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Use of vegetable transplants to introduce beneficial and biocontrol microbes into the crop environment

Ian Macleod
Serve-Ag Research Pty Ltd

Project Number: VG02088

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FINAL REPORT

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Tasmania, 2003

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Table of Contents

Media Summary

There are currently several products being marketed in Australia which claim to assist in root development and control of soil-borne diseases. Typically, these products are sold as soil-enhancers or soil amendments, and there has been no requirement to demonstrate product efficacy for registration with the Australian Pesticides and Veterinary Medicines Authority.

The aim of this project was to independently assess a range of commercially available products, and to determine whether treatment of transplants with microbial inoculants can improve crop vigour, yields and quality.

Trials were conducted in transplanted lettuce and broccoli crops grown on the north west coast of Tasmania. Trials were conducted over the 2002/03 and 2003/04 growing seasons.

No treatments caused any crop phytotoxicity at any stage of growth in lettuce or broccoli plants. No treatments resulted in any obvious quality defects. Generally, differences in subjective quality measurements were only relative, and all product harvested from the field trials was of acceptable commercial quality.

In the trials conducted as part of this project, the only product that consistently improved yields in all field trials in both seasons for both lettuce and broccoli was worm castings. This is not to say that other products might not perform very well under different growing conditions. Average head weight improvements in plots treated with worm castings were 10% or higher in both crops. Total crop yields of broccoli treated with worm castings were significantly higher than other treatments.

In the 2003/04 trials, efforts were made to determine whether treatment benefits were increased with nursery application as well as field application. Was the use of microbial inoculants in the nursery improving root development and the crops' potential for yield improvements? Data to address this question was inconsistent. No treatment consistently promoted root growth in transplant plugs. Yield and quality results showed no pattern in beneficial effects from nursery application of microbial inoculants.

Trial work in the nursery highlighted some critical considerations for the use of microbial inoculants in the nursery. Typically, transplant nurseries provide all transplants for a district. It is critical that the nursery has excellent disease management strategies in place to prevent spread of disease within an area. A topical example is management of white blister in brassica transplants to prevent district outbreaks. Given that there are currently no biofungicides registered with the APVMA, this means that few transplant growers are prepared to take the risk to use products with unproven claims. A further issue with using biological products in transplant nurseries is compatibility with necessary synthetic chemical spray programs. The majority of beneficial microbial products are not compatible with synthetic chemicals. In many cases, no information on product compatibility is given on the labels of biological products.

Undoubtedly, there is considerable interest in the application of various microbial products in agriculture. The scope of this project only allowed for limited evaluation of a few commercially available products. There are a lot of other available products that could not be included in trials.

Use of these products in conventional agriculture requires a considered approach. Growers must be prepared to evaluate how these products perform in their own production systems. Manufacturers of biological products should aim to provide as much information as possible to assist growers with decision making. A basic checklist can assist growers to learn how well a product has been developed. The label, packaging, storage requirements and formulation can all give the grower clues as to the professionalism of product development. Product performance under particular growing conditions is often best evaluated by the grower, as long as a control strip is left in the paddock for comparison.

Technical Summary

There are currently several products being marketed in Australia which claim to assist in root development and control of soil-borne diseases. Typically, these products are sold as soil-enhancers or soil amendments, and there has been no requirement to demonstrate product efficacy for registration with the Australian Pesticides and Veterinary Medicines Authority.

The aim of this project was to independently assess a range of commercially available products, and to determine whether treatment of transplants with microbial inoculants can improve crop vigour, yields and quality.

Trials were conducted in transplanted lettuce and broccoli crops grown on the north west coast of Tasmania. Trials were conducted over the 2002/03 and 2003/04 growing seasons. Field trials were conducted in conjunction with pot trials to evaluate the same treatments for *Sclerotinia minor* disease control. Pots were inoculated with *Sclerotinia minor* cultured on barley grains.

A range of different 'biological' products was used, including *Bacillus subtilis* strains, *Trichoderma* strains, compost teas and worm castings. The products chosen were nearly all commercial products, which are routinely advertised in major national growers' magazines. A number of the products selected for evaluation were certified for use in organic agriculture.

Trial treatments were carried out in a commercial transplant nursery with liquid formulations applied as a drench at seeding, and granular formulations incorporated into the plug media. Some treatments were applied during transplant growth, but the majority were applied as a second drench at transplanting, or soil incorporated prior to transplanting.

No treatments caused any crop phytotoxicity at any stage of growth in lettuce or broccoli plants. No treatments resulted in any obvious quality defects. Generally, differences in subjective quality measurements were only relative, and all product harvested from the field trials was of acceptable commercial quality.

In the trials conducted as part of this project, the only product that consistently improved yields in all field trials in both seasons for both lettuce and broccoli was worm castings. Average head weight improvements in plots treated with worm castings were 10% or higher in both crops. Total crop yields of broccoli treated with worm castings were significantly higher than other treatments.

Different results could be expected under different growing conditions. The performance of many of these types of products depends on localised microbial interactions within the crop environment. No products were comparable with commercial treatments for disease control under the high *Sclerotinia* pressure in pot trials.

In the 2003/04 trials, efforts were made to determine whether treatment benefits were increased with nursery application as well as field application. Was the use of microbial inoculants in the nursery improving root development and the crops' potential for yield improvements? Data to address this question was inconsistent. No treatment consistently promoted root growth in transplant plug. Yield and quality results showed no pattern in beneficial effects from nursery application of microbial inoculants.

Trial work in the nursery highlighted some critical considerations for the use of microbial inoculants in the nursery. Typically, transplant nurseries provide all transplants for a district. It is critical that the nursery has excellent disease management strategies in place to prevent spread of disease within an area. A topical example is management of white blister in brassica transplants to prevent district outbreaks. Given that there are currently no biofungicides registered with the APVMA, this means few transplant growers are prepared to take the risk to use products with unproven claims. A further issue with using biological products in transplant nurseries is compatibility with necessary synthetic chemical spray programs. The majority of beneficial microbial products are not compatible with synthetic chemicals. In many cases, no information on product compatibility is given on the labels of biological products.

Technical Summary (Cont.)

Undoubtedly, there is considerable interest in the application of various microbial products in agriculture. The scope of this project only allowed for limited evaluation of a few commercially available products. There are lot of other available products that could not be included in trials.

Use of these products in conventional agriculture requires a considered approach. Growers must be prepared to evaluate how these products perform in their own production systems. Manufacturers of biological products should aim to provide as much information as possible to assist growers with decision making. A basic checklist can assist growers to learn what how well a product has been developed. The label, packaging, storage requirements and formulation can all give the grower clues as to the professionalism of product development. Product performance under particular growing conditions is often best evaluated by the grower, as long as a control strip is left in the paddock for comparison.

Introduction

Within the last decade, there has been global growth in 'biological agriculture'. The current edition of the BioPesticides Manual (2002) contains descriptions of 273 active ingredients for biological products. In Australia, various microbial products are being marketed to growers with claims for improved root development, crop growth and control of soil-borne diseases. Typically, these products are sold as soil-enhancers or soil-amendments, and are applied directly to the soil. However, it is difficult for these introduced microbes to compete with existing biota and establish adequate populations to exert disease control over soil-borne pathogens.

Inoculating transplants to establish desired microbial populations within the root environment prior to transplanting can potentially enhance the ability of the biocontrol agent to combat pathogens. This approach is currently also being trialed overseas.

There is interest in beneficial and biocontrol products from both conventional and organic vegetable growers. However, Australian regulatory authorities have not assessed many of these products, and there is no replicated trial data available.

The aim of this project was to independently assess a range of commercially available products, and to determine whether treatment of transplants with microbial inoculants can improve crop vigour, yields and quality.

Aims

- To screen commercial microbial inoculants for potential to improve crop vigour, quality and yield in Iceberg lettuce.
- To determine whether inoculation of transplants is a means of enhancing the ability of biocontrol microorganisms to combat pathogens.
- To determine if there are any phytotoxicity problems associated with application at sowing or drenching of young, tender plants.

Review of Available Products

Over recent years, there has been an increase in the number of commercial formulations of biological type compounds marketed to industry. These products include a broad range of compounds which claim to promote crop health in a number of ways, including:

- Biological control
- Stimulation of plant defence responses
- Improved nutrient uptake and nutrient balance within the plant
- Promotion of plant health

It is often hard to distinguish between products which are based on microbial constituents and products whose mode of action is to stimulate microbial activity in the soil. Products marketed in this area include:

- Compost teas
- Plant tonics
- Soil and microbial amendments
- Soil and biological enhancers
- Microbial brews (strains of *Trichoderma, Bacillus subtilis, Coniothyrium minitans*)
- Worm castings
- Humic and fulvic acids
- Kelp extracts
- Fish emulsions

Currently, no microbial amendment products have been registered with the Australian Pesticides and Veterinary Medicines Authority. All these types of products are promoted through retailers and in trade magazines. Products for inclusion in this project were chosen by:

- Consultation with growers and vegetable agronomists
- Reviews of advertisements in *Good Fruit and Vegetables*
- Internet searches
- Reviews of previous project work conducted by Serve-Ag Research

A range of different 'biological' products was used, including *Bacillus subtilis* strains, *Trichoderma* strains, compost teas and worm castings. The products chosen were nearly all commercial products, which are routinely advertised in major national growers' magazines. A number of the products selected for evaluation were certified for use in organic agriculture.

Trial treatments were carried out in a commercial transplant nursery, with liquid formulations applied as a drench at seeding, and granular formulations incorporated into the plug media. Some treatments were applied during transplant growth, but the majority were applied as a second drench at transplanting, or soil incorporated prior to transplanting. The following table shows a simplified treatment list for the trials, which indicates when different products were incorporated.

Lettuce and broccoli were chosen as target crops because a lot of biological products include these crops as target crops in their promotional material. Broccoli and lettuce are among the major transplanted crops in Australia.

Review of Available Products (Cont.)

Simplified treatment list showing application regimes for different products

TREATMENT NAME	Sowing	During seedling growth	Soil applicaiotn/ incorporation prior to transplanting	At transplanting	During crop growth
Control					
Beneficial micro-organisms	✓	✓	✗	✓	✓
Bacillus subtilis A	✓	✗	✗	✓	✓
Biological program	✓	✗	✗	✓	✓
Compost tea program	✗	✗	✓	✓	✓
Trichoderma program A	✗	✗	✗	✓	✓
Trichoderma program B	✗	✗	✓	✓	✓
Bacillus subtilis B	✓	✓	✗	✓	✓
Trichoderma program C	✓	✓	✗	✓	✓
Trichoderma program D	✓	✗	✗	✗	✗
Worm castings	✓	✗	✓	✗	✗
Trichoderma program E	✓	✗	✗	✓	✓
Biocontrol mixture	✓	✗	✗	✓	✓
Commercial control (Sumisclex)	✗	✗	✗	✓	✓

The same treatments were applied to both lettuce and broccoli field and pot trials.

Lettuce Field Trials

Methods and Materials

Lettuce trials were conducted in the summers of 2002/03 and 2003/04. Both trials were conducted at Forthside Vegetable Research Station

In the 2002/03 season, the emphasis of trial work was on screening a large range of products. There were 4 treatment replicates in trials.

Products evaluated in 2002/03 trials

NO.	TREATMENT CODE	PRODUCTS IN TREATMENT (MANUFACTURER)
1	Control	Untreated Control
2	Beneficial micro-organisms	Effective Micro-organisms (Vital Resources)
3	*Bacillus subtilis* A	Companion (Spray Gro)
4	Compost tea program	Mend Compost Tea + Aloe Tech + Bio-N + Bio-P + Seed Start + Nutri-Kelp + Bio-Plex (Nutri-Tech Solutions)
5	*Trichoderma* program A	Trichoshield + Seed Start + Black Gold + Bio-Plex + Humatech (Nutri-Tech Solutions)
6	*Trichoderma* program B	Trichoshield + Aloe Tech + Nutrikelp + B-sub (Nutri-Tech Solutions)
7	*Bacillus subtilis* B	BC 403 (Organic Crop Protectants – experimental product)
8	*Trichoderma* program C	BC 702/703 (Organic Crop Protectants – experimental product)
9	*Trichoderma* program D	Trichodry 6S (Agrimm Technologies)
10	Worm castings A	Bioverm (Vermitech)
11	Worm castings B	Granular Bioverm (Vermitech)
12	*Trichoderma* program E	Tri-D25 (Zadco)
13	Biocontrol mixture	Superzyme (Zadco)
14	Commercial control	Sumisclex (Sumitomo Chemical)

Products were applied at rates recommended by the manufacturer. A detailed treatment list is given in Appendix ii.

Lettuce Field Trials (Cont.)

In 2003/04, the number of treatment replicates was increased from 4 to 7 in order to better detect treatment differences. Only 4 different biological treatments were used in the trials, and the emphasis on trial work was to quantify the extent of treatment effects. For each of the treatments listed below, one treatment regime included nursery application and one regime included nursery and field application.

Products evaluated in 2003/04 Trials

NO.	TREATMENT	PRODUCTS IN TREATMENT (MANUFACTURER)
1	Control	Untreated Control
2	Biological Program (field only)	Mend Compost Tea + Aloe Tech + Bio-N + Bio-P + Bio-Plex + Nutri-Kelp + B-sub + Fulvic 1400 + Shuttle Seven + Brix Master + Veg-Tech Triple Ten + Tonic Tech + Cloak Spray Oil (Nutri-Tech Solutions)
3	Biological Program (nursery, field)	
4	Worm Castings (field only)	Bioverm (Vermitech)
5	Worm Castings (nursery, field)	
6	*Bacillus subtilis* (field only)	Companion (Spray Gro)
7	*Bacillus subtilis* (nursery, field)	
8	Biocontrol mixture (field only)	Superzyme (Zadco)
9	Biocontrol mixture (nursery, field)	
10	Commercial Control (field only)	Sumisclex (Sumitomo)
11	Commercial Control (nursery, field)	

Trials were sown at Hills Transplants using a commercial seeding line. Trays (198 cells/tray) were marked with coloured tape to indicate different treatments. After sowing, trays were placed in a germination room for 2 days and then moved to outside bays, where drench treatments were applied with a watering can (Photograph 1). Trays were drenched until saturated.

Prior to transplanting in 2003/04, seedlings were assessed for growth development in the nursery. Visual observation of root development were made, and a photograph was taken of 10 representative seedlings from each treatment. No visual differences were observed between plants.

A sub-sample of 100 seedlings was randomly selected from the planting trays. Leaves were cut off at soil level with a razor blade. Root plugs and leaves were dried separately in a drying oven for one week to determine dry matter root:shoot ratios. The assumption was that the volume of each root plug was

identical and any differences in the mass of root plugs was attributable to additional root development. Dry weight root:shoot ratios are given in Table 1.

Lettuce Field Trials (Cont.)

No pre-planting fertiliser was applied because the aim of the trial was to grow the plants under base conditions so that additional benefits resulting from microbial interactions could be detected. A soil test (Appendix i) showed that the trial site had reasonable fertility. The trial was top dressed with Nitrophoska Blue Special at 4 and 6 weeks after transplanting. Fertiliser recommendations were made by a senior district agronomist and he viewed the trial at regular intervals.

Treatments were applied as per application schedule recommended by product manufacturers. Sprays were applied using a carbon dioxide pressurised 1.5 m boom sprayer. Three TeeJet TX12 nozzles spaced at 50 cm were used. Application volume was 250 L/ha and the pressure was 225 kPa.

Site Details for Lettuce Field Trials

Grower	Forthside Vegetable Research Station
Location	Forth, North West Tasmania
Grid Reference	55GDQ378383
Soil Type	Ferrosol (see Appendix i for 2003/04 site soil test)
Crop	Iceberg Lettuce
Varieties	Magnum (2002/03 season) and Target (2003/04 season)
Trial Design	Randomised complete block
Replicates	4 (2002/03 aseason) and 7 (2003/04 season)
Plot Size	6 m x 1 bed (1.2 m)
Plant Spacing	30 cm
Row Spacing	40 cm

Lettuce Field Trials (Cont.)

Chronology of Events for 2002/03 Trial

DATE	DAYS AFTER SOWING	EVENT
02/10/02	0	Lettuce trays sown. Media-incorporation of treatments 9, 10, 11. Lettuce trays in shade house to prevent thermo-dormancy.
04/10/02	2	Lettuce trays moved to outside bay. Treatments 2, 3, 7, 8, 12, 13 applied as tray drenches with watering can (Photograph 1).
6/11/02	35	Treatments 2, 7, 8 applied with a watering can.
11/11/02	40	Trial area pegged.
12/11/02	41	Treatments 4, 5, 6, 10, 11 applied to field plots.
13/11/02	42	Treatments 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14 applied as drench to transplants with watering can. Transplants planted using commercial transplanter (Photograph 2).
	DAYS AFTER TRANSPLANTING	
15/11/02	2	Kerb applied for weed control. Rate of 4.5 L/ha applied with water rate of 250 L/ha using DG8002 fan jets at 225 kPa.
26/11/02	13	Pirimor applied for aphid control. Rate of 500 g/ha applied with water rate of 280 L/ha using TX12 nozzles at 300 kPa.
29/11/02	16	Treatments 2, 3, 4, 5, 6, 7, 14 applied.
03/12/02	20	Calcium nitrate applied at rate of 125 kg/ha. Broadcast by hand and irrigated in.
06/12/02	23	Treatments 2, 4, 5, 6 applied.
12/12/02	29	Treatments 2, 3, 4, 5, 6, 7, 8, 14 applied.
18/12/02	35	Nitrophoska Perfekt applied at rate of 250 kg/ha. Broadcast by hand and irrigated in.
19/12/02	36	Treatments 2, 4, 5, 6, 7, 12, 13 applied.
23/12/02	40	Hand weeding of trial area.
02/01/03	50	Harvest assessment. (Photographs 4 & 5).
03/01/03	51	Pegs removed.
06/01/03	54	Trial area mulched in.

Lettuce Field Trials (Cont.)

Chronology of Events for 2003/04 Trial

DATE	DAYS AFTER SOWING*	EVENT
12/12/03	0	Sowing. Treatment 5 incorporated into plug media. Trays moved to germination room.
15/12/03	3	Treatments 3, 7, 9 applied as drench. Trays moved to outside bays.
08/01/04	27	Trial area pegged. Treatments 4 & 5 incorporated into field plots using a rake.
12/01/04	31	Transplanting. Treatments 2, 3, 6, 7, 8, 9, 10, 11 applied.
	DAYS AFTER TRANSPLANTING	
20/01/04	8	Treatments 2 & 3 applied (270 L/ha water). Weeds in crop hoed out.
27/01/04	15	Treatments 2, 3, 6, 7 applied (270 L/ha water). Weeds in crop hoed out.
03/02/04	22	Treatments 2 & 3 applied.
10/02/04	29	Treatments 2, 3, 6, 7 applied (270 L/ha water). Weeds in crop hoed out.
11/02/2004	30	Nitrophoska Blue Special applied at 65 kg/ha. Broadcast by hand and irrigated in.
17/02/04	36	Treatments 2 & 3 applied (270 L/ha water).
24/02/04	43	Treatments 2, 3, 6, 7, 8, 9 applied (270 L/ha).
25/02/04	44	Nitrophoska Blue Special applied at 65 kg/ha. Broadcast by hand and irrigated in.
02/03/04	50	Treatments 2 & 3 applied (270 L/ha water).
10/03/04	58	Harvest

* A previous trial was sown on 5/11/03. However, these plants were accidentally sprayed by nursery staff with a Kocide, Mancozeb and Bravo mix. The trial had to be abandoned and a new trial was commenced.

Lettuce Field Trials (Cont.)

The following parameters were assessed in the field:

1. NUTRIENT UPTAKE ASSESSMENT

TIMING - 3 and 7 weeks after transplanting

SAMPLE SIZE - 10 leaves per replicate plot. Replicates were bulked for treatment samples.

METHOD - The youngest fully expanded leaf was collected at 7.30 am. Samples were stored in an Eski and were processed the same day in the Serve-Ag Analytical Services Laboratory using commercial methodology.

SUMMARISED RESULTS - Tables 2 & 3

2. PLOT VIGOUR ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Whole plot

METHOD - Visual rating of crop vigour

SUMMARISED RESULTS - Tables 4 & 5

3. COLOUR ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - 2002/03: Subsample of 10 heads, with chosen heads being the best from across the plot.
2003/04: Whole plot assessed

METHOD - Visual rating of crop colour

SUMMARISED RESULTS - Tables 4 & 5

4. HEAD SIZE ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - 2002/03: Subsample of 10 heads, with chosen heads being the best from across the plot. Heads were assessed quantitatively using method below.
2003/04: Whole plot assessed using visual rating

METHOD - 2002/03: The diameter of each head was measured at the widest part, using a flexible tape measure. The heads were measured with the wrapping leaves remaining after commercial cutting.
2003/04: Visual rating of crop vigour

SUMMARISED RESULTS - Table 5, Graph 1

COMPLETE DATA - Appendix iii

STATISTICAL ANALYSES - Appendix iv
Analysis of variance was used to determine significant differences at $p<0.05$ for assessments for 2002/03 season. There were no significant differences between treatments.

Lettuce Field Trials (Cont.)

5. HEAD SHAPE ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - 2002/03: Subsample of 10 heads, with chosen heads being the best from across the plot.
2003/04: Whole plot assessed visually.

