1.832
    Treat      Cult  Mustard99   NoCult
              1.748     1.842    1.907

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0773

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1094

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.2281
```

2.1.4. Difference between Total nematode counts 1 and 3.

```
279  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogTotNem13

Analysis of variance
====================
Variate: DifflogTotNem13
Source of variation      d.f.       s.s.        m.s.      v.r.   F pr.
Site stratum                1     0.11632     0.11632     1.58
```

```
Site.*Units* stratum
Treat                      2     0.20849     0.10424     1.42  0.265 ns
  Must99vCult              1     0.00014     0.00014     0.00  0.966 ns
  Must99vNoCult            1     0.15163     0.15163     2.06  0.166 ns
Residual                  20     1.46876     0.07344
Total                     23     1.79356

Tables of contrasts
===================
Variate: DifflogTotNem13
Must99vCult        0.01,  s.e. 0.135,  ss.div. 4.00
Must99vNoCult     -0.19,  s.e. 0.135,  ss.div. 4.00

Tables of means
===============
Variate: DifflogTotNem13
Grand mean  -0.069
    Treat .    Cult  Mustard99   NoCult
            -0.138   -0.132     0.063

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0958

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1355

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.2826
```

2.1.5. Lesion nematode count 1 (transformed to log10).

```
286  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logLesion1

Analysis of variance
====================
Variate: logLesion1
Source of variation     d.f.       s.s.        m.s.      v.r.  F pr.
Site stratum               1     0.09393     0.09393     2.89
Site.*Units* stratum
Treat                      2     0.05083     0.02541     0.78  0.471 ns
  Must99vCult              1     0.00865     0.00865     0.27  0.611 ns
  Must99vNoCult            1     0.05034     0.05034     1.55  0.227 ns
Residual                  20     0.64913     0.03246
Total                     23     0.79388

Tables of contrasts
===================
Variate: logLesion1
```

```
Must99vCult       0.046,  s.e. 0.0901,  ss.div. 4.00
Must99vNoCult     0.112,  s.e. 0.0901,  ss.div. 4.00

Tables of means
===============
Variate: logLesion1
Grand mean  1.846
    Treat      Cult  Mustard99   NoCult
              1.852     1.899    1.787

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0637

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.0901

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.1879
```

2.1.6. Lesion nematode count 2 (transformed to log10).

```
292  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logLesion2

Analysis of variance
====================
Variate: logLesion2
Source of variation     d.f.      s.s.       m.s.     v.r.  F pr.
Site stratum               1   0.01518    0.01518     0.35
Site.*Units* stratum
Treat                      2   0.46899    0.23449     5.38  0.014 *
  Must99vCult              1   0.45828    0.45828    10.51  0.004 **
  Must99vNoCult            1   0.18326    0.18326     4.20  0.054
Residual                  20   0.87238    0.04362
Total                     23   1.35655

Tables of contrasts
===================
Variate: logLesion2
Must99vCult        0.34,  s.e. 0.104,  ss.div. 4.00
Must99vNoCult      0.21,  s.e. 0.104,  ss.div. 4.00

Tables of means
===============
Variate: logLesion2
Grand mean  1.881
    Treat      Cult  Mustard99   NoCult
              1.726     2.065    1.851
```

```
Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.0738

Standard errors of differences of means
---------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
s.e.d.                0.1044

Least significant differences of means (5% level)
-------------------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
l.s.d.                0.2178
```

2.1.7. Lesion nematode count 3 (transformed to log10).

```
298  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logLesion3

Analysis of variance
====================
Variate: logLesion3
Source of variation     d.f.       s.s.       m.s.    v.r.   F pr.
Site stratum               1    0.01728    0.01728    0.43
Site.*Units* stratum
Treat                      2    0.11890    0.05945    1.47   0.254 ns
  Must99vCult              1    0.01184    0.01184    0.29   0.594 ns
  Must99vNoCult            1    0.05243    0.05243    1.30   0.268 ns
Residual                  20    0.80868    0.04043
Total                     23    0.94486

Tables of contrasts
===================
Variate: logLesion3
Must99vCult       0.05,  s.e. 0.101,  ss.div. 4.00
Must99vNoCult    -0.11,  s.e. 0.101,  ss.div. 4.00

Tables of means
===============
Variate: logLesion3
Grand mean  1.785
    Treat      Cult  Mustard99   NoCult
              1.711    1.765    1.879

Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.0711

Standard errors of differences of means
---------------------------------------
```

```
Table                    Treat
rep.                         8
d.f.                        20
s.e.d.                  0.1005

Least significant differences of means (5% level)
--------------------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
l.s.d.                  0.2097
```

2.1.8. Difference between Lesion nematode counts 1 and 3.

```
304  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogLesion13

Analysis of variance
====================
Variate: DifflogLesion13
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum               1    0.19180    0.19180     3.06
Site.*Units* stratum
Treat                      2    0.28389    0.14194     2.27  0.130 ns
  Must99vCult              1    0.00025    0.00025     0.00  0.950 ns
  Must99vNoCult            1    0.20550    0.20550     3.28  0.085 ns
Residual                  20    1.25182    0.06259
Total                     23    1.72750

Tables of contrasts
===================
Variate: DifflogLesion13
Must99vCult        0.01,  s.e. 0.125,  ss.div. 4.00
Must99vNoCult     -0.23,  s.e. 0.125,  ss.div. 4.00

Tables of means
===============
Variate: DifflogLesion13
Grand mean  -0.061
    Treat      Cult  Mustard99   NoCult
             -0.142   -0.134    0.093

Standard errors of means
------------------------
Table                    Treat
rep.                         8
d.f.                        20
e.s.e.                  0.0885

Standard errors of differences of means
---------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
s.e.d.                  0.1251

Least significant differences of means (5% level)
--------------------------------------------------
Table                    Treat
rep.                         8
```

```
d.f.                    20
l.s.d.              0.2609
```

2.2. Mustard 119

2.2.1. Total nematode count 1 (transformed to log10).

```
262  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem1

Analysis of variance
====================
Variate: logTotNem1
Source of variation      d.f.       s.s.        m.s.      v.r.  F pr.
Site stratum                1    0.00062     0.00062      0.01
Site.*Units* stratum
Treat                       2    0.10095     0.05048      1.14  0.340 ns
  Must119vCult              1    0.09757     0.09757      2.20  0.153 ns
  Must119vNoCult            1    0.04265     0.04265      0.96  0.338 ns
Residual                   20    0.88653     0.04433
Total                      23    0.98810

Tables of contrasts
===================
Variate: logTotNem1
Must119vCult       -0.16,  s.e. 0.105,  ss.div. 4.00
Must119vNoCult     -0.10,  s.e. 0.105,  ss.div. 4.00

Tables of means
===============
Variate: logTotNem1
Grand mean  1.992
   Treat       Cult    NoCult    Mustard119
              2.062     2.009     1.906

Standard errors of means
------------------------
Table                   Treat
rep.                        8
d.f.                       20
e.s.e.                 0.0744

Standard errors of differences of means
---------------------------------------
Table                   Treat
rep.                        8
d.f.                       20
s.e.d.                 0.1053

Least significant differences of means (5% level)
-------------------------------------------------
Table                   Treat
rep.                        8
d.f.                       20
l.s.d.                 0.2196
```

2.2.2. Total nematode count 2 (transformed to log10).

```
268  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem2
```

Analysis of variance
===================

Variate: logTotNem2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.	
Site stratum	1	0.02757	0.02757	0.68		
Site.*Units* stratum						
Treat	2	0.93985	0.46993	11.59	<.001	***
Must119vCult	1	0.52561	0.52561	12.97	0.002	**
Must119vNoCult	1	0.84619	0.84619	20.88	<.001	***
Residual	20	0.81057	0.04053			
Total	23	1.77800				

Tables of contrasts
===================

Variate: logTotNem2

Must119vCult	0.36,	s.e. 0.101,	ss.div. 4.00
Must119vNoCult	0.46,	s.e. 0.101,	ss.div. 4.00

Tables of means
===============

Variate: logTotNem2

Grand mean 1.872

Treat	Cult	NoCult	Mustard119
	1.783	1.686	2.146

Standard errors of means

Table	Treat
rep.	8
d.f.	20
e.s.e.	0.0712

Standard errors of differences of means

Table	Treat
rep.	8
d.f.	20
s.e.d.	0.1007

Least significant differences of means (5% level)

Table	Treat
rep.	8
d.f.	20
l.s.d.	0.2100

2.2.3. Total nematode count 3 (transformed to log10).

```
274  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logTotNem3
```

Analysis of variance
===================

Variate: logTotNem3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.

```
Site stratum                1     0.04525    0.04525     1.31
Site.*Units* stratum
Treat                       2     0.20815    0.10407     3.01   0.072 ns
  Must119vCult              1     0.19420    0.19420     5.61   0.028 *
  Must119vNoCult            1     0.01394    0.01394     0.40   0.533 ns
Residual                   20     0.69230    0.03461
Total                      23     0.94570

Tables of contrasts
===================

Variate: logTotNem3
Must119vCult       0.220,  s.e. 0.0930,  ss.div. 4.00
Must119vNoCult     0.059,  s.e. 0.0930,  ss.div. 4.00

Tables of means
===============

Variate: logTotNem3
Grand mean  1.816
    Treat       Cult    NoCult   Mustard119
               1.688    1.850     1.909

Standard errors of means
------------------------

Table               Treat
rep.                    8
d.f.                   20
e.s.e.             0.0658

Standard errors of differences of means
---------------------------------------

Table               Treat
rep.                    8
d.f.                   20
s.e.d.             0.0930

Least significant differences of means (5% level)
-------------------------------------------------

Table               Treat
rep.                    8
d.f.                   20
l.s.d.             0.1940
```

2.2.4. Difference between Total nematode counts 1 and 3.

```
280  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogTotNem13

Analysis of variance
====================

Variate: DifflogTotNem13
Source of variation       d.f.      s.s.       m.s.      v.r.   F pr.
Site stratum                1     0.05649    0.05649     1.02
Site.*Units* stratum
Treat                       2     0.57068    0.28534     5.13   0.016 *
  Must119vCult              1     0.56709    0.56709    10.20   0.005 **
  Must119vNoCult            1     0.10538    0.10538     1.90   0.184 ns
Residual                   20     1.11158    0.05558
Total                      23     1.73875

Tables of contrasts
```

```
===================
Variate: DifflogTotNem13
Must119vCult        0.38,   s.e. 0.118,   ss.div. 4.00
Must119vNoCult      0.16,   s.e. 0.118,   ss.div. 4.00

Tables of means
===============
Variate: DifflogTotNem13
Grand mean  -0.176
    Treat      Cult    NoCult   Mustard119
             -0.373   -0.159     0.003

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.              0.0834

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.1179

Least significant differences of means (5% level)
-------------------------------------------------
Table                Treat
rep.                     8
d.f.                    20
l.s.d.              0.2459
```

2.2.5. Lesion nematode count 1 (transformed to log10).

