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Period of investigation: April 1995 - November 1995
Date of issue of report: March 1996
No. of pages in report: 50
No. of copies of report: 10
This is copy no. 3: Issued to Horticultural Development Council

CONTRACT REPORT
FINAL REPORT
The Influence of Fertigation on
on New Everbearing
Strawberry Cultivars 1995

Undertaken for Horticultural Development Council
Project SF 33

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

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HDC SF 33

Influence of Fertigation on on New Everbearing Strawberry Cultivars 1995

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Commenced : April 1995

Third Year Trial Completed : November 1995

Key Words: Strawberry, everbearing, cultivar, variety, extended season, fertigation, nutrition

RELEVANCE TO GROWERS AND PRACTICAL APPLICATION

Application

This project's aims were to achieve a better understanding of, and improve the basis for, field nutrition recommendations for new everbearer strawberry cultivars, with particular reference to nitrogen requirements. Evita, Calypso and Tango have shown similar requirements for moderate quantities of nitrogen. On a fine sandy silt loam soil with a low background level of N, a base dressing containing 40 kg/ha N plus fertigation containing a total of 40 kg/ha N applied between late April/early May and September gave good results.

Summary

Everbearer strawberries were grown as annual crops from spring plantings on black polythene mulched raised beds in double rows at a density of 26,300 plants/ha. Two lines of T-tape trickle irrigation tubing was used per bed.

In 1993, the first year of the three year project, marked growth and yield increases were achieved from fertigation of all four cultivars under trial (Rapella, Calypso, Tango and Evita), where either a season total of 40 kg/ha N or 80 kg/ha N was compared with a control nil N treatment on a site with a low background level of available soil mineral nitrogen. Other macronutrients were at adequate levels so no base dressings were required. Potted plants were used which had been liquid fed prior to planting in late April. Potash to 80 kg/ha K_2O and magnesium to 10 kg/ha Mg was also supplied in the fertigated treatment, although initial soil levels of these elements were adequate.

A clear requirement for some additional nitrogen in the field over the nil N control was demonstrated for all the cultivars, with yield increases averaging 45% Class 1 fruit obtained from total applications over the season equivalent to 40 and 80 kg/ha N. While not proved significant, there was a trend towards higher Class 1 yields with the high rate of N over the low rate for Rapella and Calypso, but not for Tango or Evita. Fertigation treatments did not appear to significantly affect other aspects of fruit quality such as shelf life, firmness or flavour in that year. The trial illustrated the greater requirement for nitrogen post-planting shown by everbearing cultivars in contrast to Junebearers where additional nitrogen is not normally recommended in the year of planting.

The 1994 trial was aimed at comparing regimes with nitrogen supplied as a base dressing, as fertigation, or both. Base dressing plus fertigation treatments of 0+40, 40+0, 40+40 and 40+80 kg/ha N season totals were compared across the three best everbearer cultivars, Calypso, Tango and Evita, on a site with an available soil mineral N level in the spring of about 35 kg/ha (0 - 30 cm). As in 1993, potash and magnesium were included in the fertigation treatments to

provide a 'balanced feed'. The nil N control treatment was excluded as it was felt there was little point in demonstrating again the overall requirement for some nitrogen by the crop. Pot raised plants were planted in raised, mulched beds in late April.

Yields from the initial flush of fruit from early July up to the end of August showed little difference between the 0+40 and 40+0 treatments, suggesting that the base dressing was as effective as the nominally equivalent fertigation rate. There was, however, some indication that fertigations at a 40 or 80 kg/ha seasonal total rate, in addition to the base dressing, gave a small increase in early yield of up to 10%. This trend was not statistically significant, and this small early yield increase applied to Calypso and Evita, but not Tango, in that year. Little fruit was produced during September, but a late flush of fruit was produced from Calypso and Evita during October and early November while protected by polythene tunnels. At this time the lower total nutrient treatments cropped more heavily so that by the end of the season there was little separating the nutrition treatments for the final accumulated yields. Powdery mildew developed in this trial and Tango, followed by Calypso, were most affected, but Evita showed good resistance.

Treatments used in 1994 were repeated for the final trial of the project in 1995. The yield profile was broadly similar to the previous year, the hot summer producing a large and condensed early flush of fruit, followed by very little crop during late August and September, and a late flush of fruit in October and early November. Yields were somewhat better from Calypso and Tango in 1995 than the previous year due to better control of powdery mildew and two-spotted spider mite, and averaged 1135 g/plant (29.8 tonnes/ha) Class 1 fruit cumulative total for the season. Evita did not perform as well as in 1994, and Class 1 yields averaged 925 g/plant (24.3 tonnes/ha).

Yields were again similar for the lower nutrition rate treatments, the 0+40 treatment giving a 2% increase over the 40+0 treatment though again this did not prove significant. The higher fertigation rate plus base dressing (40+80) gave the highest mean yields with a small early yield increase over the 40+0 treatment of up to 10%, and in 1995 this yield advantage was maintained throughout the season. While the mean yields were not as great from the 40+40 treatment, differences between this and the 40+80 treatment were not significant.

Effects on fruit quality, including flavour and shelf life, were also not markedly affected by nutrition treatments, although there was some indication that the treatment receiving the highest total rate of N produced more rots on late season fruit in the final year.

Over the three years of the project, none of the three everbearer cultivars differed significantly in their nutritional requirements. Leaf nutrient analysis data throughout the cropping season did show some differences between cultivars but, in the main, was not significantly affected by nutrition treatments. This data may help provide a reference baseline for these modern cultivars to confirm cases of marked deficiency, for example.

The project has also provided some experience with the use of soil mineral N analysis in spring as a potential tool for tailoring specific recommendations more closely to other sites and soil types.

Action Points

- Most of the N requirement for everbearers on a sandy silt loam soil is able to be met from a total of 40 kg/ha N applied either as a base dressing, or as fertigation. However, small increases in early yield may be obtained from some additional fertigation.

- Early feeding is of most importance for rapid initial plant growth before fruiting starts. Incorporation of a base dressing containing N when raised beds are made should ensure levels are adequate at the time of planting. Even if made up in the autumn, a polythene mulch should prevent leaching losses by winter rainfall, and help preserve soil structure. Further applications of N as fertigation will be most effective if started soon after spring plantings or by early May. Whether the use of varying N:K_2O ratios during the season would be of benefit needs further investigation.

- Consider using soil mineral N analysis from a sample in spring to help determine what rate of fertigation is appropriate for your site and soil type. Otherwise a knowledge of previous cropping history, whether or not soil has been sterilised etc. will help determine an equivalent ADAS N index. Correct sampling and handling procedures are important for mineral N analyses, so seek advice if in doubt.

- Late crops may be picked until October or November by using French Tunnels. Covering by early September and leaving tunnel sides raised initially will protect the fruit from rain and dew while maintaining good ventilation.

- Fertigation beyond early September is unlikely to be beneficial, even if cropping is extended by the use of French Tunnels. Gross overfeeding with nitrogen may make late season fruit was more susceptible to rots.

- For Efford's sandy silt loam, with a low background level of N, a base dressing containing about 40 kg/ha N plus additional fertigation containing 40 kg/ha of N applied from late April / early May to early September gave good results without risking problems from poor late season fruit quality.

- A similar nutrition regime appears appropriate for Calypso, Tango and Evita.

INTRODUCTION

The 1995 trial was the last in a series of three over this three year project, with the overall objective of investigating the field nutrition of everbearers, with particular reference to their nitrogen requirements. The first two years trials have been reported separately but are briefly summarised here.

In the first trial, cropped in 1993, the cultivars Rapella, Calypso, Tango and Evita were used in combination with nil, low and high nitrogen fertigation treatments on a site with a relatively low background level of N in the soil. Other macronutrients were at adequate levels so no base dressings were required. Potted plants were used which had been liquid fed prior to planting in late April. A clear requirement for additional nitrogen in the field was demonstrated for all the cultivars with yield increases averaging 45% Class 1 fruit obtained from total applications over the season equivalent to 40 and 80 kg/ha N. There was a trend towards higher Class 1 yields with the high rate of N for Rapella and Calypso, but not for Tango or Evita. Fertigation treatments did not appear to significantly affect other aspects of fruit quality such as shelf life, firmness or flavour.

The second trial in 1994 investigated combinations of nitrogen applications as base dressings and as fertigation. As the site chosen for this trial had a similar background available mineral N level to that in 1993, there was no merit in including a control treatment with nil N, since it was already clear that all the everbearer cultivars responded favourably to some additional N. Also, it was decided to exclude Rapella from this trial in view of the greatly improved fruit quality shown by the newer cultivars Tango, Calypso, and particularly Evita which, together, form a complementary group for late season cropping from mid July onwards.

Within the resources available, a treatment structure was designed to help answer the following questions:

1 How effective is nitrogen applied in the base dressing compared with the same (nominal) rate applied as fertigation?

2 If fertigation is used, is there any additional benefit from using a base dressing as well?

3 With moderate levels of N in the soil at planting (from a base dressing), what is the response from further N applications at fertigation up to 80 kg/ha?

4 Are there cultivar differences in response to the above with Calypso, Tango and Evita?

Although the project concentrated on responses to nitrogen, fertigation treatments included K and Mg at appropriate rates to achieve a 'balanced feed' in line with commonly accepted horticultural practice.

In 1994, there was some indication that fertigations at a 40 or 80 kg/ha seasonal total rate, in addition to a base dressing of 40 kg/ha N, gave a small increase in early yield of up to 10% compared to applying 40 kg/ha N in the base alone, or as fertigation alone. This result did not prove to be statistically significant, and only applied to Calypso and Evita, not Tango, in that year. Little fruit was produced during September, but a late flush of fruit was produced from Calypso and Evita during October and early November while protected by polythene tunnels. At this time the lower total nutrient treatments cropped more heavily so that by the end of the season there was little separating the nutrition treatments for the final accumulated yields.

It was decided to apply identical treatments for the 1995 trial, to confirm results of the previous year. However, minor cultural adjustments were made such as when beds were raised, the trial planted and when fertigation commenced.

MATERIALS AND METHODS

Treatments

Cultivars:	**A**	Calypso
	B	Tango
	C	Evita
Nutrition:	**0+40**	40 kg/ha N as fertigation only
	40+0	40 kg/ha N as base dressing, nil additional fertigation
	40+40	40 kg/ha N as base dressing plus 40 kg/ha N as fertigation
	40+80	40 kg/ha N as base dressing plus 80 kg/ha N as fertigation

Design and layout

Factorial trial with 3 cultivars and 4 nutrition treatments = 12 treatments in total. A randomised block layout with 4 replicates was used, giving a total of 48 plots. See Appendix I, p. 30 for planting plan and layout. Twenty four plants per plot were arranged in staggered double rows 400 mm apart with 500 mm between plants in the row. Raised beds running north-south were spaced at 1.52 m centres with a guard bed either side of the recorded plots. Overall plant density was 26,316 plants/ha (10,650 plants/acre).

Site

Field S7 (north west) on a sandy silt loam of the Waterstock soil series. The site was cultivated from an ex-ryegrass sward following strawberries in this part of the field in 1990. No soil sterilisation was used in order to reduce unwanted mineralisation of organic soil nitrogen, and to maintain a low background N level.

The site was soil sampled (0 - 300 mm depth) before raised beds were prepared in the autumn of 1994, in order to assess P_2O_5, K_2O and Mg base dressing requirements. Sampling was repeated from both N and nil N base treatments prior to planting in spring 1995, with four samples taken in areas corresponding to the four trial replicate positions. Analysis results for the replicates did not vary excessively and the mean data is shown in Table 1, p. 7.

Available soil mineral N analysis was also carried out on the Nil N and 40 kg/ha N base dressing treatment pre-planting samples. Table 2, p. 7, shows the concentration of available nitrate and ammonium nitrogen present, together with an *approximate* conversion to total available N in kg/ha present in the top 300 mm. This shows an increase in available N from the base dressing broadly in line with what might be expected from the treatment applied. There was relatively little N remaining as ammonium at this time, compared to the 1994 trial where beds were made up and base dressings added in spring. The N base dressing was applied as ammonium nitrate (50% NH_4-N and 50% NO_3-N), and more time would have been available for nitrification by soil bacteria of the ammonium to nitrate forms from the autumn application.