METHOD - Visual rating of head shape.

SUMMARISED RESULTS - Tables 4 & 5

COMPLETE DATA - Appendix iii

6. HEAD FIRMNESS ASSESSMENT

DATE - 2/01/03

SAMPLE SIZE - Subsample of 10 heads, with chosen heads being the best from across the plot.

METHOD - Pressing on lettuce with hand to rate head firmness. Excellent firmness was for heads which were compact with good heart developent. Poor firmness was given for soft heads with little or no heart formation.

SUMMARISED RESULTS - Tables 4 & 5

COMPLETE DATA - Appendix iii

7. HEAD WEIGHT ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Subsample of 10 heads, with chosen heads being the best from across the plot.

METHOD - Heads were weighed on field scales and weights recorded.

SUMMARISED RESULTS - Graphs 2 & 3. Tables 6 & 7

COMPLETE DATA - Appendix iii

STATISTICAL ANALYSES - Appendix iv
Analysis of variance was used to determine significant differences at $p<0.05$. There were significant differences between treatments.

8. CROP PHYTOTOXICITY ASSESSMENT

TIMING - Throughout crop growth

SAMPLE SIZE - Whole plot

METHOD - Visual observation of crop

SUMMARISED RESULTS - There were no signs of phytotoxicity observed in any plots. All treatments were safe to the lettuce crop

Lettuce Field Trials (Cont.)

Photograph 1 - Drenching treatments being applied after transplant trays were sown (2002/03)

Photograph 2 - Transplanting at Forthside Vegetable Research Station (2002/03)

Lettuce Field Trials (Cont.)

Photograph 3 - View of field trial on 23/12/02, 10 days before harvest

Photograph 4 - Harvest assessment, 2/01/03

Lettuce Field Trials (Cont.)

Photograph 5 - Weighing individual heads using field scales (2002/03)

Photograph 6 - Harvest assessment, 10/03/04

Lettuce Field Trials (Cont.)

Results

Table 1 - Lettuce dry weight root:shoot ratios (2003/04)

Treatment	Root:Shoot Ratio
Untreated Control	8.57
Biological Program	9.11
Worm castings	9.82
Bacillus subtillus	8.95
Biocontrol mixture	9.24

Table 2 - Nutrient uptake in lettuce at 3 weeks after transplanting (2003/04)

No.	TREATMENT	NO3	P	K	Ca	Mg	S
1	Untreated control	830	64	2549	314	89	82
3	Biological program	770	57	2543	283	86	73
5	Worm castings	512	56	2370	320	84	79
7	Bacillus subtilis	709	51	2514	332	89	71
9	Biocontrol mixture	703	57	2419	368	89	87
11	Commercial control	833	52	2374	283	80	70

No.	TREATMENT	Zn	B	Cu	Fe	Mn	Na	Mo
1	Untreated control	1.01	0.56	0.40	3.31	35	117	0.02
3	Biological program	0.87	0.56	0.36	2.55	20	115	0.01
5	Worm castings	0.81	0.62	0.34	2.70	16	124	0.03
7	Bacillus subtilis	0.77	0.57	0.39	2.55	18	116	0.02
9	Biocontrol mixture	0.81	0.61	0.37	2.87	19	122	0.02
11	Commercial control	0.75	0.50	0.35	2.47	19	118	0.01

Lettuce Field Trials (Cont.)

Table 3 - Nutrient uptake in lettuce at 7 weeks after transplanting (2003/04)

No.	TREATMENT	NO3	P	K	Ca	Mg	S
1	Untreated control	1050	50	2635	520	138	53
3	Biological program	592	55	2108	344	105	43
5	Worm castings	571	56	2265	416	125	45
7	Bacillus subtilis	710	53	2222	314	98	41
9	Biocontrol mixture	841	59	2334	434	133	45
11	Commercial control	749	64	2031	308	99	49

No.	TREATMENT	Zn	B	Cu	Fe	Mn
1	Untreated control	0.45	0.17	0.35	5.64	2.26
3	Biological program	0.48	0.09	0.47	3.74	1.63
5	Worm castings	0.38	0.10	0.35	4.77	1.99
7	Bacillus subtilis	0.45	0.08	0.42	3.75	1.49
9	Biocontrol mixture	0.51	0.14	0.32	4.30	2.18
11	Commercial control	0.44	0.05	0.31	3.95	1.77

Lettuce Field Trials (Cont.)

Table 4 - Mean Visual Ratings at Harvest for 2002/03 Season

NO.	TREATMENT	Plot vigour#	Colour*	Shape*	Firmness*
1	Control	1.25	1.00	1.25	1.13
2	Beneficial micro-organisms	2.33	1.00	1.18	1.30
3	*Bacillus subtilis* A	1.50	1.00	1.00	1.25
4	Compost tea program	1.00	1.00	1.38	1.08
5	*Trichoderma* program A	1.25	1.00	1.48	1.35
6	*Trichoderma* program B	1.25	1.00	1.18	1.45
7	*Bacillus subtilis* B	1.75	1.00	1.25	1.18
8	*Trichoderma* program C	1.50	1.00	1.50	1.13
9	*Trichoderma* program D	1.50	1.00	1.35	1.33
10	Worm castings A	1.00	1.00	1.13	1.13
11	Worm castings B	1.00	1.00	1.33	1.13
12	*Trichoderma* program E	1.25	1.00	1.20	1.38
13	Biocontrol mixture	2.00	1.00	1.08	1.18
14	Sumisclex	1.25	1.00	1.55	1.30

Assessed as rating for whole plot.
* Assessed as individual ratings for 10 heads cut from each plot.

1 = Excellent
2 = Good
3 = Poor

Lettuce Field Trials (Cont.)

Table 5 - Mean Visual Ratings at Harvest for 2003/04 Season

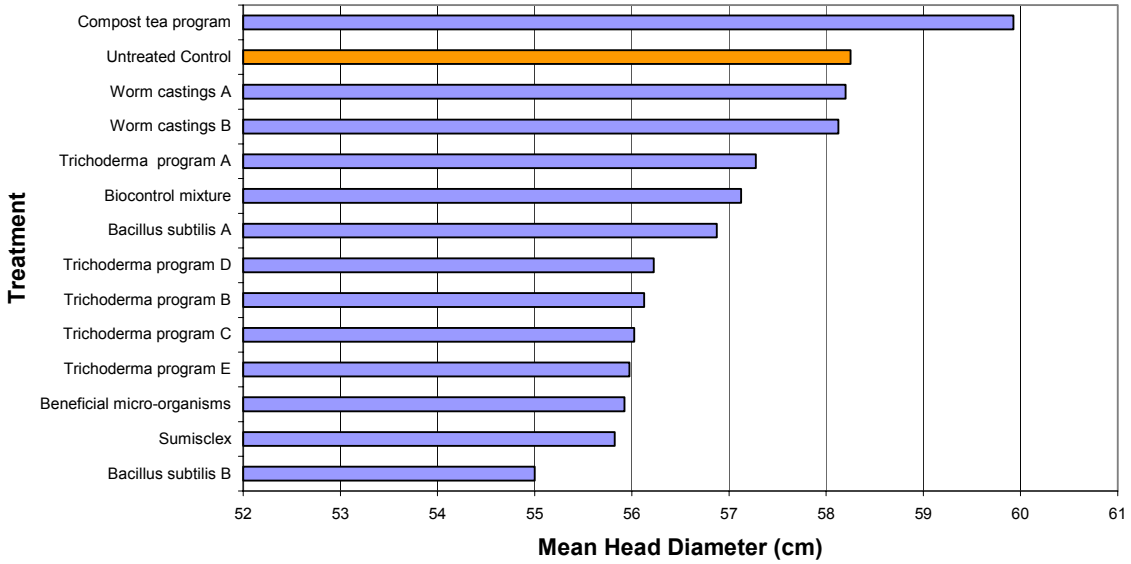
NO.	TREATMENT	Vigour	Colour	Size	Shape	Firmness
1	Untreated Control	2.1	3.0	2.1	1.9	2.0
2	Biological Program (field only)	2.4	3.0	2.5	2.1	2.4
3	Biological Program (nursery, field)	2.7	3.0	2.6	2.6	2.6
4	Worm Castings (field only)	2.2	3.0	2.4	2.0	2.4
5	Worm Castings (nursery, field)	2.7	3.0	2.4	2.3	2.6
6	Bacillus Subtilis (field only)	2.6	2.9	2.3	2.3	1.9
7	Bacillus Subtilis (nursery, field)	2.5	2.9	2.5	2.6	2.2
8	Biocontrol mixture (field only)	2.4	3.0	2.4	2.4	2.2
9	Biocontrol mixture (nursery, field)	2.6	3.0	2.8	2.7	2.5
10	Commercial Control (field only)	2.3	3.0	2.6	2.3	2.1
11	Commercial Control (nursery, field)	2.4	2.9	2.4	2.1	2.4

All ratings for the whole plot assessed prior to harvest.

3 = Excellent
2 = Good
1 = Poor

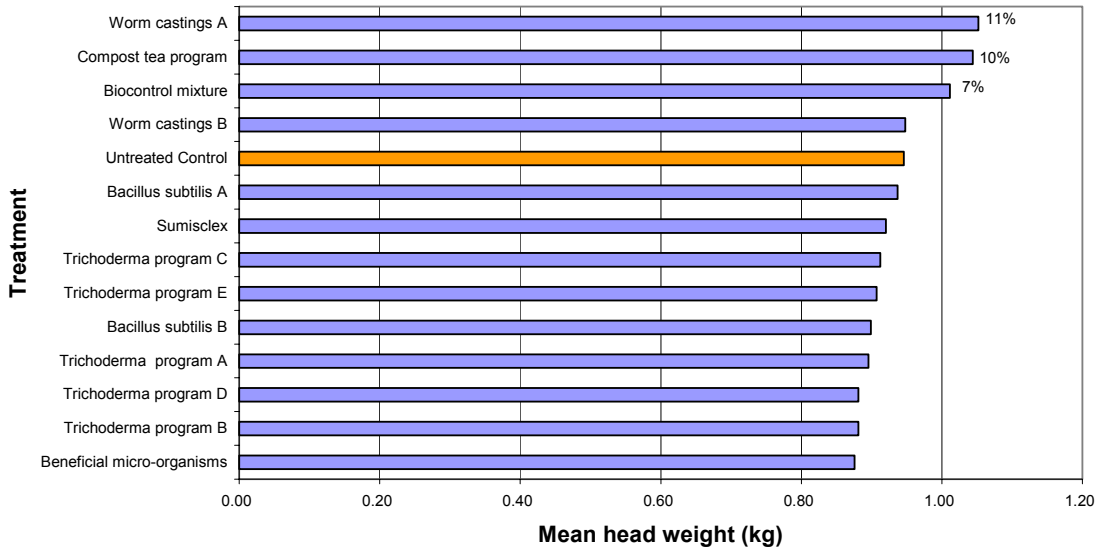
Lettuce Field Trials (Cont.)

Graph 1 - Lettuce Head Size At Harvest (2002/03)



At p<0.05, there were no statistically significant differences between treatments according to analysis of variance test.

Graph 2 - Lettuce Head Weight At Harvest (2002/03)



Lettuce Field Trials (Cont.)

Table 6 - Mean Yield Assessment at Harvest (2002/03)

NO.	TREATMENT (Rate/ha)	Mean Head Weight (kg)
1	Control	0.95 abcde
2	Beneficial micro-organisms	0.88 ab
3	*Bacillus subtilis* A	0.94 abcd
4	Compost tea program	1.04 de
5	*Trichoderma* program A	0.90 ab
6	*Trichoderma* program B	0.88 a
7	*Bacillus subtilis* B	0.90 ab
8	*Trichoderma* program C	0.91 abc
9	*Trichoderma* program D	0.88 ab
10	Worm castings A	1.05 e
11	Worm castings B	0.95 bcde
12	*Trichoderma* program E	0.91 abc
13	Biocontrol mixture	1.01 cde
14	Sumisclex	0.92 abcd
P value		0.007
LSD		0.108

Means within columns followed by the same letter are not significantly different at the 5% level according to Least Significant Difference (LSD) test.

Lettuce Field Trials (Cont.)

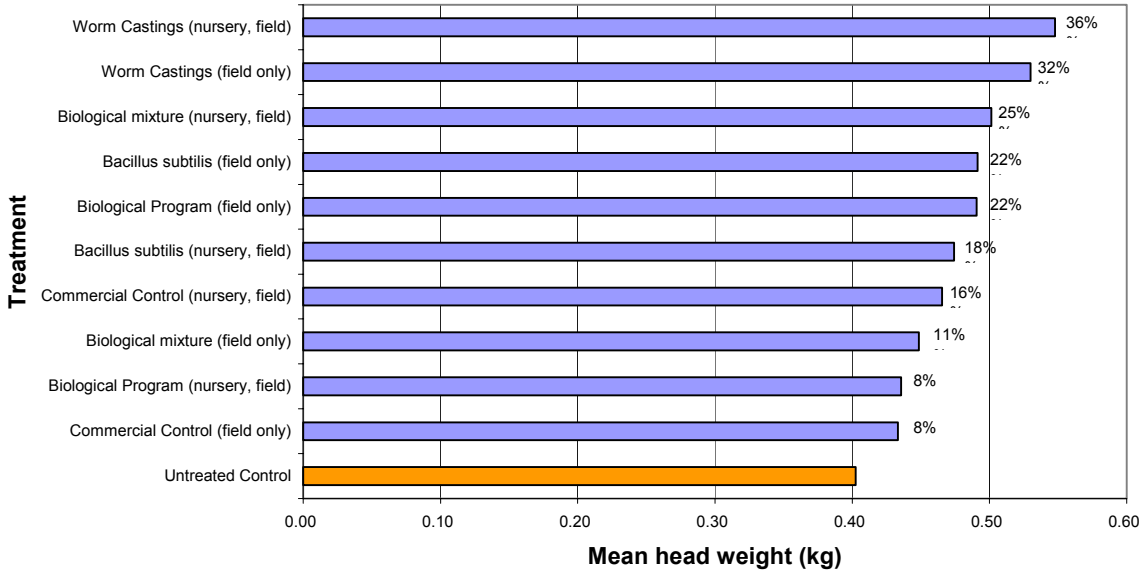
Table 7 - Mean Yield Assessment at Harvest (2003/04)

NO.	TREATMENT (Rate/ha)	Mean Head Weight (kg)
1	Untreated Control	0.40 a
2	Biological Program (field only)	0.49 bcd
3	Biological Program (nursery, field)	0.44 ab
4	Worm Castings (field only)	0.53 cd
5	Worm Castings (nursery, field)	0.55 d
6	*Bacillus subtilis* (field only)	0.49 bcd
7	*Bacillus subtilis* (nursery, field)	0.47 abcd
8	Biocontrol mixture (field only)	0.45 ab
9	Biocontrol mixture (nursery, field)	0.50 bcd
10	Commercial Control (field only)	0.43 ab
11	Commercial Control (nursery, field)	0.47 abc
P value		0.0081
LSD		0.074

Means within columns followed by the same letter are not significantly different at the 5% level according to Least Significant Difference (LSD) test.

Graph 3 - Lettuce Head Weight at Harvest (2003/04)

Percentage increases over untreated control yields are shown for each treatment.



Lettuce Field Trials (Cont.)

Discussion

Assessments at harvest showed some clear differences between plots. Visual differences in crop vigour were most obvious in the 2002/03 season. The crop looked particularly good, and season conditions were ideally suited to the variety (Magnum). In 2003/04, a different variety (Target) was planted. This was grown because the bulk of commercial sowings at the time were also Target. However, the 2003/04 growing season was relatively cool and Target is a warm climate variety. Target crops generally did not perform well. At harvest, the trial crop was average and most plants were not forming big hearts. The difference in performance of the two varieties is obvious with a comparison of average yields between seasons.

In the 2002/03 trial, visual differences in crop vigour (Table 4) were more obvious and corresponded with yield measurements (Table 6). Plots treated with the compost tea program and both types of worm castings looked good in the paddock, and this was confirmed with the increased yields from these plots (Table 6). The biocontrol mixture treatment also resulted in higher yields compared to other treatments.

There were no significant differences in head diameter of lettuce from difference plots, although lettuce treated with the compost tea program were slightly larger (Graph 1). Given the considerable effort involved in measuring head diameters, it was decided to just use a visual rating score for head size assessments in 2003/04.

Subjective ratings for firmness and shape (Table 4) indicated that lettuce from the plots treated with the compost tea program and both types of worm castings were of excellent quality in the 2002/03 season. Because of the overall high quality of the crop, quality differences in the crop were less marked than in the 2003/04 season. Similar trends in quality were seen in the second season, where the best quality lettuce were harvested from plots treated with worm castings and the biological program based on compost tea (Table 5). In the second season, it was clear that the plots treated with worm castings also matured earlier than other plots.

Dry weight root:shoot ratios for the 2003/04 season, showed that incorporation of worm castings in the transplant media improved the development of root biomass. Improved root development may have assisted crop growth because the plants that were treated with worm castings in both the nursery and in the field were the highest yielding in the trial. Average yields were 35% higher than yields from untreated control plots.

Nutrient uptake results were surprising in that nutrient levels in plots treated with worm castings were not any higher than other plots. Nitrogen levels in plants treated with worm castings were lower than in untreated control plants. This result indicates that the improved growth observed in plants treated with worm castings was not related to increased nutrition from the worm castings. Further study of nutrient uptake in other crops treated with worm castings would be beneficial to gain an understanding of how yield increases are being achieved. Are the worm castings improving the nutrient balance within the plant or are the worm castings stimulating microbial interactions in the soil that are beneficial to the plant?

Lettuce Pot Trials

Materials and Methods

Site Details

Grower	Department of Primary Industries
Locations	Department of Primary Industries Glasshouse (2002/03) and Serve-Ag Research Compound (2003/04)
Potting Mix	Premium grade with osmocote (Horticultural Supplies) mixed in ratio of 70:30 with local alluvial sandy loam sourced from garden supply centre.
Crop	Iceberg Lettuce
Variety	Magnum (2002/03) and Target (2003/04)
Trial Design	Randomised complete block
Replicates	3 (2002/03) and 4 (2003/04)
Plot Size	One rectangular basket containing 6 lettuces planted in 20 L of soil
Plant Spacing	15 cm
Row Spacing	15 cm

Inoculum culture

Sclerotinia minor (Serve-Ag Research culture) was grown on moist barley grains. 15 g of barley grains per basket were raked through the surface of the potting soil in 2002/03 trials. 2002/03 disease incidence assessments indicated that the level of inoculum was insufficient to get consistent disease pressure. A number of plots had no disease present, including the untreated control. Several plots had quite severe disease infestation but this could have been because only 15 g of inoculated barley grains were raked through the potting mix, and there may have been uneven distribution of disease.

In 2003/04, the amount of inoculum was increased to 25 g of barley grains per plot to ensure more even disease pressure.

Lettuce Pot Trials (Cont.)

Chronology of Events for 2002/03 Trial

DATE	DAYS AFTER SOWING	EVENT
02/10/02	0	Lettuce trays sown. Media-incorporation of treatments 9, 10, 11. Lettuce trays in shade house to prevent thermo-dormancy.
04/10/02	2	Lettuce trays moved to outside bay. Treatments 2, 3, 7, 8, 12, 13 applied as tray drenches with watering can (Photograph 1).
06/11/02	35	Treatments 2, 7, 8 applied with a watering can.
11/11/02	40	Trial baskets filled with 70:30 mix of potting soil to alluvial soil. Trial baskets marked with coloured tape. Each basket inoculated with 15 g of barley grains with cultured *Sclerotinia minor,* and watered in.
12/11/02	41	Treatments 4, 5, 6, 10, 11 applied to soil in baskets.
13/11/02	42	Treatments 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14 applied as drench to transplants with watering can. Transplants planted into baskets by hand.
26/11/02	55	Pirimor applied for aphid control. Rate of 500 g/ha applied with water rate of 280 L/ha using TX12 nozzles at 300 kPa.
29/11/02	58	Treatments 2, 3, 4, 5, 6, 7, 14 applied.
05/12/02	64	Vigour and disease assessment.
06/12/02	65	Treatments 2, 4, 5, 6 applied.
12/12/02	71	Treatments 2, 3, 4, 5, 6, 7, 8, 14 applied.
19/12/02	78	Treatments 2, 4, 5, 6, 7, 12, 13 applied.
20/12/02	79	Vigour assessment. Disease assessment. (Photographs 7-11). Baskets emptied and cleaned.

Chronology of Events for 2003/04 Trial

DATE	DAYS AFTER SOWING	EVENT
12/12/2003	0	Sowing. Treatment 5 incorporated into plug media. Trays moved to germination room.
15/12/2003	3	Treatments 3, 7, 9 applied as drench to trays moved to outside bays.
08/01/2004	27	Trial baskets filled with 70:30 mix of potting soil to alluvial soil. Trial baskets marked with coloured tape. Each basket inoculated with 25 g of barley grains with cultured *Sclerotinia minor,* and watered in. Treatments 4 & 5 incorporated into growing baskets by hand.
12/01/2004	31	Transplanting. Treatments 2, 3, 6, 7, 8, 9, 10, 11 applied to transplants prior to hand transplanting.
20/01/2004	8	Treatments 2 & 3 applied (270 L/ha water).
27/01/2004	15	Final assessment.

