Project title:	Improving Strawberry Plant Establishment In Used Beds
Project number:	SF 108
Project leader:	Robert Irving, ADAS
Report:	Annual report, January 2010
Previous report	None
Key staff:	Robert Irving
Location of project:	New Farm Produce, Elmhurst Nr. Lichfield, Staffs, WS13 8EX
Project coordinator:	Mr S McGuffie, New Farm Produce, Nr. Lichfield, Staffs, WS13 8EX
Date project commenced:	1st February 2009
Date project completed (or expected completion date):	31st January 2011
Key words:	Strawberry, soil, establishment, root treatment.

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

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AUTHENTICATION

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

Robert Irving
Consultant
ADAS

Signature .....R Irving..... Date ..1st February 2010.....

Report authorised by:

T M O'Neill
Horticulture Research Manager
ADAS

Signature .....p.p. S Perkins..... Date ..3rd February 2010.....

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GROWER SUMMARY

Headline

- A range of products that claim to improve crop establishment were trialled on two bare root everbearer strawberry varieties planted into once-used strawberry beds on light soil. No beneficial effects on crop growth or yield occurred on this site.

Background and expected deliverables

Most of the UK strawberry crop is still grown in plastic-covered raised beds in field soils. The soil is commonly fumigated and there is a strong desire to prolong the value of this investment into a second crop by replanting the beds. This saves costs and reduces the use of soil disinfectants.

Good plant establishment has a significant effect on yield. Strawberry growers are increasingly considering whether to continue producing in field soils or switch to soil-less substrate systems. Replanting of beds has become more problematic as soils on many farms are repeatedly used for strawberries.

Specific objectives are:

- To indentify non-pesticide products that improve plant establishment of replanted everbearer crops into previously cropped raised beds in field soils.

- To compare the performance of these products with standard agronomic treatments.

- To quantify the establishment treatments on initial canopy development and on yield in July, August and September.

- To ascertain the financial worthiness of the treatments applied.

Summary of the project and main conclusions

Twelve products (Bio-Fungus Granules, Broadleaf P4, Broadleaf root dip, Humaroot SP, Omex Bio 18, Omex DP98, Plantmate Drench, Scotts Miracle Gro, Side forking, Standard feed solution 1:1:1 and Vaminoc S) were applied to bare root strawberry cvs Albion and

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Camarillo as they were planted into once-used beds on a light soil in Staffordshire in March 2009.

Two treatments initially hindered establishment. None improved canopy development over the control. Examination of the total yields showed no significant difference between any of the treatments. This corresponded with field canopy observations through picking.

Bare root everbearer varieties were chosen to provide the most challenging plant material for establishment. The plants were graded to size before planting but the rate of establishment within all plots was still variable. This indicates that runner uniformity is the greatest factor affecting overall establishment for the industry. The statistical analysis showed that the plant size variability, though unavoidable, was equally spread across treatments, therefore enabling effective comparison of the treatments. Root stimulating treatments may enable small improvements beyond the large variance in growth of bare root runners on some sites, but no effect was detected on this site.

Financial benefits

No treatment showed a significant improvement in growth or yield over the control. The trial will be repeated on a different soil type for 2010. Some treatments will also be adjusted to reflect trends noted in the 2009 trial.

Action points for growers

- There are none at this stage.

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SCIENCE SECTION

Introduction

Everbearer strawberry varieties respond to rapid establishment right from the start. Establishment rates are presently improved with fleecing at planting and early tunnelling. Both lift the soil temperature early in the season and improve the speed of root development and establishment. This trial reviewed treatments that may improve this process further. Bare root material was chosen as it may better express the benefits of enhanced root zone development compared to potted material.

Materials and methods

Site details

A second year raised bed crop was chosen at New Farm Produce, Lichfield, Staffordshire. This was a site that had potential for excellent establishment. The soil was a well-graded, free draining sandy loam, pH 6.9 - 7.3, with no obvious signs of compaction or root disease. The trial was planted within a large block of replanted Camarillo. The 2008 crop was everbearer Jubilee planted into beds after soil disinfestation with chloropicrin. The dead Jubilee crowns were pulled out immediately before replanting. All of the 2009 runners were planted directly into the previous plant holes.

Treatments

Twelve root zone treatments including the control were administered at planting (Table 1 and 2). Normal crop management practices, including trickle feeding using a conventional feed, were applied thereafter.

Table 1: Details of treatments

Treatment number	Treatment	Application rate per plant
1	Scotts Miracle Gro	3 g granules in planting hole per plant
2	Bio Fungus Granules	10 g granules in planting hole per plant
3	Broadleaf P4	1 g granules in planting hole per plant
4	Broadleaf Root Dip	Pre planting root dip at 6 g per litre of water 6 g/L root dip
5	Omex DP98	2 ml per litre of water, 250 ml drench per plant
6	Huma-Root SP	1 g in 10 litres, 250 ml drench per plant
7	Omex Bio 18	2 ml per litre of water, 250 ml drench per plant
8	Side forking	One four pronged fork per planting hole
9	Standard feed solution 1:1:1	250 ml drench per plant
10	Plantmate	Pre planting root dip at 10 g per litre of water for 10-15 minutes
11	Vaminoc	2 g granules in planting hole per plant
12	Control	No treatment

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Table 2: Detail of product content and claims