```
286  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logLesion1

Analysis of variance
====================
Variate: logLesion1
Source of variation        d.f.       s.s.        m.s.     v.r.   F pr.
Site stratum                  1    0.00008     0.00008     0.00
Site.*Units* stratum
Treat                         2    0.15846     0.07923     1.33   0.286 ns
  Must119vCult                1    0.15573     0.15573     2.62   0.121 ns
  Must119vNoCult              1    0.05883     0.05883     0.99   0.331 ns
Residual                     20    1.18748     0.05937
Total                        23    1.34601

Tables of contrasts
===================
Variate: logLesion1
Must119vCult      -0.20,   s.e. 0.122,   ss.div. 4.00
Must119vNoCult    -0.12,   s.e. 0.122,   ss.div. 4.00

Tables of means
===============
Variate: logLesion1
Grand mean  1.945
    Treat      Cult    NoCult   Mustard119
```

```
              2.036     1.960     1.838

Standard errors of means
------------------------
Table                    Treat
rep.                         8
d.f.                        20
e.s.e.                  0.0861

Standard errors of differences of means
---------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
s.e.d.                  0.1218

Least significant differences of means (5% level)
-------------------------------------------------
Table                    Treat
rep.                         8
d.f.                        20
l.s.d.                  0.2541
```

2.2.6. Lesion nematode count 2 (transformed to log10).

```
292  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd, means; LSDLEVEL=5] logLesion2

Analysis of variance
====================
Variate: logLesion2
Source of variation        d.f.        s.s.        m.s.     v.r.  F pr.
Site stratum                  1     0.09541     0.09541     1.97
Site.*Units* stratum
Treat                         2     0.74586     0.37293     7.69  0.003 **
  Must119vCult                1     0.31700     0.31700     6.53  0.019 *
  Must119vNoCult              1     0.72021     0.72021    14.84  <.001 ***
Residual                     20     0.97047     0.04852
Total                        23     1.81174

Tables of contrasts
===================
Variate: logLesion2
Must119vCult        0.28,   s.e. 0.110,   ss.div. 4.00
Must119vNoCult      0.42,   s.e. 0.110,   ss.div. 4.00

Tables of means
===============
Variate: logLesion2
Grand mean   1.797
    Treat       Cult     NoCult    Mustard119
               1.750     1.608     2.032

Standard errors of means
------------------------
Table                    Treat
rep.                         8
d.f.                        20
e.s.e.                  0.0779
```

```
Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1101

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
l.s.d.               0.2297
```

2.2.7. Lesion nematode count 3 (transformed to log10).

```
298  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] logLesion3

Analysis of variance
====================
Variate: logLesion3
Source of variation      d.f.        s.s.        m.s.     v.r.  F pr.
Site stratum                1     0.00715     0.00715     0.13
Site.*Units* stratum
Treat                       2     0.07785     0.03892     0.70  0.509 ns
  Must119vCult              1     0.05765     0.05765     1.04  0.321 ns
  Must119vNoCult            1     0.00001     0.00001     0.00  0.990 ns
Residual                   20     1.11330     0.05567
Total                      23     1.19830

Tables of contrasts
===================
Variate: logLesion3
Must119vCult         0.12,   s.e. 0.118,   ss.div. 4.00
Must119vNoCult       0.00,   s.e. 0.118,   ss.div. 4.00

Tables of means
===============
Variate: logLesion3
Grand mean   1.704
    Treat       Cult    NoCult    Mustard 119
               1.623     1.745     1.743

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.0834

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1180

Least significant differences of means (5% level)
-------------------------------------------------
Table                 Treat
```

```
rep.                    8
d.f.                   20
l.s.d.             0.2461
```

2.2.8. Difference between Lesion nematode counts 1 and 3.

```
304  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,lsd,means; LSDLEVEL=5] DifflogLesion13

Analysis of variance
====================
Variate: DifflogLesion13
Source of variation      d.f.        s.s.        m.s.     v.r.  F pr.
Site stratum                1     0.00575     0.00575     0.08
Site.*Units* stratum
Treat                       2     0.41097     0.20548     2.98  0.074
  Must119vCult              1     0.40289     0.40289     5.83  0.025
  Must119vNoCult            1     0.05737     0.05737     0.83  0.373
Residual                   20     1.38113     0.06906
Total                      23     1.79785

Tables of contrasts
===================
Variate: DifflogLesion13
Must119vCult       0.32,  s.e. 0.131,  ss.div. 4.00
Must119vNoCult     0.12,  s.e. 0.131,  ss.div. 4.00

Tables of means
===============
Variate: DifflogLesion13
Grand mean  -0.241
    Treat      Cult    NoCult   Mustard119
             -0.413    -0.215     -0.095

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.              0.0929

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.1314

Least significant differences of means (5% level)
-------------------------------------------------
Table                Treat
rep.                     8
d.f.                    20
l.s.d.              0.2741
```

end of Mustard 119 v. Nematodes

start of Mustard 99 v. Stubby and Stunt

3.1.1. Stubby nematode count 1 (transformed to log10).

```
311  "General Analysis of Variance."
 312  BLOCK Site
 313  TREATMENTS COMP(Treat;2;Cont)
315  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby1

Analysis of variance
====================
Variate: logStubby1
Source of variation       d.f.       s.s.       m.s.     v.r.   F pr.
Site stratum                1      0.7929     0.7929     5.94
Site.*Units* stratum
Treat                       2      0.0083     0.0041     0.03   0.969
  Must99vCult               1      0.0054     0.0054     0.04   0.842
  Must99vNoCult             1      0.0001     0.0001     0.00   0.979
Residual                   20      2.6708     0.1335
Total                      23      3.4720

Tables of contrasts
===================
Variate: logStubby1
Must99vCult        0.04,   s.e. 0.183,   ss.div. 4.00
Must99vNoCult      0.00,   s.e. 0.183,   ss.div. 4.00

Tables of means
===============
Variate: logStubby1
Grand mean  0.447
    Treat      Cult   Mustard99    NoCult
              0.421     0.458     0.463

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.1292

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1827
```

3.1.2. Stubby nematode count 2 (transformed to log10).

```
322  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby2

Analysis of variance
====================
Variate: logStubby2
Source of variation       d.f.       s.s.       m.s.     v.r.   F pr.
Site stratum                1     3.59012    3.59012    44.82
Site.*Units* stratum
Treat                       2     0.58145    0.29073     3.63  0.045
  Must99vCult               1     0.41636    0.41636     5.20  0.034
```

```
  Must99vNoCult                   1     0.45496     0.45496     5.68  0.027
Residual                        20    1.60209     0.08010
Total                           23    5.77366

Tables of contrasts
===================
Variate: logStubby2
Must99vCult        0.32,   s.e. 0.142,   ss.div. 4.00
Must99vNoCult      0.34,   s.e. 0.142,   ss.div. 4.00

Tables of means
===============
Variate: logStubby2
Grand mean  0.507
    Treat      Cult  Mustard99    NoCult
              0.405     0.727     0.390

Standard errors of means
------------------------
Table                   Treat
rep.                        8
d.f.                       20
e.s.e.                 0.1001

Standard errors of differences of means
---------------------------------------
Table                   Treat
rep.                        8
d.f.                       20
s.e.d.                 0.1415
```

3.1.3. Stubby nematode count 2 (transformed to log10).

```
329  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby3

Analysis of variance
====================
Variate: logStubby3
Source of variation      d.f.        s.s.        m.s.     v.r.   F pr.
Site stratum                1     0.03120     0.03120     0.38
Site.*Units* stratum
Treat                       2     0.05674     0.02837     0.34   0.714
  Must99vCult               1     0.00047     0.00047     0.01   0.940
  Must99vNoCult             1     0.04680     0.04680     0.57   0.461
Residual                   20     1.65450     0.08273
Total                      23     1.74244

Tables of contrasts
===================
Variate: logStubby3
Must99vCult        0.01,   s.e. 0.144,   ss.div. 4.00
Must99vNoCult      0.11,   s.e. 0.144,   ss.div. 4.00

Tables of means
===============
Variate: logStubby3
Grand mean  0.166
    Treat      Cult  Mustard99    NoCult
              0.195     0.205     0.097
```

```
Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.1017

Standard errors of differences of means
---------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
s.e.d.                0.1438
```

3.1.4. Difference Stubby nematode counts 1 and 3.

```
336  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]DifflogStubby13

Analysis of variance
====================
Variate: DifflogStubby13
Source of variation      d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum                1     0.5096     0.5096     2.53
Site.*Units* stratum
Treat                       2     0.0873     0.0437     0.22  0.807
  Must99vCult               1     0.0027     0.0027     0.01  0.909
  Must99vNoCult             1     0.0511     0.0511     0.25  0.620
Residual                   20     4.0336     0.2017
Total                      23     4.6305

Tables of contrasts
===================
Variate: DifflogStubby13
Must99vCult       -0.03,  s.e. 0.225,  ss.div. 4.00
Must99vNoCult      0.11,  s.e. 0.225,  ss.div. 4.00

Tables of means
===============
Variate: DifflogStubby13
Grand mean  -0.282
    Treat      Cult  Mustard99   NoCult
             -0.227   -0.253   -0.366

Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.1588

Standard errors of differences of means
---------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
s.e.d.                0.2245
```

3.1.5. Stunt nematode count 1 (transformed to log10).

```
342  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt1

Analysis of variance
====================
Variate: logStunt1
Source of variation        d.f.         s.s.         m.s.      v.r.   F pr.
Site stratum                  1       0.0008       0.0008      0.01
Site.*Units* stratum
Treat                         2       0.4116       0.2058      1.57   0.232
  Must99vCult                 1       0.3835       0.3835      2.93   0.102
  Must99vNoCult               1       0.2069       0.2069      1.58   0.223
Residual                     20       2.6146       0.1307
Total                        23       3.0270

Tables of contrasts
===================
Variate: logStunt1
Must99vCult         0.31,   s.e. 0.181,   ss.div. 4.00
Must99vNoCult       0.23,   s.e. 0.181,   ss.div. 4.00

Tables of means
===============
Variate: logStunt1
Grand mean  0.590
    Treat       Cult  Mustard99    NoCult
               0.460     0.769     0.542

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.1278

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.1808
```

3.1.6. Stunt nematode count 2 (transformed to log10).