Lettuce Pot Trials (Cont.)

The following parameters were assessed:

1. PLOT VIGOUR ASSESSMENT

TIMING -	5/12/02, 20/12/02
SAMPLE SIZE -	Whole plot
METHOD -	Visual rating of crop vigour
RATING SCALE -	1 = excellent vigour 2 = good vigour 3 = poor vigour
SUMMARISED RESULTS -	Graph 4
COMPLETE DATA -	Appendix iii
PHOTOGRAPHS -	Photographs 7 -11

2. DISEASE ASSESSMENT

DATE -	5/12/02, 20/12/02, 27/01/04
SAMPLE SIZE -	Whole plot
METHOD -	The number of lettuce with signs of *Sclerotinia* disease were counted and recorded.
SUMMARISED RESULTS -	Graph 5, Table 8
COMPLETE DATA -	Appendix iii
PHOTOGRAPHS -	Photographs 7-12

3. CROP PHYTOTOXICITY ASSESSMENT

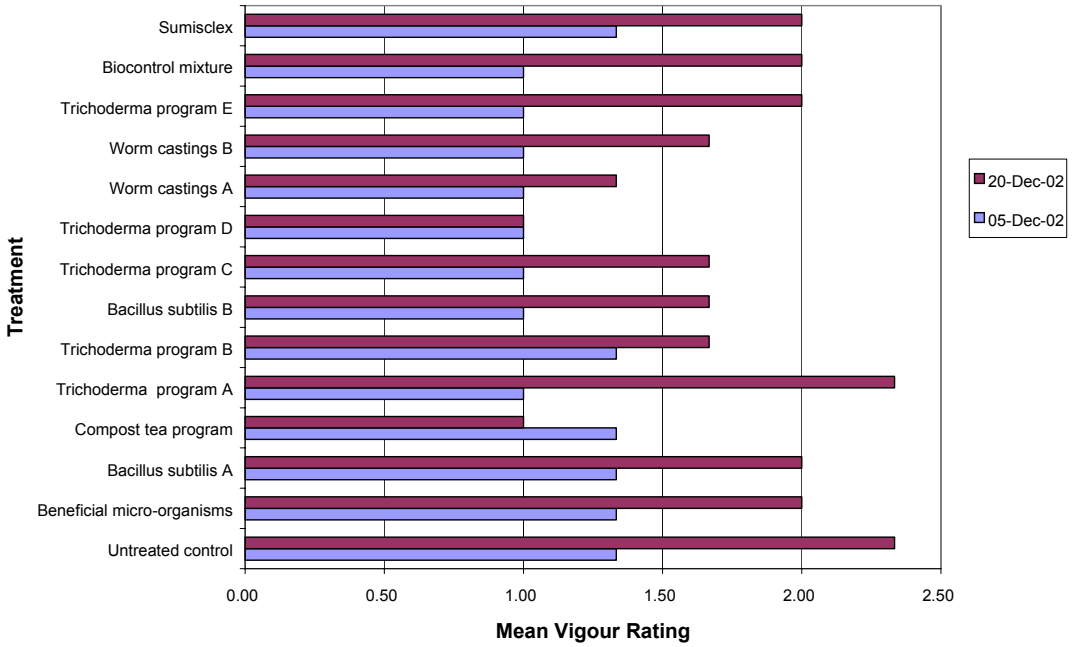
DATES -	Throughout trial
SAMPLE SIZE -	Whole plot
METHOD -	Visual observation of crop.
SUMMARISED RESULTS -	There were no signs of phytoxicity observed in any plots. All treatments were safe to the lettuce.

Photograph 7 - View of lettuce in glasshouse trial at final assessment (2002/03)

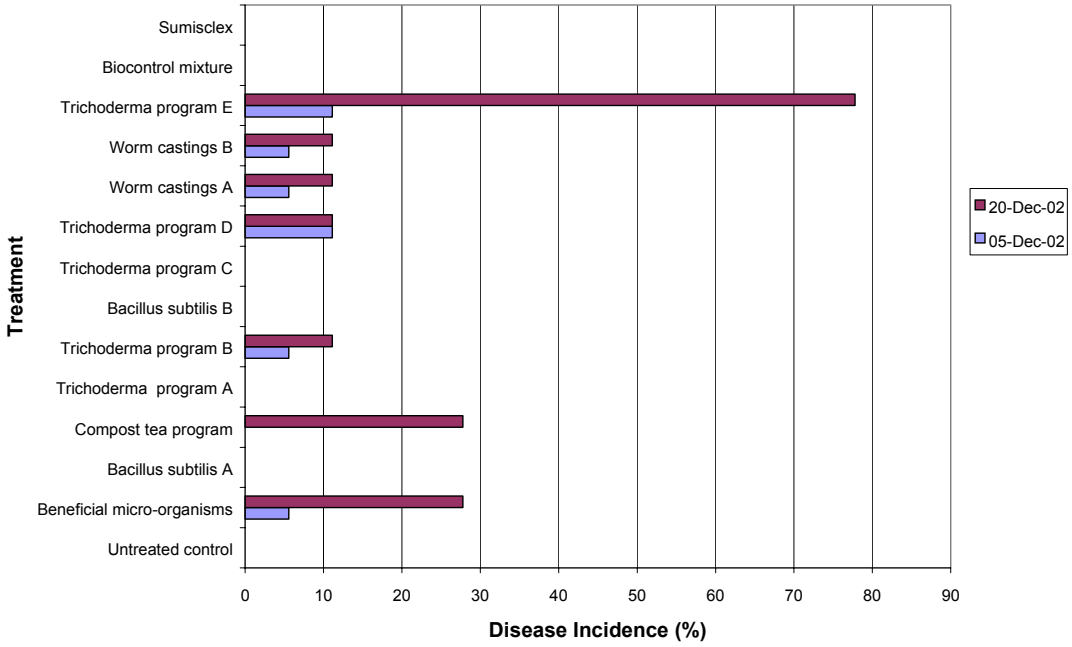
Lettuce Pot Trials (Cont.)

Results

Graph 4 - Mean Vigour Ratings (2002/03)



Graph 5 - Mean Disease Incidence (2002/03)



Lettuce Pot Trials (Cont.)

Photograph 8 - 2002/03 untreated control plots at harvest assessment (mean vigour rating = 2.33)

Photograph 9 - 2002/03 commercial control plots treated with Sumisclex at harvest assessment (mean vigour rating = 2.00)

Lettuce Pot Trials (Cont.)

Photograph 10 – 2002/03 lettuce treated with compost tea program (mean vigour rating = 1.33)

Photograph 11 – 2002/03 diseased lettuce at harvest. This treatment had the highest mean disease incidence of 78%

Lettuce Pot Trials (Cont.)

Table 8 - Mean percentage of live plants remaining at 2 weeks after transplanting (2003/04)

NO.	TREATMENT (Rate/ha)	% LIVE PLANTS REMAINING
1	Untreated Control	0
2	Biological Program (field only)	8
3	Biological Program (nursery, field)	0
4	Worm Castings (field only)	4
5	Worm Castings (nursery, field)	0
6	Bacillus Subtilis (field only)	0
7	Bacillus Subtilis (nursery, field)	0
8	Biocontrol mixture (field only)	0
9	Biocontrol mixture (nursery, field)	0
10	Commercial Control (field only)	0
11	Commercial Control (nursery, field)	100

Photograph 12 - 2003/04 pot trial at final assessment. There was 100% survival of plants treated with Sumisclex and close to 100% mortality for all biological treatments and the untreated control.

Lettuce Pot Trials (Cont.)

Discussion

2002/03 Trial
Lettuce treated with *Trichoderma* program D had excellent vigour at both assessments. Treatment with the compost tea program and worm castings A also resulted in excellent quality lettuce.

Disease incidence assessments indicated that the level of inoculum was insufficient to get consistent disease pressure. A number of plots had no disease present, including the untreated control. Several plots had quite severe disease infestation but this could have been because only 15 g of inoculated barley grains were raked through the potting mix, and there may have been uneven distribution of disease.

2003/04 Trial
There was much greater disease pressure in this pot trial. In addition to an increased number of inoculated barley grains, it was thought that the potency of the *Sclerotinia minor* strain was higher. Nearly all plants except those treated with Sumisclex were dead within 2 weeks of transplanting. There was no mortality of plants treated with Sumisclex.

This result indicates that none of the biological products could compare to Sumisclex for disease management under high disease pressure. In order to better understand disease thresholds for efficacy of different biological compounds, it would be necessary to do screening trials with a range of inoculum dosages.

This type of study was beyond the scope of this project. Whether or not it is warranted is also debatable because it is usually quite hard to quantify disease pressure within a paddock, given the spatial variability of soil-borne diseases like *Sclerotinia.*

Broccoli Field Trial

Methods and Materials

A field broccoli trial was conducted in the summer of 2003/04. The trial was conducted at Forthside Vegetable Research Station The broccoli trial followed on from screening work done in the previous season. The emphasis on trial design was to detect treatment effects so the trial had 7 replicates so that treatment differences could be better observed as real effects.

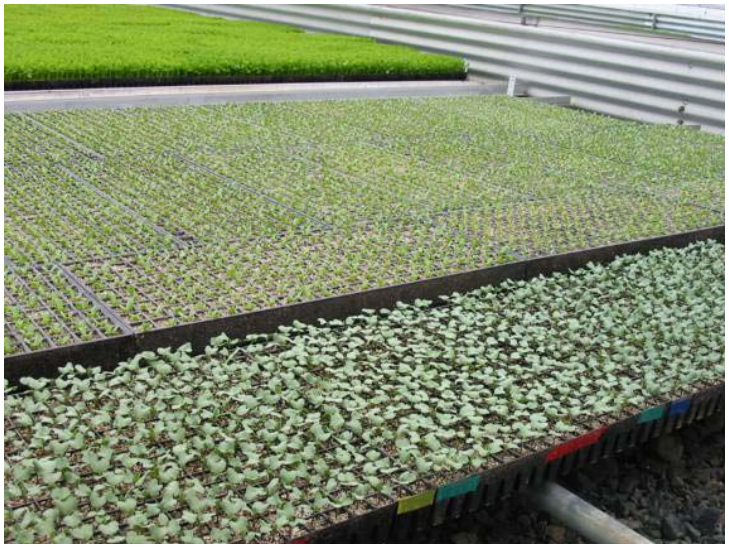
For each of the treatments listed below, one treatment regime included nursery application and one regime included nursery and field application.

Products evaluated in 2003/04 Trial

NO.	TREATMENT	PRODUCTS IN TREATMENT (MANUFACTURER)
1	Control	Untreated Control
2	Biological Program (field only)	Mend Compost Tea + Aloe Tech + Bio-N + Bio-P + Bio-Plex + Nutri-Kelp + B-sub + Fulvic 1400 + Shuttle Seven + Brix Master + Veg-Tech Triple Ten + Tonic Tech + Cloak Spray Oil (Nutri-Tech Solutions)
3	Biological Program (nursery, field)	
4	Worm Castings (field only)	Bioverm (Vermitech)
5	Worm Castings (nursery, field)	
6	*Bacillus subtilis* (field only)	Companion (Spray Gro)
7	*Bacillus subtilis* (nursery, field)	
8	Biocontrol mixture (field only)	Superzyme (Zadco)
9	Biocontrol mixture (nursery, field)	
10	Commercial Control (field only)	Sumisclex (Sumitomo)
11	Commercial Control (nursery, field)	

Trials were sown at Hills Transplants using a commercial seeding line. Trays were marked with coloured tape to indicate different treatments. After sowing, trays were placed in a germination room for 2 days and then moved to outside bays (Photograph 13).

Broccoli Field Trial (Cont.)



Photograph 13 - Broccoli seedlings growing in outside bays at Hills Transplant Nursery

Prior to transplanting, seedlings were assessed for growth development in the nursery. Visual observations of root development were made, and a photograph was taken of 10 representative seedlings from each treatment (eg. Photograph 14). No visual differences were observed between plants.

Photograph 14 - Untreated control transplant plugs prior to transplanting

Photograph 15 - Broccoli field site on day of transplanting (22/01/04)

Broccoli Field Trial (Cont.)

A sub-sample of 100 seedlings was randomly selected from the planting trays. Leaves were cut off at soil level with a razor blade. Root plugs and leaves were dried separately in a drying oven for one week to determine dry matter root:shoot ratios. The assumption was that the volume of each root plug was identical and any differences in the mass of root plugs were attributable to additional root development. Dry weight root:shoot ratios are given in Table 9. None of the treatments improved development of roots compared to the untreated control.

Seedlings were transplanted by hand to the field site (Photograph 15). No pre-planting fertiliser was applied because the aim of the trial was to grow the plants under base conditions so that additional benefits resulting from microbial interactions could be detected. A soil test (Appendix i) showed that the trial site had reasonable fertility. The trial was top dressed with Nitrophoska Blue Special at 4 and 6 weeks after transplanting. Fertiliser recommendations were made by a senior district agronomist and he viewed the trial at regular intervals.

Treatments were applied as per application schedule recommended by product manufacturers. Sprays were applied using a carbon dioxide pressurised 1.5 m boom sprayer. Three TeeJet TX12 nozzles spaced at 50 cm were used. Application volume was 250 L/ha and the pressure was 225 kPa.

Site Details for Broccoli Field Trial

Grower	Forthside Vegetable Research Station
Location	Forth, North West Tasmania
Grid Reference	55GDQ378383
Soil Type	Ferrosol
Crop	Broccoli
Variety	Marathon (grown for processing and fresh market)
Trial Design	Completely randomised design
Replicates	7
Plot Size	6 m x 1 bed (1.2 m)
Plant Spacing	37.5 cm
Row Spacing	40 cm
Transplanting date	22/01/04

Broccoli Field Trial (Cont.)

Chronology of Events

DATE	DAYS AFTER SOWING#	EVENT
12/12/03	0	Sowing. Treatment 5 incorporated into plug media. Trays moved to germination room.
15/12/03	3	Treatments 3, 7, 9 applied as drench to trays moved to outside bays.
19/01/04	38	Treatments 4 & 5 incorporated into field plots using a rake.
22/01/04	41	Transplanting. Treatments 2, 3, 6, 7, 8, 9, 10, 11 applied.
	DAYS AFTER TRANSPLANTING	
27/01/04	5	Treatment 2, 3 applied (270 L/ha water).
3/02/04	12	White blister and aphids observed in the trial. Treatments 2 & 3 applied. Pirimor 1 kg/ha and Ridomil 2.5 kg/ha applied with 270 L/ha water.
10/02/04	19	Treatments 2, 3, 6, 7 applied (270 L/ha water).
11/02/04	20	Nitrophoska Blue Special applied at 125 kg/ha. Spread by hand and watered in.
17/02/04	26	Treatments 2 & 3 applied (270 L/ha water).
19/02/04	28	Continued white blister pressure. Diamond back moth (DBM) larvae observed in trial. Ridomil 2.5 kg/ha and 2 L/ha Dipel applied with 270 L/ha water.
24/02/04	33	Treatments 2, 3, 6, 7, 8, 9 applied (270 L/ha water). Pirimor 1 kg/ha applied (270 L/ha water).
25/02/04	34	Nitrophoska Blue Special applied at 125 kg/ha. Spread by hand and watered in.
02/03/04	40	Treatments 2 & 3 applied (270 L/ha water).
04/03/04	42	Continued DBM pressure. Avatar 280 g/ha and Agral 40 mL/100L applied with 270 L/ha water. Nutrient uptake sampling and analysis.
09/03/04	47	Treatments 2*, 3*, 6, 7 applied (215 L/ha water).
16/03/04	54	Treatments 2*, 3*, 6, 7 applied (400 L/ha).
30/03/04	68	Treatments 2*, 3*, 6, 7 applied (400 L/ha).
19/04/04	88	Harvest - first cut commenced.
20/04/04	89	Harvest - first cut finished.
23/04/04	92	Harvest - second cut.

A previous trial was sown on 5/11/03. However, these plants were accidentally sprayed by nursery staff with a Kocide, Mancozeb and Bravo mix. The trial had to be abandoned and a new trial was commenced.

* 100 g additional VAM was added to the 10 L mix for Treatments 2 and 3. This was advised by Nutri-Tech Solutions in order to offset the effect of Ridomil applications for white blister control.

Broccoli Field Trial (Cont.)

The following parameters were assessed in the field:

1. NUTRIENT UPTAKE ASSESSMENT

TIMING - 6 weeks after transplanting

SAMPLE SIZE - 10 leaves per replicate plot. Replicates were bulked for treatment samples.

METHOD - The youngest fully expanded leaf was collected at 7.30 am. Samples were stored in an Eski and were processed the same day in the Serve-Ag Analytical Services Laboratory using commercial methodology.

SUMMARISED RESULTS - Table 10

2. PLOT VIGOUR ASSESSMENT

TIMING - Throughout crop growth

SAMPLE SIZE - Whole plot.

METHOD - Visual rating of crop vigour.

SUMMARISED RESULTS - In the earlier stages of crop growth, it appeared that the plots treated with worm castings were growing with larger frames. However, as the crop matured it was very difficult to distinguish any differences in vigour between treatments.

3. YIELD ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Entire plot

METHOD - Heads were weighed on field scales and weights recorded (Photographs 16 & 17)

SUMMARISED RESULTS - Graph 6, Tables 11& 12

COMPLETE DATA - Appendix iii

STATISTICAL ANALYSES - Appendix iv
Analysis of variance was used to determine significant differences at $p<0.05$. There were significant differences between treatments.

4. WHITE BLISTER ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Entire plot

METHOD - All heads were observed for presence of white blister on the florets.

SUMMARISED RESULTS - Table 13

Broccoli Field Trial (Cont.)

5. HOLLOW STEM ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Entire plot

METHOD - All heads were observed for presence of hollow stem

SUMMARISED RESULTS - Table 14

6. FLORET RECOVERY ASSESSMENT

TIMING - Harvest

SAMPLE SIZE - Twenty heads randomly selected across all replicates.

METHOD - Processing broccoli field officers advised on typical cutting pattern of floret trimmers in the processing factory. Broccoli heads were trimmed by hand to simulate operation of trimming knives in the factory. The weight of head was recorded and the weight of florets trimmed was recorded. The percentage recovery was calculated as the weight of the whole head minus the 'waste' stem portion.

SUMMARISED RESULTS - Table 15

COMPLETE DATA - Appendix iii

Broccoli Field Trial (Cont.)

Results

Table 9 - Broccoli dry weight root:shoot ratios

Treatment	Root:Shoot Ratio
Untreated Control	4.91
Biological Program	4.74
Worm castings	4.44
Bacillus subtillus	4.15
Biocontrol mixture	4.85

Table 10 - Nutrient uptake in broccoli crop 6 weeks after transplanting

No.	TREATMENT	NO3	P	K	Ca	Mg	S
1	Untreated control	3150	229	2639	848	167	589
3	Biological program	3260	236	2449	853	164	605
5	Worm castings	2620	205	2163	918	158	508
7	*Bacillus subtilis*	3380	213	2239	757	146	553
9	Biocontrol mixture	2460	196	2552	864	158	558
11	Commercial control	3410	230	2443	880	170	615

No.	TREATMENT	Zn	B	Cu	Fe	Mn	Na	Mo
1	Untreated control	2.27	0.55	0.37	2.42	0.39	242	0.033
3	Biological program	2.44	0.44	0.74	2.48	0.38	257	0.034
5	Worm castings	1.88	0.31	0.39	2.05	0.31	279	0.025
7	*Bacillus subtilis*	2.38	0.32	0.37	2.24	0.35	236	0.029
9	Biocontrol mixture	1.89	0.48	0.47	2.16	0.31	254	0.028
11	Commercial control	2.34	0.45	0.36	2.58	0.37	246	0.033

Broccoli Field Trial (Cont.)

Photograph 16 - View of trial area at harvest

Photograph 17 - Individual heads from every plant were weighed for head weight assessments

Broccoli Field Trial (Cont.)