Treatment Number	Description and claims
1. Scotts Miracle Gro	Scotts Agroblen SF 8653 (unavailable) was substituted with Scotts Miracle Gro 18+9+11, 2-6 month longevity release pattern at 3 g/plant. This closely matched the rates used in Dutch trials for Evita. Controlled release fertilisers slowly release fertiliser through a polymer coated granule. They are widely and successfully used for container ornamental production, where nutrition is placed in the compost for the life of the crop and only water is applied thereafter. Scotts have been developing their use for soil grown crops. This type of product may reduce the amount of soil leached nutrients.
2. Bio-Fungus Granules	Bio Fungus Granules is a coarse granule formulation that contains six strains of *Trichoderma asperellum*. This formulation is recommended for soil and compost incorporation. The product claims to develop a healthy root environment in which the population of beneficial microbes out-competes disease-causing plant pathogens. It does not claim to control or prevent diseases that pre-exist on planting material.
3. Broadleaf P4	Broadleaf P4 is a granular polymer formulation that absorbs and stores hundreds of times its own weight of water. This property claims to reduce losses to moisture stress and improve establishment & growth. Dissolved nutrients are also absorbed, though available to the crop, and may reduce leaching.
4. Broadleaf root dip	Identical to Broadleaf P4 but a finer powder that creates a gel. Bare root transplants are immersed in the gel before planting. The product is primarily used to protect bare roots at lifting and through transport. Its inclusion in this trial was to observe any benefits as a pre-plant treatment. It could also be used as a carrier for other planting inoculants.
5. Omex DP98	A phosphite source of phosphorous that is normally applied as a foliar spray or sometimes as a drench at planting. Claimed improved rooting and plant health as a foliar application.
6. Humaroot SP	A humic and fulvic acid powder that is applied as a drench. Their high cation exchange capacity is claimed to enhance nutrient uptake, improve root growth and reduce transplant stress.
7. Omex Bio 18	A formulation of kelp, major and minor elements. It can be applied as a drench or foliar spray. The contained 'bio stimulants' and nutrients are claimed to produce improvements in root growth and nutrient uptake.
8. Side forking	Poor soil structure is a major cause of failed plant establishment. Side forking a used bed can loosen the soil and may improve root development. A four-pronged fork was sunk 30 cm deep to the side of the replanting hole immediately after planting, then gently firmed back to ensure good root contact.
9. Standard feed solution 1:1:1	A basic feed of N:P:K. Vegetable transplant work in the eighties showed a yield benefit from nutrient solution drenching at planting. The application of a feed strength solution using straights, coupled with the consolidating process of a drench may improve establishment in strawberry beds.
10. Plantmate Drench	A wettable powder formulation containing proprietary strains of *Trichoderma harzianum*. It claims a protective quality against pathogens e.g. *Pythium, Rhizoctonia* and *Phytophthora.* Also claimed to stimulate auxins for better growth.
11. Vaminoc S	Vaminoc S is a non-soluble granular formulation containing arbuscular mycorrhizal fungi specially selected for strawberries. Fungal hyphae extend from the inoculated roots improving the absorptive surface area of root systems. This process claims more rapid crop establishment, disease protection and increased yields.
12. Control	No treatment applied.

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Soil compaction assessment

An analogue soil compaction gauge (manufacturers Spectrum Technologies Inc) was used to assess bed compaction after removal of the previous crop but before planting on the same day. Ten readings were taken in a zigzag pattern across the site for each variety.

Crop assessment

Two parameters were chosen, canopy development and picked yield. It was considered that measuring root volumes would be excessively time consuming and possibly inaccurate for this project.

Canopy development was measured as ground cover for the first three months (before there was significant overlapping of plants). The crop canopy area was recorded as a digital image using a fixed height tripod to ensure a standardised recorded area. The images were later scored manually using a standard overlaid grid. Four recordings were made to provide three sets of canopy expansion data. Each plot was photographed and scored separately. The canopy score is the proportion of squares filled per plot (Figs 1-2). Each plant was scored each time then totalled for the plot. The canopy score was not converted into m^2 of canopy as it contributed nothing to the assessment which was calculated as the increase in filled squares since the previous recording.

The results are presented as grid scores per replicate.

Fig 1. Canopy measurement with fixed height camera, early April 2009.

Fig 2. A grid is placed over each image for manual scoring, May 2009.

Picked yield was established as three picks per plot to reflect a weeks' picking during early August, early and late September. This was a total of nine picks. Picking dates were:

- August 2nd, 6th & 10th
- August 28th, Sept 1st & 8th
- Sept 17th, 23rd & 30th

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This was not a total harvest of the season, but provided a second check for the canopy data to identify if there were significant advantages from any particular treatment in the main yielding times of the season. Each plot was weighed separately and recorded by New Farm staff. The results are presented as a combined weight for the four replicates.

Each plot of nine treated plants was picked and weighed separately.

Fig 3. Albion (LHS) Camarillo, July 2009, part of instructions for farm staff

Planting material

Bare root everbearers cv. Albion and Camarillo were used. Runners differed greatly in size (Fig 4.). They were size-graded on delivery to reduce the size variability within each plot.