Table 1 Soil sample results pre-base dressing and pre-planting; mean of 4 replicates

	Sampled 11/10/94 before beds prepared	**Sampled 11/4/95 before planting**
pH	6.6	6.9
P	44 mg/l (Index 3)	69 mg/l (Index 4)
K	187 mg/l (Index 2)	286 mg/l (Index 3)
Mg	96 mg/l (Index 2)	120 mg/l (Index 3)

Table 2 Soil analysis for available mineral N prior to planting, 0 - 300 mm depth

	Nil N base dressing			**40 kg/ha N base dressing**		
Replicate	**mg/kg NO_3-N**	**mg/kg NH_4-N**	**≡ kg/ha N**	**mg/kg NO_3-N**	**mg/kg NH_4-N**	**≡ kg/ha N**
Replicate I	0.90	12.44	53	0.83	18.20	76
Replicate II	0.75	11.61	49	0.88	23.53	98
Replicate III	0.82	8.78	38	0.94	13.18	56
Replicate IV	0.72	6.78	30	1.00	17.19	73
Mean	***0.80***	***9.90***	***43***	***0.91***	***18.03***	***76***

Application of nutrition treatments

An overall base dressing of 40 kg/ha K_2O + 40 kg/ha Mg, in line with ADAS recommendations following the initial soil sample, was applied to the site following primary cultivations. In addition, a base dressing of 40 kg/ha N was applied to all plots, except the Nil N base treatment, after the site had been rotary cultivated, but before the beds were raised. The appropriate rate of ammonium nitrate (Nitram) was weighed out for each plot and spread over an area extending to the centres of adjacent alleys in width and to a mid point between adjacent plots down the bed. Beds were raised by running the bedmaker in one direction only, and allowance was made for the displacement of the soil by approximately 0.5 m by the action of the rotary tines. In addition, a 1.0 m gap left between adjacent plots down the bed provided a guard area between different treatments.

Fertigations and irrigations were made via two lines of T-tape 8 per bed (low flow with outlets at 200 mm spacings). Fertigations started about a month earlier than in 1994, and a total of 20 fertigation applications at weekly intervals were made between 27 April and 7 September, each in 3.0 mm of water (3 litres/m^2 of bed plus alley area), (see Appendix II, p. 31 for details). Tensiometers at 150 mm and 300 mm depths at two stations in the trial site were used to help decide when and how much irrigation to apply in addition to regular fertigations. In accordance with current convention, fertigation and irrigation applications were calculated on a cropped area basis including alleyways. Thus 40 kg/ha N (or 4 g/m^2 N) calculated on the whole treatment area based on a bed spacing of 1.52 m, was applied to the actual bed area watered by the trickle lines (nominally about half the area based on a 0.8 m bed width). Likewise, 3.0 mm (3 litres/m^2) of irrigation or fertigation was equivalent to nearer 6 litres/m^2 of watered bed area.

In addition to nitrogen applied at two rates, all the fertigation treatments also received a total of 80 kg/ha K_2O and 10 kg/ha Mg over the season in the feed.

An Access AD6 bag dilutor was used to apply the feeds for each of the two fertigation treatments. The concentrated stock solutions diluted at 1:100 applied feed at the following concentrations:

133 mg/litre N (High rate N) or 67 mg/litre N (Low rate N)
plus 133 mg/litre K_2O
plus 17 mg/litre Mg

Applied in 3.0 mm water per application, this supplied:

4 kg/ha N per feed (High rate N) or 2 kg/ha N per feed (Low rate N)
plus 4 kg/ha K_2O per feed
plus 0.5 kg/ha Mg per feed

General culture

Appendix III p. 33 details the main cultural operations including timings, chemical rates etc.

The plants used for this trial were propagated from mist rooted cuttings in two batches (taken in mid August and mid September 1994), and stuck direct into 7 cm pots (0.25 litres) into a peat mix containing 2.0 kg/m^3 Osmocote Plus 3-4 months (15+11+13+2 MgO + trace elements). These were held overwinter under a cold and well ventilated polythene tunnel, and grown on there until planting in spring. There was sufficient cold weather overwinter to ensure natural winter chilling, and avoid the need for a period of artificial cold storage.

The pot grown plants were given fungicidal sprays for *Botrytis* and powdery mildew during autumn and early spring using approved pesticides, and a precautionary spray of fosetyl-aluminium (Aliette) in mid March against red core and crown rot. Liquid feeding with 200 mg/litre N + 50 mg/litre P_2O_5 + 200 mg/litre K_2O was given twice a week from 20 March until planting. This was required to supplement the short term CRF in the growing medium once rapid growth started in the spring.

The trial was planted on 13 April 1995 and watered in. Care was taken to ensure any dense rootballs were teased apart to encourage root growth into the soil. Several waterings were made with a hand lance during the establishment phase until mid May, in addition to that supplied via the T-tape lines, to help prevent the mix around the plants from drying out. This was particularly important with the unusually hot weather in 1995 which started in April. A half rate residual herbicide of chlorthal-dimethyl (Dacthal W-75) + propachlor (Allbrass) was sprayed overall on 28 April to minimise weed germination in the planting holes. In addition to the deblossoming at planting, flowers were removed again on 17 May and finally on 1 June. Runner removal was also undertaken at intervals as required during the life of the crop, to help concentrate plant energy towards the growth, flowering and fruiting of the main discrete plants, and to avoid the development of a matted bed which would have made picking more difficult.

A regular fungicide programme for *Botrytis* and powdery mildew was used including sprays of dichlofluanid (Elvaron), triadimefon (Bayleton 5), fenpropimorph (Corbel), iprodione (Rovral WP) and chlorothalonil (Bravo 500). Sprays of bupirimate (Nimrod) and myclobutanil (Systhane Flo) for powdery mildew, were reserved until after picking commenced on 3 July due to their short harvest interval, and the restriction on total seasonal applications permitted.

As in 1994, low levels of blossom weevil and thrips were noted in mid July, and these were controlled with a light spray of malathion (Malathion 60) targeted at the flowers. A spray of clofentazine (Apollo 50SC) in mid May, followed by introductions of *Phytoseiulus* predators from late June, successfully controlled two-spotted spider mite for much of the season, although two sprays of bifenthrin (Talstar) were required in September following an extended period of hot, dry weather. Some applications of methiocarb (Draza) were applied to alleys in late September and October to control slugs and seed beetle. A 'gas gun' audible bird scarer was used against birds, and the trial was surrounded by electrified netting to help deter squirrels from taking fruit during the very dry weather. Jam jar water traps were used to trap wasps.

Portable or French Tunnels were used to protect the late crop from wind and rain, and extend the picking season as long as possible to evaluate any late season effects of the treatments. Tunnels were covered in early September and used as a rain cover with the sides lifted to about 1.0 m above the ground to give good ventilation. Towards the end of the crop in October and November, the tunnel sides were dropped to the ground to help maintain warmer air temperatures and ripen the fruit, with some ventilation given occasionally as required.

Records and analysis of results

Crown count at planting

Shortly after planting, and before plants had made any significant growth in the field, crowns of 12+ mm, 7 - 11 mm and < 7 mm were counted on a sample of 12 plants per plot. Plot means were subjected to an analysis of variance (ANOVA).

Yields

Fruit was picked and plot yields recorded as Class 1 and 2 according to EC quality standards. Fruit size grades used were as in 1994 and incorporated the 1993 changes in the EC standards for minimum diameter for Class 1 berries from 18 mm to 22 mm. In addition, account was taken of the maximum size normally accepted by supermarkets of 45 mm, although these berries are still within the EC Class 1 specifications.

Class 1 fruit was thus size graded into:	Extra large	Large	Small
	> 45 mm	35 - 45 mm	22 - 35 mm

Class 2 fruit (typically of slightly poorer shape and of 22 mm minimum size), and waste fruit (very poor shape, undersized, damaged or soiled) was also picked and recorded.

Picking was carried out twice weekly from the beginning of cropping on 3 July, until 23 October when the final five harvests were made at weekly intervals. There were 37 picks in total over a harvest period of 21 weeks.

Final cumulative yields of each grade, and cumulative Class 1 monthly yields were analysed by ANOVA.

Soil and foliage analyses

In addition to the pre-planting soil analyses already described (p. 6), a final 0 - 300 mm sample was taken from each plot on 12 September once fertigation treatments had finished. These were analysed for pH, P, K, Mg, and available NO_3-N and NH_4-N.

Foliage samples, consisting of 25 trifoliate leaf laminae per plot, were taken on three occasions at 9 week intervals during the trial:

7 July (week 27)
5 September (week 36)
7 November (week 45)

These were analysed for N, P, K, Mg, Mn, and Ca, and the results subjected to ANOVA.

Shelf life

Fruit quality attributes such as firmness, resistance to post harvest rotting, and general appearance typically declines later in the season as plant growth, fruit development and ripening slows down. A sample of 25 berries per plot were taken on 9 October from the late flush of fruit to observe treatment effects on shelf life. Fruit was held in a shelf life environment at approximately 10 °C, and a relative humidity > 70% for an assessment period of 14 days. Berries were placed on the bases of the cells of inverted Hassy plug trays so that any evidence of decay could be seen with the minimum of handling, and also to minimise the risk of fungal spread through fruit contact. Fruit was recorded daily, and berries showing any signs of post harvest decay removed. They were also scored for shininess and colour using the following scale:

Berry shine score:	1 = very dull and matt	Berry colour score:	1 = pale orange
	2 = dull		2 = orangy red
	3 = average sheen		3 = red
	4 = shiny and bright		4 = crimson
	5 = very glossy		5 = very dark

ANOVA was used to analyse the number of days until 10% and 50% of fruit had rotted, the percentage remaining clean after 14 days, and the shine and colour scores.

Results of a similar shelf life assessment from the 1994 trial, which were unavailable for the second year trial report, are also presented. In this case the fruit sample was picked on 13 October 1994, and also held at 10 °C and a high humidity. In this trial, an overall 'visual appearance' score taking account of both colour and shininess was attempted but was difficult to interpret during scoring and subsequent analysis, and therefore these results are not included.

Two small scale taste assessments on some of the late fruit (picked 6th and 17th October) was also undertaken in 1995 with tasters being asked to score sweetness, sharpness, 'strawberry flavour', and overall firmness on a 0 - 9 scale.

RESULTS

Crown count at planting

Table 3: **Number of crowns per plant recorded 3 May 1995, means of 12 plants / plot**

Cultivar	diameter of crowns 12+ mm	7 - 11 mm	<7 mm	Total
A Calypso	0.84	0.86	0.28	1.98
B Tango	0.60	1.18	0.78	2.56
C Evita	0.92	0.56	0.19	1.67
SED (33df)	*0.058*	*0.068*	*0.070*	*0.062*
LSD (5%)	*0.12*	*0.14*	*0.14*	*0.13*
Significance, P	*<0.001*	*<0.001*	*<0.001*	*<0.001*

Differences in crown numbers between cultivars were statistically highly significant ($P<0.001$), and were larger than in 1994. As in the previous trial, Tango had most crowns in total although of smaller size than the other cultivars. In contrast to 1994, where Evita and Calypso had very similar initial crown counts, Evita had slightly fewer crowns in total than Calypso, but they tended towards being thicker.

General growth

In 1994, the weather after planting, particularly during May, was cooler and wetter than normal, followed by a long, hot spell during July, August and September (Appendix VI, Tables 1-4, pp. 40-43). In 1995, the hot weather started in April, and remained unusually hot right through until early September. This resulted in an even larger and more condensed first flush of fruit than in the previous trial, followed by a period with very little fruit and new flower, and then a sizeable late crop which was picked mainly during October. Powdery mildew was controlled better in 1995 than in 1994 following a more rigorous programme of early sprays, as was two-spotted spider mite with the IPM programme.

Only one plant in the trial failed to establish, but in early July a proportion of cv. Elsanta plants were discovered as rogues within the plots of Evita. These were identified by their different leaf shape and habit which only became clearly evident at that time. The source of the error could not be determined by that stage. The proportion of rogue plants averaged 30% within the Evita plots. These plants were left *in situ* to avoid potential problems due to uneven plant spacings within the plots, but the rogue plants were treated as missing plants and plot yields corrected accordingly. No fruit was picked off the Elsanta, as flowers were removed along with the everbearers during the deblossoming phase. The Elsanta leaves were trimmed back later in the season when they began to develop powdery mildew infection. Subsequent analysis showed that, although unfortunate, the presence of the rogue plants did not unduly affect the yield estimates for the Evita treatments.

No differences in appearance (amount of vegetative growth or foliage colour) could be observed between nutrition treatments, within cultivars, during both the 1994 and 1995 trials.