Graph 6 - Mean head weights of broccoli harvested from trial (both cuts)

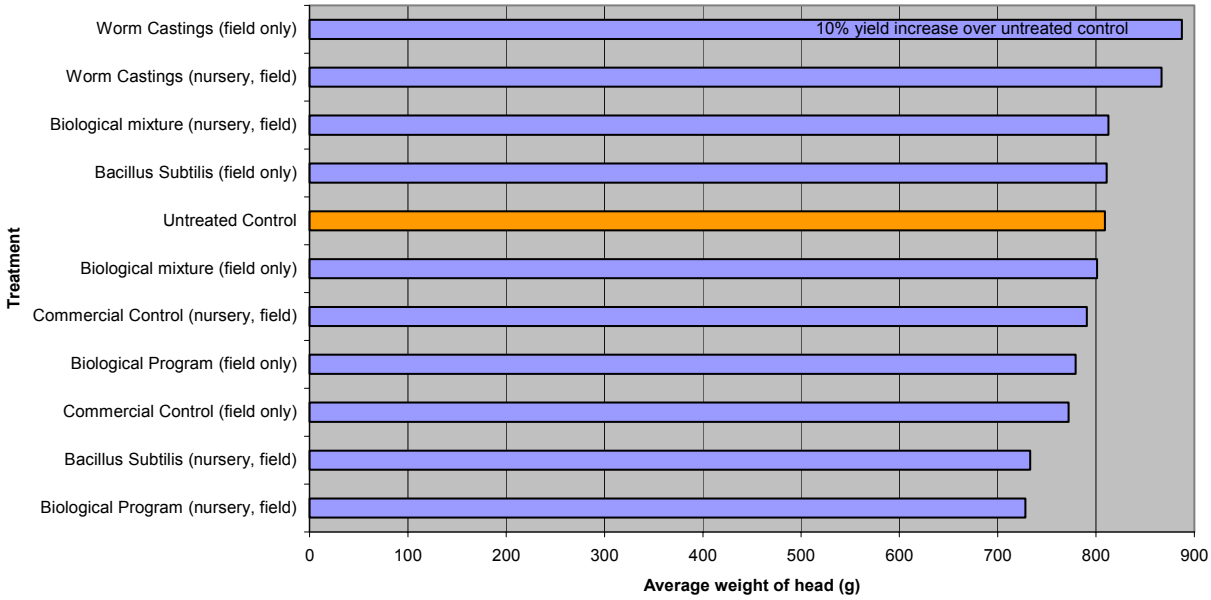


Table 11 - Mean total yield from each plot (both cuts)

No.	Treatment	Total Yield (g)	
10	Commercial Control (field only)	13467	a
9	Biological mixture (nursery, field)	13933	a
1	Untreated Control	13946	a
3	Biological Program (nursery, field)	13983	a
7	*Bacillus subtilis* (nursery, field)	14060	a
8	Biological mixture (field only)	14115	a
11	Commercial Control (nursery, field)	14240	a
2	Biological Program (field only)	14406	a
6	*Bacillus subtilis* (field only)	16374	ab
5	Worm Castings (nursery, field)	17937	b
4	Worm Castings (field only)	18007	b
P value		0.0186	
LSD		3051	

Broccoli Field Trial (Cont.)

Table 12 - Mean percentage of plot harvestable on first cut

No.	Treatment	% Harvestable
8	Biocontrol mixture (field only)	53%
2	Biological Program (field only)	54%
9	Biocontrol mixture (nursery, field)	54%
1	Untreated Control	54%
11	Commercial Control (nursery, field)	55%
10	Commercial Control (field only)	56%
7	*Bacillus subtilis* (nursery, field)	57%
3	Biological Program (nursery, field)	58%
6	*Bacillus subtilis* (field only)	63%
4	Worm Castings (field only)	63%
5	Worm Castings (nursery, field)	64%

Table 13 - Mean percentage of harvested heads with signs of white blister (both cuts)

No.	Treatment	Total % with white blister (±SE)
7	*Bacillus subtil*is (nursery, field)	22 (±9)
3	Biological Program (nursery, field)	31 (±15)
10	Commercial Control (field only)	31 (±13)
8	Biocontrol mixture (field only)	32 (±9)
11	Commercial Control (nursery, field)	32 (±15)
6	*Bacillus subtilis* (field only)	34 (±13)
1	Untreated Control	35 (±12)
9	Biocontrol mixture (nursery, field)	36 (±8)
2	Biological Program (field only)	41 (±8)
5	Worm Castings (nursery, field)	43 (±16)
4	Worm Castings (field only)	44 (±12)

Broccoli Field Trial (Cont.)

Table 14 - Mean percentage of harvested heads with hollow stem (both cuts)

No.	Treatment	Total % with hollow stem (±SE)
6	*Bacillus subtilis* (field only)	44 (±8)
7	*Bacillus subtilis* (nursery, field)	52 (±8)
10	Commercial Control (field only)	54 (±5)
2	Biological Program (field only)	54 (±8)
9	Biocontrol mixture (nursery, field)	57 (±7)
3	Biological Program (nursery, field)	59 (±3)
8	Biocontrol mixture (field only)	59 (±7)
5	Worm Castings (nursery, field)	59 (±10)
11	Commercial Control (nursery, field)	61 (±7)
1	Untreated Control	65 (±5)
4	Worm Castings (field only)	65 (±4)

Table 15 - Mean percentage floret recovery

No.	Treatment	Total % floret recovery (±SE)
6	*Bacillus subtilis* (field only)	72 (±0.61)
2	Biological Program (field only)	72 (±1.33)
7	*Bacillus subtilis* (nursery, field)	73 (±0.58)
5	Worm Castings (nursery, field)	73 (±0.91)
3	Biological Program (nursery, field)	74 (±0.94)
11	Commercial Control (nursery, field)	75 (±0.88)
4	Worm Castings (field only)	75 (±0.75)
10	Commercial Control (field only)	75 (±0.70)
1	Untreated Control	76 (±1.00)
8	Biocontrol mixture (field only)	76 (±0.82)
9	Biocontrol mixture (nursery, field)	76 (±0.71)

Broccoli Field Trial (Cont.)

Discussion

Results from all aspects of the trial are consistent. Early in crop growth, plots treated with worm castings had obviously larger frames; however, differences in vegetative vigour were obscured as the crop matured. Incorporation of worm castings improved average head size by 10% and resulted in a 10% increase in percentage of heads that were harvestable on the first cut. The total amount of harvestable crop was significantly higher from plots treated with worm castings. Despite the growth improvement, there was no increase in nutrient uptake compared to the untreated control. N levels in plants treated with worm castings were lower than in untreated control plants.

There was a 10% increase in white blister incidence on heads grown in plots treated with worm castings. This relates to degree of crop maturity at harvest. The trial was grown in an area known for high white blister pressure. Applications of Ridomil and Bravo kept the crop relatively clean during growth crop. Four days before the first cut, there were no signs of white blister development on the florets. However, over the weekend, there were strong winds and moist conditions. It was ideal conditions for an inoculum source to be blown in and develop in the crop prior to harvest. Disease development was most obvious in mature heads, and there were more mature heads in plots treated with worm castings. Other growers in the area also noted a marked increase in white blister development over the same period. When the trial was harvested, there was considerably more white blister in plants exposed to north-westerly prevailing winds. In the south-east corner of the trial area, there was very limited white blister development.

Results for hollow stem incidence do not appear to be related to treatments. Treatment differences for floret recovery were negligible.

Broccoli Pot Trial

In the summer of 2003/04, a pot trial was established to determine whether any of the treatments resulted in improved management of *Sclerotinia minor* disease in broccoli. Materials and Methods for establishment of this trial were the same as described for the 2003/04 lettuce pot trial. Four broccoli plants were grown in each planting basket.

The *Sclerotinia minor* strain used was aggressive on lettuce but proved to have no impact on broccoli plants (Photograph 18).

Treatment applications were made as per field trial regimes until one month after transplanting. At this point, the trial was abandoned because no disease was apparent, and the plants were under continued pressure from diamond back moth grubs.

Photograph 18 - Broccoli pot trial 2 weeks after transplanting.

General Discussion

No treatments caused any crop phytotoxicity at any stage of growth in lettuce or broccoli plants. No treatments resulted in any obvious quality defects. Generally, differences in subjective quality measurements were only relative, and all product harvested from the field trials was of acceptable commercial quality.

In the trials conducted as part of this project, the only product that consistently improved yields in all field trials in both seasons, in both lettuce and broccoli, was worm castings. This is not to say that other products might not perform very well under different growing conditions. Yield improvements in plots treated with worm castings were 10% or higher in both crops.

Nursery applications
In the 2003/04 trials, efforts were made to determine whether treatment benefits were increased with nursery application as well as field application. Was the use of microbial inoculants in the nursery improving root development and the crops' potential for yield improvements? Data to address this question was inconsistent. No treatment consistently promoted root growth in transplant plug. Yield and quality results showed no pattern in beneficial effects from nursery application of microbial inoculants.

The trial work in the nursery highlighted some critical considerations for the use of microbial inoculants in the nursery. In the 2003/04 season, trials were delayed by 6 weeks because the first sowing of trial plants was accidentally sprayed with a mixture of Kocide/Bravo/Mancozeb the day before the first plantings were due to commence. This spray mix would have killed any beneficial fungi and bacteria that were established in the transplant plugs. However, this spray mix was also essential for ensuring that all transplants left the nursery disease free and there was no potential for spread of disease from nursery plants.

Typically transplant nurseries are providing all transplants for a district. It is critical that the nursery has excellent disease management strategies in place to prevent spread of disease within an area. A topical example is management of white blister in brassica transplants to prevent district outbreaks. Given that there are currently no biofungicides registered with the APVMA, this means few transplant growers are prepared to take the risk to use products with unproven claims. A further issue with using biological products in transplant nurseries is compatibility with necessary synthetic chemical spray programs. The majority of beneficial microbial products are not compatible with synthetic chemicals. In many cases, no information on product compatibility is given on the labels of biological products.

Development of biologicals
Undoubtedly, there is considerable interest in the application of various microbial products in agriculture. The scope of this project only allowed for limited evaluation of a few commercially available products. There are lot of other available products that could not be included in trials.

Use of these products in conventional agriculture requires a considered approach. Growers must be prepared to evaluate how these products perform in their own production systems. This is a different approach to the use of synthetic agricultural chemicals, which are formulated to perform across a much wider range of growing conditions. The mode of action of most agricultural chemicals is to target specific biochemical pathways within target organisms. The mode of action of most biologicals is to target interactions between organisms and their growing environment. Understandably, the interactions are more complicated and variability in outcomes is greater.

Recommendations to Growers

When growers purchase conventional agricultural chemicals, they can have some confidence that the product will perform according to product claims because the product has been through a stringent registration process with the Australian Pesticides and Veterinary Medicines Authority.

The only way that growers can really have confidence in the claims made by biological product manufacturers is to evaluate the products themselves and see how they perform under the growing conditions on their own farm. There is an incredible diversity of soil microflora across cropping environments. It is to be expected that different introduced fungi and bacteria will interact differently with different soil types, crops, climates and cultivation methods. For this reason, it is hard for manufacturers of biological products to produce data demonstrating consistent performance across cropping regimes. If manufacturers are able to make claims about product efficacy over a wide range of growing conditions, then they should consider applying for product registration.

For all on-farm evaluations of biological products, it is important to have an area of the paddock for comparison. There should always be a representative part of the paddock that is treated as per normal practice for comparison with the biological regime.

If manufacturers of biological products are able to provide good information, it makes it a lot easier for growers to make informed choices. If product manufacturers cannot provide detailed information about their product, it is justified for growers to be sceptical.

A basic checklist that growers can use to assess the merits of different biological products on the market could include things such as:

1. Label

- What is in the product? Often labels state “contains micro-organisms” but strains are not named.
- What are product claims? One product is unlikely to be able to do everything for the crop.
- What is product compatibility? This important information is missing from most labels of biological products.
- Are rates and use protocols clearly stated? Often label descriptions are too general or too complicated. Is the regime time consuming? One treatment regime in this project involved mixing 5 products on a weekly basis.
- How comprehensive is the label? There is a minimum amount of information that should be on a label for occupational health and safety purposes. One product supplied for use in this project was sent in a plastic bottle without a label.

2. Packaging

- What are product claims? One product is unlikely to be able to do everything for the crop.
- Design of packaging. How is the product sealed? Will packaging withstand paddock use?

3. Storage

- Does it need to be stored in refrigeration or require refrigeration after opening?
- What is the shelf life?

4. Formulation

- Does the product dissolve readily?
- What is the consistency and colour of the product mix? Will it leave crop residues? A number of biologicals evaluated in this project did not dissolve readily or they left visible residues on the crop until the next irrigation.

Technology Transfer

Forthside Vegetable Research Station Field Day presentations – 2002 and 2003

'Worm poo works' – article in Good Fruit and Vegetables magazine (May 2003)

Agricultural Research and Advisory Committee oral presentations – 2002 and 2003

Paper (oral) at 'Organic Futures for Australia Conference', Adelaide, 2003

Some data from this project was presented at World Potato Congress, China, 2004, as part of oral presentation on 'Environmentally friendly crop protectants'

Appendices

Appendix i - 2003/04 Lettuce and Broccoli Trial Site Soil Test

TEST	RESULT
pH - water	6.8
pH - CaCl	6
Organic Carbon (C)	2.3%
Nitrate Nitrogen (NO3)	10 mg/kg
Ammonium (NH4)	3 mg/kg
Phosphorus - Colwell (P)	89 mg/kg
P Buffer Index - PBI	660
Potassium - Colwell (K)	214 mg/kg
Sulphur - KCl (S)	5.9 mg/kg
Electrical Conductivity (EC)	0.05 dS/m
EC of saturated extract	0.5 dS/m
Chloride (Cl)	15 mg/kg
Cation Exchange Capacity	14.061 meq/100
Calcium (Ca)	9.75 meq/100 (69%)
Magnesium (Mg)	3.558 meq/100 (25%)
Potassium (K)	0.549 meq/100 (4%)
Sodium (Na)	0.206 meq/100 (1%)
Calcium to Magnesium Ratio	2.74
Potassium to Magnesium Ratio	0.154
Zinc - DTPA (Zn)	0.51 mg/kg
Copper - DTPA (Cu)	1.7 mg/kg
Manganese - DTPA (Mn)	51 mg/kg
Iron - DTPA (Fe)	16 mg/kg
Boron (B)	1.1 mg/kg

Appendix ii – Trial Details

Trial Plans

Trial Plans - 2002/03

Field trial was set out using a completely randomised block design as below.
↗N

3	11	4	2	7	13	14	8	9	1	5	10	6	12	**Block 4**
10	8	3	1	5	11	6	13	2	9	12	7	4	14	**Block 3**
2	4	13	9	8	12	1	14	11	3	10	5	7	6	**Block 2**
5	9	10	12	14	7	6	4	3	2	11	13	8	1	**Block 1**

Different beds are shown in different colours. There were six 6 m plots per bed.

In the glasshouse trial, baskets were randomly arranged on 4 benches. Placement of baskets varied, depending on how they were moved for application of treatments and assessments.

Trial Plans - 2003/04

Field trials were set out using a completely randomised design as below.
↘N

1	7	2	1	6	3	7	10	11	6	11	4	8
2	1	8	4	9	2	8	1	4	5	7	1	6
3	4	5	2	8	4	10	2	9	3	6	5	10
4	8	11	9	10	6	5	8	1	4	10	7	11
5	11	7	5	11	7	3	11	3	5	8	2	9
6	9	6	10	3	1	9	10	7	2	9	3	

Pot trials were set out using a randomised complete block design as below.
→N

5	8	10	1	4	9	3	6	7	11	2	**Block 1**
6	2	3	7	11	5	10	9	8	1	4	**Block 2**
9	6	5	2	1	8	4	7	11	10	3	**Block 3**
8	3	11	4	10	7	6	2	9	5	1	**Block 4**

Appendix ii - Trial Details (Cont.)

Treatment Application Details - 2002/03

At sowing

NO.	TREATMENT	TREATMENT COMPONENT		APPLICATION SCHEDULE
		Product	Activation Required	
1	Control			None
2	Beneficial micro-organisms	Effective Micro-organisms 1 (EM1)	N	20 mL/10L drenched over sown plugs
3	*Bacillus subtilis* A	Companion	N	10.5mL/10L drenched over plugs
4	Compost tea program	None	N	None
5	*Trichoderma* program A	None	N	None
6	*Trichoderma* program B	None	N	None
7	*Bacillus subtilis* B	BC 403	N	40 g/kg seed at planting – mix with enough water to coat all seeds (actual amount used = 0.8 g)
8	*Trichoderma* program C	BC 702/703	N	100 g BC702/703 + 10 g Acadian in enough water to coat all seeds (actual amount BC 702/703= 0.2 g +)
9	*Trichoderma* program D	Trichodry 6S	N	Mix 1 kg with 0.5 cu m of growing media
10	Worm castings A	Bioverm	N	Incorporated as 5% of plug media
11	Worm castings B	Granular Bioverm	N	Incorporated as 2% of plug media
12	*Trichoderma* program E	Tri-D25	N	20 g/10L drenched over sown plugs
13	Biocontrol mixture	SuperZyme	Y Mix 3-4 hours before application.	20 g/10L drenched over sown plugs
14	Commercial control	Sumisclex	N	None

During transplant growth/soil amendment

NO.	TREATMENT	TREATMENT COMPONENT		APPLICATION SCHEDULE (to seedlings or plots)
		Product	Activation Required	
1	Control			None
2	Beneficial micro-organisms	EM 1	N	20 mL/10L drenched over seedlings
3	*Bacillus subtilis* A	Companion	N	None
4	Compost tea program	Mend Compost Tea + Aloe Tech	Y	400 mL Mend + 20mL Aloe Tech in 4 L per plot
5	*Trichoderma* program A	Nutrilife 4/20 + sugar	Y	400 mL 4/20 + 30 g sugar in 4 L per plot
6	*Trichoderma* program B	Trichoshield + B-Sub + Aloe Tech	N	10 g Trichshield + 10 mL B-sub + 20 mL Aloe Tech in 4 L per plot
7	*Bacillus subtilis* B	BC 403	N	2.5 g/ 10 L drench to seedlings
8	*Trichoderma* program C	BC 702/703	N	10 g/10 L drench to seedlings
9	*Trichoderma* program D	Trichodry 6S	N	None
10	Worm castings A	Bioverm	N	300 g/sq. m raked into plots
11	Worm castings B	Granular Bioverm	N	100 g/sq. m raked into plots
12	*Trichoderma* program E	Tri-D25	N	None
13	Biocontrol mixture	SuperZyme	Y	None
14	Commercial control	Sumisclex	N	None

At transplanting

NO.	TREATMENT	TREATMENT COMPONENT		APPLICATION SCHEDULE (to seedlings or plots)
		Product	Activation Required	
1	Control			None
2	Beneficial micro-organisms	EM 1	N	20 mL/10L drenched over seedlings
3	*Bacillus subtilis* A	Companion	N	10.5 mL/10 L drenched over plugs
4	Compost tea program	Bio-N + Bio-P + Seed Start	N	Soak seedlings in 2 mL Bio-N + 2 mL Bio-P + 5 mL Seed Start in 200 mL water
5	*Trichoderma* program A	Seed Start + Trichoshield	N	Soak seedlings in 5 mL Seed Start and 5 g Trichoshield in 200 mL water
6	*Trichoderma* program B	Nutrikelp + Mend Compost Tea	N	Soak seedlings in 1 g Nutrikelp and 10 mL Mend in 500 mL water
7	*Bacillus subtilis* B	BC 403	N	2.5 g/ 10 L drench to seedlings
8	*Trichoderma* program C	BC 702/703	N	10 g/10 L drench to seedlings
9	*Trichoderma* program D	Trichoflow 6S		100 g/100 L drench to transplants
10	Worm castings A	Bioverm	N	None
11	Worm castings B	Granular Bioverm	N	None
12	*Trichoderma* program E	Tri-D25	Y (soaked 4-6 hours before use)	20 g/10 L drenched over transplants
13	Biocontrol mixture	SuperZyme	Y (soaked 4-6 hours before use)	20 g/10 L drenched over transplants
14	Commercial control	Sumisclex	N	50 mL/10L

During crop growth

NO.	TREATMENT	TREATMENT COMPONENT		APPLICATION RATE (schedule)
		Product	Activation Required	
1	Control			None
2	Beneficial micro-organisms	EM 1	N	2 mL/ L (7 days)
3	*Bacillus subtilis* A	Companion	N	250 mL/100 L (14 days)
4	Compost tea program	Nutri-Kelp, Fulvic 1400, Aloe Tech, Tonic Tech	N	1 g Nutri-Kelp, 7 mL Fulvic 1400, 7 mL Aloe Tec, 2 mL Tonic Tech in 1L water per bed (14 days)
5	*Trichoderma* program A	Black Gold, Bio-Plex, Tonic Tech, Trichoshield, Aloe Tech, Humatech Liquid Humus.	N	7mL Black Gold, 1mL Bio-Plex, 2mL Tonic Tech in 1L water per bed (14 days) Alternate applications with 4 g Trichoshield, 5 mL Aloe Tech, 7 mL Humatech Liquid Humus in 1L water (14 days)
6	*Trichoderma* program B	Nutrikelp + Mend Compost Tea	N	5 mL Mend CFB, 1 mL Bio-Plex in 1 L water per bed (14 days). Alternate applications of 2 mL B-Sub, 5 mL Aloe Tech in 1 L water (14 days).
7	*Bacillus subtilis* B	BC 403	N	1 kg/ha as foliar spray (14 days)
8	*Trichoderma* program C	BC 702/703	N	2.5 kg/ha as banded foliar spray (monthly)
9	*Trichoderma* program D	Trichoflow 6S	N	100 g/100 L drench to transplants
10	Worm castings A	Bioverm	N	None
11	Worm castings B	Granular Bioverm	N	None
12	*Trichoderma* program E	Tri-D25	Y (soaked 4-6 hours before use)	1 kg /ha as foliar spray (6 weeks after planting)
13	Biocontrol mixture	SuperZyme	Y (soaked 4-6 hours before use)	1 kg /ha as foliar spray (6 weeks after planting)
14	Commercial control	Sumisclex		100 mL/100 L (14 days)