Fig 4 Albion runners Camarillo runners

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Crop management and treatment application

The crop followed the conventional cropping pattern for the farm. The soil beds were prepared, sterilised with chloropicrin and cropped in 2008. Plants were killed after harvest with glyphosate and the dead plants removed just before replanting in 2009.

Treatments were applied on the 10 March and the crops planted. Granule treatments were placed in the hole before planting, root dip treatments immediately before planting and drenches immediately after planting. The area was covered with holed polythene plus fleece on 2 April and tunnelled on 24 April. The holed polythene upper layer was removed 18 May and finally the fleeced layer on 28 May. Runners were cut on 11 June and 27 July.

2008 dead plants removed

2009 plants use 2008 holes

Trial site with drench treatments, March 2009.

Vaminoc in pre-planting hole

Broadleaf P4 in pre-planting hole

Broadleaf root dip

Fig. 5. Application of treatments at planting.

Experiment design and analysis

The two varieties, Albion and Camarillo, were planted as two adjacent randomised block trials. Each trial contained four adjacent beds with a full replication of the 12 treatments in each bed. Individual plots contained nine plants plus three guard plants, approximately 1.6 m of bed length. The trial was planted at the conventional density of 50,000 plants/ha on a triple row bed with triple trickle tapes.

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Results

Soil compaction and nutrient status

The soil was moist and easy to penetrate. Soil within a range of 0-200 PSI (0-1380 KN/m² = K Pa) is regarded as free of compaction problems. There was minimal compaction - the lower the number, the less the resistance to the meter tip (Table 3). Many of the higher scores recorded were due to a stone being in the way. No areas of compaction were identified in the trial site. This was a well constructed bed in its second year.

Table 3: Soil compaction readings pre-planting – 10 March 2009

PSI (KN/m² = K Pa) at 0 cm depth	PSI (KN/m² = K Pa) at 10 cm depth	PSI (KN/m² = K Pa) at 20 cm depth	PSI (KN/m² = K Pa) at 30 cm depth
Albion			
0	0	5 (35)	5 (35)
0	5 (35)	10 (69)	15 (104)
0	0	10 (69)	10 (69)
0	10 (69)	15 (104)	10 (69)
0	10 (69)	5 (35)	25 (173)
0	10 (69)	0	5 (35)
0	0	10 (69)	25 (173)
0	25 (173)	25 (173)	30 (207)
0	10 (69)	20 (138)	20 (138)
0	10 (69)	20 (138)	20 (138)
5 (35)	10 (69)	10 (69)	15 (104)
Camarillo			
0	0	0	0
0	0	0	10 (69)
0	10 (69)	20 (138)	80 (552)
0	10 (69)	10 (69)	10 (69)
0	15 (104)	10 (69)	10 (69)
0	5 (35)	10 (69)	10 (69)
0	10 (69)	10 (69)	20 (138)
0	0	10 (69)	10 (69)
0	15 (104)	10 (69)	20 (138)
0	20 (138)	20 (138)	20 (138)

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Soil samples for nutrient analysis were taken in a zigzag pattern on 10 March 2009 and analysed for major nutrients and texture (Table 4). Both blocks had closely matched nutrient status. The two blocks also had closely matched textures (Table 5).

Table 4: Soil nutrient status, March 2009

		Index			**mg/l (Available)**		
	Soil pH	*P*	*K*	*Mg*	*P*	*K*	*Mg*
Camarillo	7.3	5	2+	2	70.6	220	54
Albion	6.9	5	3	2	74.4	260	57

Table 5: Soil texture

	Albion	**Camarillo**
Sand (2.00 – 0.06mm) %	68	68
Silt (0.060 - 0.002mm) %	13	15
Clay (< 0.002mm) %	19	17
Textural Classification	Sandy Clay Loam	Sandy Loam

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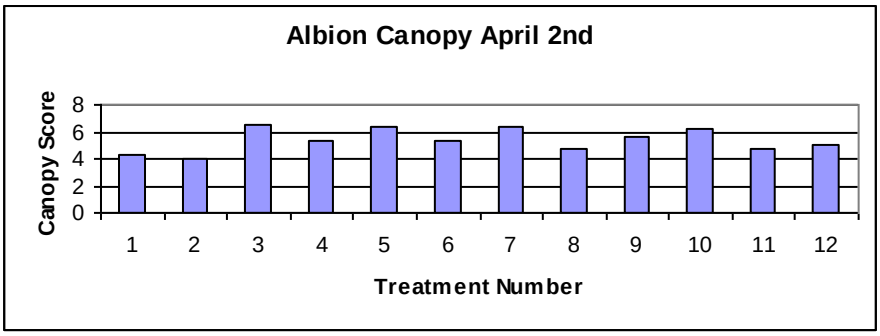
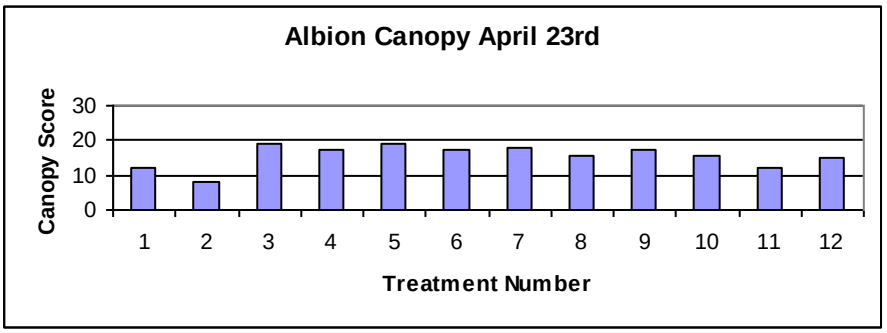
Canopy Growth