```
349  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt2

Analysis of variance
====================
Variate: logStunt2
Source of variation        d.f.         s.s.         m.s.      v.r.   F pr.
Site stratum                  1       0.2069       0.2069      0.80
Site.*Units* stratum
Treat                         2       1.3428       0.6714      2.61   0.099
  Must99vCult                 1       0.5161       0.5161      2.00   0.172
  Must99vNoCult               1       1.3148       1.3148      5.10   0.035
Residual                     20       5.1518       0.2576
Total                        23       6.7015
```

```
Tables of contrasts
===================
Variate: logStunt2
Must99vCult       0.36,   s.e. 0.254,   ss.div. 4.00
Must99vNoCult     0.57,   s.e. 0.254,   ss.div. 4.00

Tables of means
===============
Variate: logStunt2
Grand mean  0.65
    Treat      Cult  Mustard99   NoCult
               0.60      0.96     0.38

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.               0.179

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.               0.254
```

3.1.7. Stunt nematode count 3 (transformed to log10).

```
356  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt3

Analysis of variance
====================
Variate: logStunt3
Source of variation     d.f.      s.s.       m.s.     v.r.  F pr.
Site stratum               1    0.3731     0.3731     1.68
Site.*Units* stratum
Treat                      2    1.2109     0.6054     2.72  0.090
  Must99vCult              1    1.1733     1.1733     5.28  0.032
  Must99vNoCult            1    0.5033     0.5033     2.27  0.148
Residual                  20    4.4440     0.2222
Total                     23    6.0280

Tables of contrasts
===================
Variate: logStunt3
Must99vCult       0.54,   s.e. 0.236,   ss.div. 4.00
Must99vNoCult     0.35,   s.e. 0.236,   ss.div. 4.00

Tables of means
===============
Variate: logStunt3
Grand mean  0.491
    Treat      Cult  Mustard99   NoCult
              0.248     0.789    0.435

Standard errors of means
------------------------
Table                Treat
rep.                     8
```

```
d.f.                   20
e.s.e.             0.1667

Standard errors of differences of means
---------------------------------------
Table               Treat
rep.                    8
d.f.                   20
s.e.d.             0.2357
```

3.1.8. Difference Stunt nematode counts 1 and 3.

```
363  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]DifflogStunt13

Analysis of variance
====================
Variate: DifflogStunt13
Source of variation       d.f.        s.s.       m.s.      v.r.  F pr.
Site stratum                 1      0.3384     0.3384      1.87
Site.*Units* stratum
Treat                        2      0.2159     0.1079      0.60  0.561
  Must99vCult                1      0.2152     0.2152      1.19  0.289
  Must99vNoCult              1      0.0648     0.0648      0.36  0.557
Residual                    20      3.6247     0.1812
Total                       23      4.1790

Tables of contrasts
===================
Variate: DifflogStunt13
Must99vCult         0.23,  s.e. 0.213,  ss.div. 4.00
Must99vNoCult       0.13,  s.e. 0.213,  ss.div. 4.00

Tables of means
===============
Variate: DifflogStunt13
Grand mean  -0.100
    Treat       Cult  Mustard99    NoCult
              -0.212      0.020    -0.107

Standard errors of means
------------------------
Table               Treat
rep.                    8
d.f.                   20
e.s.e.             0.1505

Standard errors of differences of means
---------------------------------------
Table               Treat
rep.                    8
d.f.                   20
s.e.d.             0.2129
```

end of Mustard 99 stubby stunt

start of Mustard 119 stubby stunt

3.2.1. Stubby nematode count 1 (transformed to log10).

```
314  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby1

Analysis of variance
====================
Variate: logStubby1
Source of variation       d.f.        s.s.        m.s.     v.r.   F pr.
Site stratum                 1      3.0492      3.0492    26.86
Site.*Units* stratum
Treat                        2      0.0109      0.0055     0.05   0.953
  Must119vCult               1      0.0002      0.0002     0.00   0.965
  Must119vNoCult             1      0.0068      0.0068     0.06   0.810
Residual                    20      2.2705      0.1135
Total                       23      5.3307

Tables of contrasts
===================
Variate: logStubby1
Must119vCult         0.01,  s.e. 0.168,  ss.div. 4.00
Must119vNoCult      -0.04,  s.e. 0.168,  ss.div. 4.00

Tables of means
===============
Variate: logStubby1
Grand mean  0.432
    Treat      Cult    NoCult    Mustard119
              0.413     0.462     0.420

Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.1191

Standard errors of differences of means
---------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
s.e.d.                0.1685
```

3.2.2. Stubby nematode count 2 (transformed to log10).

```
321  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby2

Analysis of variance
====================
Variate: logStubby2
Source of variation       d.f.        s.s.        m.s.     v.r.   F pr.
Site stratum                 1      2.1658      2.1658    15.51
Site.*Units* stratum
Treat                        2      0.4934      0.2467     1.77   0.197
  Must119vCult               1      0.4411      0.4411     3.16   0.091
  Must119vNoCult             1      0.2811      0.2811     2.01   0.171
Residual                    20      2.7926      0.1396
Total                       23      5.4518
```

```
Tables of contrasts
===================
Variate: logStubby2
Must119vCult        0.33,   s.e. 0.187,   ss.div. 4.00
Must119vNoCult      0.27,   s.e. 0.187,   ss.div. 4.00

Tables of means
===============
Variate: logStubby2
Grand mean  0.351
    Treat      Cult    NoCult    Mustard119
              0.218     0.285     0.550

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.              0.1321

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.1868
```

3.2.3. Stubby nematode count 3 (transformed to log10).

```
327  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStubby3

Analysis of variance
====================
Variate: logStubby3
Source of variation       d.f.        s.s.        m.s.     v.r.   F pr.
Site stratum                 1      0.1296      0.1296     0.95
Site.*Units* stratum
Treat                        2      0.0896      0.0448     0.33  0.725
  Must119vCult                  1      0.0707      0.0707     0.52  0.481
  Must119vNoCult                1      0.0002      0.0002     0.00  0.970
Residual                    20      2.7367      0.1368
Total                       23      2.9558

Tables of contrasts
===================
Variate: logStubby3
Must119vCult        0.13,   s.e. 0.185,   ss.div. 4.00
Must119vNoCult      0.01,   s.e. 0.185,   ss.div. 4.00

Tables of means
===============
Variate: logStubby3
Grand mean  0.535
    Treat      Cult    NoCult    Mustard119
              0.449     0.575     0.582

Standard errors of means
------------------------
```

```
Table              Treat
rep.                   8
d.f.                  20
e.s.e.            0.1308

Standard errors of differences of means
---------------------------------------
Table              Treat
rep.                   8
d.f.                  20
s.e.d.            0.1850
```

3.2.4. Difference Stubby nematode counts 1 and 3.

```
333  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]DifflogStubby13

Analysis of variance
====================
Variate: DifflogStubby13
Source of variation      d.f.       s.s.       m.s.    v.r.  F pr.
Site stratum                1     1.9216     1.9216   12.32
Site.*Units* stratum
Treat                       2     0.0642     0.0321    0.21  0.816
  Must119vCult              1     0.0630     0.0630    0.40  0.532
  Must119vNoCult            1     0.0092     0.0092    0.06  0.810
Residual                   20     3.1190     0.1559
Total                      23     5.1048

Tables of contrasts
===================
Variate: DifflogStubby13
Must119vCult        0.13,  s.e. 0.197,  ss.div. 4.00
Must119vNoCult      0.05,  s.e. 0.197,  ss.div. 4.00

Tables of means
===============
Variate: DifflogStubby13
Grand mean  0.103
    Treat      Cult   NoCult   Mustard119
              0.036    0.113    0.161

Standard errors of means
------------------------
Table              Treat
rep.                   8
d.f.                  20
e.s.e.            0.1396

Standard errors of differences of means
---------------------------------------
Table              Treat
rep.                   8
d.f.                  20
s.e.d.            0.1975
```

3.2.5. Stunt nematode count 1 (transformed to log10).

```
340  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt1
```

```
Analysis of variance
====================
Variate: logStunt1
Source of variation      d.f.       s.s.        m.s.       v.r.   F pr.
Site stratum                1     1.0597      1.0597       9.65
Site.*Units* stratum
Treat                       2     0.1906      0.0953       0.87   0.435
  Must119vCult              1     0.0075      0.0075       0.07   0.796
  Must119vNoCult            1     0.1714      0.1714       1.56   0.226
Residual                   20     2.1968      0.1098
Total                      23     3.4472

Tables of contrasts
===================
Variate: logStunt1
Must119vCult      -0.04,   s.e. 0.166,   ss.div. 4.00
Must119vNoCult    -0.21,   s.e. 0.166,   ss.div. 4.00

Tables of means
===============
Variate: logStunt1
Grand mean   0.517
    Treat       Cult    NoCult    Mustard 119
               0.476     0.640     0.433

Standard errors of means
------------------------
Table                   Treat
rep.                        8
d.f.                       20
e.s.e.                 0.1172

Standard errors of differences of means
---------------------------------------
Table                   Treat
rep.                        8
d.f.                       20
s.e.d.                 0.1657
```

3.2.6. Stunt nematode count 2 (transformed to log10).

```
347  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt2

Analysis of variance
====================
Variate: logStunt2
Source of variation      d.f.       s.s.        m.s.       v.r.   F pr.
Site stratum                1     2.3456      2.3456       9.05
Site.*Units* stratum
Treat                       2     0.5072      0.2536       0.98   0.393
  Must119vCult              1     0.4271      0.4271       1.65   0.214
  Must119vNoCult            1     0.3271      0.3271       1.26   0.275
Residual                   20     5.1817      0.2591
Total                      23     8.0345
```

```
Tables of contrasts
===================
Variate: logStunt2
Must119vCult        0.33,  s.e. 0.255,  ss.div. 4.00
Must119vNoCult      0.29,  s.e. 0.255,  ss.div. 4.00

Tables of means
===============
Variate: logStunt2
Grand mean  0.64
    Treat       Cult    NoCult    Mustard119
                0.52      0.56      0.85

Standard errors of means
------------------------
Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                 0.180

Standard errors of differences of means
----------------------------------------
Table                  Treat
rep.                       8
d.f.                      20
s.e.d.                 0.255
```

3.2.7. Stunt nematode count 3 (transformed to log10).