Yield and grade out

Details of the cumulative total yields for the whole cropping season is given in Appendix IV, Table 1, p. 36. Figure 1, p. 14 summarises the final yields of >35 mm and <35 mm Class 1 fruit, and Class 2 plus waste.

Unlike 1994, where there were no significant differences in cumulative yields by the end of the cropping period, there was a trend towards slightly higher yields with the 40+40 and 40+80 treatments. The interaction with cultivars was not significant, but the main effects of nutrition treatment on total crop yields (including Class 2 and waste), compared to the 40+0 treatment, were 8% and 10% greater for the 40+40 and 40+80 treatments respectively ($P<0.05$). The nil N base treatment (0+40) gave a similar result to the nil fertigation (40+0) treatment. A similar trend was shown for the total of Class 1 fruit, with 6.5% and 9% increases over the 40+0 treatment for the 40+40 and 40+80 treatments respectively, but this result was not statistically significant. The amount of waste fruit for the two higher N treatments was slightly greater than for the lower N treatments ($P<0.01$), although this only represented a mean increase in waste fruit as a proportion of the total crop from 16.0% to 17.5% for these treatments.

Differences in mean yields between cultivars, as in 1994, were much greater than for nutritional effects, and were statistically highly significant ($P<0.001$) for all variates analysed. Calypso gave the highest Class 1 yield in 1995 of 1165 g/plant, equivalent to 30.7 tonnes/ha or 12.3 tons/acre, though this was not significantly more than Tango at 1104 g/plant (29.1 tonnes/ha or 11.6 tons/acre). Evita gave the best Class 1 yield in 1994, but performed less well in 1995 with 925 g/plant Class 1 (24.3 tonnes/ha or 9.7 tons/acre). Yields overall were greater than in 1994.

Figure 1.

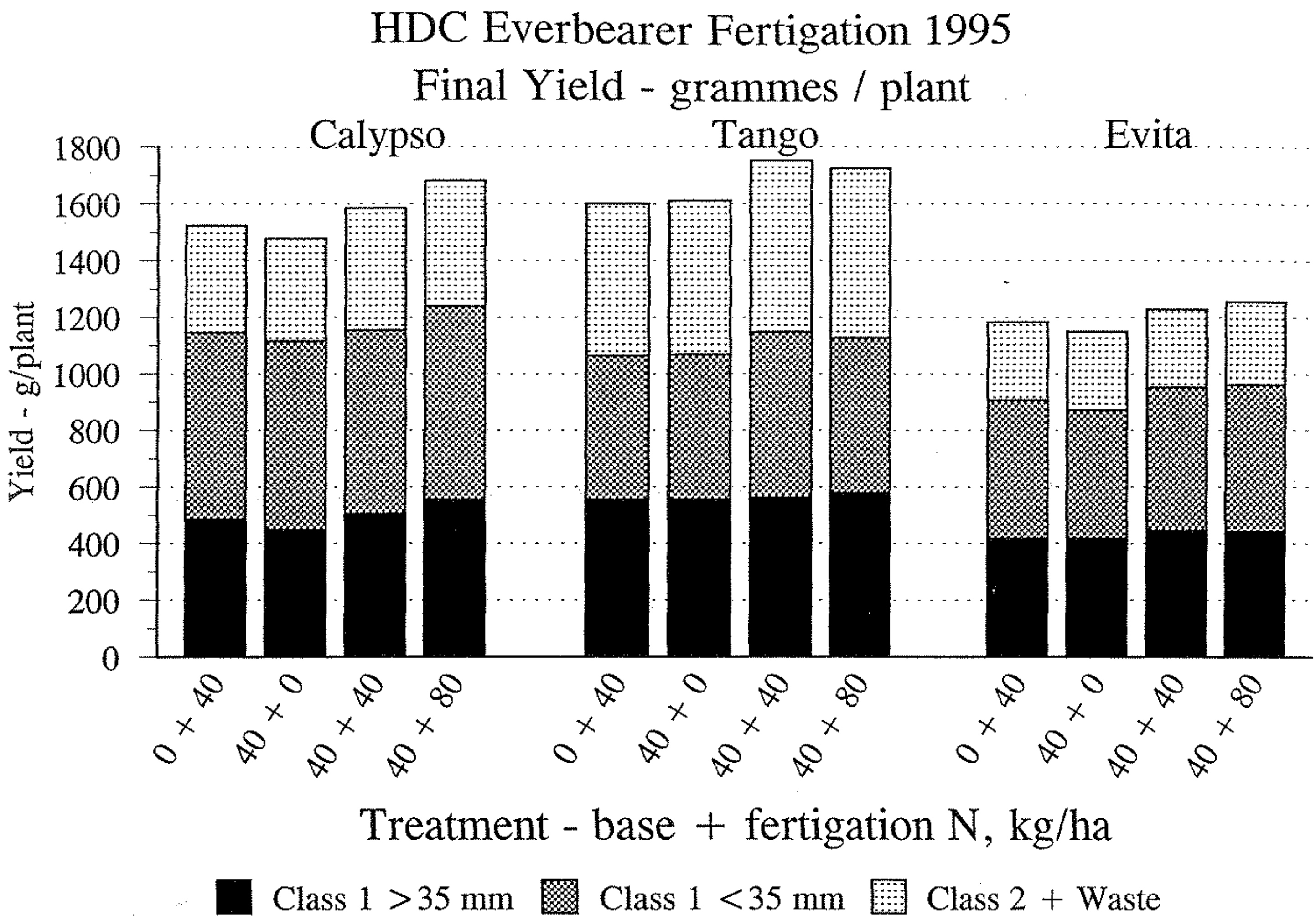
HDC Everbearer Fertigation 1995
Final Yield - grammes / plant
Calypso
Tango
Evita
Yield - g/plant
1800
1600
1400
1200
1000
800
600
400
200
0
0 + 40
40 + 0
40 + 40
40 + 80
Treatment - base + fertigation N, kg/ha
Class 1 >35 mm
Class 1 <35 mm
Class 2 + Waste

Table 4 shows a summary of the grade out of all large (>35 mm) and extra large fruit (>45 mm) as a proportion of the total Class 1 yield, and also the proportions of Class 1, 2 and waste fruit of the total crop. The differences due to nutrition treatments were small, and results are therefore presented as overall means for each cultivar. As in 1994, Tango produced a lower proportion of Class 1 fruit than the other cultivars. Some of the early primary berries were typically of poor shape with this cultivar, and it was also slightly less firm than Calypso and Evita. In addition late fruit tended to be more susceptible to rots. Tango fruits can become affected by powdery mildew under severe disease conditions, although there was much wastage due to this than in 1994 since better control of Powdery Mildew was achieved. Some berries of all cultivars were damaged by wasps unusually early in the season in August, and in the hottest weather some fruit developed sunken brown lesions believed to be the result of sun scorch. Most other causes of waste were from mechanical damage, bird pecks, malformation, undersize berries, and some fruit splitting. Losses from *Botrytis* and other rots were almost exclusively confined to the late flush of fruit.

Both Tango and Calypso produced a higher proportion of very large fruit (>45 mm) in 1995 than the previous year, although all the cultivars produced a smaller proportion of fruit >35 mm. There is no defined upper limit for fruit size within Class 1 under EC grading regulations, but >45 mm berries are typically too large for supermarket outlets.

Table 4: Size and quality grade out of final cumulative yield - cultivar means

Treatment	% of Class 1		% of Total Crop		
	> 45 mm	> 35 mm	Class 1	Class 2	Waste
Calypso	6.4	43.0	74.3	10.1	15.6
Tango	10.3	51.2	66.0	14.4	19.6
Evita	7.8	46.8	76.8	8.8	14.4

Cropping season

Figure 2, p.17 illustrates how the proportion of Class 1 fruit changed throughout the cropping period for each cultivar. The amount of fruit picked during September was small, but quality remained good. Tango produced a better late flush of fruit than in 1994, but with a significantly lower proportion of Class 1 fruit in October than Calypso and Evita, and negligible quality fruit in November.

Figure 3, p. 17, illustrates the cropping profile for Class 1 fruit for the three cultivars averaged over the nutrition treatments. In many ways it is similar to that for the 1994 trial, except that the early flush of fruit was more condensed, and Evita did not crop as heavily. There was also less fruit from all cultivars during late August and September. Calypso produced the most late fruit in 1995, but Tango did better than in 1994 with a heavy late crop in October.

Table 5, p. 18, gives the cumulative Class 1 total yields at the end of each month of the cropping season. Nutrition treatment yields averaged across cultivars are shown together with percentage yield differences from the 40+0 treatment. Although nutrition effects were not significant overall, differences did almost reach statistical significance at $P<0.05$ for yields up to the end of July, September and October. Data for total crop yields, including waste (not shown) did show some significant differences ($P<0.05$) for these periods. Also, the yield difference trends were consistent over the cropping period, with the base dressing plus high rate of fertigation (40+80) producing an 8 - 10% yield increase over the base dressing plus nil fertigation (40+0) treatment. The trend contrasts somewhat to 1994 where a trend towards higher early yields from fertigation (shown only by Calypso and Evita) had disappeared by the end of the trial.

Figure 2. HDC Fertigation 1995 - Monthly % Class 1 of Total Crop
Mean of fertigation treatments

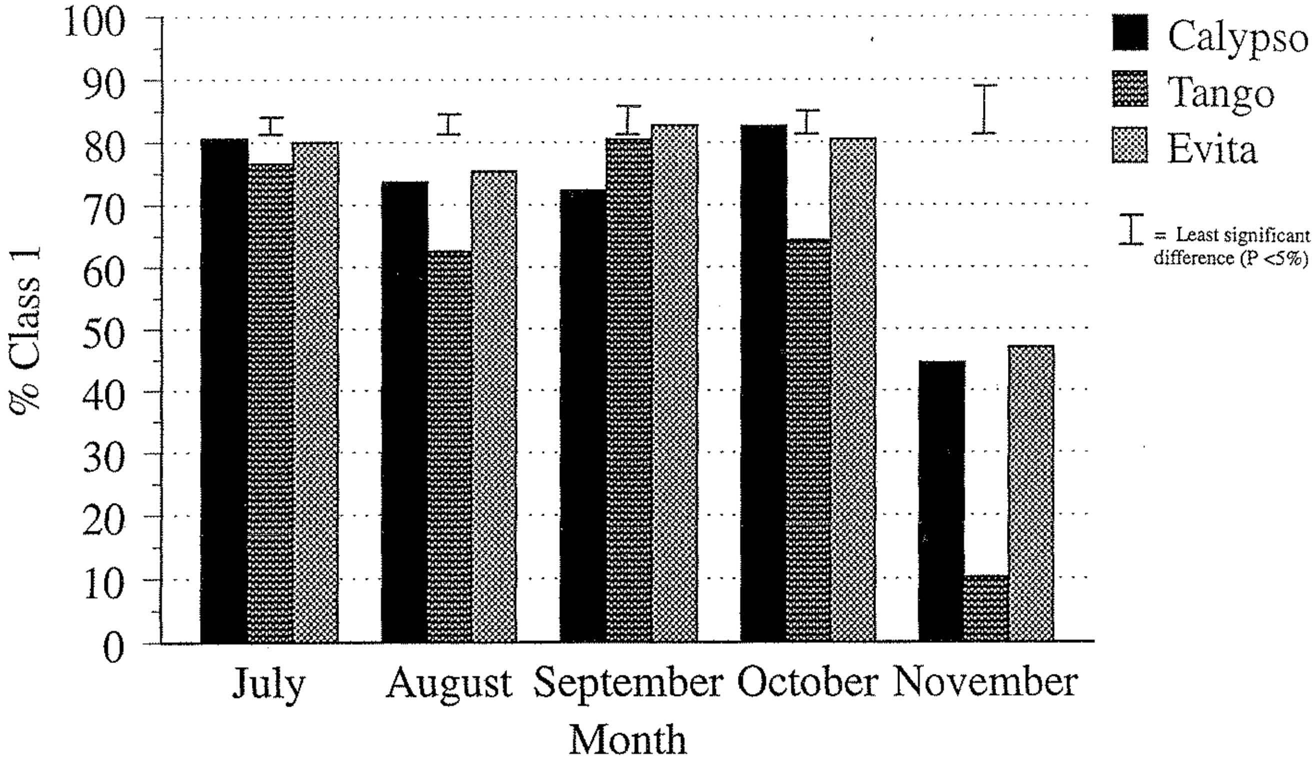

Figure 3. HDC Fertigation 1995 - Class 1 Weekly yields
Mean of fertigation treatments