Treatment Application Details - 2003/04

No.	Treatment	Nursery Treatment	Nursery Treatment Details	Paddock Treatment	Paddock Treatment Details
1	Untreated control	✗		✗	
2	Biological program	✗		✓	Transplanting drench as per seeding. For foliar program see next page.
3	Biological program	✓	Plug media liquid drench after seeding – 10 L water: 30 mL Bio-N 100 g Vam-Tech 50 mL Fulvic 1400 15 g Nutri-Kelp 50 mL Aloe-Tech 40 mL Shuttle Seven	✓	
4	Worm castings	✗		✓	300 g/sq. m raked into plots = 2.16 kg per plot.
5	Worm castings	✓	Incorporation as 5% of plug media	✓	
6	*Bacillus subtilis*	✗		✓	10.5 mL /10L drenched over plugs at transplanting. 250 mL /100 L every 14 days.
7	*Bacillus subtilis*	✓	Plug media liquid drench after seeding.	✓	
8	Biocontrol mixture	✗		✓	20 g/10 L drenched over plugs at transplanting. 1 kg/ha as foliar spray 6 weeks after planting.
9	Bioncontrol mixture	✓	20 g/ 10 L drenched over sown plugs.	✓	
10	Commercial control	✗		✓	50 mL/10 L drenched over plugs at transplanting. 100 mL/100 L (14 days)
11	Commercial control	✓	Sumisclex drench applied	✓	

Foliar program for Treatments 2 and 3 – 10 L recipe

Week No.	Lettuce	Broccoli
1	15 mL of Nutri-Life Bio-Plex 25 mL of Nutri-Life B-Sub 100 mL of Aloe-Tech 60 mL of Fulvic 1400	
2	100 mL of Shuttle Seven 100 mL of Aloe-Tech 250 mL of MEND LCI 100 mL of Brixmaster 20 mL of Cloak Spray Oil (*20mL Tonic Tech added to broccoli spray)	
3	15 mL of Nutri-Life Bio-Plex 25 mL of Nutri-Life B-Sub 100 mL of Aloe-Tech 100 mL of Veg-Tech Triple Ten	
4	100 mL of Brixmaster 250 mL of MEND LCI 20 mL of Tonic-Tech 20 mL of Cloak Spray Oil	
5	100 mL of Veg-Tech Triple Ten 10 g of Nutri-Kelp 250 mL of MEND LCI 20 mL of Cloak Spray Oil	100 mL of Veg-Tech Triple Ten 15 mL Nutrilife Bio-Plex 100 mL Aloe Tech 20 mL Tonic Tech 20 mL Cloak Spray oil
6	100 mL of Veg-Tech Triple Ten 10 g of Nutri-Kelp 250 mL of MEND LCI 20 mL of Cloak Spray Oil	100 mL Brixmaster 250 mL MEND LCI 10 g Nutri-Kelp 20 mL Cloak Spray oil 20 mL Tonic Tech
7, 8, 9	Last spray applied in Week 7. Recipe same as Week 6.	100 mL of Veg-Tech Triple Ten 15 mL Nutrilife Bio-Plex 100 mL Aloe Tech 20 mL Tonic Tech 20 mL Cloak Spray oil

Appendix iii - Complete Data

2002/03 Data

Field Trial – Harvest Assessment for Vigour

No.	Treatment	Rep	Vigour Rating
1	Control	1	1
		2	1
		3	2
		4	1
		Mean	1.25
2	Beneficial micro-organisms	1	2
		2	3
		3	
		4	2
		Mean	2.33
3	Bacillus subtilis A	1	2
		2	1
		3	1
		4	2
		Mean	1.50
4	Compost tea program	1	1
		2	1
		3	1
		4	1
		Mean	1.00
5	Trichoderma program A	1	2
		2	1
		3	1
		4	1
		Mean	1.25
6	Trichoderma program B	1	1
		2	1
		3	2
		4	1
		Mean	1.25
7	Bacillus subtilis B	1	2
		2	1
		3	2
		4	2
		Mean	1.75
8	Trichoderma program C	1	1
		2	2
		3	2
		4	1
		Mean	1.50
9	Trichoderma program D	1	1
		2	2
		3	2
		4	1
		Mean	1.50
10	Worm castings A	1	1
		2	1
		3	1
		4	
		Mean	1.00
11	Worm castings B	1	1
		2	1
		3	1
		4	1
		Mean	1.00
12	Trichoderma program E	1	1
		2	1
		3	2
		4	1
		Mean	1.25
13	Biocontrol mixture	1	2
		2	
		3	2
		4	2
		Mean	2.00
14	Sumisclex	1	2
		2	1
		3	1
		4	1
		Mean	1.25

Appendix iii - Complete Data (Cont.)

Field Trial - Harvest Assessment for Head Weight

No.	Treatment	Rep	Head 1	Head 2	Head 3	Head 4	Head 5	Head 6	Head 7	Head 8	Head 9	Head 10	Mean Wt
1	Control	1	0.98	0.94	1.14	1.30	0.92	1.16	1.30	0.84	0.82	0.86	1.03
		2	1.02	0.94	1.22	0.72	0.94	0.94	0.76	0.86	0.88	0.72	0.90
		3	0.90	0.84	0.80	1.16	1.04	0.86	0.86	1.02	1.12	1.10	0.97
		4	0.90	0.78	0.92	0.76	1.18	0.72	0.86	0.72	0.96	1.08	0.89
		Mean	0.95	0.88	1.02	0.99	1.02	0.92	0.95	0.86	0.95	0.94	0.95
2	Beneficial micro-organisms	1	0.82	1.04	0.66	0.74	0.70	0.60	0.78	0.72	0.78	1.00	0.78
		2	0.78	0.90	0.92	0.92	0.82	1.06	0.70	1.12	1.04	0.90	0.92
		3	0.94	0.84	0.98	1.02	0.80	0.96	0.88	1.04	0.88	0.82	0.92
		4	1.06	0.88	0.78	0.94	0.96	1.08	0.74	0.76	0.70	0.98	0.89
		Mean	**0.90**	**0.92**	**0.84**	**0.91**	**0.82**	**0.93**	**0.78**	**0.91**	**0.85**	**0.93**	**0.88**
3	Bacillus subtilis A	1	0.84	0.82	0.88	1.02	0.96	0.88	0.82	0.92	0.88	0.92	0.89
		2	0.90	1.10	0.82	0.84	0.86	1.02	0.84	0.88	0.84	1.20	0.93
		3	0.96	0.94	0.74	1.14	1.06	0.64	0.84	1.24	1.06	0.98	0.96
		4	0.92	1.04	0.98	0.84	1.02	1.16	1.10	0.86	0.82	0.90	0.96
		Mean	**0.91**	**0.98**	**0.86**	**0.96**	**0.98**	**0.93**	**0.90**	**0.98**	**0.90**	**1.00**	**0.94**
4	Compost tea program	1	1.14	1.04	1.26	1.12	1.02	1.22	0.90	1.02	1.04	0.92	1.07
		2	1.06	1.10	1.08	1.10	1.06	0.83	0.92	0.82	1.06	1.08	1.01
		3	1.10	1.04	1.26	1.06	1.00	1.18	0.94	0.74	1.10	1.12	1.05
		4	0.78	1.02	1.10	1.12	0.94	1.26	1.10	1.14	0.86	1.12	1.04
		Mean	**1.02**	**1.05**	**1.18**	**1.10**	**1.01**	**1.12**	**0.97**	**0.93**	**1.02**	**1.06**	**1.04**
5	Trichoderma program A	1	0.88	0.58	0.66	0.98	0.72	0.64	0.64	0.84	1.06	0.72	0.77
		2	0.68	0.68	0.84	0.70	0.84	0.88	0.82	1.02	0.80	0.70	0.80
		3	0.84	1.20	1.12	1.00	0.94	0.78	1.02	0.80	1.14	1.04	0.99
		4	1.04	1.10	1.02	0.96	0.88	1.16	0.88	1.14	1.24	0.84	1.03
		Mean	**0.86**	**0.89**	**0.91**	**0.91**	**0.85**	**0.87**	**0.84**	**0.95**	**1.06**	**0.83**	**0.90**
6	Trichoderma program B	1	1.02	0.98	0.92	1.06	1.02	0.90	1.00	1.08	0.92	1.24	1.01
		2	1.04	0.92	0.92	0.78	0.78	0.68	1.16	0.66	0.60	0.66	0.82
		3	0.80	0.96	0.70	0.82	0.86	0.56	0.74	1.04	0.94	1.02	0.84
		4	0.92	0.92	0.80	0.76	0.76	0.92	0.72	1.14	0.86	0.66	0.85
		Mean	**0.95**	**0.95**	**0.84**	**0.86**	**0.86**	**0.77**	**0.91**	**0.98**	**0.83**	**0.90**	**0.88**
7	Bacillus subtilis B	1	0.76	1.02	0.82	0.76	0.86	0.76	0.98	1.02	0.80	0.88	0.87
		2	0.88	0.80	1.16	1.14	0.90	1.00	1.02	0.94	0.90	0.80	0.95
		3	0.84	0.90	0.90	0.68	0.72	0.82	0.78	0.82	0.94	0.96	0.84
		4	0.94	0.76	0.88	1.22	1.06	0.86	0.84	1.04	1.06	0.74	0.94
		Mean	**0.86**	**0.87**	**0.94**	**0.95**	**0.89**	**0.86**	**0.91**	**0.96**	**0.93**	**0.85**	**0.90**
8	Trichoderma program C	1	1.04	0.90	1.06	0.94	1.06	1.10	0.72	0.88	0.86	0.84	0.94
		2	0.88	0.72	0.96	1.12	0.96	0.76	0.96	1.06	0.94	0.72	0.91
		3	1.10	0.90	0.76	0.74	1.08	0.72	1.10	0.94	1.08	0.74	0.92
		4	0.84	0.68	0.94	1.02	0.98	0.60	0.78	1.14	1.12	0.76	0.89
		Mean	**0.97**	**0.80**	**0.93**	**0.96**	**1.02**	**0.80**	**0.89**	**1.01**	**1.00**	**0.77**	**0.91**
9	Trichoderma program D	1	0.74	0.96	0.80	1.04	0.89	0.96	0.82	0.90	0.88	0.78	0.88
		2	0.84	1.04	0.88	0.76	0.92	0.94	0.70	0.80	0.66	0.74	0.83
		3	0.84	0.76	0.68	0.90	0.86	0.82	0.98	1.06	0.74	1.02	0.87
		4	0.88	1.22	0.88	0.90	0.80	0.84	0.80	1.12	1.14	0.96	0.95
		Mean	**0.83**	**1.00**	**0.81**	**0.90**	**0.87**	**0.89**	**0.83**	**0.97**	**0.86**	**0.88**	**0.88**
10	Worm castings A	1	0.84	1.18	1.06	0.98	1.26	0.98	1.02	0.96	0.86	0.78	0.99
		2	1.06	1.12	1.02	1.18	0.90	1.26	0.98	1.28	1.20	1.10	1.11
		3	1.44	1.20	1.24	1.24	1.14	0.98	1.20	1.26	1.02	1.28	1.20
		4	0.82	0.84	0.84	1.02	1.08	0.88	0.96	0.76	0.96	0.90	0.91
		Mean	**1.04**	**1.09**	**1.04**	**1.11**	**1.10**	**1.03**	**1.04**	**1.07**	**1.01**	**1.02**	**1.05**
11	Worm castings B	1	1.00	1.10	0.76	0.92	1.02	0.84	0.96	0.80	0.86	0.82	0.91
		2	1.08	0.94	0.84	1.22	1.18	0.82	0.86	0.94	0.84	0.84	0.96
		3	0.82	0.94	0.88	0.90	1.10	1.10	0.82	0.78	1.10	0.86	0.93
		4	1.06	0.92	1.02	0.96	1.04	1.00	0.96	0.92	1.04	1.06	1.00
		Mean	**0.99**	**0.98**	**0.88**	**1.00**	**1.09**	**0.94**	**0.90**	**0.86**	**0.96**	**0.90**	**0.95**
12	Trichoderma program E	1	1.12	0.96	0.92	1.14	0.90	0.96	1.00	0.94	0.96	1.08	1.00
		2	0.68	0.96	0.74	0.86	0.88	0.76	1.00	0.78	0.92	0.80	0.84
		3	0.80	0.82	0.86	0.78	1.00	0.76	0.90	0.84	0.72	0.74	0.82
		4	0.96	0.92	1.02	0.94	0.92	0.92	0.94	1.04	1.12	0.92	0.97
		Mean	**0.89**	**0.92**	**0.89**	**0.93**	**0.93**	**0.85**	**0.96**	**0.90**	**0.93**	**0.89**	**0.91**
13	Biocontrol mixture	1	1.22	1.18	0.90	0.98	1.28	1.08	1.04	1.14	1.30	1.24	1.14
		2	1.08	1.20	1.10	1.02	0.96	1.06	1.04	1.14	1.04	0.98	1.06
		3	0.94	1.08	0.96	1.10	1.00	0.78	0.96	0.78	0.80	1.14	0.95
		4	0.80	0.84	0.72	0.96	0.94	0.72	0.80	1.10	1.00	1.06	0.89
		Mean	**1.01**	**1.08**	**0.92**	**1.02**	**1.05**	**0.91**	**0.96**	**1.04**	**1.04**	**1.11**	**1.01**
14	Sumisclex	1	0.80	0.90	0.96	0.92	0.88	0.82	0.78	0.82	0.98	0.86	0.87
		2	0.84	1.00	1.16	1.02	0.92	1.08	1.08	1.10	0.98	0.70	0.99
		3	0.78	0.82	0.96	1.00	0.86	0.88	0.90	0.90	1.08	0.84	0.90
		4	0.86	0.58	1.14	0.84	0.80	1.06	1.08	1.14	0.82	0.88	0.92
		Mean	**0.82**	**0.83**	**1.06**	**0.95**	**0.87**	**0.96**	**0.96**	**0.99**	**0.97**	**0.82**	**0.92**

Appendix iii - Complete Data (Cont.)

Field Trial - Harvest Assessment for Head Size

No.	Treatment	Rep	Head 1	Head 2	Head 3	Head 4	Head 5	Head 6	Head 7	Head 8	Head 9	Head 10	Mean Size
1	Control	1	58	59	59	62	54	54	65	55	52	56	57.40
		2	59	62	69	62	61	63	62	60	61	59	61.80
		3	57	60	47	62	58	53	56	62	63	63	58.10
		4	57	54	57	53	58	57	57	52	62	50	55.70
		Mean	57.75	58.75	58.00	59.75	57.75	56.75	60.00	57.25	59.50	57.00	58.25
2	Beneficial micro-organisms	1	52	58	49	54	52	44	54	48	53	59	52.30
		2	61	58	61	63	54	66	55	64	66	63	54.80
		3	58	55	56	50	52	58	52	57	53	57	61.10
		61	57	56	56	56	58	57	53	56	54	52	55.50
		Mean	57.00	56.75	55.50	55.75	54.00	56.25	53.50	56.25	56.50	57.75	55.93
3	Bacillus subtilis A	1	58	59	56	59	57	51	60	55	56	55	56.60
		2	56	60	62	56	54	59	50	58	54	65	57.40
		3	64	62	62	54	49	60	60	50	58	63	58.20
		4	48	52	55	62	62	56	56	50	54	58	55.30
		Mean	56.50	58.25	58.75	57.75	55.50	56.50	56.50	53.25	55.50	60.25	56.88
4	Compost tea program	1	63	64	60	64	58	57	56	59	61	55	59.70
		2	66	66	66	55	59	62	63	65	64	63	62.90
		3	60	55	67	58	55	58	57	50	59	58	57.70
		4	54	58	62	62	56	60	59	61	58	64	59.40
		Mean	60.75	60.75	63.75	59.75	57.00	59.25	58.75	58.75	60.50	60.00	59.93
5	Trichoderma program A	1	56	53	60	64	51	53	53	57	61	53	56.10
		2	49	49	53	53	56	57	53	57	52	53	53.20
		3	55	69	64	61	55	57	58	50	61	66	59.60
		4	62	61	60	53	54	63	57	64	70	58	60.20
		Mean	55.50	58.00	59.25	57.75	54.00	57.50	55.25	57.00	61.00	57.50	57.28
6	Trichoderma program B	1	61	58	55	54	57	55	56	57	57	62	57.20
		2	59	56	57	52	54	51	62	48	50	54	54.30
		3	57	58	52	52	56	51	55	61	61	59	56.20
		4	58	61	56	55	50	60	57	62	58	51	56.80
		Mean	58.75	58.25	55.00	53.25	54.25	54.25	57.50	57.00	56.50	56.50	56.13
7	Bacillus subtilis B	1	53	53	53	50	54	49	59	58	52	54	53.50
		2	53	53	61	65	53	57	58	58	58	47	56.30
		3	58	54	51	48	53	55	51	56	56	55	53.70
		4	59	51	60	59	56	53	53	62	60	52	56.50
		Mean	55.75	52.75	56.25	55.50	54.00	53.50	55.25	58.50	56.50	52.00	55.00
8	Trichoderma program C	1	63	56	58	55	60	60	52	50	54	52	56.00
		2	56	47	61	59	59	50	55	59	54	50	55.00
		3	67	55	53	49	57	52	54	57	63	50	55.70
		4	59	51	60	61	63	50	54	64	60	52	57.40
		Mean	61.25	52.25	58.00	56.00	59.75	53.00	53.75	57.50	57.75	51.00	56.03
9	Trichoderma program D	1	57	62	61	64	60	53	57	58	52	54	57.80
		2	61	57	57	53	57	55	53	55	53	52	55.30
		3	51	57	50	59	56	52	52	55	51	56	53.90
		4	58	66	54	61	50	56	55	66	59	54	57.90
		Mean	56.75	60.50	55.50	59.25	55.75	54.00	54.25	58.50	53.75	54.00	56.23
10	Worm castings A	1	56	61	62	57	64	57	58	54	54	53	57.60
		2	54	58	56	61	52	62	57	62	61	58	58.10
		3	55	56	55	55	58	55	61	46	50	56	54.70
		4	64	56	63	64	59	53	67	62	67	69	62.40
		Mean	57.25	57.75	59.00	59.25	58.25	56.75	60.75	56.00	58.00	59.00	58.20
11	Worm castings B	1	59	58	51	56	56	51	53	56	55	49	54.40
		2	60	59	53	63	58	52	56	53	52	49	55.50
		3	61	59	58	60	64	60	52	98	67	55	63.40
		4	64	64	56	62	67	57	54	56	53	59	59.20
		Mean	61.00	60.00	54.50	60.25	61.25	55.00	53.75	65.75	56.75	53.00	58.13
12	Trichoderma program E	1	60	55	50	60	52	53	57	54	56	55	55.20
		2	56	57	58	58	58	51	60	52	60	56	56.60
		3	55	51	58	55	57	51	52	55	51	52	53.70
		4	61	62	60	58	55	53	56	58	65	56	58.40
		Mean	58.00	56.25	56.50	57.75	55.50	52.00	56.25	54.75	58.00	54.75	55.98
13	Biocontrol mixture	1	56	61	55	58	61	56	58	61	61	55	58.20
		2	63	67	63	62	59	58	61	62	54	60	60.90
		3	59	53	53	55	56	48	57	50	49	55	53.50
		4	57	60	62	64	48	58	58	51	52	49	55.90
		Mean	58.75	60.25	58.25	59.75	56.00	55.00	58.50	56.00	54.00	54.75	57.13
14	Sumisclex	1	51	51	56	54	55	54	53	53	56	53	53.60
		2	53	56	59	54	53	55	54	60	62	48	55.40
		3	56	53	56	55	51	54	58	56	60	55	55.40
		4	59	50	64	58	56	67	60	64	55	56	58.90
		Mean	54.75	52.50	58.75	55.25	53.75	57.50	56.25	58.25	58.25	53.00	55.83

Appendix iii - Complete Data (Cont.)