```
354  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]logStunt3

Analysis of variance
====================
Variate: logStunt3
Source of variation     d.f.       s.s.       m.s.     v.r.   F pr.
Site stratum               1     3.4642     3.4642    16.66
Site.*Units* stratum
Treat                      2     0.5726     0.2863     1.38   0.275
  Must119vCult             1     0.3571     0.3571     1.72   0.205
  Must119vNoCult           1     0.4912     0.4912     2.36   0.140
Residual                  20     4.1597     0.2080
Total                     23     8.1965

Tables of contrasts
===================
Variate: logStunt3
Must119vCult        0.30,  s.e. 0.228,  ss.div. 4.00
Must119vNoCult      0.35,  s.e. 0.228,  ss.div. 4.00

Tables of means
===============
Variate: logStunt3
Grand mean  0.593
    Treat       Cult    NoCult    Mustard119
               0.511     0.459     0.809

Standard errors of means
------------------------
Table                  Treat
rep.                       8
```

```
d.f.                    20
e.s.e.              0.1612

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.2280
```

3.2.8. Difference Stunt nematode counts 1 and 3.

```
360  ANOVA [PRINT=aovtable,information,means,contrast; FACT=32;
FPROB=yes; PSE=diff,means]DifflogStunt13

Analysis of variance
====================
Variate: DifflogStunt13
Source of variation      d.f.       s.s.       m.s.    v.r.  F pr.
Site stratum                1     0.6919     0.6919    3.69
Site.*Units* stratum
Treat                       2     1.2643     0.6321    3.37  0.055
  Must119vCult                1     0.4682     0.4682    2.50  0.130
  Must119vNoCult              1     1.2428     1.2428    6.63  0.018
Residual                   20     3.7462     0.1873
Total                      23     5.7024

Tables of contrasts
===================
Variate: DifflogStunt13
Must119vCult        0.34,  s.e. 0.216,  ss.div. 4.00
Must119vNoCult      0.56,  s.e. 0.216,  ss.div. 4.00

Tables of means
===============
Variate: DifflogStunt13
Grand mean  0.076
    Treat      Cult   NoCult   Mustard119
              0.034   -0.181    0.376

Standard errors of means
------------------------
Table                Treat
rep.                     8
d.f.                    20
e.s.e.              0.1530

Standard errors of differences of means
---------------------------------------
Table                Treat
rep.                     8
d.f.                    20
s.e.d.              0.2164
```

end of Mustard 119 stubby stunt

4. Cultivated v Mustard 99/Mustard 119, difference between counts 2 and 3.

4.1. Difference between log nematode counts 2 and 3 for Mustard 99 (both sites).

4.1.1. Difference between log total nematodes counts 2 and 3, Mustard 99

```
335  "General Analysis of Variance."
 336  BLOCK Site
 337  TREATMENTS COMP(Treat;2;Cont)
 338  COVARIATE "No Covariate"
 339  ANOVA []difflogTot23
Analysis of variance
====================

Variate: difflogTot23
Source of variation      d.f.       s.s.        m.s.      v.r.   F pr.
Site stratum                1    0.00068     0.00068      0.01
Site.*Units* stratum
Treat                       2    0.40823     0.20411      4.04   0.034
  Must99vCult               1    0.30994     0.30994      6.13   0.022
  Must99vNocult             1    0.30236     0.30236      5.98   0.024
Residual                   20    1.01163     0.05058
Total                      23    1.42053

Tables of contrasts
===================

Variate: difflogTot23
Must99vCult      -0.28,   s.e. 0.112,   ss.div. 4.00
Must99vNocult    -0.27,   s.e. 0.112,   ss.div. 4.00

Tables of means
===============

Variate: difflogTot23
Grand mean  -0.145
    Treat      Cult  Mustard99    NoCult
             -0.051    -0.329    -0.055

Standard errors of means
------------------------

Table                  Treat
rep.                       8
d.f.                      20
e.s.e.                0.0795

Standard errors of differences of means
---------------------------------------

Table                  Treat
rep.                       8
```

d.f.	20
s.e.d.	0.1125

4.1.2. Difference between log Lesion nematodes counts 2 and 3, Mustard 99

```
341  "General Analysis of Variance."
345  ANOVA []difflogLesion23
Analysis of variance
====================
Variate: difflogLesion23
```

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Site stratum	1	0.00007	0.00007	0.00	
Site.*Units* stratum					
Treat	2	0.50830	0.25415	5.64	0.011
Must99vCult	1	0.32282	0.32282	7.17	0.014
Must99vNocult	1	0.43173	0.43173	9.58	0.006
Residual	20	0.90095	0.04505		
Total	23	1.40931			

```
Tables of contrasts
===================
Variate: difflogLesion23
Must99vCult      -0.28,  s.e. 0.106,  ss.div. 4.00
Must99vNocult    -0.33,  s.e. 0.106,  ss.div. 4.00

Tables of means
===============
Variate: difflogLesion23
Grand mean  -0.096
    Treat      Cult  Mustard99   NoCult
             -0.016   -0.300    0.029

Standard errors of means
========================
```

Table	Treat
rep.	8
d.f.	20
e.s.e.	0.0750

Standard errors of differences of means

Table	Treat
rep.	8
d.f.	20
s.e.d.	0.1061

4.1.3. Difference between log Stunt nematodes counts 2 and 3, Mustard 99

```
347  "General Analysis of Variance."
351  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
Source of variation     d.f.       s.s.       m.s.     v.r.   F pr.
```

Site stratum	1	0.0243	0.0243	0.11	
Site.*Units* stratum					
Treat	2	0.6449	0.3225	1.52	0.243
Must99vCult	1	0.1331	0.1331	0.63	0.438
Must99vNocult	1	0.1911	0.1911	0.90	0.354
Residual	20	4.2473	0.2124		
Total	23	4.9166			

Tables of contrasts
====================

Variate: difflogStunt23

Must99vCult 0.18, s.e. 0.230, ss.div. 4.00

Must99vNocult -0.22, s.e. 0.230, ss.div. 4.00

Tables of means
===============

Variate: difflogStunt23

Grand mean -0.154

Treat	Cult	Mustard99	NoCult
	-0.349	-0.167	0.052

Standard errors of means

Table	Treat
rep.	8
d.f.	20
e.s.e.	0.1629

Standard errors of differences of means

Table	Treat
rep.	8
d.f.	20
s.e.d.	0.2304

4.1.4. Difference between log Stubby nematodes counts 2 and 3, Mustard 99

353 "General Analysis of Variance."

357 ANOVA []difflogStubby23

Analysis of variance
====================

Variate: difflogStubby23

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Site stratum	1	2.9520	2.9520	18.38	
Site.*Units* stratum					
Treat	2	0.4173	0.2087	1.30	0.295
Must99vCult	1	0.3887	0.3887	2.42	0.135
Must99Nocult	1	0.2099	0.2099	1.31	0.266
Residual	20	3.2126	0.1606		
Total	23	6.5819			

Tables of contrasts
====================

```
Variate: difflogStubby23
Must99vCult      -0.31,  s.e. 0.200,  ss.div. 4.00
Must99vNocult    -0.23,  s.e. 0.200,  ss.div. 4.00

Tables of means
===============
Variate: difflogStubby23
Grand mean  -0.342
    Treat      Cult  Mustard99   NoCult
            -0.210    -0.522    -0.293

Standard errors of means
------------------------
Table               Treat
rep.                    8
d.f.                   20
e.s.e.             0.1417

Standard errors of differences of means
---------------------------------------
Table               Treat
rep.                    8
d.f.                   20
s.e.d.             0.2004
```

4.2. Difference between nematodes counts 2 and 3, Mustard 99, Elveden

4.2.1. Difference log Total nematodes counts 2 and 3, Mustard 99, Elveden

```
372  "General Analysis of Variance."
376  ANOVA []difflogTot23
Analysis of variance
====================
Variate: difflogTot23
Source of variation     d.f.        s.s.       m.s.     v.r.  F pr.
Treat                      2     0.14462    0.07231     1.06  0.387
  Must99vCult              1     0.06522    0.06522     0.95  0.355
  Must99vNocult            1     0.13818    0.13818     2.02  0.189
Residual                   9     0.61637    0.06849
Total                     11     0.76100

Tables of contrasts
===================
Variate: difflogTot23
Must99vCult      -0.18,  s.e. 0.185,  ss.div. 2.00
Must99vNocult    -0.26,  s.e. 0.185,  ss.div. 2.00

Tables of means
===============
Variate: difflogTot23
Grand mean  -0.140
    Treat      Cult  Mustard99   NoCult
            -0.107    -0.288    -0.025
```

```
Standard errors of means
------------------------
Table                    Treat
rep.                         4
d.f.                         9
e.s.e.                  0.1308

Standard errors of differences of means
---------------------------------------
Table                    Treat
rep.                         4
d.f.                         9
s.e.d.                  0.1850
```

4.2.2. Difference log Lesion nematodes counts 2 and 3, Mustard 99, Elveden

```
378  "General Analysis of Variance."
382  ANOVA []difflogLesion23
Analysis of variance
====================
Variate: difflogLesion23
Source of variation      d.f.       s.s.       m.s.     v.r.  F pr.
Treat                       2    0.12061    0.06031     0.82  0.470
  Must99vCult               1    0.06935    0.06935     0.94  0.357
  Must99vNocult             1    0.10742    0.10742     1.46  0.257
Residual                    9    0.66103    0.07345
Total                      11    0.78164

Tables of contrasts
===================
Variate: difflogLesion23
Must99vCult      -0.19,  s.e. 0.192,  ss.div. 2.00
Must99vNocult    -0.23,  s.e. 0.192,  ss.div. 2.00

Tables of means
===============
Variate: difflogLesion23
Grand mean  -0.094
    Treat      Cult  Mustard99   NoCult
             -0.047    -0.233    -0.002

Standard errors of means
------------------------
Table                    Treat
rep.                         4
d.f.                         9
e.s.e.                  0.1355

Standard errors of differences of means
---------------------------------------
Table                    Treat
rep.                         4
```

```
d.f.                    9
s.e.d.             0.1916
```

4.2.3. Difference log Stunt nematodes counts 2 and 3, Mustard 99, Elveden

```
384  "General Analysis of Variance."
388  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Treat                      2     0.4829     0.2415     1.19  0.347
  Must99vCult              1     0.0051     0.0051     0.03  0.878
  Must99vNocult            1     0.4023     0.4023     1.99  0.192
Residual                   9     1.8189     0.2021
Total                     11     2.3018