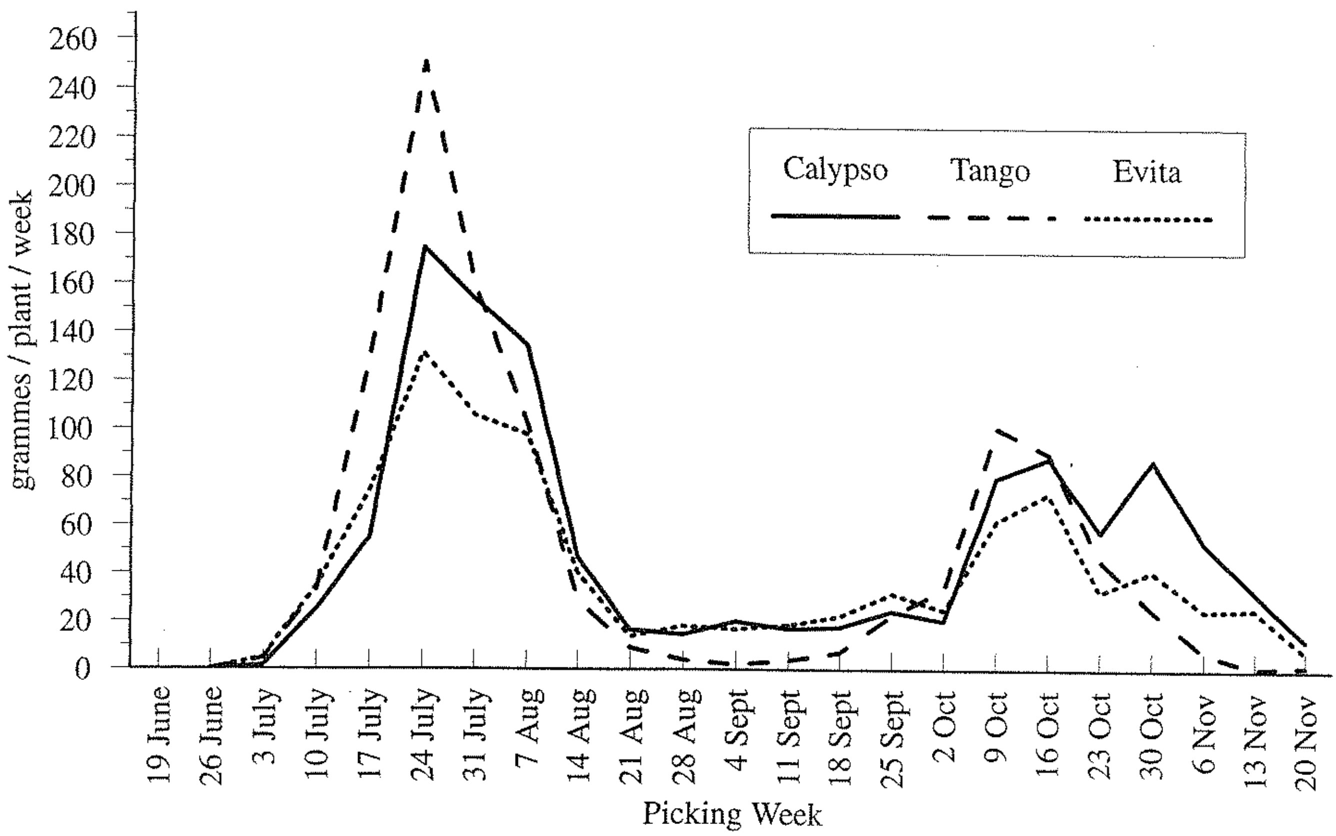

Table 5: Cumulative monthly yields 1995, Class 1 g/plant*

Treatment		end July	end Aug	end Sept	end Oct	end Crop
Calypso	0 + 40	359	624	702	1057	1148
	40 + 0	325	587	645	1003	1118
	40 + 40	343	594	682	1066	1156
	40 + 80	366	683	774	1145	1240
Tango	0 + 40	485	699	730	1058	1065
	40 + 0	508	697	732	1065	1071
	40 + 40	518	731	768	1129	1151
	40 + 80	545	761	800	1123	1129
Evita	0 + 40	304	512	602	859	908
	40 + 0	288	520	609	813	873
	40 + 40	291	543	616	880	953
	40 + 80	318	508	611	917	964
Means for cultivars						
Calypso		348	622	701	1067	1165
% of final yield		30	53	60	92	100
Tango		514	722	758	1094	1104
% of final yield		47	65	69	99	100
Evita		300	520	610	867	925
% of final yield		32	56	66	94	100
Means for nutrition						
	0 + 40 (% diff. from •)	383 +2.4%	611 +1.6%	678 +2.4%	991 +3.2%	1040 +2.0%
	40 + 0	374 •	602 •	662 •	960 •	1020 •
	40 + 40	384 +2.6%	622 +3.5%	689 +4.0%	1025 +6.8%	1086 +6.5%
	40 + 80	410 +9.5%	651 +8.2%	728 +10.0%	1062 +10.6%	1111 +8.8%
Comparing individual treatment means						
SED (33 df)		*22.6*	*44.6*	*44.5*	*65.6*	*79.3*
Significance, P		*NS*	*NS*	*NS*	*NS*	*NS*
Comparing nutrition main effects, yield						
SED (33 df)		*13.1*	*25.7*	*25.7*	*37.9*	*45.8*
LSD (5%)		*27*	-	*52*	*77*	-
Significance, P		*0.058*	*NS*	*0.083*	*0.066*	*NS*
Comparing cultivar main effects, yield						
SED (33 df)		*11.3*	*22.3*	*22.2*	*32.8*	*39.6*
LSD (5%)		*23*	*45*	*45*	*67*	*81*
Significance, P		*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*

* g/plant divided by 38 = tonnes/ha, g/plant divided by 95 = tons/acre

Foliage analyses

Analyses of the three leaf samples taken during the cropping season are detailed in Tables 1 - 3, Appendix V, pp. 37 - 39. Leaf sampling started about one month earlier than in 1994, but the three samples were spaced further apart and the final sample was taken in week 45 in both years.

Leaf analysis data can be difficult to interpret unless there are very marked deficiencies or excess levels present. Data presented here will help accumulate a reference database for these cultivars, as differences between cultivars can be significant, and existing reference standards are based on either old UK cultivars (Bould, 1964), or American cultivars (Ulrich, Mostafa and Allen, 1980). Please refer to the SF 33 Year 2 (1994) trial report for further information on interpretation, but a summary of key points is given here.

As in 1994, leaf N concentration did not appear to respond markedly to the nutrition treatments applied. For July and September, levels were within Bould's 'marginal' range, particularly for Evita, but, as last year, had recovered for all cultivars by the November sample.

Levels of K were above the 1.5% recommended by Bould during fruiting for the July sample, but following the first heavy flush of fruit all levels had dropped, with Tango and Evita showing < 1.5% K in early September. By the November sample they had recovered. Interestingly there were statistically significant differences between nutrition treatment effects in September with the nil fertigation (40+0) and highest N treatment (40+80) showing lower levels of K on average for Tango and Evita, but not for Calypso. In 1994 the 40+80 treatment also showed a low K level for a sample taken later in September, and a high N:K_2O ratio in the feed was suggested as possibly causing reduced K uptake.

P levels were adequate in July and September, but had dropped to 'marginal' levels for Calypso and Evita by November. Mg leaf concentrations were within Bould's 'sufficiency' zone (>0.15%) throughout, and as in 1993 and 1994, Tango maintained higher Mg levels than the other cultivars. Ca levels were also well above Ulrich *et al*'s 'critical' concentration of 0.3%, and again Tango showed higher levels than the other cultivars. Mn levels were lower overall than in 1994, but were well above critical concentrations.

Late season soil analyses

See Table 6, p. 20. The soil analysis for available mineral N showed that the non fertigated (40+0) treatment had very slightly lower levels than at the start of the trial whereas the all the fertigated treatments had slightly elevated levels. Differences were relatively small, however, and not quite as marked as in the 1994 trial, where the non fertigated (40+0) treatment had dropped to low levels equivalent to 28 kg/ha N by the time the soil was sampled after cropping had finished.

As in 1994, soil K levels were little changed at the end of the trial, even on the non fertigated 40+0 plots, which did not receive the total of 80 kg/ha as fertigation that the other treatments had. P levels were very similar, and Mg levels had risen slightly.

Table 6: Soil analyses of samples taken 12 September 1995

Means of samples (0 - 300 mm depth) from 4 nutrition treatments x 4 replicates. Samples bulked over cultivars within a nutrition treatment

Treatment	pH	mg/litre P	mg/litre K	mg/litre Mg	mg/kg NO_3-N	mg/kg NH_4-N	≡kg/ha N
Means for nutrition							
0 + 40	6.6	57	273	137	14.75	0.96	63
40 + 0	6.5	62	268	134	14.36	0.89	61
40 + 40	6.5	57	271	141	19.34	1.15	82
40 + 80	6.5	56	264	134	20.81	1.03	87

Shelf life

Table 7, p. 21 shows the amount of post-harvest decay for the late season fruit samples held in a 10 °C shelf life room from the 1994 and 1995 trials. Results varied slightly between the two years, but there was a clear indication that Tango had poorer shelf life, with more rapid development of decay, than the other cultivars, especially in the 1995 trial ($P<0.001$). Nutrition treatment effects were generally not statistically significant in either year, but in 1995 the 40+80 treatment did show a trend towards poorer shelf life.

The berry shine scores in 1995 showed no significant effects, and mean scores for berry colour over the shelf life period showed that Tango remained palest and Calypso darkest (data not shown). There was a trend towards slightly darker colour with the higher N regimes, but this was not quite significant at $P<0.05$.

The small scale taste assessments did not produce any clear cut results, and no evidence that the nutrition treatments affected the flavour of the early and mid October fruit samples. Tango, however, was generally regarded as having a poorer flavour than the other cultivars at this time.

Table 7: Shelf life of fruit from 1994 trial and 1995 trial. Number of days until 10%, 50% and 75% had decayed, and proportion of original number of berries remaining clean after 14 days. Fruit held at 10 °C. Main treatment effects

Treatment	Days until decayed 10%	50%	75%	Percentage remaining clean after 14 days
	1994 Trial (sampled 13 Oct)			
Cultivar means				
Calypso	6.4	14.6	18.7	46.2
Tango	5.8	11.5	15.5	37.3
Evita	8.0	15.6	19.5	49.6
Nutrition means				
0 + 40	5.9	15.1	18.6	46.3
40 + 0	8.3	13.7	18.0	46.0
40 + 40	7.1	13.7	16.9	42.1
40 + 80	5.4	13.1	18.1	43.2
Comparing nutrition main effects				
SED (33 df)	*1.35*	*1.73*	*1.58*	*7.08*
LSD (5%)	-	-	-	-
Significance, P	*NS*	*NS*	*NS*	*NS*
Comparing cultivar main effects				
SED (33 df)	*1.17*	*1.50*	*1.37*	*6.13*
LSD (5%)	-	*3.1*	*2.8*	-
Significance, P	*NS*	*0.024*	*0.015*	*NS*
	1995 Trial (sampled 9 Oct)			
Cultivar means				
Calypso	6.2	11.0	na	30.0
Tango	4.9	7.6	na	7.6
Evita	5.3	9.4	na	24.3
Nutrition means				
0 + 40	6.1	9.6	na	21.8
40 + 0	5.4	9.8	na	22.4
40 + 40	5.9	9.5	na	23.1
40 + 80	4.4	8.5	na	15.2
Comparing nutrition main effects				
SED (33 df)	*0.57*	*0.61*		*3.97*
LSD (5%)	*1.2*	-		-
Significance, P	*0.019*	*NS*		*NS*
Comparing cultivar main effects				
SED (33 df)	*0.49*	*0.52*		*3.44*
LSD (5%)	*1.0*	*1.1*		*7.0*
Significance, P	*0.034*	*<0.001*		*<0.001*

DISCUSSION

Crown numbers, cultural conditions and yield

Previous experience with everbearers has shown that the initial size of plant, when planted in the field in spring, can have a significant effect on subsequent yield. A comparable propagation history between cultivars, as in this trial, is important if valid comparisons are to be made. In 1994, initial crown counts for Evita were as good as the other cultivars and yields were comparable. Evita plants had fewer crowns in the 1995 trial compared to Tango and Calypso, which might have contributed to its poorer performance. However indications from growers' experience was that Evita generally did not perform as well in 1995 as in 1994. Tango appeared, in both years, to produce more crowns than the other cultivars, but of smaller diameter.