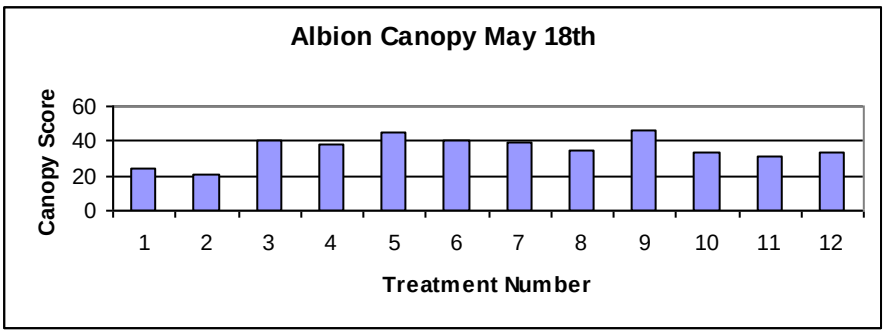
For both varieties, treatments 1 and 2 had consistently lower canopy scores from April 23 to June 11. These were significantly different to the other ten treatments, which had no significant difference between them and the control (Figs 6 and 7).



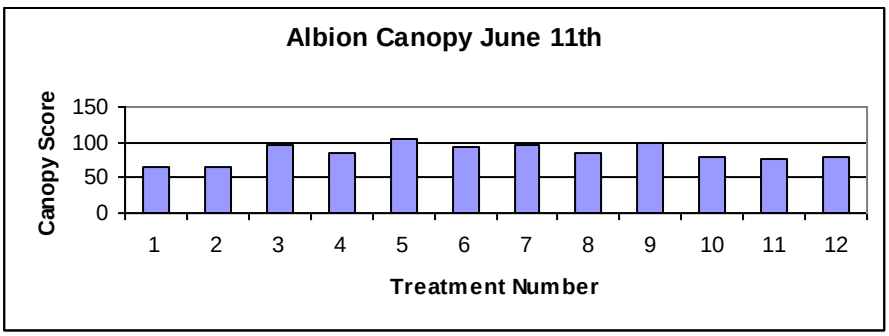
LSD (At 5% level) 1.640



LSD (At 5% level) 4.467



LSD (At 5% level) 11.89



LSD (At 5% level) 24.49

Treatments
1 Miracle Gro 18+9+11
2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control

Fig 6: Effect of soil amendments at planting on canopy growth, cv. Albion

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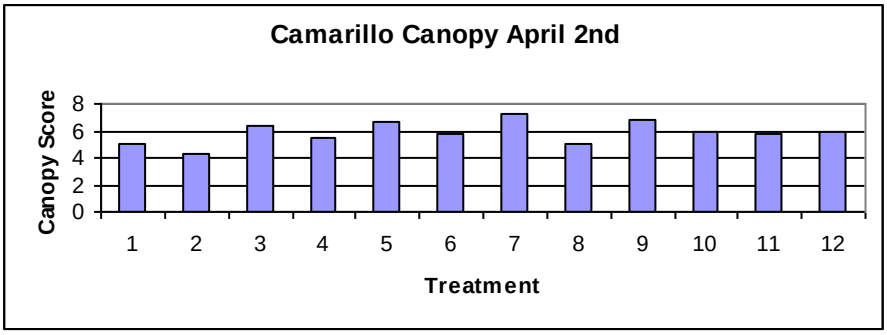
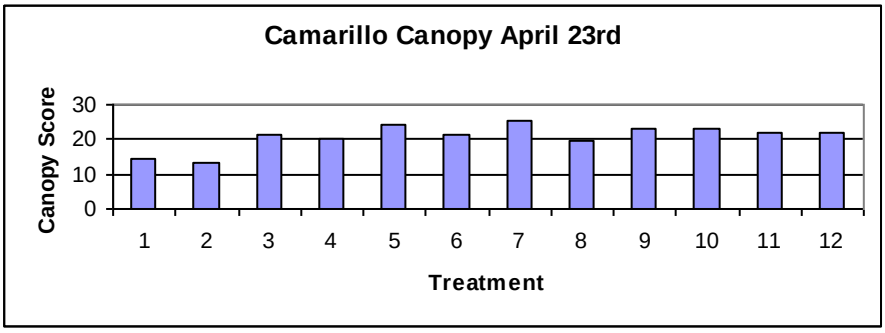
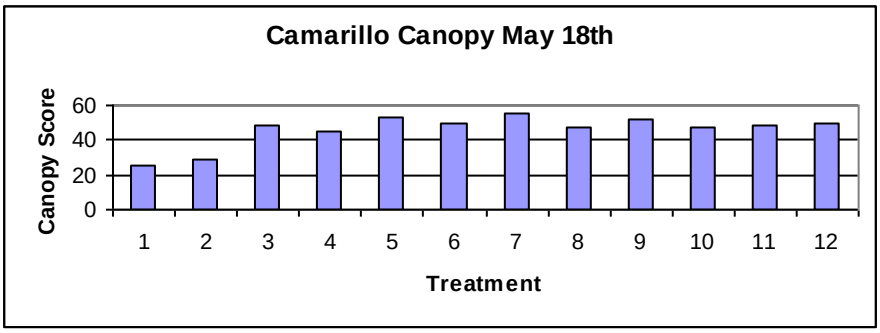