Tables of contrasts
===================
Variate: difflogStunt23
Must99vCult       -0.05,  s.e. 0.318,  ss.div. 2.00
Must99vNocult     -0.45,  s.e. 0.318,  ss.div. 2.00

Tables of means
===============
Variate: difflogStunt23
Grand mean  -0.12
    Treat       Cult  Mustard99    NoCult
               -0.24     -0.29      0.16

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.                0.225

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      4
d.f.                      9
s.e.d.                0.318
```

4.2.4. Difference log Stubby nematodes counts 2 and 3, Mustard 99, Elveden

```
390  "General Analysis of Variance."
394  ANOVA []difflogStubby23
Analysis of variance
====================
Variate: difflogStubby23
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Treat                      2     0.0114     0.0057     0.02  0.976
  Must99vCult              1     0.0054     0.0054     0.02  0.882
```

```
  Must99vNocult              1       0.0009      0.0009     0.00   0.952
Residual                     9       2.0876      0.2320
Total                       11       2.0989


Tables of contrasts
===================
Variate: difflogStubby23
Must99vCult          0.05,   s.e. 0.341,   ss.div. 2.00
Must99vNocult       -0.02,   s.e. 0.341,   ss.div. 2.00

Tables of means
===============
Variate: difflogStubby23
Grand mean  -0.69
    Treat       Cult  Mustard99    NoCult
               -0.73     -0.68      -0.66

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.                0.241

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      4
d.f.                      9
s.e.d.                0.341

**************NOW RESTRICTED TO KNIGHTS, still MUSTARD 99**************
```

4.3. Difference between log nematodes counts 2 and 3 for Mustard 99, Knights

4.3.1. Difference log Total nematodes counts 2 and 3 for Mustard 99, Knights

```
409  "General Analysis of Variance."
413  ANOVA []difflogTot23
Analysis of variance
====================
Variate: difflogTot23
Source of variation      d.f.       s.s.        m.s.      v.r.   F pr.
Treat                      2      0.30906     0.15453     3.98   0.058
  Must99vCult              1      0.28295     0.28295     7.28   0.024
  Must99vNocult            1      0.16476     0.16476     4.24   0.070
Residual                   9      0.34980     0.03887
Total                     11      0.65886
```

```
Tables of contrasts
===================
Variate: difflogTot23
Must99vCult      -0.38,  s.e. 0.139,  ss.div. 2.00
Must99vNocult    -0.29,  s.e. 0.139,  ss.div. 2.00

Tables of means
===============
Variate: difflogTot23
Grand mean  -0.150
    Treat      Cult  Mustard99   NoCult
              0.005    -0.371    -0.084

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.               0.0986

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      4
d.f.                      9
s.e.d.               0.1394
```

4.3.2. Difference log Lesion nematodes counts 2 and 3 for Mustard 99, Knights

```
415  "General Analysis of Variance."
419  ANOVA []difflogLesion23
Analysis of variance
====================
Variate: difflogLesion23
Source of variation     d.f.       s.s.       m.s.    v.r.  F pr.
Treat                      2    0.43821    0.21910   10.41  0.005
  Must99vCult              1    0.29179    0.29179   13.87  0.005
  Must99vNocult            1    0.36176    0.36176   17.19  0.002
Residual                   9    0.18939    0.02104
Total                     11    0.62760

Tables of contrasts
===================
Variate: difflogLesion23
Must99vCult      -0.38,  s.e. 0.103,  ss.div. 2.00
Must99vNocult    -0.43,  s.e. 0.103,  ss.div. 2.00

Tables of means
===============
Variate: difflogLesion23
Grand mean  -0.097
```

```
    Treat      Cult  Mustard99   NoCult
              0.016   -0.366     0.059

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.               0.0725

Standard errors of differences of means
---------------------------------------

Table                 Treat
rep.                      4
d.f.                      9
s.e.d.               0.1026
```

4.3.3. Difference log Stunt nematodes counts 2 and 3 for Mustard 99, Knights

```
421  "General Analysis of Variance."
425  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
Source of variation     d.f.      s.s.      m.s.    v.r.  F pr.
Treat                     2     0.4475    0.2237    0.94  0.426
  Must99vCult             1     0.3448    0.3448    1.45  0.260
  Must99vNocult           1     0.0003    0.0003    0.00  0.975
Residual                  9     2.1429    0.2381
Total                    11     2.5904

Tables of contrasts
===================
Variate: difflogStunt23
Must99vCult        0.42,  s.e. 0.345,  ss.div. 2.00
Must99vNocult      0.01,  s.e. 0.345,  ss.div. 2.00

Tables of means
===============
Variate: difflogStunt23
Grand mean  -0.19
    Treat      Cult  Mustard99   NoCult
              -0.46    -0.04     -0.06

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.                0.244
```

```
Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      4
d.f.                      9
s.e.d.                0.345
```

4.3.4. Difference log Stubby nematodes counts 2 and 3 for Mustard 99, Knights

```
427  "General Analysis of Variance."
431  ANOVA []difflogStubby23
Analysis of variance
====================
Variate: difflogStubby23
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Treat                      2    0.93916    0.46958     7.14  0.014
  Must99vCult              1    0.91289    0.91289    13.88  0.005
  Must99vNocult            1    0.38202    0.38202     5.81  0.039
Residual                   9    0.59181    0.06576
Total                     11    1.53096

Tables of contrasts
===================
Variate: difflogStubby23
Must99vCult       -0.68,  s.e. 0.181,  ss.div. 2.00
Must99vNocult     -0.44,  s.e. 0.181,  ss.div. 2.00

Tables of means
===============
Variate: difflogStubby23
Grand mean   0.009
    Treat      Cult  Mustard99    NoCult
              0.314    -0.362     0.075

Standard errors of means
------------------------
Table                 Treat
rep.                      4
d.f.                      9
e.s.e.               0.1282

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      4
d.f.                      9
s.e.d.               0.1813

***********************END OF KNIGHTS MUSTARD 99****************
```

4.4. Difference between log nematodes counts 2 and 3 for Mustard 119

4.4.1. Difference between log Total nematode counts 2 and 3 for Mustard 119

```
-3  C:/ajpNowNew/aaShocklandNov2005/Analysis1/ajpMustard 1191.GSH"
307  CALCULATE [SEED=18467] difflogStunt23=logStunt3-logStunt2
310  CALCULATE [SEED=18467] difflogStubby23=logStubby3-logStubby2
332  "General Analysis of Variance."
 333  BLOCK Site
 334  TREATMENTS COMP(Treat;2;Cont)
336  ANOVA []difflogTot23
Analysis of variance
====================
Variate: difflogTot23
Source of variation     d.f.       s.s.       m.s.     v.r.   F pr.
Site stratum               1    0.14347    0.14347     1.73
Site.*Units* stratum
Treat                      2    0.66100    0.33050     3.98   0.035
  Must119vCult             1    0.26780    0.26780     3.22   0.088
  Must119vNocult           1    0.64287    0.64287     7.73   0.012
Residual                  20    1.66230    0.08311
Total                     23    2.46677

Tables of contrasts
===================
Variate: difflogTot23
Must119vCult       0.26,  s.e. 0.144,  ss.div. 4.00
Must119vNocult     0.40,  s.e. 0.144,  ss.div. 4.00

Tables of means
===============
Variate: difflogTot23
Grand mean  -0.056
    Treat      Cult   NoCult   Mustard119
             -0.095    0.164   -0.237

Standard errors of means
------------------------
Table              Treat
rep.                   8
d.f.                  20
e.s.e.            0.1019

Standard errors of differences of means
---------------------------------------
Table              Treat
rep.                   8
d.f.                  20
s.e.d.            0.1441
```

4.4.2. Difference between log Lesion nematodes counts 2 and 3 for Mustard 119

```
344  "General Analysis of Variance."
 345  BLOCK Site
348  ANOVA []difflogLesion23
```

```
Analysis of variance
====================
Variate: difflogLesion23
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum               1     0.0503     0.0503     0.45
Site.*Units* stratum
Treat                      2     0.7395     0.3697     3.32  0.057
  Must119vCult             1     0.2796     0.2796     2.51  0.129
  Must119vNocult           1     0.7253     0.7253     6.51  0.019
Residual                  20     2.2294     0.1115
Total                     23     3.0192


Tables of contrasts
===================
Variate: difflogLesion23
Must119vCult       0.26,  s.e. 0.167,  ss.div. 4.00
Must119vNocult     0.43,  s.e. 0.167,  ss.div. 4.00

Tables of means
===============
Variate: difflogLesion23
Grand mean  -0.093
    Treat      Cult   NoCult   Mustard119
             -0.127    0.137   -0.289

Standard errors of means
========================
Table                   Treat
rep.                        8
d.f.                       20
e.s.e.                 0.1180

Standard errors of differences of means
---------------------------------------
Table                   Treat
rep.                        8
d.f.                       20
s.e.d.                 0.1669
```

4.4.3. Difference between log Stunt nematodes counts 2 and 3 for Mustard 119

```
350  "General Analysis of Variance."
 351  BLOCK Site
354  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Site stratum               1     0.1087     0.1087     0.45
Site.*Units* stratum
Treat                      2     0.0360     0.0180     0.07  0.928
```

```
  Must119vCult              1      0.0342     0.0342    0.14   0.710
  Must119vNocult            1      0.0166     0.0166    0.07   0.795
Residual                   20      4.8185     0.2409
Total                      23      4.9632

Tables of contrasts
===================
Variate: difflogStunt23
Must119vCult      -0.09,  s.e. 0.245,  ss.div. 4.00
Must119vNocult    -0.06,  s.e. 0.245,  ss.div. 4.00


Tables of means
===============
Variate: difflogStunt23
Grand mean  -0.05
    Treat      Cult    NoCult    Mustard119
              -0.01    -0.10     -0.04

Standard errors of means
------------------------
Table               Treat
rep.                    8
d.f.                   20
e.s.e.              0.174

Standard errors of differences of means
---------------------------------------
Table               Treat
rep.                    8
d.f.                   20
s.e.d.              0.245
```

4.4.4. Difference between log Stubby nematodes counts 2 and 3 for Mustard 119