Field Trial - Harvest Assessment for Head Firmness Rating

No.	Treatment	Rep	Head 1	Head 2	Head 3	Head 4	Head 5	Head 6	Head 7	Head 8	Head 9	Head 10	Mean Firmness
1	Control	1	1.00	1.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	2.00	1.40
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.00**	**1.00**	**1.00**	**1.25**	**1.00**	**1.00**	**1.25**	**1.25**	**1.25**	**1.25**	**1.13**
2	Beneficial micro-organisms	1	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.20
		2	2.00	2.00	2.00	1.00	1.00	2.00	2.00	2.00	1.00	2.00	1.70
		3	1.00	1.00	2.00	1.00	2.00	1.00	1.00	2.00	1.00	1.00	1.30
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.25**	**1.25**	**1.75**	**1.00**	**1.25**	**1.25**	**1.25**	**1.50**	**1.00**	**1.50**	**1.30**
3	Bacillus subtilis A	1	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.20
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	2.00	2.00	2.00	1.00	2.00	2.00	2.00	1.00	1.60
		4	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.20
		Mean	**1.25**	**1.00**	**1.25**	**1.50**	**1.50**	**1.00**	**1.25**	**1.25**	**1.50**	**1.00**	**1.25**
4	Compost tea program	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.20
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.10
		Mean	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.25**	**1.00**	**1.00**	**1.50**	**1.08**
5	Trichoderma program A	1	1.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00	1.60
		2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	1.70
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		4	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		Mean	**1.50**	**1.50**	**1.50**	**1.25**	**1.50**	**1.50**	**1.50**	**1.25**	**1.00**	**1.00**	**1.35**
6	Trichoderma program B	1	2.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.20
		2	1.00	1.00	1.00	1.00	11.00	1.00	1.00	1.00	1.00	1.00	2.00
		3	1.00	2.00	2.00	1.00	2.00	2.00	2.00	1.00	1.00	2.00	1.60
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.25**	**1.25**	**1.25**	**1.00**	**3.75**	**1.25**	**1.50**	**1.00**	**1.00**	**1.25**	**1.45**
7	Bacillus subtilis B	1	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.10
		2	1.00	1.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.20
		3	1.00	1.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	1.40
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.00**	**1.00**	**1.00**	**1.25**	**1.25**	**1.75**	**1.50**	**1.00**	**1.00**	**1.00**	**1.18**
8	Trichoderma program C	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	2.00	2.00	1.00	1.00	1.00	2.00	1.00	1.00	1.30
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.10
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.10
		Mean	**1.00**	**1.00**	**1.25**	**1.25**	**1.00**	**1.00**	**1.00**	**1.50**	**1.00**	**1.25**	**1.13**
9	Trichoderma program D	1	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.20
		2	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00
		3	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.10
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.50**	**1.25**	**1.25**	**1.25**	**1.25**	**1.25**	**1.50**	**1.25**	**1.25**	**1.50**	**1.33**
10	Worm castings A	1	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.20
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.10
		4	2.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.30
		Mean	**1.25**	**1.00**	**1.50**	**1.50**	**1.00**	**1.00**	**1.00**	**1.00**	**1.25**	**1.00**	**1.15**
11	Worm castings B	1	1.00	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.20
		2	1.00	2.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.20
		3	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.00**	**1.25**	**1.25**	**1.25**	**1.00**	**1.25**	**1.25**	**1.00**	**1.00**	**1.00**	**1.13**
12	Trichoderma program E	1	2.00	2.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.40
		2	2.00	1.00	2.00	2.00	1.00	2.00	2.00	2.00	1.00	1.00	1.60
		3	1.00	1.00	1.00	2.00	1.00	2.00	1.00	2.00	2.00	1.00	1.40
		4	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.10
		Mean	**1.50**	**1.25**	**1.25**	**1.75**	**1.00**	**2.00**	**1.25**	**1.50**	**1.25**	**1.00**	**1.38**
13	Biocontrol mixture	1	2.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.20
		2	1.00	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	1.00	1.20
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		4	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.30
		Mean	**1.50**	**1.25**	**1.00**	**1.25**	**1.25**	**1.00**	**1.00**	**1.25**	**1.00**	**1.25**	**1.18**
14	Sumisclex	1	1.00	2.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	1.00	1.30
		2	2.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.30
		3	1.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	1.00	1.00	1.40
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.25**	**1.75**	**1.25**	**1.50**	**1.00**	**1.25**	**1.00**	**1.25**	**1.25**	**1.00**	**1.25**

Appendix iii - Complete Data (Cont.)

Field Trial - Harvest Assessment for Head Shape Rating

No.	Product	Rep	Head 1	Head 2	Head 3	Head 4	Head 5	Head 6	Head 7	Head 8	Head 9	Head 10	Mean Shape
1	Control	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	2.00	1.60
		4	1.00	1.00	2.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.40
		Mean	**1.00**	**1.25**	**1.50**	**1.25**	**1.25**	**1.00**	**1.00**	**1.25**	**1.50**	**1.50**	**1.25**
2	Beneficial micro-organisms	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00		1.00	1.00	2.00	2.00	1.00	2.00	1.00	2.00	1.44
		4	2.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.00	1.00	1.30
		Mean	**1.25**	**1.00**	**1.00**	**1.00**	**1.50**	**1.50**	**1.00**	**1.25**	**1.00**	**1.25**	**1.19**
3	Bacillus subtilis A	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
4	Compost tea program	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.00	2.00	2.00	1.90
		4	1.00	1.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.00	1.60
		Mean	**1.25**	**1.25**	**1.50**	**1.25**	**1.50**	**1.50**	**1.50**	**1.25**	**1.50**	**1.25**	**1.38**
5	Trichoderma program A	1	1.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	1.00	1.00	1.60
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	2.00	2.00	2.00	2.00	1.00	2.00	1.00	2.00	2.00	1.70
		4	1.00	1.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.00	1.60
		Mean	**1.00**	**1.50**	**1.75**	**1.25**	**1.75**	**1.50**	**1.75**	**1.50**	**1.50**	**1.25**	**1.48**
6	Trichoderma program B	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.10
		3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		4	2.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00	1.00	2.00	1.60
		Mean	**1.25**	**1.25**	**1.00**	**1.25**	**1.00**	**1.25**	**1.25**	**1.25**	**1.00**	**1.25**	**1.18**
7	Bacillus subtilis B	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	2.00	1.00	1.00	1.10
		3	2.00	1.00	1.00	1.00	1.00	2.00	2.00	2.00	1.00	1.00	1.40
		4	1.00	1.00	2.00	1.00	2.00	1.00	1.00	2.00	2.00	2.00	1.50
		Mean	**1.25**	**1.00**	**1.25**	**1.00**	**1.25**	**1.25**	**1.25**	**1.75**	**1.25**	**1.25**	**1.25**
8	Trichoderma program C	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	2.00	1.80
		3	2.00	2.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	1.00	1.80
		4	1.00	1.00	1.00	2.00	2.00	1.00	1.00	2.00	2.00	1.00	1.40
		Mean	**1.25**	**1.25**	**1.50**	**1.75**	**1.50**	**1.50**	**1.50**	**1.75**	**1.75**	**1.25**	**1.50**
9	Trichoderma program D	1	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	2.00	2.00	2.00	1.00	2.00	2.00	1.00	2.00	1.60
		4	2.00	2.00	1.00	2.00	2.00	2.00	1.00	2.00	2.00	1.00	1.70
		Mean	**1.50**	**1.25**	**1.25**	**1.50**	**1.50**	**1.25**	**1.25**	**1.50**	**1.25**	**1.25**	**1.35**
10	Worm castings A	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	2.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.00	2.00	1.50
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.25**	**1.00**	**1.25**	**1.00**	**1.00**	**1.00**	**1.25**	**1.25**	**1.00**	**1.25**	**1.13**
11	Worm castings B	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		3	1.00	2.00	2.00	2.00	1.00	2.00	1.00	1.00	2.00	1.00	1.50
		4	2.00	2.00	2.00	2.00	2.00	1.00	1.00	1.00	2.00	2.00	1.70
		Mean	**1.25**	**1.50**	**1.50**	**1.75**	**1.25**	**1.25**	**1.00**	**1.00**	**1.50**	**1.25**	**1.33**
12	Trichoderma program E	1	1.00	1.00	2.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.10
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	2.00	1.00	2.00	1.00	1.00	1.00	2.00	2.00	1.00	1.00	1.40
		4	1.00	1.00	1.00	2.00	1.00	1.00	1.00	1.00	2.00	2.00	1.30
		Mean	**1.25**	**1.00**	**1.50**	**1.25**	**1.00**	**1.00**	**1.25**	**1.25**	**1.25**	**1.25**	**1.20**
13	Biocontrol mixture	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		3	1.00	1.00	1.00	2.00	1.00	1.00	2.00	1.00	1.00	2.00	1.30
		4	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		Mean	**1.00**	**1.00**	**1.00**	**1.25**	**1.00**	**1.00**	**1.25**	**1.00**	**1.00**	**1.25**	**1.08**
14	Sumisclex	1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
		2	1.00	2.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	2.00	1.80
		3	1.00	2.00	1.00	2.00	2.00	1.00	2.00	2.00	2.00	2.00	1.70
		4	2.00	1.00	2.00	1.00	2.00	2.00	1.00	2.00	2.00	2.00	1.70
		Mean	**1.25**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.50**	**1.75**	**1.75**	**1.75**	**1.55**

Appendix iii - Complete Data (Cont.)

Pot Trial – Vigour Assessments

No.	Treatment	Rep	5/12/02	20/12/02
1	Untreated control	1	2	2
		2	1	2
		3	1	3
		Mean	1.33	2.33
2	Beneficial micro-organisms	1	2	2
		2	1	2
		3	1	2
		Mean	1.33	2.00
3	Bacillus subtilis A	1	2	2
		2	1	2
		3	1	2
		Mean	1.33	2.00
4	Compost tea program	1	2	1
		2	1	1
		3	1	1
		Mean	1.33	1.00
5	Trichoderma program A	1	1	2
		2	1	2
		3	1	3
		Mean	1.00	2.33
6	Trichoderma program B	1	2	1
		2	1	2
		3	1	2
		Mean	1.33	1.67
7	Bacillus subtilis B	1	1	1
		2	1	2
		3	1	2
		Mean	1.00	1.67
8	Trichoderma program C	1	1	1
		2	1	2
		3	1	2
		Mean	1.00	1.67
9	Trichoderma program D	1	1	1
		2	1	1
		3	1	1
		Mean	1.00	1.00
10	Worm castings A	1	1	1
		2	1	1
		3	1	2
		Mean	1.00	1.33
11	Worm castings B	1	1	1
		2	1	2
		3	1	2
		Mean	1.00	1.67
12	Trichoderma program E	1	1	1
		2	1	3
		3	1	2
		Mean	1.00	2.00
13	Biocontrol mixture	1	1	3
		2	1	2
		3	1	1
		Mean	1.00	2.00
14	Sumisclex	1	2	2
		2	1	2
		3	1	2
		Mean	1.33	2.00

Appendix iii - Complete Data (Cont.)

Pot Trial - Disease Assessments

No.	Treatment	Rep	5/12/2002	20/12/2002	5/12/2002	20/12/2002
1	Untreated control	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
2	Beneficial micro-organisms	1	1	2	16.67	33.33
		2	0	2	0.00	33.33
		3	0	1	0.00	16.67
		Mean	0.33	1.67	5.56	27.78
3	Bacillus subtilis A	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
4	Compost tea program	1	0	5	0.00	83.33
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	1.67	0.00	27.78
5	Trichoderma program A	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
6	Trichoderma program B	1	1	2	16.67	33.33
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.33	0.67	5.56	11.11
7	Bacillus subtilis B	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
8	Trichoderma program C	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
9	Trichoderma program D	1	2	2	33.33	33.33
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.67	0.67	11.11	11.11
10	Worm castings A	1	1	2	16.67	33.33
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.33	0.67	5.56	11.11
11	Worm castings B	1	1	0	16.67	0.00
		2	0	2	0.00	33.33
		3	0	0	0.00	0.00
		Mean	0.33	0.67	5.56	11.11
12	Trichoderma program E	1	1	5	16.67	83.33
		2	1	4	16.67	66.67
		3	0	5	0.00	83.33
		Mean	0.67	4.67	11.11	77.78
13	Biocontrol mixture	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00
14	Sumisclex	1	0	0	0.00	0.00
		2	0	0	0.00	0.00
		3	0	0	0.00	0.00
		Mean	0.00	0.00	0.00	0.00

Appendix iii - Complete data (Cont.)

2003/04 Data

Lettuce Field trial – Yield Assessment

No.	Treatment	Rep	Head 1	Head 2	Head 3	Head 4	Head 5	Head 6	Head 7	Head 8	Head 9	Head 10	Mean Wt
1	Untreated Control	1	0.72	0.48	0.60	0.48	0.46	0.60	0.52	0.60	0.48	0.42	0.54
		2	0.52	0.54	0.48	0.40	0.56	0.44	0.56	0.62	0.64	0.62	0.54
		3	0.40	0.44	0.72	0.50	0.38	0.40	0.36	0.40	0.48	0.44	0.45
		4	0.26	0.36	0.44	0.40	0.38	0.66	0.28	0.50	0.40	0.52	0.42
		5	0.16	0.22	0.24	0.24	0.16	0.40	0.18	0.30	0.20	0.38	0.25
		6	0.40	0.34	0.38	0.36	0.24	0.42	0.32	0.46	0.30	0.26	0.35
		7	0.28	0.26	0.22	0.36	0.28	0.24	0.24	0.26	0.36	0.26	0.28
		Mean	0.39	0.38	0.44	0.39	0.35	0.45	0.35	0.45	0.41	0.41	0.40
2	Biological Program (field only)	1	0.34	0.48	0.38	0.26	0.47	0.50	0.36	0.54	0.52	0.40	0.43
		2	0.66	0.54	0.72	0.60	0.64	0.56	0.54	0.46	0.54	0.52	0.58
		3	0.66	0.54	0.58	0.70	0.50	0.50	0.48	0.46	0.54	0.32	0.53
		4	0.46	0.66	0.58	0.56	0.58	0.62	0.50	0.48	0.54	0.62	0.56
		5	0.38	0.46	0.42	0.42	0.54	0.38	0.50	0.46	0.44	0.40	0.44
		6	0.34	0.30	0.48	0.38	0.36	0.42	0.64	0.46	0.36	0.52	0.43
		7	0.42	0.50	0.72	0.52	0.44	0.48	0.38	0.46	0.46	0.40	0.48
		Mean	0.47	0.50	0.55	0.49	0.50	0.49	0.49	0.47	0.49	0.45	0.49
3	Biological Program (nursery, field)	1	0.36	0.45	0.42	0.38	0.70	0.28	0.44	0.46	0.54	0.40	0.44
		2	0.54	0.42	0.52	0.58	0.52	0.52	0.60	0.42	0.62	0.54	0.53
		3	0.42	0.30	0.38	0.40	0.42	0.44	0.36	0.54	0.50	0.62	0.44
		4	0.46	0.30	0.32	0.44	0.46	0.42	0.48	0.52	0.34	0.40	0.41
		5	0.46	0.42	0.38	0.48	0.40	0.42	0.40	0.44	0.50	0.46	0.44
		6	0.48	0.46	0.50	0.30	0.42	0.52	0.48	0.32	0.46	0.30	0.42
		7	0.40	0.26	0.30	0.50	0.38	0.34	0.38	0.26	0.48	0.36	0.37
		Mean	0.45	0.37	0.40	0.44	0.47	0.42	0.45	0.42	0.49	0.44	0.44
4	Worm Castings (field only)	1	0.34	0.40	0.50	0.40	0.72	0.46	0.38	0.56	0.72	0.42	0.49
		2	0.88	0.68	0.70	0.46	0.68	0.68	0.98	0.78	0.70	0.67	0.72
		3	0.66	0.68	0.60	0.58	0.48	0.56	0.46	0.54	0.60	0.60	0.58
		4	0.46	0.48	0.50	0.38	0.50	0.32	0.46	0.36	0.36	0.36	0.42
		5	0.24	0.34	0.54	0.56	0.28	0.46	0.50	0.56	0.44	0.48	0.44
		6	0.54	0.54	0.40	0.38	0.46	0.30	0.28	0.70	0.42	0.58	0.46
		7	0.74	0.84	0.54	0.64	0.60	0.52	0.58	0.48	0.54	0.56	0.60
		Mean	0.55	0.57	0.54	0.49	0.53	0.47	0.52	0.57	0.54	0.52	0.53
5	Worm Castings (nursery, field)	1	0.44	0.61	0.56	0.75	0.66	0.48	0.48	0.48	0.74	0.42	0.56
		2	0.52	0.60	0.78	0.64	0.66	0.64	0.80	0.46	0.52	0.50	0.61
		3	0.62	0.52	0.66	0.60	0.98	0.66	0.54	0.66	0.66	0.72	0.66
		4	0.58	0.32	0.44	0.42	0.56	0.62	0.40	0.46	0.48	0.32	0.46
		5	0.26	0.48	0.50	0.28	0.52	0.36	0.44	0.42	0.52	0.64	0.44
		6	0.62	0.50	0.58	0.50	0.58	0.74	0.48	0.44	0.66	0.52	0.56
		7	0.66	0.44	0.50	0.48	0.52	0.40	0.68	0.56	0.54	0.56	0.53
		Mean	0.53	0.50	0.57	0.52	0.64	0.56	0.55	0.50	0.59	0.53	0.55
6	Bacillus subtilis (field only)	1	0.70	0.64	0.58	0.58	0.50	0.64	0.34	0.68	0.48	0.40	0.55
		2	0.54	0.64	0.54	0.58	0.50	0.52	0.50	0.62	0.60	0.66	0.57
		3	0.34	0.34	0.34	0.36	0.48	0.22	0.54	0.40	0.32	0.38	0.37
		4	0.54	0.50	0.36	0.34	0.50	0.44	0.30	0.36	0.44	0.28	0.41
		5	0.26	0.48	0.50	0.28	0.52	0.36	0.44	0.42	0.52	0.64	0.44
		6	0.62	0.50	0.58	0.50	0.58	0.74	0.48	0.44	0.66	0.52	0.56
		7	0.66	0.44	0.50	0.48	0.52	0.40	0.68	0.56	0.54	0.56	0.53
		Mean	0.52	0.51	0.49	0.45	0.51	0.47	0.47	0.50	0.51	0.49	0.49

Appendix iii - Complete data (Cont.)

7	Bacillus subtilis (nursery, field)	1	0.48	0.48	0.50	0.46	0.46	0.56	0.42	0.38	0.42	0.60	0.48
		2	0.45	0.40	0.38	0.68	0.54	0.48	0.36	0.62	0.60	0.50	0.50
		3	0.52	0.48	0.48	0.58	0.58	0.56	0.54	0.48	0.68	0.46	0.54
		4	0.50	0.46	0.34	0.56	0.54	0.40	0.42	0.46	0.36	0.40	0.44
		5	0.48	0.42	0.42	0.34	0.50	0.48	0.40	0.28	0.56	0.40	0.43
		6	0.42	0.46	0.40	0.46	0.50	0.34	0.52	0.44	0.50	0.46	0.45
		7	0.58	0.52	0.38	0.68	0.46	0.46	0.42	0.46	0.42	0.46	0.48
		Mean	0.49	0.46	0.41	0.54	0.51	0.47	0.44	0.45	0.51	0.47	0.47
8	Biological mixture (field only)	1	0.52	0.44	0.36	0.62	0.52	0.48	0.58	0.52	0.84	0.46	0.53
		2	0.64	0.50	0.52	0.52	0.50	0.52	0.32	0.38	0.48	0.66	0.50
		3	0.56	0.68	0.60	0.60	0.54	0.44	0.46	0.58	0.46	0.44	0.54
		4	0.34	0.32	0.30	0.38	0.38	0.34	0.26	0.46	0.38	0.22	0.34
		5	0.52	0.32	0.42	0.44	0.38	0.38	0.34	0.46	0.52	0.38	0.42
		6	0.28	0.42	0.50	0.54	0.26	0.44	0.28	0.26	0.38	0.50	0.39
		7	0.46	0.36	0.30	0.36	0.46	0.40	0.46	0.44	0.58	0.44	0.43
		Mean	0.47	0.43	0.43	0.49	0.43	0.43	0.39	0.44	0.52	0.44	0.45
9	Biological mixture (nursery, field)	1	0.66	0.54	0.62	0.58	0.48	0.50	0.40	0.48	0.72	0.64	0.56
		2	0.72	0.68	0.56	0.88	0.46	0.70	0.56	0.62	0.60	0.50	0.63
		3	0.58	0.56	0.64	0.40	0.48	0.68	0.58	0.42	0.44	0.58	0.54
		4	0.48	0.36	0.40	0.52	0.42	0.58	0.56	0.62	0.48	0.52	0.49
		5	0.44	0.46	0.48	0.40	0.36	0.54	0.32	0.36	0.42	0.38	0.42
		6	0.36	0.50	0.48	0.40	0.40	0.38	0.32	0.44	0.38	0.40	0.41
		7	0.42	0.48	0.54	0.52	0.56	0.54	0.48	0.46	0.30	0.38	0.47
		Mean	0.52	0.51	0.53	0.53	0.45	0.56	0.46	0.49	0.48	0.49	0.50
10	Commercial Control (field only)	1	0.68	0.56	0.54	0.62	0.84	0.72	0.54	0.52	0.44	0.74	0.62
		2	0.42	0.40	0.48	0.46	0.48	0.38	0.32	0.48	0.46	0.38	0.43
		3	0.40	0.42	0.46	0.30	0.36	0.28	0.46	0.40	0.36	0.36	0.38
		4	0.52	0.44	0.48	0.44	0.52	0.42	0.54	0.40	0.28	0.40	0.44
		5	0.26	0.52	0.30	0.22	0.36	0.34	0.40	0.32	0.22	0.32	0.33
		6	0.36	0.38	0.44	0.34	0.48	0.44	0.42	0.36	0.44	0.38	0.40
		7	0.40	0.48	0.46	0.46	0.58	0.46	0.30	0.40	0.42	0.38	0.43
		Mean	0.43	0.46	0.45	0.41	0.52	0.43	0.43	0.41	0.37	0.42	0.43
11	Commercial Control (nursery, field)	1	0.56	0.58	0.78	0.64	0.74	0.84	0.66	0.72	0.62	0.48	0.66
		2	0.66	0.42	0.78	0.50	0.42	0.40	0.62	0.44	0.38	0.40	0.50
		3	0.60	0.72	0.52	0.58	0.72	0.62	0.62	0.58	0.66	0.64	0.63
		4	0.28	0.38	0.42	0.36	0.36	0.36	0.44	0.38	0.44	0.44	0.39
		5	0.36	0.34	0.50	0.38	0.52	0.44	0.36	0.36	0.32	0.34	0.39
		6	0.30	0.20	0.22	0.22	0.32	0.28	0.24	0.26	0.32	0.36	0.27
		7	0.40	0.44	0.44	0.36	0.40	0.46	0.42	0.48	0.42	0.36	0.42
		Mean	0.45	0.44	0.52	0.43	0.50	0.49	0.48	0.46	0.45	0.43	0.47

Appendix iii - Complete data (Cont.)