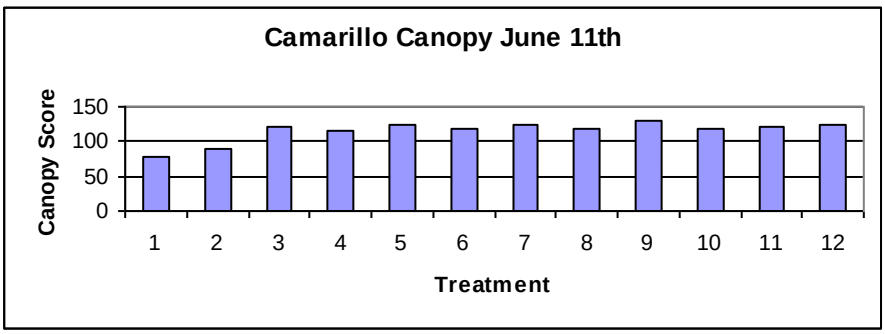
LSD (At 5% level) 1.594



LSD (At 5% level) 4.298



LSD (At 5% level) 10.76



LSD (At 5% level) 23.31

Treatments
1 Miracle Gro 18+9+11
2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control

Fig 7: Effect of soil treatments at planting on canopy growth of cv. Camarillo

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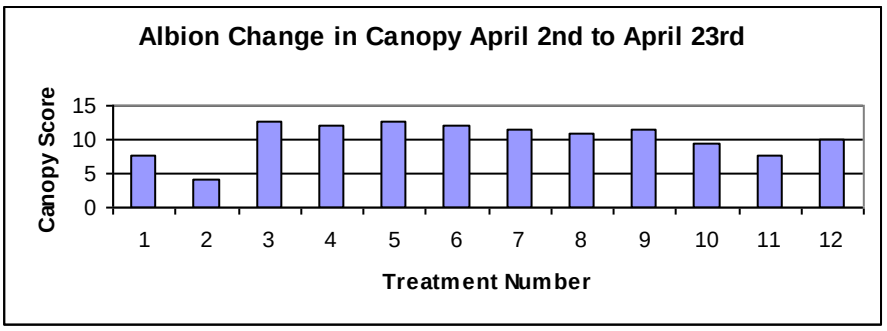
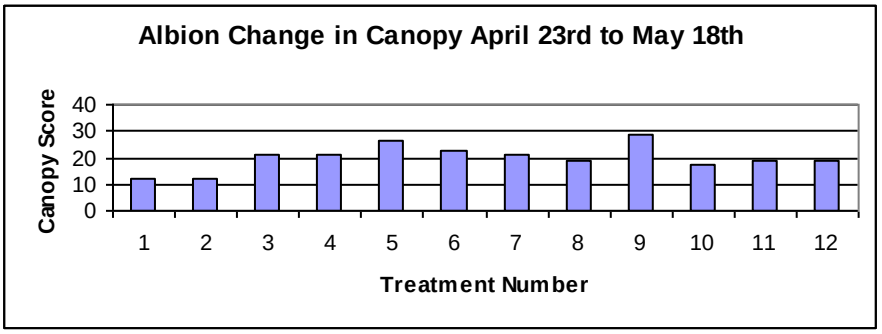
Change in Canopy Cover with time

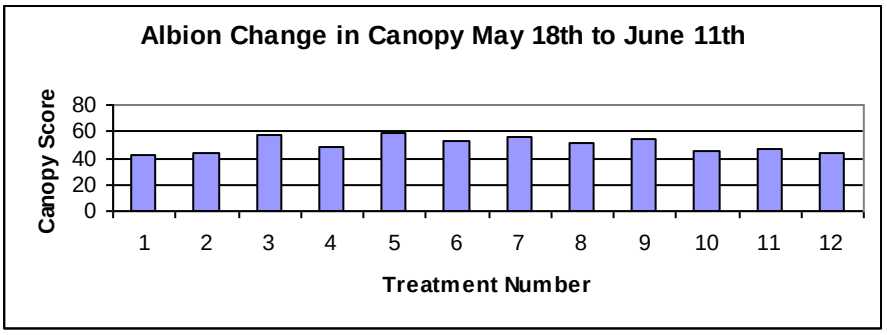
For both varieties, treatments 1 and 2 were consistently below all the other treatments, and mostly as a significant difference (Figs 8 and 9). The remaining ten treatments were rarely significantly different from the control.