```
356  "General Analysis of Variance."
 357  BLOCK Site
360  ANOVA []difflogStubby23
Analysis of variance
====================
Variate: difflogStubby23
Source of variation      d.f.      s.s.       m.s.     v.r.  F pr.
Site stratum                1    1.2359     1.2359     5.52
Site.*Units* stratum
Treat                       2    0.2927     0.1464     0.65  0.531
  Must119vCult              1    0.0139     0.0139     0.06  0.806
  Must119vNocult            1    0.2665     0.2665     1.19  0.288
Residual                   20    4.4779     0.2239
Total                      23    6.0065

Tables of contrasts
===================
```

```
Variate: difflogStubby23
Must119vCult        0.06,   s.e. 0.237,   ss.div. 4.00
Must119vNocult      0.26,   s.e. 0.237,   ss.div. 4.00

Tables of means
===============
Variate: difflogStubby23
Grand mean  0.184
    Treat      Cult    NoCult   Mustard119
             0.231     0.290     0.032

Standard errors of means
------------------------
Table                 Treat
rep.                      8
d.f.                     20
e.s.e.               0.1673

Standard errors of differences of means
---------------------------------------
Table                 Treat
rep.                      8
d.f.                     20
s.e.d.               0.2366

*************RESTRICTED TO ELVEDEN, still MUSTARD 119**********************
```

4.5.1. Difference log Total nematodes counts 2 and 3 for Mustard 119, Elveden

```
375  "General Analysis of Variance."
379  ANOVA []difflogTot23
Analysis of variance
====================
Variate: difflogTot23
Source of variation     d.f.        s.s.        m.s.     v.r.  F pr.
Treat                      2      0.0916      0.0458     0.43  0.661
  Must119vCult               1      0.0871      0.0871     0.83  0.387
  Must119vNocult             1      0.0422      0.0422     0.40  0.543
Residual                   9      0.9499      0.1055
Total                     11      1.0415

Tables of contrasts
===================
Variate: difflogTot23
Must119vCult        0.21,   s.e. 0.230,   ss.div. 2.00
Must119vNocult      0.15,   s.e. 0.230,   ss.div. 2.00

Tables of means
===============
Variate: difflogTot23
Grand mean  -0.133
    Treat      Cult    NoCult   Mustard119
```

-0.224	-0.015	-0.161

Standard errors of means

Table	Treat
rep.	4
d.f.	9
e.s.e.	0.1624

Standard errors of differences of means

Table	Treat
rep.	4
d.f.	9
s.e.d.	0.2297

4.5.2. Difference log Lesion nematodes counts 2 and 3 for Mustard 119, Elveden

381 "General Analysis of Variance."
385 ANOVA []difflogLesion23

Analysis of variance

Variate: difflogLesion23

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treat	2	0.0647	0.0324	0.27	0.772
Must119vCult	1	0.0644	0.0644	0.53	0.485
Must119vNocult	1	0.0122	0.0122	0.10	0.758
Residual	9	1.0920	0.1213		
Total	11	1.1568			

Tables of contrasts

Variate: difflogLesion23

Must119vCult	0.18,	s.e. 0.246,	ss.div. 2.00
Must119vNocult	0.08,	s.e. 0.246,	ss.div. 2.00

Tables of means

Variate: difflogLesion23

Grand mean -0.14

Treat	Cult	NoCult	Mustard119
	-0.23	-0.05	-0.13

Standard errors of means

Table	Treat
rep.	4
d.f.	9
e.s.e.	0.174

Standard errors of differences of means

Table	Treat
rep.	4
d.f.	9
s.e.d.	0.246

4.5.3. Difference log Stunt nematodes counts 2 and 3 for Mustard 119, Elveden

```
387  "General Analysis of Variance."
391  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
```

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treat	2	0.0137	0.0069	0.02	0.981
Must119vCult	1	0.0121	0.0121	0.03	0.858
Must119vNocult	1	0.0081	0.0081	0.02	0.883
Residual	9	3.2227	0.3581		
Total	11	3.2364			

```
Tables of contrasts
===================
Variate: difflogStunt23
Must119vCult      -0.08,  s.e. 0.423,  ss.div. 2.00
Must119vNocult    -0.06,  s.e. 0.423,  ss.div. 2.00

Tables of means
===============
Variate: difflogStunt23
Grand mean  -0.12
    Treat      Cult   NoCult   Mustard119
              -0.09    -0.16     -0.10

Standard errors of means
========================
```

Table	Treat
rep.	4
d.f.	9
e.s.e.	0.299

```
Standard errors of differences of means
---------------------------------------
```

Table	Treat
rep.	4
d.f.	9
s.e.d.	0.423

4.5.4. Difference log Stubby nematodes counts 2 and 3 for Mustard 119, Elveden

```
393  "General Analysis of Variance."
397  ANOVA []difflogStubby23
Analysis of variance
====================
```

Variate: difflogStubby23

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treat	2	0.5495	0.2748	0.79	0.483
Must119vCult	1	0.1953	0.1953	0.56	0.473
Must119vNocult	1	0.5422	0.5422	1.56	0.243
Residual	9	3.1265	0.3474		
Total	11	3.6760			

Tables of contrasts
===================

Variate: difflogStubby23

Must119vCult 0.31, s.e. 0.417, ss.div. 2.00
Must119vNocult 0.52, s.e. 0.417, ss.div. 2.00

Tables of means
===============

Variate: difflogStubby23

Grand mean -0.04

Treat	Cult	NoCult	Mustard119
	-0.08	0.24	-0.29

Standard errors of means

Table	Treat
rep.	4
d.f.	9
e.s.e.	0.295

Standard errors of differences of means

Table	Treat
rep.	4
d.f.	9
s.e.d.	0.417

*********NOW RESTRICTED TO KNIGHTS, still MUSTARD 119**********************

4.6.1. Difference log Total nematodes counts 2 and 3 for Mustard 119, Knights

412 "General Analysis of Variance."
416 ANOVA []difflogTot23
Analysis of variance
====================

Variate: difflogTot23

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Treat	2	0.86323	0.43162	9.28	0.006
Must119vCult	1	0.19066	0.19066	4.10	0.074
Must119vNocult	1	0.86221	0.86221	18.54	0.002
Residual	9	0.41858	0.04651		
Total	11	1.28181			

Tables of contrasts

```
====================
Variate: difflogTot23
Must119vCult        0.31,  s.e. 0.152,  ss.div. 2.00
Must119vNocult      0.66,  s.e. 0.152,  ss.div. 2.00

Tables of means
===============
Variate: difflogTot23
Grand mean  0.021
    Treat      Cult    NoCult   Mustard119
              0.034     0.343   -0.313

Standard errors of means
========================
Table                  Treat
rep.                       4
d.f.                       9
e.s.e.                0.1078

Standard errors of differences of means
=======================================
Table                  Treat
rep.                       4
d.f.                       9
s.e.d.                0.1525
```

4.6.2. Difference log Lesion nematodes counts 2 and 3 for Mustard 119, Knights

```
418  "General Analysis of Variance."
422  ANOVA []difflogLesion23
Analysis of variance
====================
Variate: difflogLesion23
Source of variation     d.f.       s.s.       m.s.    v.r.  F pr.
Treat                      2    1.20027    0.60013    8.83  0.008
  Must119vCult               1    0.24406    0.24406    3.59  0.091
  Must119vNocult             1    1.19654    1.19654   17.60  0.002
Residual                   9    0.61182    0.06798
Total                     11    1.81209

Tables of contrasts
===================
Variate: difflogLesion23
Must119vCult        0.35,  s.e. 0.184,  ss.div. 2.00
Must119vNocult      0.77,  s.e. 0.184,  ss.div. 2.00

Tables of means
===============
Variate: difflogLesion23
Grand mean  -0.047
    Treat      Cult    NoCult   Mustard119
             -0.022     0.327   -0.447
```

```
Standard errors of means
------------------------
Table                   Treat
rep.                        4
d.f.                        9
e.s.e.                 0.1304

Standard errors of differences of means
---------------------------------------
Table                   Treat
rep.                        4
d.f.                        9
s.e.d.                 0.1844
```

4.6.3. Difference log Stunt nematodes counts 2 and 3 for Mustard 119, Elveden

```
424  "General Analysis of Variance."
428  ANOVA []difflogStunt23
Analysis of variance
====================
Variate: difflogStunt23
Source of variation     d.f.      s.s.      m.s.    v.r.  F pr.
Treat                     2     0.0234    0.0117    0.07  0.937
  Must119vCult            1     0.0230    0.0230    0.13  0.727
  Must119vNocult          1     0.0085    0.0085    0.05  0.832
Residual                  9     1.5947    0.1772
Total                    11     1.6181

Tables of contrasts
===================
Variate: difflogStunt23
Must119vCult       -0.11,  s.e. 0.298,  ss.div. 2.00
Must119vNocult     -0.07,  s.e. 0.298,  ss.div. 2.00

Tables of means
===============
Variate: difflogStunt23
Grand mean  0.02
    Treat      Cult    NoCult   Mustard119
               0.07     -0.04       0.03

Standard errors of means
------------------------
Table                   Treat
rep.                        4
d.f.                        9
e.s.e.                  0.210

Standard errors of differences of means
---------------------------------------
Table                   Treat
```

```
rep.                      4
d.f.                      9
s.e.d.                0.298
```

4.6.4. Difference log Stubby nematodes counts 2 and 3 for Mustard 119, Elveden

```
430  "General Analysis of Variance."
434  ANOVA []difflogStubby23
Analysis of variance
====================

Variate: difflogStubby23

Source of variation     d.f.       s.s.       m.s.     v.r.  F pr.
Treat                      2     0.0987     0.0493     0.45  0.654
  Must119vCult             1     0.0757     0.0757     0.68  0.430
  Must119vNocult           1     0.0000     0.0000     0.00  0.985
Residual                   9     0.9959     0.1107
Total                     11     1.0946

Tables of contrasts
===================

Variate: difflogStubby23

Must119vCult       -0.19,  s.e. 0.235,  ss.div. 2.00
Must119vNocult      0.00,  s.e. 0.235,  ss.div. 2.00

Tables of means
===============

Variate: difflogStubby23

Grand mean  0.411

    Treat      Cult   NoCult   Mustard119
              0.540    0.345       0.349

Standard errors of means
------------------------

Table                 Treat
rep.                      4
d.f.                      9
e.s.e.               0.1663