Despite plants being slightly smaller for Calypso and Tango in 1995 than 1994, yields were greater. Whereas a period of cool weather following planting delayed early plant growth in the earlier trial, conditions were warmer during establishment in 1995, and, coupled with a plentiful irrigation supply, plants appeared slightly larger by the time cropping started. Other significant factors in favour of the final trial were that the raised beds were made the previous autumn (wet conditions meant this had to be delayed until spring for the 1994 trial), and powdery mildew and two-spotted spider mite were better controlled.

Nutrition treatments and yield

The general conclusions from the first two years of this project appear to hold good for this final year. Namely, that while these everbearers appear to have a greater need for nitrogen in the spring and summer than Junebearers, to build up plant size for flowering and fruiting, their total requirement is still only moderate. *Large* yield increases from applying more than 40 kg/ha N either as a base dressing or as fertigation were not found on the sandy silt loam at Efford which had a fairly low background level of N. In contrast to the previous season, the early Class 1 yield increase (over the 40+0 treatment) of up to about 10% for the highest fertigation rate (40+80) treatment, was not cancelled out by the late flush of fruit in the 1995 trial. Also, the higher fertigation rate for N (40+80) gave a trend of greater mean yield than the lower rate (40+40), though these differences did not prove to be statistically significant.

Certainly, most benefit appears to be gained from early season nutrition, which includes adequate feeding before planting where pot grown material is used. Any check to growth before or after planting, due to nutrient deficiency in the pot, is unlikely to be fully compensated for by feeding in the field. Commencement of fertigation very soon after planting, as done in the 1995 trial, appears advantageous, particularly if plants establish from their pots with little check, as rapid crown development at this stage will lead to more and stronger sites for flower initiation and cropping. If a base dressing is not used, and there is little background available nitrogen or the soil type is particularly subject to leaching losses, early fertigation could be particularly important.

The comparison of the same nominal 40 kg/ha N applied as a base dressing or fertigation in this project showed no significant difference in yield response, although there was a very small non-significant trend towards higher yields with the 0+40 treatment in 1995. Although the same nominal rates of N were used for both methods of application, based on the rate per full crop area including alleyways, the fertigation application was obviously concentrated in the raised bed zone, whereas the base dressing was incorporated as a broadcast treatment over bed plus alley area. Fertigation ought to be a more efficient method of supplying nutrients, especially N, by minimising losses to soil outside the rooting zone, including losses by leaching, and by supplying the plant 'a little and often' throughout the growing season. If, however, the plant requires most nitrogen early on to maximise growth before cropping, then a base dressing may meet a significant proportion of that need. A more comprehensive set of treatments was outside the scope of this project, but, speculatively, a higher rate of base dressing may have given as good result as using additional fertigation. The fertigation regime was also simplified for this project by maintaining uniform nutrient concentrations throughout the dosing period. However, as is sometimes advocated by consultants, a higher ratio of $N:K_2O$ earlier in the season followed by a lower ratio once plants started fruiting, might match plant requirements more closely. This needs further investigation, alhtough in this trial a simple `level ratio' feed appeared to work well.

The cultivars used in this project do not appear to differ significantly in their nutritional requirement. Although there have been some minor differences (nutrition x cultivar interactions) throughout the project, these have not been consistent or statistically significant, and it appears that, for Calypso, Tango and Evita, at least, similar feeding recommendations can be applied.

Influence of soil type and extrapolation of results to other sites

Strawberries are capable of growing well in a very wide range of soils, providing soil structure and water supply is adequate. The sandy silt loam at Efford is typical of many of the soils used for commercial strawberry production in the UK, and has a medium to high available water capacity. However, there are also very large areas of production on much lighter sandy soils, which leach nutrients more easily, and where nutritional recommendations may need to be adapted accordingly. If the soil has very little ability to hold nutrient reserves, ('buffering capacity'), then weekly fertigation applications as carried out in this trial might be flushed out by additional in-between applications of plain water to supply the crop's irrigation need. In that case, applications of weaker feeds more frequently would be more sensible. An extreme example exists with peat bag or hydroponic growing systems, where there is minimal buffering capacity of the growing medium, and several daily applications of feed solution are typically applied.

The use of raised beds and polythene mulches, is now the widely accepted norm for most fresh market everbearer strawberry crops, and has the advantage of minimising leaching by rain of any incorporated base dressings, as well as preserving soil structure, particularly for sites prepared in the autumn, and planted the following spring. Given the relatively low cost of applying a base dressing at the time when raised beds are made, and that other major nutrients often need adding at the same time, it still seems a practical method of boosting the starting level of N in the soil, whether or not additional fertigation is applied.

The processes involved in nitrogen chemistry in the soil are complex and dynamic. For example the action of cultivation and the use of soil sterilisation will enhance the rate of mineralisation of organic sources of N in the soil which makes nitrogen available to plants. Results from soil mineral N analysis can therefore only give a guideline, but if a sample is taken from the mulched raised beds in spring, it should give some indication of the amount of N available to the crop at the beginning of the season, and enable fertigation rates to be amended if necessary to minimise the risk of over or underfeeding. If soil is not analysed for nitrogen, then at least a knowledge of previous cropping history, whether or not soil sterilisation has been used, and the rate of any N applied as a base dressing using current ADAS guidelines to arrive at an N index, should be used to guide decisions. The soil analyses in this trial showed that following the base dressing, which brought levels up to about 75 kg/ha N in the top 300 mm, with no additional fertigation, levels were still equivalent to around 60 kg/ha by September, and where fertigation was used, it had only risen to less than 90 kg/ha. This indicates that none of the treatments had developed any major accumulations or depletions in soil nitrogen during the trial, and helps explain the relatively low response from the crop to the higher rates of added N in this project.

A tentative guideline would be that if levels of available N, in the top 300 mm, at planting in spring, and after any base dressing has been applied, were around 75 - 100 kg/ha, then fertigation up to 40 kg/ha N total could be of benefit. On some soil types, such as clays, even this might not be required. If levels of available N are below 30 - 40 kg/ha, higher rates of fertigation up to a total of 80 kg/ha N could give worthwhile yield increases, particularly on very light soils, but lower rates of 40 kg/ha N should still be adequate on heavy soils.

A base dressing alone has given good results in these trials, and would be a cheaper option. However, only a small increase in yields from additional fertigation, as indicated in these trials, may be necessary to cover the costs of dosing equipment and the extra management involved. A cost-benefit analysis should be considered taking into account the circumstances applicable to the site.

Cropping season

Both 1994 and 1995 at Efford were characterised by very hot weather during most of the summer cropping period, although temperatures were highest, on average, in 1995 and the warm weather started earlier. In both years cropping dropped to a low ebb during late August and September, followed by a late flush during October and early November. The late crop was better in 1995, particularly for Tango. In the first trial in 1993, during a generally cooler season, the main early flush of fruit was followed by a gradual decline in weekly yields through to the end of cropping in early November. Possible explanations for the clearly separated early and late flushes in the two hot summers are discussed in the 1994 report. Although further work would be required to understand the mechanisms involved, high temperatures may have affected flowering and fruiting directly by reducing flower initiation or subsequent development ('thermodormancy'), or competition for assimilates from the heavy early fruit load may have interrupted the concurrent development of flowers which normally occurs in everbearers.

In 1995, 30 - 40% of the seasonal crop total was picked after the end of September. As in 1994, the use of French Tunnels for protecting this late crop may well have been economically justified, particularly as fruit prices remained quite firm.

Fruit quality and shelf life

None of the nutritional treatments produced any large or consistent effects on fruit quality, such as proportion Class 1 grade-out, flavour, firmness or shelf life. Differences between cultivars were always greater than effects of nutrition. However, the indication of poorer shelf-life, together with the slightly larger proportion of waste fruit from the 40+80 treatment in the 1995 trial, did support the view that high rates of feeding, particularly with nitrogen, could increase the susceptibility of fruit to rots such as *Botrytis*. This effect was most likely to show up on the late season fruit which tended to be more susceptible to rots than that picked in high summer. Thus fertigation at these rates is unlikely to be a problem early in the season, but unnecessarily continuing to fertigate at high rates of N later in the year, as well as wasting feed, might reduce fruit quality. In this trial fertigation stopped in early September, but the shelf-life sample of affected fruit was picked a month later in October. How far the higher concentration of N in the feed is a potential problem, or the higher ratio of $N:K_2O$ was not considered in this work, as rates of K_2O applied were kept constant between fertigation treatments. Again this would need further investigation. Previous experience suggests that there is a close correlation between the rate of post harvest rotting in a shelf life room and fruit firmness, and this showed up clearly in Tango's late fruit which tended to be softer and more susceptible to rotting.

As in the earlier trials, neither shelf life nor flavour were any worse from the 40+0 treatment which had received no K as fertigation. An adequate supply of K is believed to be important in the maintenance of fruit flavour and firmness, so it is likely that sufficient K was available from soil reserves in these trials.

Importance of nutrition in relation to other cultural factors

This project has concentrated on the field nutrition requirements of everbearers, and the trial in the first year clearly demonstrated that without any added N as a base dressing or any fertigation, they can suffer a sizeable reduction in plant growth and yield. The project has also demonstrated, however, that the overall nutrition requirement of everbearers is only moderate, and that provided some 40-80 kg/ha total N is added on a sandy silt loam soil, higher N rates result in only marginal or nil yield increases. It would also appear that the same requirements exist for three of the newest commercially important cultivars.

There is possibly some scope for fine tuning the timing and balance of nutrients applied during the season, given that the early field growth phase is the most important, and that the practical application of these results should take soil type into account. Nevertheless, there are other key factors for successful everbearer cultivation that could be of equal or greater importance for yield and quality. These include the quality and size of plants used and whether planted as bare root or from pots, the time of planting, the choice of plant spacing, and the maintenance of unchecked growth during spring and summer. Also important is close attention to irrigation requirements, the use of tunnels for protection of late fruit, and successful pest and disease control.

CONCLUSIONS

The overall objective of this three year project was to achieve a better understanding of, and improve the basis for, field nutrition recommendations for new everbearer strawberry cultivars in the UK, with particular reference to nitrogen.

- Most of the N requirement for everbearers is able to be met from a total of 40 kg/ha N applied either as a base dressing, or as fertigation on a sandy silt loam soil. However, small increases in early yield may be obtained from additional fertigation.

- Early feeding is of most importance for rapid initial plant growth before fruiting starts. The use of a base dressing will ensure N levels are adequate at the time of planting. Further applications of N as fertigation appear most effective if started soon after spring plantings or by early May.

- Fertigation beyond early September is unlikely to be beneficial, even if cropping is extended by the use of French Tunnels. There was some indication in the final year that the late season fruit was more susceptible to rots from the highest rate of feeding.

- For Efford's sandy silt loam with a low background level of N, a base dressing containing about 40 kg/ha N plus additional fertigation containing 40 kg/ha of N applied from late April/early May to early September should give good results without risking problems from poor late season fruit quality.

- The project has provided some experience on the use of soil mineral N analysis in spring as a potential tool for tailoring specific recommendations more closely to other sites and soil types.

- Calypso, Tango and Evita appear to have similar nutrition requirements.