LSD (At 5% level) 3.682



LSD (At 5% level) 8.698



LSD (At 5% level) 14.79

Treatments
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2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control

Fig 8: Change in canopy score with time, cv. Albion

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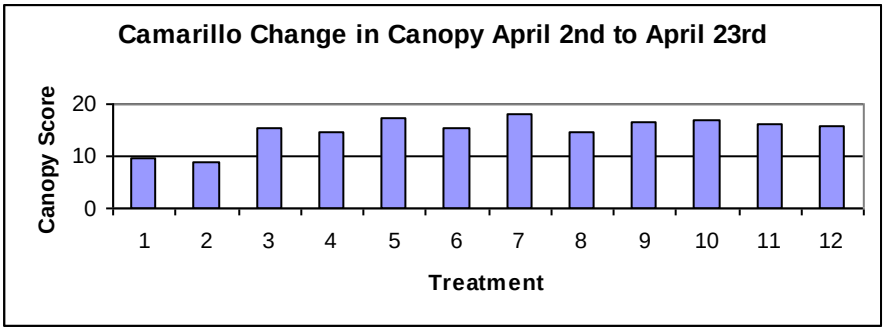
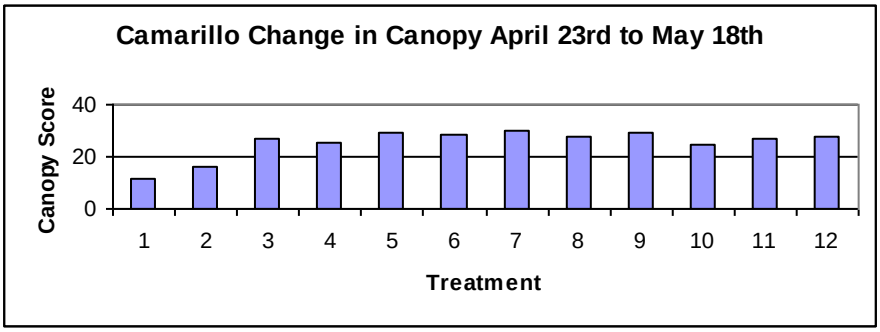
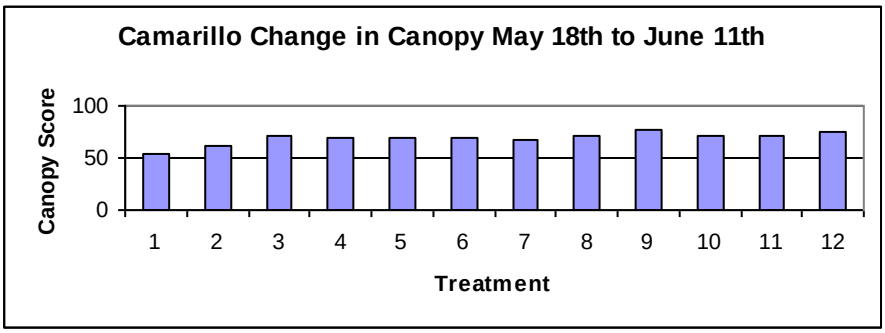


LSD (At 5% level) 3.668



LSD (At 5% level) 7.889



LSD (At 5% level) 18.02

Treatments
1 Miracle Gro 18+9+11
2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control

Fig 9: Change in canopy score with time cv. Camarillo

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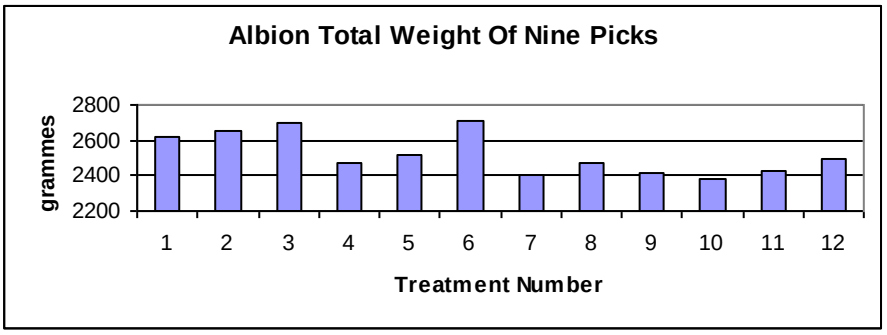
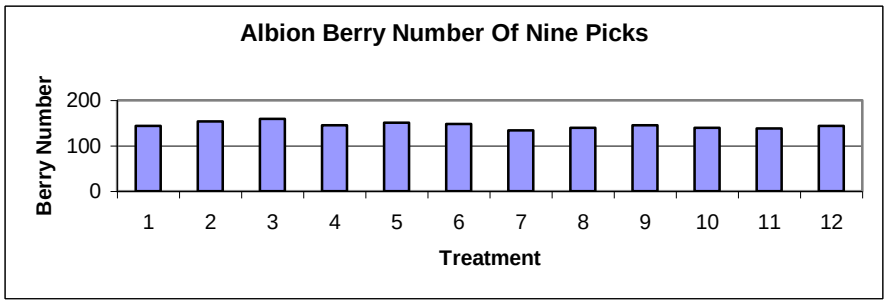
Fruit Yields

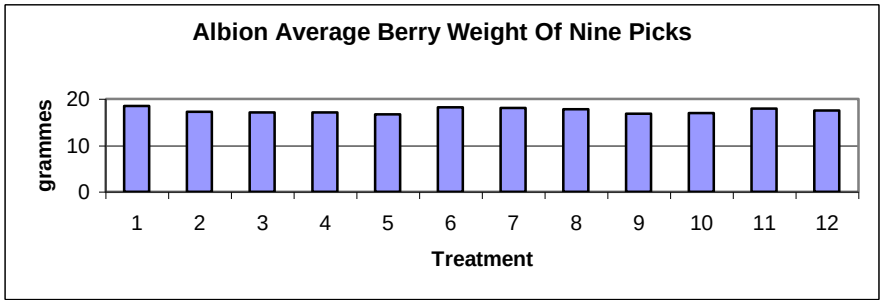
None of the treatments significantly affected fruit yield compared with the control (Figs 10 and 11).