Standard errors of differences of means
---------------------------------------

Table                 Treat
rep.                      4
d.f.                      9
s.e.d.               0.2352
```

AJP.

Statistical analysis of soil nutrient data, including N

All analyses were performed using Genstat 8.

Means (n=4) and their individual standard errors are tabulated in Table 1 for each treatment at each site.

NB. June = pre-drilling, Aug = pre-incorporation Sep = six weeks post-incorporation

Table 1. HDC Soil analyses - means and standard errors

1.a. Nitrogen at 30 and 60cm

Group means (N=4)		N30June	N60June	N30Aug	N60Aug	N30Sep	N60Sep
Elveden	Mustard 99	3.78	2.43	9.00	6.57	19.62	15.68
Elveden	None	3.50	2.42	34.23	22.06	22.85	13.87
Knights	Mustard 99	3.52	2.14	9.00	5.18	9.17	14.60
Knights	None	4.18	2.68	9.47	12.81	8.44	13.45
Elveden	Mustard 119	4.16	2.99	7.48	7.27	19.44	14.52
Elveden	None	3.98	2.27	31.21	18.30	17.32	22.07
Knights	Mustard 119	3.81	2.13	6.01	5.59	9.11	11.20
Knights	None	3.28	2.59	6.93	6.84	8.29	8.56
Standard errors		N30June	N60June	N30Aug	N60Aug	N30Sep	N60Sep
Elveden	Mustard 99	0.83	0.34	0.36	0.97	2.00	2.96
Elveden	None	0.51	0.26	2.56	1.17	4.03	4.18
Knights	Mustard 99	0.45	0.23	1.69	0.66	0.91	0.74
Knights	None	0.92	0.43	0.39	2.81	0.29	3.14
Elveden	Mustard 119	0.15	0.24	0.16	0.94	3.20	1.76
Elveden	None	0.50	0.43	1.40	3.78	2.83	5.34
Knights	Mustard 119	0.48	0.22	1.27	1.71	0.95	1.34
Knights	None	0.24	0.29	0.57	1.89	0.30	0.43

1.b. Phosphorus and potassium

Group means (N=4)		PJune	PAug	PSep	KJune	KAug	KSep
Elveden	Mustard 99	99.00	113.00	87.50	175.50	145.00	156.75
Elveden	None	92.25	106.50	79.75	162.25	155.75	131.75
Knights	Mustard 99	44.50	53.00	38.00	87.50	81.00	88.00
Knights	None	43.75	54.00	36.00	79.25	81.75	82.75
Elveden	Mustard 119	76.25	93.75	77.25	141.00	130.75	147.25
Elveden	None	79.25	91.00	72.00	157.50	147.50	132.75
Knights	Mustard 119	43.75	52.50	41.00	74.50	102.00	86.75
Knights	None	46.50	57.25	40.00	111.25	80.25	92.25
Standard errors		PJune	PAug	PSep	KJune	KAug	KSep
Elveden	Mustard 99	4.18	8.22	5.91	10.91	9.68	13.57
Elveden	None	1.44	1.32	4.91	14.10	6.60	10.26
Knights	Mustard 99	1.94	1.08	0.91	0.50	5.34	11.11
Knights	None	0.85	1.41	1.08	6.65	7.16	1.44
Elveden	Mustard 119	2.39	2.50	2.06	3.51	9.82	5.38
Elveden	None	3.42	3.74	1.58	18.75	13.22	14.50
Knights	Mustard 119	1.65	1.55	1.08	2.10	20.55	4.44
Knights	None	2.22	1.11	1.08	12.57	5.12	7.81

1.c. Magnesium and pH

Group means (N=4)		MgJune	MgAug	MgSep	pHJune	pHAug	pHSep
Elveden	Mustard 99	91.50	87.25	83.50	7.20	7.29	6.65
Elveden	None	82.00	80.50	79.00	7.20	7.11	6.74
Knights	Mustard 99	44.50	42.25	35.75	7.80	7.74	7.50
Knights	None	42.50	47.00	37.75	7.69	7.74	7.53
Elveden	Mustard 119	85.25	91.50	84.00	7.33	7.35	6.91
Elveden	None	92.75	87.00	84.00	7.38	7.03	6.93
Knights	Mustard 119	48.75	53.75	45.25	7.48	6.98	7.08
Knights	None	49.75	55.25	48.00	7.46	6.99	7.06
Standard errors		MgJune	MgAug	MgSep	pHJune	pHAug	pHSep
Elveden	Mustard 99	4.33	6.79	4.77	0.04	0.09	0.03
Elveden	None	4.18	2.99	1.22	0.04	0.08	0.06
Knights	Mustard 99	3.66	1.03	1.49	0.04	0.01	0.00
Knights	None	0.96	3.11	0.85	0.04	0.02	0.08
Elveden	Mustard 119	7.22	3.07	3.29	0.03	0.05	0.04
Elveden	None	2.25	1.08	4.56	0.02	0.03	0.07
Knights	Mustard 119	3.42	4.59	3.75	0.13	0.19	0.21
Knights	None	3.71	2.84	5.51	0.17	0.17	0.23

To compare the difference between the August and September soil analyses, statistical analysis was by Analysis of variance (Anova) with Mustard 99/Mustard 119 as the two treatments and the two sites as blocks. The Mustard 99 and Mustard 119 trials were analysed separately.

Analyses were performed on both the change between August and September and the proportionate change. Examination of the residuals in the analyses of proportionate values showed no sign of non-normality and hence transformation was not necessary. A summary of the outcome is given in Table 2.

Table 2. Comparisons between Crop and Nocults (Anova, Genstat8)

Variate is the change between August and September, either as percentage or actual
Percentage (e.g. %23K) calculated as (Sep-Aug)/Aug*100
Actual (e.g. diff23K) calculated as Sep-Aug
Difference between the changes calculated as Mustard 99-NoCult

2.a. Mustard 99

Variate	Mean change Mustard 99	NoCult	SE	difference	SE diff	F (df=1,13)	p	
%23K	7.8	-6.3	4.6	14.1	6.5	4.73	0.049	*
%23Mg	-9.5	-10.0	3.1	0.5	4.3	0.01	0.924	
%23N30	64.0	-21.0	17.1	85.0	24.2	12.59	0.004	**
%23N60	169.0	-10.0	19.9	179.0	28.1	40.85	<0.001	***
%23P	-25.3	-29.2	2.2	3.9	3.1	1.58	0.231	
%23pH	-5.89	-4.00	0.65	-1.89	0.92	4.22	0.061	

	Mustard 99	NoCult	SE	difference	SE diff	F (df=1,13)	p	
diff23K	9.4	-11.5	5.5	20.9	7.7	7.31	0.018	*
diff23Mg	-5.1	-5.4	2.0	0.3	2.9	0.01	0.932	
diff23N30	5.4	-6.2	2.7	11.6	3.9	8.94	0.01	**
diff23N60	9.3	-3.8	2.0	13.1	2.9	20.37	<0.001	***
diff23P	-20.2	-22.4	2.7	2.2	3.7	0.32	0.58	
diff23pH	-0.44	-0.29	0.05	-0.14	0.07	4.14	0.063	

2.b. Mustard 119

Variate	Mean change Mustard 119	NoCult	SE	difference	SE diff	F (df=1,13)	p	
%23K	6.1	3.4	10.4	2.7	14.6	0.03	0.855	
%23Mg	-12.0	-8.6	2.9	-3.4	4.1	0.66	0.433	
%23N30	116.0	-11.0	23.4	127.0	33.0	17.73	0.002	**
%23N60	131.0	60.0	37.6	71.0	53.1	1.79	0.204	
%23P	-19.6	-25.4	1.7	5.8	2.4	6.09	0.028	*
%23pH	-2.25	-0.20	0.85	-2.05	1.21	2.89	0.113	
diff23K	0.6	-1.4	10.9	2.0	15.4	0.02	0.899	
diff23Mg	-8.0	-5.1	2.0	-2.9	2.8	1.05	0.324	
diff23N30	7.5	-6.3	2.8	13.8	4.0	12.17	0.004	**
diff23N60	6.4	2.8	2.6	3.6	3.7	0.98	0.341	
diff23P	-14.0	-18.1	1.6	4.1	2.3	3.21	0.096	
diff23pH	-0.17	-0.01	0.06	-0.16	0.09	3.21	0.097	

K

There was a significant difference between Mustard 99 and NoCult in the change in K between August and September (7.8% increase for Mustard 99 but 6.3% drop for NoCult) but this did not occur in the Mustard 119 trial.

Mg

No statistically significant differences - similar approximate 10% decrease for Mustard 99 and Nocult and also Mustard 119 and NoCult.

N30

Large increase with both Mustard 99 and Mustard 119, versus small loss with NoCult. All comparisons statistically significant.

N60

With Mustard 99 there was a statistically significant difference between the large increase with Mustard 99 and the small loss with NoCult (this difference was more pronounced than that with N30). However, although there was also a large increase with Mustard 119, there was also a (smaller) increase with NoCult, resulting in there being no statistically significant difference between Mustard 119 and NoCult.

P

No statistically significant difference with Mustard 99, but with Mustard 119 the percentage change (%23P) differed but not the actual change (diff23P).

pH

No statistically significant differences with either Mustard 99 or Mustard 119.

The initial values in June were compared by Anova (Genstat) to see if they differed between the Crop and NoCult plots (Table 3).

Table 3. Comparisons between Crop and NoCult initial June values (Anova)

Difference calculated as Crop-NoCult

3.a. Mustard 99

Variate	Means						
	Mustard 99	NoCult	SE	difference	SE diff	F (df=1,13)	p
N30June	3.7	3.8	0.5	-0.2	0.7	0.08	0.785
N60June	2.3	2.6	0.2	-0.3	0.3	0.70	0.418
PJune	71.8	68.0	1.8	3.8	2.5	2.25	0.157
KJune	131.5	120.8	6.5	10.7	9.2	1.37	0.262
MgJune	68.0	62.2	2.5	5.8	3.6	2.59	0.131
pHJune	7.50	7.44	0.03	0.06	0.04	1.95	0.186

3.b. Mustard 119