REFERENCES

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APPENDICES

Appendix I **Planting plan and layout**

Version A2
C M Burgess
7/4/95

HDC SF 33
GLP 2043
IAS 30627

1995 Everbearer Fertigation Trial

N

S7
north west corner

Obs/guards (first and last beds)

III / IV (Header pipes)

D 40/40 52	A 40/80 4	A 0/40 8	B 40/40 12	B 40/80 16	C 40/0 20	A 40/40 24	C 40/0 28	B 0/40 32	B 40/40 36	A 40/0 40	C 0/40 44	A 40/40 48	A 40/0 56	B 40/0 60
D 40/40 51	B 40/0 3	C 40/80 7	C 40/40 11	C 0/40 15	A 40/0 19	B 0/40 23	B 40/0 27	C 40/40 31	C 40/80 35	A 0/40 39	A 40/80 43	B 40/80 47	C 40/0 55	E 40/40 59
D 40/40 50	B 0/40 2	B 40/0 6	C 0/40 10	A 40/40 14	B 40/80 18	C 40/40 22	A 40/40 26	A 0/40 30	B 40/40 34	B 40/80 38	A 40/80 42	C 0/40 46	C 40/80 54	E 40/40 58
D 40/40 49	C 40/80 1	B 40/40 5	C 40/0 9	A 40/0 13	A 0/40 17	A 40/80 21	B 40/0 25	C 40/0 29	C 40/40 33	B 0/40 37	A 40/0 41	C 40/80 45	B 40/80 53	A 40/80 57

I / II (Header pipes)

28m incl. 3 x 1.0m between plots

6.25m

15 beds @ 1.52m
= 22.8m

Treatments

A Calypso
B Tango
C Evita

kg/ha N
base / fertigation

0 + 40
40 + 0
40 + 40
40 + 80

Observation / guard cultivars

D EMR 63
E SBJ 7

Spring planted April 1995

500mm in row x 400mm between double rows

2 x 12 plants/plot staggered

Cropped area
28m x 22.8 m
= $638m^2$

APPENDIX II Irrigation and fertigation applications

Some waterings were applied with a hand lance and hose after planting for a few days. Irrigation quantities were calculated on a full cropped area basis including alleyways (ie based on raised bed spacings at 1.52 m centres). Irrigations and fertigations were applied via two lines of T-tape per bed. To convert from mm irrigation (ie litres/m^2) based on full crop area, to quantity applied in litres/m run of bed, multiply figures below by 1.52.

	mm fertigation	mm plain water
1995		
27 Apr	3.0	
3 May	3.0	
5 May		13.3
10 May		19.5
11 May	3.0	
16 May		19.0
19 May	3.1	
24 May	3.0	
28 May		8.4
31 May		7.0
1 Jun	3.0	
8 Jun	3.0	19.9
14 Jun		15.2
15 Jun	3.0	
22 Jun		14.4
23 Jun	3.0	
27 Jun		18.6
29 Jun	3.0	
3 Jul		12.8
6 Jul		9.3
7 Jul	3.0	
11 Jul		17.0
13 Jul	3.0	
18 Jul		12.2
20 Jul	3.0	
25 Jul		16.9
28 Jul	3.0	
1 Aug		14.6
3 Aug	3.0	
7 Aug		5.0
8 Aug		18.0
11 Aug	3.0	5.3
15 Aug		31.1
18 Aug	3.0	
23 Aug		15.5
24 Aug	3.0	
30 Aug		20.6
31 Aug	3.0	

continued .....

7 Sept	3.0		
9 Sept		6.3	
15 Sept		9.5	
27 Sept		4.0	
3 Oct		6.2	
10 Oct		5.8	
24 Oct		5.9	
10 Nov		4.4	
Total	**60.1**	**355.7**	
Total feed + plain water			**415.8**

This total of 415.8 mm feed + water applied over a period of 28.1 weeks is an average of about 14.8 mm/week or 2.1 mm/day. However, during the period 1 June - 31 August, which included the flowering through fruit swelling to end of harvesting the first flush of fruit, 288.4 mm was applied over 13.0 weeks which averaged 22.2 mm/week or 3.2 mm/day.

Appendix III Diary of cultural operations

1994

mid Aug & mid Sept	Strawberries mist rooted from runner cuttings direct into 7 cm (0.25 litre) pots. Overwintered in cold and well ventilated polythene tunnel, and grown on there until planting in spring.
11 Oct	Primary cultivations to field site.
19 Oct	Base dressings of K_2O and Mg applied overall following soil analysis, and 40 kg/ha N to appropriate plots.
20 Oct	Beds raised, T-tape laid, and beds mulched under good conditions.
28 Oct	Residual herbicide to alleys, simazine as Gesatop 500L at 2.0 l/ha + propyzamide as Kerb 50W at 0.75 kg/ha + chlorthal-dimethyl as Dacthal W75 at 9.0 kg/ha.

1995

13 Mar	Fosetyl-aluminium as Aliette at 3.75 g/litre HV spray (equivalent wetting to 1000 litres/ha) to potted plants as a red core and crown rot precaution.
20 Mar	Commenced liquid feeding potted plants with 200 mg/l N + 50 mg/l P_2O_5+ 200 mg/l K_2O + 25 mg/l Mg about twice per week until planting.
29 Mar	Triadimefon as Bayleton 5 at 1.0 g/litre + pirimicarb as Pirimor at 0.5 g/litre HV spray to potted plants for powdery mildew + aphids.
11 Apr	Bayleton 5 + Pirimor as above.
13 Apr	Trial planted. Plants deblossomed. Plants ball watered in, and extra waterings given with hand lance as required during the establishment period, until mid May in addition to those via T-tape listed in Appendix II.
27 Apr	Fertigation treatments started.
28 Apr	Residual herbicide as ½ rate propachlor as Allbrass at 4.5 l/ha + ½ rate Dacthal W75 at 4.5 kg/ha over beds.
1 May	Residual herbicide as Gesatop 500L at 3.0 l/ha + Kerb 50W at 0.75 kg/ha to alleys. Triazophos as Hostathion at 1.0 ml/litre + heptenophos as Hostaquick at 0.75 ml/litre HV spray for aphid and caterpillar.
2 May	Dichlofluanid as Elvaron at 4.5 kg/ha + Bayleton 5 at 1.0 kg/ha for *Botrytis* and powdery mildew.
15 May	Elvaron + Bayleton 5 as above. Clofentazine as Apollo 50SC at 0.4 l/ha for two-spotted spider mite.

17 May	Deblossomed all plants again.
24 May	Elvaron + Bayleton 5 as above.
1 Jun	Final deblossoming.
16 Jun	Plants derunnered. Fenpropimorph as Corbel at 1.0 l/ha for powdery mildew.
28 Jun	*Phytoseiulus* predators introduced at about 1.5 per plant.
30 Jun	Iprodione as Rovral Flo at 3.0 l/ha + Pirimor at 0.5 ml/litre for *Botrytis* and aphids. Derunnering continued.
3 Jul	First pick.
5 Jul	Completed strawing down crop.
20 Jul	Rovral WP at 1.5 kg/ha + myclobutanil as Systhane 6 Flo at 1.5 l/ha in 2000 litres/ha for *Botrytis* and powdery mildew. Also malathion as Malathion 60 at 1.9 mls/litre light overhead spray for flower pests.
31 Jul	Commenced truss pruning to maintain fruit size, ie during picking, trusses with only small fruits < 22 mm dia. remaining were removed and discarded.
4 Aug	Rovral WP at 1.5 kg/ha + Nimrod at 1.4 l/ha in 2000 litres/ha as above for *Botrytis* and powdery mildew.
11 Aug	Nimrod as above.
16 Aug	Second introduction of *Phytoseiulus* predators at about 1.5 per plant.
18 Aug	Some hand weeding of alleys and in planting holes.
6 Sept	Completed erecting French Tunnel hoops and all tunnels covered with polythene. Bifenthrin spray as Talstar at 0.4 litres/ha in 1000 litres/ha applied for two-spotted spider mite.
7 Sept	Final (20th) fertigation applied.
11 Sept	Systhane Flo + Rovral WP applied as above.
12 Sept	Part of the bell ends at south end of two tunnels covered with black polythene to deter bees and other insects from becoming trapped in the folds of the tunnel cover. (It appeared to work).
18 Sept	Talstar spray as above. Chlorothalonil as Bravo 500 at 6.0 litres/ha in 2000 litres/ha applied for *Botrytis* and powdery mildew.
20 Sept	Methiocarb as Draza at 5.5 kg/ha applied to alleys.
25 Sept	Rovral WP + Nimrod as above.

6 Oct	Rovral WP as above.
12 Oct	Rovral WP + Systhane 6 Flo as above.
19 Oct	Rovral WP + Nimrod as above.
25 Oct	Draza to alleys as above. Rovral WP + Systhane 6 Flo as above.
1 Nov	Rovral WP + Systhane 6 Flo as above.
7 Nov	Rovral WP + Systhane 6 Flo as above.
20 Nov	Final harvest.

APPENDIX IV

Table 1 Final cumulative yields 3 July - 20 November 1995 for each grade, g/plant*

Treatment	Class 1:	Extra large >45 mm	Large 35-45 mm	Small 22-35 mm	Total Class 1	Class 2	Waste	Total Crop incl. waste
Calypso	0 + 40	71	417	658	1148	166	210	1524
	40 + 0	69	382	665	1118	147	214	1479
	40 + 40	75	432	649	1156	160	270	1586
	40 + 80	82	475	683	1240	158	284	1682
Tango	0 + 40	104	454	507	1065	228	308	1601
	40 + 0	106	452	513	1071	242	350	1612
	40 + 40	109	455	587	1151	249	353	1753
	40 + 80	134	447	548	1129	246	350	1725
Evita	0 + 40	77	342	489	908	101	175	1184
	40 + 0	79	340	454	873	112	163	1148
	40 + 40	69	378	506	953	109	167	1229
	40 + 80	63	381	520	964	104	188	1256
Means for cultivars								
Calypso		74	427	664	1165	158	245	1568
Tango		113	452	539	1104	241	328	1673
Evita		72	361	492	925	106	173	1204
Means for nutrition								
	0 + 40	84	404	552	1040	165	231	1436
	40 + 0	85	392	543	1020	167	226	1413
	40 + 40	84	422	580	1086	172	264	1522
	40 + 80	93	434	584	1111	170	273	1554
Comparing individual treatment means								
SED (33 df)		12.8	34.5	59.9	79.3	19.1	24.8	94.1
Significance, P (interaction)		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Comparing cultivar main effects								
SED (33 df)		*6.4*	*17.2*	*29.9*	*39.6*	*9.6*	*12.4*	*47.1*
LSD (5%)		*13*	*35*	*61*	*81*	*19*	*25*	*95*
Significance, P		*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*
Comparing nutrition main effects								
SED (33 df)		*7.4*	*19.9*	*34.6*	*45.8*	*11.0*	*14.3*	*54.4*
LSD (5%)		-	-	-	-	-	*29*	*111*
Significance, P		*NS*	*NS*	*NS*	*NS*	*NS*	*0.004*	*0.040*

* g/plant divided by 38 = tonnes/ha, g/plant divided by 95 = tons/acre

Foliage analyses

Table 1 **Analysis of leaf laminae; first sample 7 July 1995 (week 27)**

Treatment		Concentration on dry weight % N	% P	% K	Mg mg/kg	Ca mg/kg	Mn mg/kg
Calypso	0 + 40	2.23	0.256	1.88	0.244	1.16	51
	40 + 0	2.31	0.253	1.90	0.253	1.15	45
	40 + 40	2.36	0.236	1.86	0.253	1.24	48
	40 + 80	2.41	0.245	1.85	0.254	1.21	51
Tango	0 + 40	2.47	0.281	2.16	0.320	1.40	43
	40 + 0	2.62	0.272	2.11	0.355	1.61	41
	40 + 40	2.48	0.303	2.16	0.330	1.41	47
	40 + 80	2.63	0.292	2.25	0.327	1.35	47
Evita	0 + 40	2.11	0.277	1.73	0.302	1.28	47
	40 + 0	2.13	0.324	1.82	0.292	1.18	49
	40 + 40	2.06	0.299	1.71	0.324	1.29	53
	40 + 80	2.24	0.287	1.82	0.310	1.31	49
Means for cultivars							
Calypso		2.33	0.247	1.87	0.251	1.19	48
Tango		2.55	0.287	2.17	0.333	1.44	44
Evita		2.13	0.297	1.77	0.307	1.27	49
Means for nutrition							
	0 + 40	2.27	0.271	1.92	0.289	1.28	47
	40 + 0	2.35	0.283	1.94	0.300	1.32	45
	40 + 40	2.30	0.279	1.91	0.302	1.31	49
	40 + 80	2.42	0.275	1.97	0.297	1.29	49
Comparing individual treatment means							
SED (33 df)		*0.163*	*0.0149*	*0.047*	*0.0146*	*0.115*	*3.9*
LSD (5%)		-	*0.030*	-	-	-	-
Significance, P		*NS*	*0.031*	*NS*	*NS*	*NS*	*NS*
Comparing cultivar main effects							
SED (33 df)		*0.082*	*0.0074*	*0.023*	*0.0073*	*0.058*	*1.9*
LSD (5%)		*0.17*	*0.015*	*0.05*	*0.015*	*0.117*	*4*
Significance, P		*<0.001*	*<0.001*	*<0.001*	*<0.001*	*<0.001*	*0.031*
Comparing nutrition main effects							
SED (33 df)		*0.094*	*0.0086*	*0.027*	*0.0084*	*0.066*	*2.2*
LSD (5%)		-	-	-	-	-	-
Significance, P		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*

Table 2 Analysis of leaf laminae; second sample 5 September 1995 (week 36)