LSD (At 5% level) 400.8



LSD (At 5% level) 26.55



LSD (At 5% level) 1.466

Treatments
1 Miracle Gro 18+9+11
2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control

Fig 10: Effect of soil treatments at planting on fruit yield, cv. Albion

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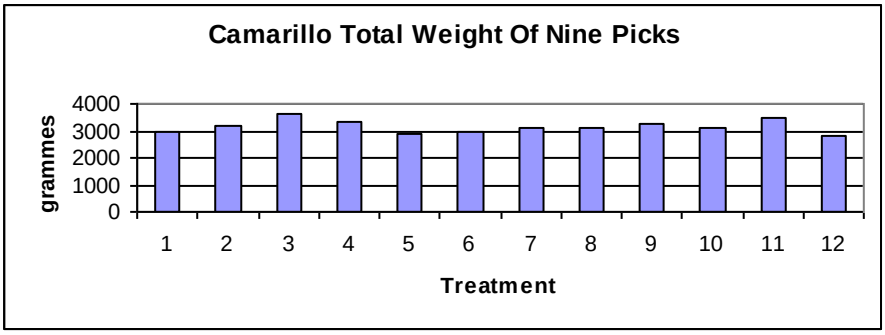
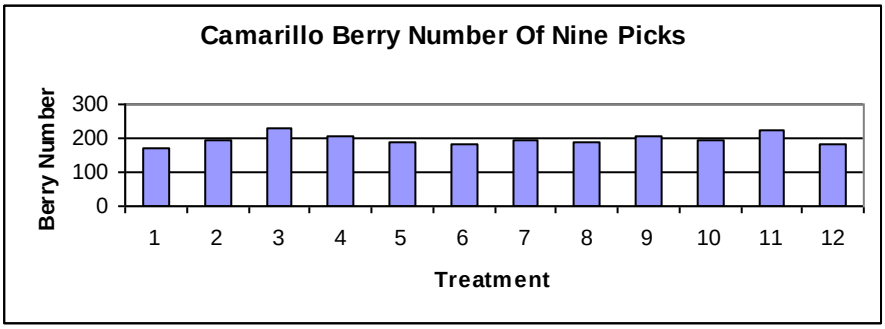
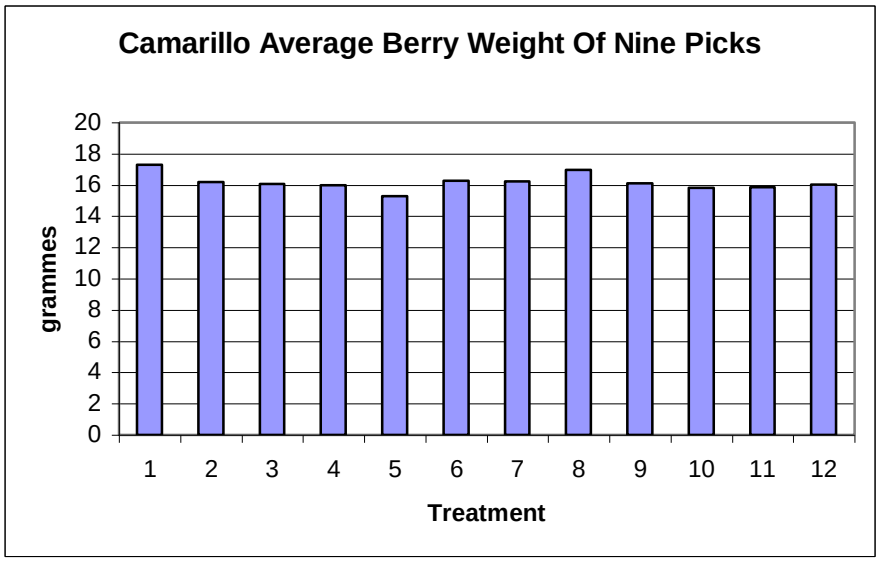


LSD (At 5% level) 573.4



LSD (At 5% level) 37.99

Treatments
1 Miracle Gro 18+9+11
2 Bio-Fungus Granules
3 Broadleaf P4
4 Broadleaf root dip
5 Omex DP98
6 Humaroot SP
7 Omex Bio 18
8 Side forking
9 Standard feed solution 1:1:1
11 Vaminoc S
10 Plantmate
12 Control



LSD (At 5% level) 1.120

Fig 11: Effect of soil treatments at planting on fruit yield, cv. Camarillo

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Discussion

Great variability of plant size was evident right from the start. It made any quick visual assess of differences between treatments impossible. This was despite grading runners to improve evenness.

Each plot had nine plants which were recorded individually for canopy size. Analysis of this data showed that size variability was uniform across all treatments. Four replicates and randomisation of plots gave confidence in the data. None of the treatments significantly improved plant growth as measured by canopy cover. Two treatments, Miracle Gro 18+9+11 and Bio-Fungus Granules, resulted in reduced growth in April and May, which was overcome by harvest. From June onwards, canopy measurement became increasingly less useful as the canopy overlap between plants and within each plant increased.