Field Trial - Plot ratings for crop quality

No.	Product	Rep	Vigour	Colour	Size	Shape	Firmness	Diseased plants (Sclerotinia, leaf slime)	Stunted plants	% Marketable
1	Untreated Control	1	2	3	3	2	2	0	0	100%
		2	3	3	2	2	2	1	0	98%
		3	2	3	2	2	2	0	0	100%
		4	2	3	1.5	2	2	0	0	100%
		5	2	3	1.5	1.5	1.5	3	0	94%
		6	2.5	3	3	2.5	2.5	0	0	100%
		7	1.5	3	1.5	1.5	2	1	0	98%
		Mean	2.1	3.0	2.1	1.9	2.0	0.7	0.0	99%
2	Biological Program (field only)	1	2	3	2	2	3	0	0	100%
		2	3	3	3	2	3	1	0	98%
		3	2	3	2	2	2.5	1	0	98%
		4	3	3	3	2	3	0	0	100%
		5	2.5	3	3	2.5	1.5	1	0	98%
		6	2.5	3	2.5	2.5	2	1	0	98%
		7	2	3	2	2	2	0	1	98%
		Mean	2.4	3.0	2.5	2.1	2.4	0.6	0.1	99%
3	Biological Program (nursery, field)	1	3	3	3	3	3	1	0	98%
		2	3	3	3	2	2	1	0	98%
		3	2	3	2	2	2	3	0	94%
		4	2	3	2	2	2.5	2	0	96%
		5	3	3	2	3	3	1	0	98%
		6	3	3	3	3	3	0	0	100%
		7	3	3	3	3	3	0	0	100%
		Mean	2.7	3.0	2.6	2.6	2.6	1.1	0.0	98%
4	Worm Castings (field only)	1	2	3	3	2	1.5	1	0	98%
		2	3	3	3	2	3	0	0	100%
		3	3	3	3	2	2	0	0	100%
		4	1	3	1.5	1.5	3	1	0	98%
		5	2	3	2	2	2	2	0	96%
		6	2.5	3	2.5	2.5	3	1	0	98%
		7	2	3	2	2	2	3	0	94%
		Mean	2.2	3.0	2.4	2.0	2.4	1.1	0.0	98%
5	Worm Castings (nursery, field)	1	3	3	2	2	2	3	0	94%
		2	3	3	3	2	3	1	0	98%
		3	3	3	2	2	2	1	0	98%
		4	2	3	2	2	2	1	0	98%
		5	2	3	2	2	3	2	0	96%
		6	3	3	3	3	3	1	0	98%
		7	3	3	3	3	3	0	0	100%
		Mean	2.7	3.0	2.4	2.3	2.6	1.3	0.0	98%

Appendix iii - Complete data (Cont.)

Field Trial - Plot ratings for crop quality

6	*Bacillus subtilis* (field only)	1	3	3	3	2	2	1	0	98%
		2	2	2	2	2	2	2	0	96%
		3	3	3	2	2	1.5	1	0	98%
		4	3	3	3	3	2	1	0	98%
		5	2	3	2	2	1.5	2	0	96%
		6	3	3	2	2	2	0	0	100%
		7	2	3	2	3	2	2	0	96%
		Mean	2.6	2.9	2.3	2.3	1.9	1.3	0.0	98%
7	*Bacillus subtilis* (nursery, field)	1	2	3	2	2	1.5	0	0	100%
		2	2	2	2	2	2	1	0	98%
		3	3	3	3	3	2.5	0	0	100%
		4	3	3	2	3	2.5	0	0	100%
		5	2	3	3	2	2	1	0	98%
		6	2.5	3	2.5	3	3	2	0	96%
		7	3	3	3	3	2	0	0	100%
		Mean	2.5	2.9	2.5	2.6	2.2	0.6	0.0	99%
8	Biocontrol mixture (field only)	1	2	3	2	2	3	2	0	96%
		2	2	3	2	2	2	1	0	98%
		3	2	3	2	2	2	2	1	94%
		4	3	3	3	3	2	0	1	98%
		5	3	3	3	3	2	1	0	98%
		6	3	3	3	3	3	1	0	98%
		7	2	3	1.5	1.5	1.5	0	0	100%
		Mean	2.4	3.0	2.4	2.4	2.2	1.0	0.3	98%
9	Biocontrol mixture (nursery, field)	1	2	3	3	3	2	0	0	100%
		2	3	3	3	2	2	2	1	94%
		3	3	3	3	3	2.5	1	0	98%
		4	3	3	3	3	3	0	0	100%
		5	2.5	3	3	3	3	3	0	94%
		6	2	3	2	2	2	2	0	96%
		7	3	3	2.5	3	3	0	0	100%
		Mean	2.6	3.0	2.8	2.7	2.5	1.1	0.1	98%
10	Commercial Control (field only)	1	2	3	3	2	2	1	0	98%
		2	1.5	3	2	1.5	3	3	1	93%
		3	2	3	2	2	2	0	0	100%
		4	1.5	3	2	1.5	2	0	2	96%
		5	3	3	3	3	2	0	0	100%
		6	3	3	3	3	2	0	0	100%
		7	3	3	3	3	2	1	0	98%
		Mean	2.3	3.0	2.6	2.3	2.1	0.7	0.4	98%
11	Commercial Control (nursery, field)	1	3	3	2	2	2	1	0	98%
		2	1.5	3	2	1.5	2	0	5	91%
		3	3	3	3	3	3	2	0	96%
		4	2.5	3	2.5	2	2	0	0	100%
		5	2	3	2	1.5	3	2	0	96%
		6	2	2	2	2	2	3	0	94%
		7	3	3	3	3	2.5	0	0	100%
		Mean	2.4	2.9	2.4	2.1	2.4	1.1	0.7	97%

Appendix iii - Complete data (Cont.)

Broccoli Field trial - Yield Assessment (First cut)

No.	Rep																																				Mean 1st cut
1	1	600	660	460	520	500	420	320	380	360	380	340	720	500	540	720	480	440	520	800	400	400	440	520	380	720	480	780									510
	2	700	480	500	560	440	380	520	300	340	520	480	340	500	460	480	540	600	360	380	340	380	260	420	560	500	460	380	440									451
	3	520	440	300	520	360	420	440	380	480	420	520	460	540	320	480	360	520	380	560	340	500	480	580	600	400	400	620	320	340	420	520	760				459
	4	420	540	460	500	620	400	240	560	260	500	640	560	560	380	540	560	540	580	480	420	480	480	380	620	460	280	480	500	320	400	340					468
	5	380	280	460	320	440	520	440	380	340	480	480	320	420	380	380	280	620	400	340	520	400	420	320	300	280											396
	6	460	400	340	500	420	420	340	420	360	400	580	300	360	300	380	420	420	500	400	380	440	460	420	380	340	580	320	420									409
	7	460	560	280	300	260	340	600	520	400	420	300	360	440	540	360	580	360	320	380	300	320	280	280	340	380	380	440	420									390
	Mean	506	480	400	460	434	414	414	420	363	446	477	437	474	417	477	460	500	437	477	386	417	403	417	454	440	430	503	420	330	410	430	760					440
2	1	300	360	340	520	500	520	340	340	280	460	440	540	300	300	460	680	420	360	420	360	560	380	340	600												422
	2	420	440	300	280	320	400	580	420	460	420	360	560	480	360	500	500	380	400	420	440	420	580	520	440	500	660	520	520	520	380	660	660	440	440		462
	3	360	540	360	340	540	440	560	460	320	320	460	600	320	520	360	460	360	340	360	400	400	300	480	640	360	600	560	480	400	360	460	540	280			433
	4	500	520	460	540	420	520	460	340	480	400	380	320	320	420	440	420	280	340	560	360	540	420	280	360	420	400	300	440	340	300	520	320	220	320	280	398
	5	260	420	420	380	400	280	500	420	400	320	340	300	320	660	580	400	420	300	420	440	360	440	400	340	340	340	440	280	400	320	400					388
	6	500	420	560	480	320	420	700	460	860	520	440	600	420	360	380	460	360	340	520	440	580	520	400	540	400	380	240	500	420	300	400	560	380	340	440	456
	7	460	560	460	440	340	360	360	400	340	280	520	460	380	480	560	360	320	300	380	280	260	320	380	300	300	260	260									375
	Mean	400	466	414	426	406	420	500	406	449	389	420	483	363	443	469	469	363	340	440	389	446	423	400	460	387	440	387	444	416	332	488	520	330	367	360	419
3	1	440	500	480	440	560	560	640	600	640	520	360	380	340	460	520	460	380	280	440	420	460	260	320	520	280	480	560	340	640	700	520	460				468
	2	600	460	260	380	620	540	300	540	520	380	480	540	620	500	320	660	560	480	420	380	500	420	260	640	480	620	400	380	440	500	420	540	480	460	440	473
	3	320	280	420	360	340	400	640	520	540	340	500	680	420	500	360	340	320	420	620	480	480	600	260	460	400	520	520	660	560	300	580	360	340	460		450
	4	560	400	340	400	420	300	440	340	320	380	400	260	480	400	320	540	460	420	420	320	380	320	400	320	480	300	360	420	400							390
	5	320	280	540	480	260	320	320	280	480	480	380	300	320	360	400	360	460	520	320	480	420	400	380	480	300	540	400	340	380	440	600	280	340			393
	6	400	580	420	340	300	340	360	280	320	420	280	360	340	360	380	480	380	420	360	460	480	280	480	300	480	340	400	580	400	380						390
	7	320	440	580	420	360	360	360	320	320	320	360	700	540	360	480	520	360	300	480	340	340	460	400	300	420	640	480	360	400	300						411
	Mean	423	420	434	403	409	403	437	411	449	406	394	460	437	420	397	480	417	406	437	411	437	391	357	431	406	491	446	440	460	437	530	410	387	460	440	425
4	1	1160	1060	1080	920	1420	1160	1080	1100	960	1010	1120	820	980	840	1020	800	1040	980	1000	920	1020	1140	940	960	1000	980	1120	1240	780	1020	880	760	840	760	520	984
	2	760	520	700	820	1000	700	460	580	500	460	780	480	780	520	360	580	580	420	440	340	560	520	400	360	460	560	400									557
	3	480	480	420	380	260	680	360	400	320	320	480	440	420	420	400	520	460	600	480	400	560	520	300	240	380	460	580	420								435
	4	500	660	400	420	380	300	380	480	240	360	460	340	460	580	240	560	400	500	600	280	480	660	660	620	500	520	360	400								455
	5	660	660	440	620	480	520	320	460	480	340	380	300	660	500	220	720	500	660	560	640	460	500	260	300	280	500	600	500	400	500	320	480				476
	6	700	620	580	520	480	420	640	580	460	620	460	700	540	320	340	620	420	280	600	420	760	560	420	320	480	520	440	480	540	340	320	480				499
	7	539	486	581	758	434	497	485	704	540	546	408	553	266	447	319	637	580	252	626	476	521	467	457	462	394	561	442	579	525	345	416	379				490
	Mean	686	641	600	634	636	611	532	615	500	522	584	519	587	518	414	634	569	527	615	497	623	624	491	466	499	586	563	603	561	551	484	525	840	760	520	557
5	1	1260	980	880	860	1440	1260	1040	920	1180	820	980	920	900	900	1060	1220	1360	980	920	1000	900	1200	480	760	880	440	680	840	300	700	560					923
	2	700	560	500	520	520	560	480	780	540	380	660	440	480	500	400	860	340	540	800	460	740	440	360	360	760	480	500	400	440							534
	3	1140	780	560	480	640	740	520	460	500	580	700	320	660	900	460	360	440	480	440	740	460	320	800	660	680	480	500	440	520	460	340	440				563
	4	980	400	640	520	640	440	720	580	400	480	340	400	380	520	560	480	440	480	440	320	380	380	520	360	360	560	320	300	340	320						467
	5	480	520	440	420	360	600	540	660	520	460	500	400	620	540	440	460	400	560	320	420	380	660	540	600	340	820	760	400	520	600						509
	6	520	580	400	620	440	700	440	380	480	500	480	440	640	400	900	480	540	520	760	240	640	380	440	460	320	580	560	480	500	680	260	360	540	300	940	511
	7	580	300	500	340	400	300	300	320	440	280	360	340	360	360	280	240	380	700	300	320	360	380	320	400	380	320	280	300	380	440	460					368
	Mean	809	589	560	537	634	657	577	586	580	500	574	466	577	589	586	586	557	609	569	500	551	537	494	514	531	526	514	451	429	533	405	400	540	300	940	554
6	1	960	940	1040	980	860	1100	900	940	1020	960	1100	820	1200	1160	900	860	860	960	1120	1240	1040	1000	980	1020	1000	1080										1002
	2	660	500	520	580	740	380	480	320	400	380	520	360	720	420	500	480	420	700	480	500	500	520	420													500
	3	860	380	500	220	380	220	380	420	540	540	480	400	540	400	440	420	280	500	360	420	500	360	360	340	380	440	300	340	540	420	440	420	420	400		422
	4	420	420	280	480	460	180	500	240	200	680	360	480	520	480	300	740	680	560	320	360	240	140	440	340	520	480	180	240	500	360	220					397
	5	420	500	700	480	480	340	440	540	640	640	440	520	700	420	560	520	420	420	440	500	420	420	520	220	500	280	460	440	320	460	420	680				477
	6	460	520	500	320	260	280	360	260	420	380	400	340	460	340	420	360	280	360	340	440	280	360	500	420	420	460	340	360	320	320	460	340	300	440	240	373
	7	413	494	376	391	346	259	282	404	427	420	427	286	376																							377
	Mean	599	536	559	493	504	394	477	446	521	571	532	458	645	537	520	563	490	583	510	577	497	467	537	468	564	548	320	345	420	390	385	480	360	420	240	507
7	1	540	580	460	620	400	500	500	540	500	480	420	480	440	720	520	680	700	500	460	560	600	440	660	420	580	340	560	560	480	540	480					525
	2	560	340	440	480	500	400	420	500	360	400	400	380	420	440	320	620	440	280	420	440	340	420	420	340	320	380	380	300	340	300						403
	3	280	480	320	660	280	340	320	360	420	380	120	300	360	360	260	340	400	360	420	300	500	360	360	620	500	440	320	360	560	460	380	240	380			380
	4	400	360	280	320	320	400	380	360	320	340	520	420	340	300	360	260	300	520	320	460	400	320	580	700	360	280	640	380	640	680	420					409
	5	200	220	480	340	600	500	280	420	260	260	400	400	680	380	300	520	400	740	400	540	580	460	420	360	500	380	440	480	400	560	420	360	420	520		430
	6	340	420	360	380	420	380	300	460	360	360	380	460	720	420	520	320	420	340	440	480	380	300	400	420	360	300	280	240	460	400	300	360	320			388
	7	400	320	320	360	360	340	320	360	380	520	320	360	320	300	440	380	420	560	280	560	500	520	320	440	360	300	360	420	360	360	460					388
	Mean	389	389	380	451	411	409	360	429	371	391	366	400	469	417	389	446	440	471	391	477	471	403	451	471	426	346	426	391	463	471	410	320	373	520		418

Appendix iii - Complete data (Cont.)

Broccoli Field trial - Yield Assessment (First cut)

8	1	420	520	460	520	700	420	460	480	480	540	440	620	500	680	260	500	620	500	440	560	480	460														503
	2	440	380	540	280	420	520	440	400	560	300	520	540	420	320	680	600	420	240	360	320	460	420	240	300	360	320	420	300								411
	3	520	540	580	420	640	460	340	280	240	380	600	420	400	360	680	580	500	460	520	320	440	620	360	380	300	420	260	500	320	360	260					434
	4	600	480	400	360	460	320	420	340	440	440	240	400	360	420	360	580	340	540	440	560	280	720	380	720	320	400	280	360	340							424
	5	560	420	400	480	500	440	360	340	360	400	400	260	280	480	360	420	580	340	460	360	340	360	360	500	360	360	360	300	320	320						393
	6	460	240	500	580	440	380	580	460	560	380	420	560	400	240	480	480	360	340	400	460	640	340	420	500	340	320	500	460	360	380	440	380				431
	7	297	287	372	423	344	413	242	369	347	327	422	394	232	371	576	517	431	582	364	484	425	264	362	386	233	474	440	558	553	479	498					402
	Mean	471	410	465	438	501	422	406	381	427	395	435	456	370	410	485	525	464	429	426	438	438	455	354	464	319	382	377	413	379	385	399	380				428
9	1	660	440	500	460	640	560	460	400	480	480	460	420	520	540	500	360	420	540	500	540	460	540														495
	2	230	540	340	300	440	520	600	480	400	380	480	380	600	520	620	440	460	340	360	360	520	360	480	560	520	420	580	400	200	480						444
	3	480	440	400	440	520	340	560	380	560	220	520	280	120	160	220	460	400	360	500	380	440	560	380	440	380	320	380	420	320	420	360	140	240			380
	4	300	640	620	620	420	640	500	440	500	500	500	420	380	380	400	540	440	540	300	500	440	580	440	260	420	280	460	440	440	380						457
	5	460	520	580	440	340	440	420	440	380	480	400	420	360	500	360	340	220	400	520	360	540	260	540	460	500	400	460	480	260	300	480	320	480			420
	6	540	600	620	640	700	540	460	360	540	600	400	320	580	540	480	480	360	460	520	620	400	480	400	500	420	420	480	340								493
	7	416	400	353	436	465	431	439	401	320	304	444	362	236	237	365	407	299	373	377	391	398	329	420	474	660	363	520	340	378							391
	Mean	441	511	488	477	504	496	491	414	454	423	458	372	399	411	421	432	371	430	440	450	457	444	443	449	483	367	480	403	320	395	420	230	360			440
10	1	620	420	380	380	420	480	400	680	440	360	380	460	340	320	440	340	140	440	400	360	420	540	600	520	540	600	340	540	460	560	300	620				445
	2	500	280	600	480	460	380	460	380	400	500	440	420	460	580	240	460	380	520	400	280	380	380	400	420	440	420	380	360	480	420	480	460	600	500		434
	3	360	640	420	460	520	540	480	440	540	520	420	460	620	360	380	340	380	380	340	420	360	420	380	280	420	340										432
	4	540	700	520	400	580	480	340	300	540	440	280	520	480	320	380	420	560	360	540	560	520	420	460	560	520	380	360	340	500	540	600					466
	5	460	400	340	340	320	380	440	280	480	460	380	400	320	420	460	240	480	300	320	340	340	320	520	440	280	500	360									382
	6	300	540	500	600	460	440	640	520	460	480	540	480	220	700	480	620	420	340	360	460	460	760	280	400	460	480	360	320	360	360	360	560				460
	7	376	297	555	384	331	349	353	382	479	454	440	275	479	300	319	393																				385
	Mean	451	468	474	435	442	436	445	426	477	459	411	431	417	429	386	402	393	390	393	403	413	473	440	437	443	453	360	390	450	470	435	547	600	500		429
11	1	360	480	480	440	460	400	500	520	400	340	660	320	500	380	400	580	520	380	580	660																468
	2	500	500	480	520	440	520	440	420	660	460	500	400	500	520	700	560	480	360	500	340	580	440	300	320	640	380										479
	3	360	440	420	420	520	520	440	620	320	420	480	420	320	400	520	240	300	340	540	360	320	300	520	380	420	460	300	500	360	420	320	180	120			394
	4	460	560	340	500	300	300	480	340	440	640	380	420	400	460	340	420	320	380	620	340	380	380	480	280	560	380	340	360	400	400	320					410
	5	400	660	340	380	320	420	420	460	400	600	380	380	480	340	280	460	320	500	500	380	400	400	440	540	460	500	400	820	400							441
	6	600	480	440	540	540	500	500	360	560	480	380	460	480	580	360	360	400	660	360	380	500	520	420	400	340	400	460	360	380	300	340	420				446
	7	300	520	452	316	274	299	591	396	391	381	334	560	265	386	353	421	327	363	358	354	354	366														380
	Mean	426	520	422	445	408	423	482	445	453	474	445	423	421	438	422	434	381	426	494	402	422	401	432	384	484	424	375	510	385	373	327	300	120			431

Appendix iii - Complete data (Cont.)

Broccoli Field trial - Yield Assessment (Second cut)

No.	Rep																			Mean 2nd cut
1	1	220	320	340	120	500														300
	2	180	320	460	480	480														384
	3																			
	4																			
	5	400	220	320	260	400														320
	6																			
	7	340	300	220	560	360	240	220	340	300	340	180	280							307
	Mean	285	290	335	355	435	240	220	340	300	340	180	280							328
2	1	360	400	400	380	500	260	380												383
	2	300																		300
	3																			
	4																			
	5	640	380																	510
	6																			
	7	320	140	240	340	240														256
	Mean	405	307	320	360	370	260	380												362
3	1																			
	2																			
	3																			
	4																			
	5																			
	6																			
	7	340																		340
	Mean	340																		340
4	1																			
	2	400	460	160	540															390
	3	220	540	280																347
	4																			
	5																			
	6																			
	7																			
	Mean	310	500	220	540															368
5	1																			
	2	520	260																	390
	3																			
	4	360	340																	350
	5																			
	6	400																		400
	7																			
	Mean	427	300																	380
6	1	320	520	420	340	400														400
	2	400	500	560	460	500	480	460	460	440										473
	3																			
	4																			
	5	180																		180
	6																			
	7	440	480	500	480	660	460	500	400	220	300	180	380	160	400	360	360	260	320	417
	Mean	335	500	493	427	520	470	480	430	330	300	180	380	160	400	360	360	260	320	368
7	1	120																		120
	2	260	480																	370
	3																			
	4	380	300	280																320
	5																			
	6																			
	7	300																		300

	Mean	253	390	280	#DIV/0!															278

Appendix iii – Complete data (Cont.)