Treatment		Concentration on dry weight					
		% N	% P	% K	Mg mg/kg	Ca mg/kg	Mn mg/kg
Calypso	0 + 40	2.45	0.300	1.58	0.237	1.17	87
	40 + 0	2.33	0.289	1.56	0.238	1.23	79
	40 + 40	2.30	0.274	1.50	0.235	1.48	84
	40 + 80	2.39	0.281	1.56	0.240	1.40	105
Tango	0 + 40	2.43	0.279	1.55	0.335	2.26	60
	40 + 0	2.34	0.242	1.21	0.397	3.26	64
	40 + 40	2.37	0.284	1.49	0.374	2.60	69
	40 + 80	2.37	0.250	1.26	0.401	2.96	117
Evita	0 + 40	2.13	0.266	1.43	0.253	1.50	70
	40 + 0	2.02	0.261	1.37	0.308	2.11	67
	40 + 40	2.07	0.290	1.44	0.296	1.93	74
	40 + 80	2.03	0.252	1.39	0.282	1.94	75
Means for cultivars							
Calypso		2.37	0.286	1.55	0.237	1.32	89
Tango		2.38	0.263	1.38	0.376	2.77	77
Evita		2.06	0.267	1.41	0.285	1.87	72
Means for nutrition							
	0 + 40	2.33	0.281	1.52	0.275	1.64	73
	40 + 0	2.23	0.264	1.38	0.314	2.20	70
	40 + 40	2.24	0.282	1.48	0.301	2.00	76
	40 + 80	2.26	0.261	1.40	0.308	2.10	99
Comparing individual treatment means							
SED (33 df)		*0.086*	*0.0222*	*0.083*	*0.0179*	*0.250*	*9.0*
LSD (5%)		-	-	*0.17*	-	-	*18*
Significance, P		*NS*	*NS*	*0.031*	*NS*	*NS*	*0.006*
Comparing cultivar main effects							
SED (33 df)		*0.043*	*0.0111*	*0.042*	*0.0090*	*0.125*	*4.5*
LSD (5%)		*0.09*	-	*0.08*	*0.018*	*0.25*	*9*
Significance, P		*<0.001*	*N.S*	*<0.001*	*<0.001*	*<0.001*	*0.002*
Comparing nutrition main effects							
SED (33 df)		*0.050*	*0.0128*	*0.048*	*0.0104*	*0.144*	*5.2*
LSD (5%)		-	-	*0.10*	*0.021*	*0.29*	*11*
Significance, P		*NS*	*NS*	*0.025*	*0.003*	*0.003*	*<0.001*

Table 3 **Analysis of leaf laminae; third sample 7 November 1995 (week 45)**

Treatment		**% N**	**% P**	**% K**	**Mg mg/kg**	**Ca mg/kg**	**Mn mg/kg**
		Concentration on dry weight					
Calypso	0 + 40	2.67	0.201	1.61	0.214	1.71	78
	40 + 0	2.88	0.227	1.68	0.231	1.73	67
	40 + 40	2.96	0.204	1.62	0.224	1.68	75
	40 + 80	3.20	0.230	1.64	0.221	1.69	96
Tango	0 + 40	2.85	0.261	1.82	0.273	1.64	90
	40 + 0	2.95	0.273	1.89	0.307	1.72	95
	40 + 40	3.13	0.267	1.86	0.259	1.62	99
	40 + 80	2.96	0.244	1.69	0.243	1.55	76
Evita	0 + 40	3.17	0.216	1.59	0.219	1.63	73
	40 + 0	2.94	0.232	1.66	0.268	1.77	74
	40 + 40	2.96	0.244	1.69	0.243	1.55	76
	40 + 80	3.25	0.246	1.71	0.214	1.60	79
Means for cultivars							
Calypso		2.93	0.215	1.64	0.222	1.70	79
Tango		2.99	0.261	1.84	0.278	1.69	104
Evita		3.08	0.234	1.66	0.236	1.64	75
Means for nutrition							
	0 + 40	2.89	0.226	1.67	0.235	1.66	80
	40 + 0	2.92	0.244	1.74	0.268	1.74	79
	40 + 40	3.02	0.238	1.72	0.242	1.62	84
	40 + 80	3.16	0.240	1.71	0.237	1.69	102
Comparing individual treatment means							
SED (33 df)		*0.254*	*0.0175*	*0.099*	*0.0199*	*0.106*	*10.9*
LSD (5%)		-	-	-	-	-	-
Significance, P		*NS*	*NS*	*NS*	*NS*	*NS*	*NS*
Comparing cultivar main effects							
SED (33 df)		*0.127*	*0.0087*	*0.050*	*0.0099*	*0.053*	*5.4*
LSD (5%)		-	*0.018*	*0.10*	*0.020*	-	*11*
Significance, P		*NS*	*<0.001*	*<0.001*	*<0.001*	*NS*	*<0.001*
Comparing nutrition main effects							
SED (33 df)		*0.147*	*0.0101*	*0.057*	*0.0115*	*0.061*	*6.3*
LSD (5%)		-	-	-	*0.023*	-	*13*
Significance, P		*NS*	*NS*	*NS*	*0.022*	*NS*	*0.003*

APPENDIX VI

HRI Efford Meteorological Data

Table 1 **Rainfall (mm)**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1995	143.8	116.8	40.2	**27.1**	**22.2**	**10.1**	**26.7**	**3.4**	**142.9**	**38.6**	**144.3**	81.7
1994	132.2	89.4	57.8	**61.3**	**81.7**	**23.4**	**19.6**	**47.6**	**70.9**	**125.8**	**91.4**	116.9
1993	98.0	6.2	45.2	**74.7**	**45.7**	**61.6**	**86.2**	**35.8**	**120.7**	**169.3**	**64.4**	185.0
1992	21.7	28.6	51.6	70.4	19.6	32.2	63.1	88.1	78.9	81.5	145.3	81.2
1991	88.5	29.3	77.9	42.3	4.0	113.0	63.3	12.3	48.6	63.0	49.2	33.4
1990	112.7	166.5	6.4	43.9	11.2	55.3	12.2	23.1	28.9	98.6	53.6	62.3
1989	30.6	69.8	74.8	71.7	13.7	34.6	22.5	23.6	37.3	91.0	56.6	242.4
1988	170.9	47.3	82.0	39.5	27.9	34.3	71.8	63.6	41.6	98.4	20.7	20.8
1987	15.8	60.4	89.4	69.1	19.3	54.4	61.4	16.4	37.7	195.6	78.3	43.2
1986	109.9	11.3	61.3	58.9	74.3	25.3	46.6	87.6	33.9	79.2	114.6	102.6
1985	69.5	47.0	51.6	43.8	44.6	61.1	37.8	88.2	24.3	32.4	53.4	88.0
1984	120.5	36.1	81.3	0.3	86.4	18.6	12.0	18.7	62.1	94.6	127.9	96.2
1983	68.1	25.9	36.9	86.0	77.3	47.8	7.1	32.7	66.3	57.2	40.9	82.0
13 yr mean	90.9	56.5	58.2	53.0	40.6	44.0	40.8	41.6	61.1	94.2	80.0	95.1
42 yr mean	83.9	55.2	59.0	45.3	47.8	54.1	46.9	57.7	70.0	83.8	84.7	88.2

N.B. **Bold** figures in body of table relate to the period of the trial covered by the three year project.

APPENDIX VI

HRI Efford Meteorological Data

Table 2 Mean Minimum Temperature (°C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1995	3.2	5.8	2.6	**5.7**	**7.8**	**10.2**	**13.7**	**13.8**	**10.5**	**11.0**	**5.1**	1.2
1994	4.1	2.1	5.6	**4.4**	**8.6**	**10.4**	**13.8**	**13.7**	**10.9**	**7.7**	**9.6**	5.3
1993	5.1	3.3	3.8	**6.5**	**8.8**	**11.4**	**12.4**	**11.3**	**10.0**	**7.0**	**2.8**	4.1
1992	1.7	2.8	5.3	5.6	9.2	10.8	13.5	13.4	12.0	5.4	6.2	2.7
1991	3.1	0.5	5.4	4.8	7.0	9.4	12.9	12.8	11.5	8.1	4.8	4.0
1990	5.5	6.3	5.6	4.3	8.6	10.8	12.6	13.5	9.7	10.3	5.8	3.3
1989	4.3	3.3	5.1	3.9	9.4	10.9	14.3	13.0	12.0	10.0	5.6	4.3
1988	4.0	2.5	4.5	4.8	8.8	10.7	12.4	11.9	10.3	7.6	3.0	5.3
1987	0.6	1.7	1.9	6.1	7.0	9.7	12.4	11.9	11.9	8.4	4.8	4.5
1986	1.8	2.2	2.2	2.9	7.8	10.5	12.4	11.5	7.6	8.8	5.9	4.2
1985	1.3	0.2	1.5	4.5	7.3	9.2	11.9	12.5	11.1	8.7	2.2	5.5
1984	2.7	2.1	2.3	3.7	6.7	10.3	11.6	13.3	11.2	9.3	6.6	3.2
1983	5.1	0.6	3.4	4.2	7.7	11.3	14.9	13.1	11.4	8.4	5.9	3.8
13 yr mean	3.3	2.6	3.8	4.7	8.1	10.4	13.0	12.7	10.8	8.5	5.3	4.0
42 yr mean	2.3	1.9	3.3	4.4	7.5	10.3	12.3	12.3	10.7	8.2	4.9	3.3

N.B. **Bold** figures in body of table relate to the period of the trial covered by the three year project.

APPENDIX VI

HRI Efford Meteorological Data

Table 3 Mean Maximum Temperature (°C)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1995	9.2	10.6	10.7	**13.6**	**16.7**	**20.2**	**22.8**	**25.5**	**18.5**	**17.2**	**12.4**	6.8
1994	9.5	8.2	11.5	**12.2**	**14.8**	**18.7**	**22.2**	**21.2**	**17.5**	**15.6**	**13.8**	11.3
1993	9.8	7.8	10.4	**13.2**	**16.5**	**19.5**	**19.1**	**19.6**	**17.1**	**13.0**	**9.4**	9.7
1992	7.2	9.0	10.9	12.7	18.7	20.6	20.1	19.5	17.6	12.9	12.3	8.2
1991	7.3	5.1	11.0	12.2	15.5	15.5	20.5	21.0	20.0	14.0	10.9	8.5
1990	10.4	11.2	11.8	13.6	18.4	16.9	21.9	22.7	19.1	16.1	10.8	7.9
1989	9.9	10.0	11.5	10.8	19.3	20.2	23.9	21.6	19.5	16.5	11.5	9.5
1988	9.1	8.9	10.2	12.7	16.7	18.8	17.5	19.1	17.7	15.1	10.6	10.7
1987	3.9	7.4	8.1	13.4	15.2	16.6	20.5	20.4	18.1	14.7	10.5	8.3
1986	7.8	2.2	8.3	9.9	13.7	20.0	19.4	17.9	15.9	15.4	12.3	10.0
1985	4.2	5.8	8.4	12.7	15.8	17.2	20.5	18.1	18.4	14.9	8.3	9.8
1984	8.5	7.7	8.6	13.7	14.4	19.5	22.0	22.0	18.0	15.0	12.1	9.8
1983	9.6	5.4	9.6	10.8	13.8	18.3	24.4	22.7	17.8	14.5	11.0	9.7
13 yr mean	8.2	7.6	10.1	12.4	16.1	18.6	21.1	20.9	18.1	15.0	11.2	9.2
42 yr mean	7.5	7.4	9.8	11.9	15.6	18.4	20.4	20.3	18.3	15.0	10.9	8.6

N.B. **Bold** figures in body of table relate to the period of the trial covered by the three year project.