It is surprising that there was not at least one outstanding treatment given the claims made by suppliers. These claims were for a range of properties that may not have been particularly relevant for this particular site. For example, not all the products recommended a single application at planting. They may have required foliar or trickle application for several applications; this was beyond the design of this trial.

The 2009 site had excellent light soil for trouble free planting, no history of major soil-borne pathogens, a high pH and phosphate index. Perhaps the conditions were too good for products to express their properties. Possibly a root promoting treatment providing phosphorous would have little additional impact under these conditions. There was similar reasoning for side forking and disease prevention. Two products, Huma-Root SP and Omex Bio 18, actually state that the greatest effects would be seen under adverse conditions.

Although there was no significant difference noted for most treatments in 2009, several consistently exceeded the control performance (Appendix 1).

The work is planned to cover two seasons, one on a light soil replant site, and the other on a heavier soil replant site. For 2010, possible treatment adjustments may be made in light of the 2009 results.

The two products which reduced growth, Scotts Miracle Gro 18+9+11 (substituted for unavailable Scotts Agroblen SF 8653) and Bio-Fungus Granules, appeared to scorch the roots. In both cases crimped leaves with tip browning were observed. This would suggest a temporary high conductivity that scorched the roots, with recovery following.

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Controlled release fertilisers are known to flash release nutrients and it may be that placing away from the planting hole will reduce the effect of this on the plants. The Bio-Fungus granules were not provided with clear guidance instructions on a per plant basis, just as a rate for compost incorporation. This material had an unusually high conductivity in solution and it is probable that this was responsible for the root scorch. A drench formulation was not available for this trial and would perhaps have been more successful, or a lower application rate of the granules may be more appropriate. The Scotts Miracle Gro 18+9+11 also produced scorch symptoms on the treated plants and may have been better placed at some distance from the planting hole; although this would probably not have contributed to enhanced establishment. It is intended that these two products will be omitted from the 2010 trial unless the manufacturers provide further information.

In 2010 it is proposed to focus on the treatments that showed an improvement over the control most frequently. The top three in 2009 were Omex DP98, Omex Bio 18 and Standard feed solution 1:1:1 (Appendix 1).

Conclusions

- No treatment significantly improved bare root strawberry establishment on a light soil replant site in 2009.
- Two treatments, Scotts Miracle Gro 18+9+11 and Bio-Fungus Granules, reduced growth, though the effect was not noticeable by harvest time.
- The treatments that most frequently exceeded the control (though differences were not significant) had a clear nutritional component on their labels, rather than a purely biological claim. These were Omex DP98, Omex Bio 18 and Standard feed solution 1:1:1. Their rates may need to be increased for a greater effect.

Technology transfer

HDC News, December 2009, ‘Get the Best from Re-used Beds’, Issue 159, p20-21.

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Appendix 1. Frequency of Exceeded Control Performance

Treatment	1 Miracle Grow 18+9+11	2 Bio-Fungus Granules	3 Broadleaf P4	4 Broadleaf root dip	5 Omex DP98	6 Humaroot SP	7 Omex Bio 18	8 Side forking	9 Standard feed solution 1:1:1	11 Vaminoc S	10 Plantmate	12 Control
Albion Canopy April 2nd	4.35	4.05	6.55	5.27	6.32	5.4	6.32	4.72	5.67	6.21	4.75	4.99
Albion Canopy April 23rd	11.95	8.3	19.27	17.22	18.9	17.42	17.92	15.47	17.22	15.65	12.37	15.02
Albion Canopy May 18th	24.4	20.6	40.8	38.1	45.1	40	39.2	34.5	45.9	33.4	30.9	33.7
Albion Canopy June 11th	66.2	64.9	97.5	85.7	103.8	92	95	85.4	99.8	79.4	77.5	77.9
Albion Change in Canopy April 2nd to April 23rd	7.6	4.25	12.73	11.95	12.57	12.03	11.6	10.75	11.55	9.44	7.62	10.04
Albion Change in Canopy April 23rd to May 18th	12.43	12.25	21.48	20.83	26.18	22.55	21.28	19	28.7	17.7	18.55	18.68

Treatment	1	2	3	4	5	6	7	8	9	10	11	12
Camarillo Canopy April 2nd	4.97	4.32	6.35	5.5	6.7	5.77	7.25	5.07	6.82	6	5.72	5.9
Camarillo Canopy April 23rd	14.4	13.05	21.6	20.25	24.02	21.15	25.15	19.65	23.3	23.02	21.72	21.85
Camarillo Canopy May 18th	25.6	28.8	48.9	45.4	53.4	49.3	55.5	47.1	52.3	47.6	48.4	49.8
Camarillo Canopy June 11th	79.2	90.7	120.7	115.4	123.3	119	122.9	118	130.1	118	120	125.3
Camarillo Change in Canopy April 2nd to April 23rd	9.43	8.73	15.25	14.75	17.33	15.38	17.9	14.58	16.48	17.02	16	15.95
Camarillo Change in Canopy April 23rd to May 18th	11.17	15.8	27.27	25.12	29.37	28.15	30.35	27.42	29.02	24.6	26.7	27.9

Frequency That Control Exceeded	0	0	7	6	11	7	11	5	12	6	2	Control

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