Broccoli Field trial - Yield Assessment (Second cut)

8	1	560	460	420	460	400	260	520	520	580	560									474
	2	340	480	420	500															435
	3																			
	4	360	240																	300
	5																			
	6																			
	7	360	440	300	540															410
	Mean	405	405	380	500	400	260	520	520	580	560									405
9	1	520	520	560	340	520														492
	2																			
	3																			
	4																			
	5																			
	6	200	340																	270
	7	300	360	360	280	240														308
	Mean	340	407	460	310	380	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!										357
10	1																			
	2																			
	3	360	340	440	320															365
	4																			
	5	280																		280
	6																			
	7	240	280	400	300	580	300	420	240	580	200	540	360							370
	Mean	293	310	420	310	580	300	420	240	580	200	540	360							338
11	1	460	480	500	540	480	420	500	340	600	460	520	480	340						482
	2																			
	3	520	420	420	200															390
	4	320																		320
	5	360	260	320	320															315
	6	220	240																	230
	7																			
	Mean	376	350	413	353	480	420	500	340	600	460	520	480	340						347

Appendix iii – Complete Data (Cont.)

Broccoli recovery assessments

Treatment 5				Treatment 6				Treatment 2				Treatment 7				Treatment 10				Treatment 8			
Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery
1	500	380	76%	1	348	253	73%	1	560	380	68%	1	435	303	0.6966	1	580	440	0.7586	1	327	250	0.7645
2	506	330	65%	2	480	360	75%	2	450	337	75%	2	300	220	0.7333	2	425	320	0.7529	2	440	340	0.7727
3	380	320	84%	3	404	277	69%	3	420	269	64%	3	340	260	0.7647	3	380	300	0.7895	3	320	257	0.8031
4	480	360	75%	4	340	240	71%	4	400	280	70%	4	455	341	0.7495	4	510	384	0.7529	4	300	220	0.7333
5	314	215	68%	5	480	347	72%	5	297	209	70%	5	347	254	0.732	5	600	420	0.7	5	340	240	0.7059
6	380	300	79%	6	820	640	78%	6	363	235	65%	6	300	220	0.7333	6	526	400	0.7605	6	400	326	0.815
7	520	400	77%	7	520	380	73%	7	500	380	76%	7	425	335	0.7882	7	340	280	0.8235	7	320	240	0.75
8	340	246	72%	8	320	240	75%	8	430	296	69%	8	560	400	0.7143	8	503	380	0.7555	8	498	345	0.6928
9	440	320	73%	9	500	380	76%	9	434	337	78%	9	373	260	0.6971	9	480	340	0.7083	9	420	320	0.7619
10	314	230	73%	10	563	410	73%	10	280	220	79%	10	308	223	0.724	10	512	360	0.7031	10	550	397	0.7218
11	340	240	71%	11	367	270	74%	11	262	170	65%	11	400	300	0.75	11	440	320	0.7273	11	380	300	0.7895
12	515	380	74%	12	280	200	71%	12	340	280	82%	12	354	260	0.7345	12	340	260	0.7647	12	588	436	0.7415
13	540	400	74%	13	365	273	75%	13	348	235	68%	13	420	300	0.7143	13	582	430	0.7388	13	440	300	0.6818
14	420	320	76%	14	280	200	71%	14	438	290	66%	14	445	340	0.764	14	280	200	0.7143	14	322	250	0.7764
15	430	300	70%	15	334	235	70%	15	320	240	75%	15	400	280	0.7	15	445	330	0.7416	15	400	320	0.8
16	660	500	76%	16	740	540	73%	16	500	360	72%	16	360	265	0.7361	16	340	260	0.7647	16	390	307	0.7872
17	635	455	72%	17	344	230	67%	17	255	183	72%	17	460	320	0.6957	17	300	233	0.7767	17	400	300	0.75
18	640	460	72%	18	260	180	69%	18	405	315	78%	18	342	239	0.6988	18	360	260	0.7222	18	280	220	0.7857
19	400	280	70%	19	315	219	70%	19	520	440	85%	19	360	260	0.7222	19	460	360	0.7826	19	318	240	0.7547
20	383	280	73%	20	420	300	71%	20	434	298	69%	20	280	200	0.7143	20	412	310	0.7524	20	440	340	0.7727
Average	456.85	335.8	73%	Average	424	308.7	72%	Average	397.8	287.7	0.7219	Average	383.2	279	0.7281	Average	440.75	329.35	0.7495	Average	393.65	297.4	0.758
Standard Dev			4%				3%				6%				3%				3%				4%
Standard Error			0.91%				0.61%				1.33%				0.58%				0.70%				0.82%

Appendix iii – Complete data (Cont.)

Treatment = 11				Treatment = 9				Treatment =3				Treatment =1				Treatment =4			
Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery	Head no.	Head wt	Floret wt	Recovery
1	380	300	0.7895	1	560	420	0.75	1	511	387	0.7573	1	722	517	0.7161	1	472	328	0.6949
2	560	452	0.8071	2	343	243	0.7085	2	440	340	0.7727	2	260	180	0.6923	2	460	380	0.8261
3	440	320	0.7273	3	520	400	0.7692	3	430	313	0.7279	3	500	380	0.76	3	518	406	0.7838
4	537	408	0.7598	4	445	333	0.7483	4	360	260	0.7222	4	410	312	0.761	4	540	400	0.7407
5	640	500	0.7813	5	460	360	0.7826	5	620	400	0.6452	5	372	293	0.7876	5	603	476	0.7894
6	474	350	0.7384	6	386	310	0.8031	6	465	356	0.7656	6	320	260	0.8125	6	440	320	0.7273
7	280	200	0.7143	7	400	280	0.7	7	500	360	0.72	7	500	376	0.752	7	462	350	0.7576
8	340	280	0.8235	8	360	280	0.7778	8	460	342	0.7435	8	420	320	0.7619	8	440	340	0.7727
9	386	290	0.7513	9	360	260	0.7222	9	760	600	0.7895	9	340	280	0.8235	9	460	340	0.7391
10	500	340	0.68	10	395	300	0.7595	10	630	480	0.7619	10	414	312	0.7536	10	445	345	0.7753
11	357	238	0.6667	11	380	300	0.7895	11	580	420	0.7241	11	582	474	0.8144	11	560	420	0.75
12	380	280	0.7368	12	487	370	0.7598	12	408	290	0.7108	12	380	260	0.6842	12	450	332	0.7378
13	365	280	0.7671	13	380	300	0.7895	13	400	280	0.7	13	324	240	0.7407	13	360	260	0.7222
14	500	400	0.8	14	444	347	0.7815	14	405	326	0.8049	14	400	280	0.7	14	266	192	0.7218
15	480	360	0.75	15	400	280	0.7	15	380	280	0.7368	15	536	392	0.7313	15	460	340	0.7391
16	353	273	0.7734	16	360	270	0.75	16	333	270	0.8108	16	320	260	0.8125	16	376	290	0.7713
17	460	340	0.7391	17	640	520	0.8125	17	460	340	0.7391	17	428	336	0.785	17	500	360	0.72
18	496	364	0.7339	18	390	293	0.7513	18	395	276	0.6987	18	380	260	0.6842	18	415	330	0.7952
19	380	280	0.7368	19	390	297	0.7615	19	300	220	0.7333	19	380	300	0.7895	19	280	200	0.7143
20	390	287	0.7359	20	420	320	0.7619	20	308	250	0.8117	20	380	280	0.7368	20	405	319	0.7877
Average	434.9	327.1	0.7506	Average	426	324.15	0.7589	Average	457.25	339.5	0.7438	Average	418.4	315.6	0.755	Average	445.6	336.4	0.7533
			4%				3%				4%				4%				3%
			0.88%				0.71%				0.94%				1.00%				0.75%

Appendix iv - Statistical Analysis

2002/03 Trials

ANOVA - Mean Yield

Analysis of Variance for Mean Yield - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Treatment	0.205044	13	0.0157726	2.76	0.0071
B:Replicate	0.00374234	3	0.00124745	0.22	0.8830
RESIDUAL	0.222651	39	0.00570899		
TOTAL (CORRECTED)	0.431436	55			

All F-ratios are based on the residual mean square error.

The StatAdvisor

The ANOVA table decomposes the variability of Mean Yield into contributions due to various factors. Since Type III sums of squares (the default) have been chosen, the contribution of each factor is measured having removed the effects of all other factors. The P-values test the statistical significance of each of the factors. Since one P-value is less than 0.05, this factor has a statistically significant effect on Mean Yield at the 95.0% confidence level.

Multiple Range Tests for Mean Weight by Treatment

Method: 95.0 percent LSD

Treatment	Count	LS Mean	Homogeneous Groups
6	4	0.8415	X
2	4	0.876	XX
9	4	0.88125	XX
5	4	0.8955	XX
7	4	0.899	XX
12	4	0.907	XXX
8	4	0.9125	XXX
3	4	0.937	XXXX
14	4	0.943375	XXXX
1	4	0.946	XXXXX
11	4	0.953375	XXXX
13	4	1.0115	XXX
4	4	1.04425	XX
10	4	1.052	X

Contrast	Difference	+/- Limits
1 - 2	0.07	0.108067
1 - 3	0.009	0.108067
1 - 4	-0.09825	0.108067
1 - 5	0.0505	0.108067
1 - 6	0.1045	0.108067
1 - 7	0.047	0.108067
1 - 8	0.0335	0.108067
1 - 9	0.06475	0.108067
1 - 10	-0.106	0.108067

1 - 11	-0.007375	0.108067
1 - 12	0.039	0.108067
1 - 13	-0.0655	0.108067
1 - 14	0.002625	0.108067
2 - 3	-0.061	0.108067
2 - 4	*-0.16825	0.108067
2 - 5	-0.0195	0.108067
2 - 6	0.0345	0.108067
2 - 7	-0.023	0.108067
2 - 8	-0.0365	0.108067
2 - 9	-0.00525	0.108067
2 - 10	*-0.176	0.108067
2 - 11	-0.077375	0.108067
2 - 12	-0.031	0.108067
2 - 13	*-0.1355	0.108067
2 - 14	-0.067375	0.108067
3 - 4	-0.10725	0.108067
3 - 5	0.0415	0.108067
3 - 6	0.0955	0.108067
3 - 7	0.038	0.108067
3 - 8	0.0245	0.108067
3 - 9	0.05575	0.108067
3 - 10	*-0.115	0.108067
3 - 11	-0.016375	0.108067
3 - 12	0.03	0.108067
3 - 13	-0.0745	0.108067
3 - 14	-0.006375	0.108067
4 - 5	*0.14875	0.108067
4 - 6	*0.20275	0.108067
4 - 7	*0.14525	0.108067
4 - 8	*0.13175	0.108067
4 - 9	*0.163	0.108067
4 - 10	-0.00775	0.108067
4 - 11	0.090875	0.108067
4 - 12	*0.13725	0.108067
4 - 13	0.03275	0.108067
4 - 14	0.100875	0.108067
5 - 6	0.054	0.108067
5 - 7	-0.0035	0.108067
5 - 8	-0.017	0.108067
5 - 9	0.01425	0.108067
5 - 10	*-0.1565	0.108067
5 - 11	-0.057875	0.108067
5 - 12	-0.0115	0.108067
5 - 13	*-0.116	0.108067
5 - 14	-0.047875	0.108067
6 - 7	-0.0575	0.108067
6 - 8	-0.071	0.108067
6 - 9	-0.03975	0.108067
6 - 10	*-0.2105	0.108067
6 - 11	*-0.111875	0.108067
6 - 12	-0.0655	0.108067
6 - 13	*-0.17	0.108067
6 - 14	-0.101875	0.108067
7 - 8	-0.0135	0.108067
7 - 9	0.01775	0.108067
7 - 10	*-0.153	0.108067
7 - 11	-0.054375	0.108067
7 - 12	-0.008	0.108067
7 - 13	*-0.1125	0.108067
7 - 14	-0.044375	0.108067
8 - 9	0.03125	0.108067
8 - 10	*-0.1395	0.108067
8 - 11	-0.040875	0.108067

8 - 12	0.0055	0.108067
8 - 13	-0.099	0.108067
8 - 14	-0.030875	0.108067
9 - 10	*-0.17075	0.108067
9 - 11	-0.072125	0.108067
9 - 12	-0.02575	0.108067
9 - 13	*-0.13025	0.108067
9 - 14	-0.062125	0.108067
10 - 11	0.098625	0.108067
10 - 12	*0.145	0.108067
10 - 13	0.0405	0.108067
10 - 14	*0.108625	0.108067
11 - 12	0.046375	0.108067
11 - 13	-0.058125	0.108067
11 - 14	0.01	0.108067
12 - 13	-0.1045	0.108067
12 - 14	-0.036375	0.108067
13 - 14	0.068125	0.108067

* denotes a statistically significant difference.

The StatAdvisor

This table applies a multiple comparison procedure to determine which means are significantly different from which others. The bottom half of the output shows the estimated difference between each pair of means. An asterisk has been placed next to 22 pairs, indicating that these pairs show statistically significant differences at the 95.0% confidence level. At the top of the page, 5 homogenous groups are identified using columns of X's. Within each column, the levels containing X's form a group of means within which there are no statistically significant differences. The method currently being used to discriminate among the means is Fisher's least significant difference (LSD) procedure. With this method, there is a 5.0% risk of calling each pair of means significantly different when the actual difference equals 0.

ANOVA – Mean Head Size

Analysis of Variance for Mean head size - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Treatment	96.5124	13	7.42403	1.15	0.3481
B:Rep	14.1249	3	4.70831	0.73	0.5396
RESIDUAL	251.119	39	6.43896		
TOTAL (CORRECTED)	361.757	55			

All F-ratios are based on the residual mean square error.

The StatAdvisor

The ANOVA table decomposes the variability of Mean head size into contributions due to various factors. Since Type III sums of squares (the default) have been chosen, the contribution of each factor is measured having removed the effects of all other factors. The P-values test the statistical significance of each of the factors. Since no P-values are less than 0.05, none of the factors have a statistically significant effect on Mean head size at the 95.0% confidence level.

2003/04 Trials

Analysis of Variance for Mean lettuce head weight - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Treatment	0.13181	10	0.013181	2.72	0.0081
B:Replicate	0.228318	6	0.038053	7.84	0.0000
RESIDUAL	0.291139	60	0.00485231		
TOTAL (CORRECTED)	0.651266	76			

All F-ratios are based on the residual mean square error.

Multiple Range Tests for Mean head weight by Treatment

Method: 95.0 percent LSD

Treatment	Count	LS Mean	Homogeneous Groups
1	7	0.402571	X
10	7	0.433429	XX
3	7	0.435571	XX
8	7	0.448571	XX
11	7	0.465429	XXX
7	7	0.474143	XXXX
2	7	0.490714	XXX
6	7	0.491429	XXX
9	7	0.501429	XXX
4	7	0.529857	XX
5	7	0.547714	X

Contrast	Difference	+/- Limits

1 - 2	*-0.0881429	0.0744794
1 - 3	-0.033	0.0744794
1 - 4	*-0.127286	0.0744794
1 - 5	*-0.145143	0.0744794
1 - 6	*-0.0888571	0.0744794
1 - 7	-0.0715714	0.0744794
1 - 8	-0.046	0.0744794
1 - 9	*-0.0988571	0.0744794
1 - 10	-0.0308571	0.0744794
1 - 11	-0.0628571	0.0744794
2 - 3	0.0551429	0.0744794
2 - 4	-0.0391429	0.0744794
2 - 5	-0.057	0.0744794
2 - 6	-0.000714286	0.0744794
2 - 7	0.0165714	0.0744794
2 - 8	0.0421429	0.0744794
2 - 9	-0.0107143	0.0744794
2 - 10	0.0572857	0.0744794
2 - 11	0.0252857	0.0744794
3 - 4	*-0.0942857	0.0744794
3 - 5	*-0.112143	0.0744794
3 - 6	-0.0558571	0.0744794
3 - 7	-0.0385714	0.0744794
3 - 8	-0.013	0.0744794
3 - 9	-0.0658571	0.0744794
3 - 10	0.00214286	0.0744794
3 - 11	-0.0298571	0.0744794
4 - 5	-0.0178571	0.0744794
4 - 6	0.0384286	0.0744794
4 - 7	0.0557143	0.0744794
4 - 8	*0.0812857	0.0744794
4 - 9	0.0284286	0.0744794
4 - 10	*0.0964286	0.0744794
4 - 11	0.0644286	0.0744794
5 - 6	0.0562857	0.0744794
5 - 7	0.0735714	0.0744794
5 - 8	*0.0991429	0.0744794
5 - 9	0.0462857	0.0744794
5 - 10	*0.114286	0.0744794
5 - 11	*0.0822857	0.0744794
6 - 7	0.0172857	0.0744794
6 - 8	0.0428571	0.0744794
6 - 9	-0.01	0.0744794
6 - 10	0.058	0.0744794
6 - 11	0.026	0.0744794
7 - 8	0.0255714	0.0744794
7 - 9	-0.0272857	0.0744794
7 - 10	0.0407143	0.0744794
7 - 11	0.00871429	0.0744794
8 - 9	-0.0528571	0.0744794
8 - 10	0.0151429	0.0744794
8 - 11	-0.0168571	0.0744794
9 - 10	0.068	0.0744794
9 - 11	0.036	0.0744794
10 - 11	-0.032	0.0744794

- denotes a statistically significant difference.

Analysis of Variance for Total cut of Broccoli - Type III Sums of Squares

Source	Sum of Squares	Df	Mean Square	F-Ratio	P-Value
MAIN EFFECTS					
A:Treatment	1.94381E8	10	1.94381E7	2.39	0.0186
B:Replicate	3.17603E8	6	5.29339E7	6.50	0.0000
RESIDUAL	4.88554E8	60	8.14257E6		
TOTAL (CORRECTED)	1.00054E9	76			

All F-ratios are based on the residual mean square error.

Multiple Range Tests for Total cut by Treatment

Method: 95.0 percent LSD

Treatment	Count	LS Mean	Homogeneous Groups
10	7	13466.6	X
9	7	13932.6	X
1	7	13945.7	X
3	7	13982.9	X
7	7	14060.0	X
8	7	14115.1	X
11	7	14240.1	X
2	7	14405.7	X
6	7	16374.4	XX
5	7	17937.1	X
4	7	18007.4	X

Contrast	Difference	+/- Limits
1 - 2	-460.0	3051.0
1 - 3	-37.1429	3051.0
1 - 4	*-4061.71	3051.0
1 - 5	*-3991.43	3051.0
1 - 6	-2428.71	3051.0
1 - 7	-114.286	3051.0
1 - 8	-169.429	3051.0
1 - 9	13.1429	3051.0
1 - 10	479.143	3051.0
1 - 11	-294.429	3051.0
2 - 3	422.857	3051.0
2 - 4	*-3601.71	3051.0
2 - 5	*-3531.43	3051.0
2 - 6	-1968.71	3051.0
2 - 7	345.714	3051.0
2 - 8	290.571	3051.0
2 - 9	473.143	3051.0
2 - 10	939.143	3051.0
2 - 11	165.571	3051.0
3 - 4	*-4024.57	3051.0
3 - 5	*-3954.29	3051.0
3 - 6	-2391.57	3051.0
3 - 7	-77.1429	3051.0
3 - 8	-132.286	3051.0
3 - 9	50.2857	3051.0
3 - 10	516.286	3051.0
3 - 11	-257.286	3051.0
4 - 5	70.2857	3051.0
4 - 6	1633.0	3051.0

4 - 7	*3947.43	3051.0
4 - 8	*3892.29	3051.0
4 - 9	*4074.86	3051.0
4 - 10	*4540.86	3051.0
4 - 11	*3767.29	3051.0
5 - 6	1562.71	3051.0
5 - 7	*3877.14	3051.0
5 - 8	*3822.0	3051.0
5 - 9	*4004.57	3051.0
5 - 10	*4470.57	3051.0
5 - 11	*3697.0	3051.0
6 - 7	2314.43	3051.0
6 - 8	2259.29	3051.0
6 - 9	2441.86	3051.0
6 - 10	2907.86	3051.0
6 - 11	2134.29	3051.0
7 - 8	-55.1429	3051.0
7 - 9	127.429	3051.0
7 - 10	593.429	3051.0
7 - 11	-180.143	3051.0
8 - 9	182.571	3051.0
8 - 10	648.571	3051.0
8 - 11	-125.0	3051.0
9 - 10	466.0	3051.0
9 - 11	-307.571	3051.0
10 - 11	-773.571	3051.0

* denotes a statistically significant difference.

Appendix v - Acknowledgments

The assistance of John and Stephen Hill, for their co-operation in nursery trial work, is gratefully acknowledged.

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Dolf de Boer supplied a *Rhizoctonia* culture for use in pot trials. Unfortunately, the sample arrived after pot trials had already commenced.