APPENDIX VI

HRI Efford Meteorological Data

Table 4 **Mean Daily Sunshine Hours**

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1995	1.7	2.7	6.2	**6.2**	**8.7**	**8.4**	**8.5**	**9.9**	**5.7**	**3.6**	**3.0**	1.6
1994	2.5	2.7	3.7	**6.3**	**5.8**	**9.5**	**9.0**	**6.8**	**5.0**	**5.7**	**1.3**	2.0
1993	1.1	2.3	4.6	**4.5**	**6.7**	**8.3**	**6.0**	**8.2**	**4.6**	**4.3**	**2.8**	1.9
1992	2.4	2.1	2.02	5.5	9.25	8.25	5.4	5.2	4.7	4.2	2.0	1.7
1991	2.20	2.76	3.55	5.80	5.81	5.20	7.2	8.6	6.1	3.0	2.2	1.7
1990	1.52	3.24	5.15	8.13	9.63	4.60	10.18	8.64	6.34	3.52	3.02	1.95
1989	2.21	3.66	3.04	5.65	10.57	9.25	9.75	9.31	4.80	3.56	3.62	1.14
1988	1.97	4.58	3.39	6.49	8.02	6.10	6.65	5.91	3.84	3.46	3.46	1.48
1987	2.13	2.96	3.94	6.68	7.77	5.79	7.15	6.47	4.97	3.54	2.10	1.42
1986	2.03	2.74	3.57	5.57	5.85	7.22	6.16	5.65	5.64	3.37	2.75	2.05
1985	2.48	2.99	4.25	5.66	6.88	6.04	7.86	6.45	5.36	4.07	2.75	1.19
1984	2.80	2.92	2.92	8.22	4.93	9.86	8.92	6.84	4.03	2.89	2.21	1.87
1983	1.86	3.67	3.56	5.42	5.56	6.60	9.17	8.48	3.87	3.66	1.88	2.10
13 yr mean	2.1	3.0	3.8	6.2	7.3	7.3	7.8	7.4	5.0	3.8	2.5	1.7
42 yr mean	2.0	2.8	4.1	5.9	7.1	7.3	7.3	6.7	5.3	3.9	2.5	1.7

N.B. **Bold** figures in body of table relate to the period of the trial covered by the three year project.

Appendix VII Copy of contract and schedule

Contract between HRI (hereinafter called the "Contractor") and the Horticultural Development Council (hereinafter called the "Council") for research/development project.

PROPOSAL

1. **TITLE OF PROJECT** **Contract No: SF/33**

STRAWBERRIES - INFLUENCE OF FERTIGATION ON NEW EVERBEARING STRAWBERRY VARIETIES

2. **BACKGROUND AND COMMERCIAL OBJECTIVE**

The two new everbearing varieties Calypso (SBJ 2) and Tango (SBJ 1) from the HRI East Malling breeding programme have been in trials under SF/18 at HRI Efford. They have shown considerable promise as possible successors to Rapella due to improved fruit quality, and in the case of Tango, very heavy early yields. Calypso is already in grower trials, and Tango will be in grower trials in 1993. In addition a privately bred seedling (provisionally approved name Evita) also appears promising, but there are only limited trial results so far. At present there is no information on nutritional responses to any of these varieties, but previous MAFF funded trials have shown different varietal responses to nitrogen (see 5 below).

Further information is needed on the yield, fruit quality and cropping season responses of new everbearer varieties to fertigation, so that more accurate and if necessary variety specific recommendations can be given. Also further controlled trials will provide additional data on which to base judgements on yield, disease susceptibility, fruit quality etc.

3. **POTENTIAL FINANCIAL BENEFIT TO THE INDUSTRY**

Apart from the obvious financial benefits of increased yields from correct nutrition, aspects of fruit quality including firmness and flavour will also be influenced by nutrition. This is particularly important since it is hoped that replacing Rapella by improved varieties might increase the quantity of everbearer fruit reaching discriminating market outlets such as the multiple retailers.

4. **SCIENTIFIC / TECHNICAL TARGET OF THE WORK**

a) To achieve a better understanding of, and improve the basis for, fertigation recommendations for new everbearer strawberry varieties.

b) Obtain some indication of any differences in varietal response of fertigation on yields, fruit quality and cropping season.

c) Achieve a more reliable assessment of the agronomic characteristics of these varieties, particularly the newer ones for which there is little trial data.

5. CLOSELY RELATED WORK

Previous MAFF trials at HRI Efford with Rapella, Ostara and Selva, 1987 - 89 (GT21/021 and GT21/028), showed different varietal responses between varieties to nitrogen rates applied as fertigation and controlled release fertilisers. On Efford's soil, Rapella generally showed no advantage, and even yield depressions in the maiden crop where nitrogen in excess of 40 kg/ha in the base was used. Ostara showed small yield increases with up to an additional 40 kg/ha N fertigation, but Selva responded with up to 30% increase in early yield and 18% increase for the season overall from additional fertigation up to 80 kg/ha N. Also, it was found that where positive responses were found, early nutrient applications were most beneficial.

It is possible that differences in varietal response may be related to how far a variety is strongly day neutral such as Selva or Tango. Certainly the foliage of Tango can rapidly appear quite pale and "starved" quite early in the cropping season compared with say Rapella, but trials are needed to determine how far this is truly indicative of a greater nutritional requirement.

6. DESCRIPTION OF THE WORK

Year 1 (1993)

Treatments

Varieties:	Rapella Tango Calypso Evita
Nutrition:	Nil N Low rate N fertigation (eg up to 40 kg/ha N total) High rate N fertigation (eg up to 80 kg/ha N total)

Site, an ex-grass site with no previous strawberry cropping history. All nitrogen and potash to be supplied as fertigation from planting with a possible reduction in N:K_2O ratios from flowering onwards. Total K_2O applied would be the same in each treatment with a "non limiting" rate applied according to soil analysis. Any phosphate and magnesium requirements according to soil analysis met from a base dressing.

Design and Layout

Randomised block trial design. 4 varieties x 3 fertigation x 4 replicates = 48 plots.

24 plants per plot. Staggered double rows 0.4 m apart on black polythene mulched raised beds at 1.52 m centres with 0.5 m in-row spacing (26,300 plants/ha). Approximate trial area 600 m^2.

Materials and methods

Ground prepared, standard base dressing applied, and beds raised winter 1992/1993. Uniformly treated potted runners (from commercial suppliers for 1993 trial) planted in April 1993. Fertigation treatments started once planted - prior to this standard liquid feed used on potted plants.

Plants deblossomed until late May and derunnered as necessary during the trial. Standard crop protection spray / biological control programme practised. Cropped from early or mid July onwards, extending season until late October / November with French tunnels.

Records

a) Yields - size graded Class 1, Class 2, Waste

b) Cropping season

c) Fruit firmness, flavour and shelf life observations with regular samples through the cropping season.

d) Initial soil analyses for site followed by treatment soil analyses at end of trial. Analysis for mineral and total N, P, K, Mg, pH.

Three leaf analyses during cropping for N, P, K, Mg.

Years 2 & 3 (1994 & 1995)

Follow on trials of similar format building on experience of year 1, but with the addition or substitution of other varieties if necessary (eg SBJ 7; plants unavailable for trial in year 1). Propagation for trials in years 2 & 3 undertaken at Efford during years 1 and 2.

7. **COMMENCEMENT DATE AND DURATION**

April 1993 for 3 years (reviewed annually)

8. **STAFF RESPONSIBILITIES**

Project Leader: C M Burgess, HRI Efford

Contract No: SF/33

TERMS AND CONDITIONS

The Council's standard terms and conditions of contract shall apply.

Signed for the Contractor(s)

Signature..

Position.... Commercial and Marketing Manager HRI

Date.......... 18/3/93

Signed for the Contractor(s)

Signature..

Position..

Date..

Signed for the Council

Signature..

Position.... CHIEF EXECUTIVE

Date.......... 20.1.93

HRI EFFORD 1993-95

HDC PROJECT (SF 33) UPDATE OF SCHEDULE FOR YEAR 2 1994

1. TITLE OF PROJECT

Strawberries - Influence of fertigation on new everbearing strawberry varieties

6. DESCRIPTION OF THE WORK

Year 2 (1994)

Background

Fertigation should be an efficient method of supplying nutrients for two reasons. Firstly, the nutrients are concentrated in the raised beds area where they are more available to the plants, instead of being broadcast overall as would be typical when applying a base dressing. Secondly, nutrients are supplied gradually to plants over the growing season and local deficiencies and losses by leaching (particularly N) are less likely to occur. Nevertheless, a soil analysis pre-planting is usually taken to establish soil fertility levels and base dressings offer a simple and sensible method of correcting major deficiencies along with liming for raising pH if required. The 1993 trial at Efford on a site of low N status with no base dressing used showed clearly that there was a large response to fertigation to a total level of 40 kg/ha N, compared with the nil control, but fertigation up to 80 kg/ha N appeared to have relatively little additional effect. The response of these everbearing varieties to fertigation needs to be tested against a higher background level of N than in 1993. If the requirement of an everbearer for N is in fact quite low, it may be that supplying it in the base dressing alone is sufficient which would save the grower from needing to use fertigation dosing equipment at least for a one year crop.

Soil mineral N analysis is also becoming more widely used as a basis for tailoring N fertiliser recommendations to individual site needs in other crops and this may have an application for everbearing strawberries.

Treatments

Varieties:
- A - Calypso
- B - Tango
- C - Evita

N Nutrition:
- **0+40** - 40 kg/ha N as fertigation only
- **40+0** - 40 kg/ha N as base dressing, nil additional fertigation
- **40+40** - 40 kg/ha N as base dressing plus 40 kg/ha N as fertigation
- **40+80** - 40 kg/ha N as base dressing plus 80 kg/ha N as fertigation

Site, an ex-grass site with no previous strawberry cropping history. Pre-planting analysis ADAS Index 4 for P, and 2 for K and Mg. Background soil mineral N level will be analysed at the beginning and end of the trial, but based on 1993 experience the site should be of low N status. A base dressing of 50 kg/ha Mg and 50 kg/ha K_2O will be applied to the whole site to raise the background soil Mg and K status, and ensure there is no gross deficiency in these elements where no fertigation is used. All treatments receiving fertigation to also receive 80 kg/ha K_2O

and 10 kg/ha Mg in the liquid feed. This is consistent with growers normal practice to apply a balance of major nutrients if fertigating. Results may also be more confidently extrapolated to situations where the grower is relying on fertigation to supply most of the nutrients required. There is no requirement for additional phosphate on this site in 1994 at least.

The treatment structure is not completely balanced and represents a compromise between what would be scientifically desirable and the need to obtain some practical recommendations with a limited number of treatments. A large factorial trial would be required to unravel the complex interactions of different nutrients, method of application, and nutrient rates involved. However with the resources available, the trial should help answer the following questions sufficiently to provide advisory guidelines:

1 How effective is the nitrogen applied in the base dressing compared with the same rate per ha applied as fertigation (cf 0+40 vs 40+0)? The 0+40 treatment also gives a common link between the set of treatments used in the 1993 trial.

2 Is the base dressing of N providing any additional benefit when fertigation is used as well (cf 0+40 vs 40+40)?

3 With moderate levels of nutrition in the soil at planting (made up as required with a base dressing), what is the response from further fertigation up to 80 kg/ha N (cf 40+0 vs 40+40 vs 40+80)?

4 Are there varietal differences in response to the above (interactions of nutrient treatments with Calypso, Tango and Evita)

Design and Layout

Randomised block trial design. 3 varieties x 4 nutrition x 4 replicates = 48 plots.

24 plants per plot. Staggered double rows 0.4 m apart on black polythene mulched raised beds at 1.52 m centres with 0.5 m in-row spacing (26,300 plants/ha). Approximate trial area 600 m^2.

Materials and methods

Ground prepared, base dressings applied, and beds raised winter 1993/1994 or early spring dependant on soil conditions. 10 - 12 mm grade runners from commercial suppliers potted on receipt in December 1993 and planted in April 1994. Standard liquid feed given to potted plants in spring until planting. Fertigation treatments started one to two weeks after planting and applied weekly over a 20 week period (until mid - late September).

Plants deblossomed until late May and derunnered as necessary during the trial. Standard crop protection spray / biological control programme practised. Cropped from early or mid July onwards, extending season until late October / November with French tunnels.

Records

a) Yields - size graded Class 1, Class 2, Waste

b) Cropping season

c) Fruit firmness, flavour and shelf life observations with regular samples through the cropping season.

d) Initial soil analyses for site followed by treatment soil analyses at end of trial. Analysis for mineral and total N, P, K, Mg, Ph.

Three leaf analyses during cropping for N, P, K, Mg.

The side guard beds in this trial will be used to observe plots of cvs. Muir, Irvine and Seascape from the University of California breeding programme. Also plots of SBJ 7 from HRI East Malling will be included. Yields and fruit quality will be recorded. Additional funding from PBI will be used for these observations.

Year 3 (1995)

To be confirmed on the basis of 1994 results, but taking the above trial on to a second cropping year may be the best option, especially as there is little knowledge of how these varieties might perform as two year old plants.

The irrigation layout will enable each nutrition treatment to be handled independently so that a different set of treatments can be applied if necessary. As there will be little or no N from the base dressings left at that time, fertigation treatments of 0, 40, 80 and 120 kg/ha N could be considered.

C M BURGESS
1/12/93
Revised 8/12/93