Variate	Means							
	Mustard 119	NoCult	SE	difference	SE diff	F (df=1,13)	p	
N30June	4.0	3.6	0.3	0.4	0.4	0.95	0.349	
N60June	2.6	2.4	0.2	0.1	0.3	0.15	0.703	
PJune	60.0	62.9	1.7	-2.9	2.4	1.43	0.254	
KJune	107.8	134.4	8.0	-26.6	11.4	5.48	0.036	*
MgJune	67.0	71.2	3.2	-4.2	4.5	0.91	0.358	
pHJune	7.40	7.42	0.07	-0.02	0.11	0.03	0.862	

There were no statistically significant differences between Crop and NoCult except for K in the Mustard 119 trial, where the mean level was higher in the NoCult plots than in the Mustard 119 plots.

The difference between N at 30 and 60cm was compared between treatments at each time point (Table 4). The difference was calculated as N60cm-N30cm (i.e. was not proportional).

Table 4. Comparisons between N at 30 and 60cm

Difference calculated as N60-N30

Variate	Mean difference Crop	NoCult	SE	difference	SE diff	F (df=1,13)	p	
Mustard 99								
diffNJune	-1.4	-1.3	0.4	-0.1	0.5	0.02	0.890	
diffNAug	-3.1	-4.4	2.1	1.3	3.0	0.19	0.670	
diffNSep	0.7	-2.0	2.1	2.7	3.0	0.83	0.379	
Mustard 119								
diffNJune	-1.2	-1.4	0.3	0.2	0.5	0.21	0.651	
diffNAug	-6.5	-0.3	1.9	-6.2	2.6	5.51	0.035	*
diffNSep	2.5	-1.4	1.9	3.9	2.7	2.13	0.168	

There was no statistical difference between the treatments (Crop,NoCult) in the difference in N between 30 and 60cm at any time with Mustard 99, nor in June and September with Mustard 119, but there was a difference (just) with Mustard 119 in August (difference greater in Crop than NoCult).

Table 5. Effect of treatment (Biocide or NoCult) on the change in nutrients between June and August.

August v June								
Variate	Biocide Aug-June	NoCult Aug-June	S.E. Aug-June	Difference	S.E. difference	F (df=1,13)	p	
Mustard 99	Mustard 99	NoCult						
%12K	-12.2	0.8	4.66	-13	6.59	3.87	0.071	n.s.
%12Mg	-3.6	4.7	5.1	-8.3	7.21	1.33	0.270	n.s.
%12N30	166	545	95.4	-379	134.9	7.88	0.015	*
%12N60	173	603	68.4	-430	96.7	19.8	<.001	***
%12P	16.8	19.5	2.86	-2.7	4.04	0.47	0.505	n.s.
%12pH	0.21	-0.28	0.634	0.49	0.896	0.30	0.592	n.s.
diff12K	-18.5	-2	5.88	-16.5	8.31	3.94	0.069	n.s.
diff12Mg	-3.2	1.5	2.57	-4.7	3.64	1.70	0.215	n.s.
diff12N30	5.4	18	2.74	-12.6	3.87	10.7	0.006	**
diff12N60	3.59	14.88	1.315	-11.29	1.86	36.83	<.001	***
diff12P	11.2	12.2	2.3	-1	3.25	0.09	0.764	n.s.
diff12pH	0.012	-0.019	0.0463	0.031	0.0655	0.23	0.641	n.s.
Mustard 119	Mustard 119	NoCult						
%12K	16.4	-15.5	13.19	31.9	18.65	2.93	0.111	n.s.
%12Mg	10.7	2.9	6.09	7.8	8.61	0.83	0.378	n.s.
%12N30	68	417	67.7	-349	95.8	13.29	0.003	**
%12N60	177	520	141	-343	199.4	2.96	0.109	n.s.
%12P	21.7	19.3	2.66	2.4	3.76	0.41	0.531	n.s.
%12pH	-3.19	-5.55	0.854	2.36	1.207	3.82	0.073	n.s.
diff12K	8.6	-20.5	11.69	29.1	16.53	3.11	0.102	n.s.

Variate	Biocide Aug-June	NoCult Aug-June	S.E. Aug-June	Difference	S.E. difference	F (df=1,13)	p	
diff12Mg	5.6	-0.1	3.81	5.7	5.39	1.14	0.305	n.s.
diff12N30	2.8	15.4	2.3	-12.6	3.25	15.23	0.002	**
diff12N60	3.9	10.1	2.02	-6.2	2.86	4.80	0.047	*
diff12P	13.12	11.25	1.412	1.87	1.997	0.88	0.365	n.s.
diff12pH	-0.237	-0.413	0.0624	0.176	0.0883	3.93	0.069	n.s.

Conclusion: The change in nutrients between June and August did not differ between Biocide and NoCult for K, Mg, P or PH (all p>0.05) but did differ for N at both 30cm and 60cm with the change in level being greater in the NoCult plots than in the Biocide plots.

Table 6. Effect of treatment (Biocide or NoCult) on the change in nutrients between June and September.

September v June								
Variate	Biocide Sept-June	NoCult Sept-June	S.E. Sept-June	Difference	S.E. difference	F (df=1,13)	p	
Mustard 99	Mustard 99	NoCult						
%13K	-5.1	-6.1	5.6	1	7.92	0.02	0.902	n.s.
%13Mg	-13	-7.1	4.03	-5.9	5.7	1.09	0.316	n.s.
%13N30	355	387	103.4	-32	146.2	0.05	0.832	n.s.
%13N60	577	454	77.7	123	109.8	1.25	0.284	n.s.
%13P	-13.1	-15.7	2.1	2.6	2.96	0.80	0.388	n.s.
%13pH	-5.74	-4.26	0.462	-1.48	0.654	5.09	0.042	*
diff13K	-9.1	-13.5	5.59	4.4	7.91	0.31	0.590	n.s.
diff13Mg	-8.4	-3.9	2.18	-4.5	3.09	2.12	0.169	n.s.
diff13N30	10.7	11.8	1.91	-1.1	2.7	0.15	0.703	n.s.
diff13N60	12.9	11.1	1.99	1.8	2.81	0.39	0.545	n.s.
diff13P	-9	-10.1	1.59	1.1	2.24	0.25	0.624	n.s.
diff13pH	-0.425	-0.312	0.0355	-0.113	0.0502	5.01	0.043	*
Mustard 119	Mustard 119	NoCult						
%13K	10.6	-14.8	4.92	25.4	6.95	13.32	0.003	**
%13Mg	-2.7	-6.6	5.7	3.9	8.06	0.24	0.634	n.s.
%13N30	258	264	51.9	-6	73.4	0.01	0.935	n.s.
%13N60	421	574	123.1	-153	174.1	0.77	0.397	n.s.
%13P	-2.3	-11.2	1.97	8.9	2.79	10.31	0.007	**
%13pH	-5.52	-5.76	0.647	0.24	0.914	0.07	0.797	n.s.
diff13K	9.2	-21.9	6.86	31.1	9.7	10.31	0.007	**
diff13Mg	-2.4	-5.2	3.81	2.8	5.39	0.28	0.603	n.s.
diff13N30	10.3	9.2	1.55	1.1	2.19	0.26	0.620	n.s.
diff13N60	10.3	12.9	2.23	-2.6	3.15	0.67	0.427	n.s.
diff13P	-0.9	-6.9	1.46	6	2.06	8.48	0.012	*
diff13pH	-0.406	-0.425	0.0453	0.019	0.064	0.09	0.774	n.s.

Conclusion:

Mustard 99: No effect with K, Mg, N30, N60 or P but significant difference with pH – slightly smaller change (decrease) in NoCult than in Biocide.

Mustard 119: No effect with Mg, N30, N60, or pH but significant difference with K (increase with Mustard 119 but decrease with NoCult) and P (greater decrease with NoCult than with Mustard 119).

Table 7. Effect of treatment (Biocide or NoCult) on the level of nutrients in September.

Variate	Biocide September	NoCult September	S.E.	Difference	S.E. difference	F (df=1,13)	p	
Mustard 99	Mustard 99	NoCult						
N30Sep	14.4	15.6	1.61	-1.2	2.28	0.30	0.5930	n.s.
N60Sep	15.1	13.7	2.06	1.4	2.91	0.26	0.6200	n.s.
PSep	62.8	57.9	2.71	4.9	3.84	1.62	0.2260	n.s.
KSep	122.4	107.2	7.18	15.2	10.16	2.22	0.1600	n.s.
MgSep	59.6	58.4	1.88	1.2	2.66	0.22	0.6470	n.s.
pHSep	7.075	7.131	0.0344	-0.056	0.0487	1.33	0.2690	n.s.

Variate	Biocide September	NoCult September	S.E.	Difference	S.E. difference	F (df=1,13)	p	
Mustard 119	Mustard 119	NoCult						
N30Sep	14.3	12.8	1.49	1.5	2.11	0.48	0.4990	n.s.
N60Sep	12.9	15.3	2.21	-2.4	3.12	0.62	0.4450	n.s.
PSep	59.12	56	1.104	3.12	1.562	4.00	0.0670	n.s.
KSep	117	112.5	6.38	4.5	9.03	0.25	0.6270	n.s.
MgSep	64.6	66	2.97	-1.4	4.21	0.11	0.7490	n.s.
pHSep	6.994	6.994	0.1096	0	0.155	0.00	1.0000	n.s.

Conclusion: No significant differences detected.

Table 8. Effect of cultivation (Cult or NoCult) on the level of Nematodes (and Pythium) at Count 2.

Variate	Cult Count2	NoCult Count2	S.E.	Difference	S.E. difference	F (df=1,13)	p	
Count2								
Mustard 99	Cult	NoCult						
logLesion2	1.726	1.851	0.0875	-0.125	0.1237	1.01	0.333	n.s
logStubby2	0.405	0.39	0.0865	0.015	0.1223	0.01	0.907	n.s
logStunt2	0.6	0.38	0.167	0.22	0.236	0.82	0.381	n.s
logTotNem2	1.799	1.961	0.0934	-0.162	0.1321	1.50	0.242	n.s
logTotPyth2	3.414	3.565	0.0422	-0.151	0.0596	6.42	0.025	*

Variate	Cult Count2	NoCult Count2	S.E.	Difference	S.E. difference	F (df=1,13)	p	
Count2								
Mustard 119	Cult	NoCult						
logLesion2	1.75	1.608	0.0854	0.142	0.1207	1.40	0.258	n.s
logStubby2	0.218	0.285	0.0948	-0.067	0.1341	0.25	0.626	n.s

Variate	Cult Count2	NoCult Count2	S.E.	Difference	S.E. difference	F (df=1,13)	p	
logStunt2	0.52	0.56	0.158	-0.04	0.224	0.03	0.858	n.s
logTotNem2	1.783	1.686	0.0789	0.097	0.1116	0.76	0.398	n.s
logTotPyth2	3.391	3.385	0.0428	0.006	0.0606	0.01	0.917	n.s

Conclusion: No significant effect on any of the nematode groups.

Small and just significant effect of cultivation on Pythium in Mustard 99 part of the trial but not in the Mustard 119 part.