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CONTRACT REPORT

Strawberry, Effect of Planting Date on Cold Stored and Fresh Module Plants of Elsanta and Pandora

Undertaken for Horticultural Development Council
HDC Project SF/18

CONTENTS

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SUMMARY

Seven planting dates at two week intervals of each of cold-stored runners (4 May to 27 July) and fresh module raised plants (29 June to 21 September) were compared for both the cultivars Elsanta and Pandora. A standard intensive culture using discrete plants grown on polythene mulched raised beds with trickle irrigation was used. Both types of plant were capable of producing equally high maiden yields the following summer, but yields declined appreciably for the later plantings. For Elsanta and Pandora respectively, this was after early and late June for cold-stored runners, and after mid and late July for fresh module plants. For fresh plants of both cultivars there was an almost linear decline in Class 1 yield of 9 g/plant for every days delay in planting after 27 July. The size of plants in the winter after planting showed a similar downward trend with lateness of planting to yields the following summer. However, for treatments with comparable yields, plants from cold-stored runners were larger than those from fresh modules.

By the following season, there were still differences in plant size, but second year crop yields had largely levelled out across all planting dates except for lower yields from the last two plantings of Elsanta from modules. Here, it appeared that plants had still not reached the minimum size for full crop potential.

Neither planting date nor plant type had a significant effect on either fruit size or quality. Cropping season was also largely unaffected except for the lowest yielding late plantings in the maiden year which cropped earlier.

With the shortage of fresh dug bare root runners for July / August plantings, module raised plants may provide a viable substitute. Some factors affecting the choice of planting material are discussed. The trial has provided quantitative yield data with up to date varieties and growing systems enabling planting options to be better assessed.

OBJECTIVE

To assess the effect of planting date for both cold-stored and fresh module raised plants on the establishment, maiden and second year yields, and picking season of the varieties Elsanta and Pandora.

INTRODUCTION

It has long been established from work at SCRI, Dundee in the mid to late 1950's, (Guttridge and Mason, 1963), and Efford EHS and East Malling in the early to mid 1960's (Hughes, 1969a&b; Hughes, 1967; Hughes 1966a&b; Way, 1966), that effects of planting date of both cold-stored and fresh dug runners has a large effect on maiden yield the following year. Fresh dug runners planted later than early August give progressively lower yields due to the shortening period available for the plant to establish, build up crowns and initiate flowers under short daylengths before the onset of cold weather and dormancy. With cold-stored runners, which initially became popular to help overcome the shortage of early fresh dug runners, they needed to be planted some 3-4 weeks earlier than fresh dug runners to achieve comparable yields (Guttridge and Mason, 1963; Hughes, 1966b). This was because a period of post-chilling vegetative growth had to be completed after planting before the plants were capable of building up reserves and initiating flowers for the following year's crop.

Fresh dug runners are still largely unavailable to UK growers before early to mid September. Although cold-stored runners are widely used, they have the disadvantage of tying up land for a longer period before their first main crop, and there is still a requirement for fresh material available for early planting. In recent years the propagation of runners as plantlet cuttings rooted under mist into module trays has developed both commercially and as a valuable experimental tool. Uniform grade module plants can be raised for planting over a wide range of planting dates, 3-4 weeks after taking cuttings. A series of trials at Efford cropped in 1988 and 1989 (refs GT11/001, GT11/002 and GT11/017) examined aspects of module propagation. They showed that among other advantages, module raised plants were as good or better than fresh dug runners planted at the same time provided they were adequately fed while in the module, and had not become excessively rootbound. An 80ml volume cell was adequate, and for Elsanta 4 weeks from sticking the cuttings was about the optimum stage for planting out.

In trial GT11/017, "Timing of Module Propagated Elsanta", for a given planting date, a yield depression of up to 27% occurred for modules planted 6 weeks after sticking compared to those 4 weeks old. However, the planting date itself had the greatest effect on yield after early August. Mean yields fell steadily from 737 g/plant to 219 g/plant between the 2 August and 13 September planting dates, representing a yield penalty of 13 g/plant/day or about 0.5 tonnes/ha/day for planting later than the first week of August.

This trial had the following aims:

1. To consolidate information on the response of Elsanta, currently the most important fresh market variety, to a range of planting dates.

2. To generate new information on Pandora's response to planting date on both yield and cropping season.

3. To compare fresh module plants with cold stored runners in a more systematic and comprehensive manner than was done in the early trials 25-35 years ago.

4. Make these comparisons over two cropping seasons using an intensive system with trickle irrigated mulched raised beds, so that crop responses could be evaluated according to current practices.

This trial was started under MAFF funding, but HDC sponsorship enabled the trial to be completed through its second cropping year in 1991.

MATERIALS AND METHODS

Site

Field S7, HRI Efford, Lymington, Hampshire. A fine sandy silt loam of the Ludford soil series.

Treatments

Code	Planting Date Week number	Date 1989	Type of Plant
A	18	4 May	} Cold-stored runners
B	20	18 May	} Cold-stored runners
C	22	1 June	} Cold-stored runners
D	24	15 June	} Cold-stored runners
E	26	29 June	} Cold-stored runners / } Fresh module plants
F	28	13 July	} Cold-stored runners / } Fresh module plants
G	30	27 July	} Cold-stored runners / } Fresh module plants
H	32	10 August	} Fresh module plants
I	34	24 August	} Fresh module plants
J	36	7 September	} Fresh module plants
H	38	21 September	} Fresh module plants

Varieties: Pandora (IHR E Malling) Elsanta (Netherlands)

Design and Layout

This factorial trial had seven planting dates for each of two types of plants to give fourteen planting date treatments. The two varieties were analysed and treated as separate trials. A randomised block layout with four replicates was used to give a total of 112 plots.

There were 24 plants per plot in staggered double rows on black polythene mulched raised beds at 1.52 m wheelings. Plants spacings were 0.3 m between rows x 0.3 m in-row for Elsanta, and 0.4 m between rows x 0.5 m in-row for Pandora. This gave planting densities of 43,860 and 26,316 plants per ha for Elsanta and Pandora respectively. One bed of Elsanta to two beds of Pandora were planted across the site with Elsanta doubling as a pollinator for the male sterile Pandora. Rows ran north - south with an extra guard bed of Pandora on the east and west sides of the site. See plan, Appendix, page 23. The total trial area was 1014 m^2.

General Culture

The trial site had been fallow in 1988. A soil analysis from a 20cm sample taken in early February 1989 was as follows:

pH	7.2
P	88 mg/l (Index 5)
K	411 mg/l (Index 4)
Mg	127 mg/l (Index 3)

No lime or base dressing was required, and raised beds were made and mulched immediately prior to the first planting of cold-stored runners on 4 May. All treatments were watered with a hand lance and rose immediately after planting and as necessary for three weeks thereafter to minimise possible effects on establishment caused by vagaries of the weather. Some irrigation was also applied via the Evaflow S irrigation tube under the mulch during this period and for all subsequent irrigations.

Cuttings for fresh module raised plants were taken at two weekly intervals 4 weeks before the batch was due to be planted out. Super Elite grade mother plants were grown in a peat based compost in gro-bags in a polythene tunnel. Plantlet cuttings with at least one expanded true leaf were taken; excess leaves were removed if necessary, and the stolon trimmed to leave a 15mm stub to aid insertion into the compost. Cuttings were inserted into Fisons M2 compost in PG Horticulture QP 54 module trays (cell capacity 80 ml).

Cuttings were misted for 10-14 days under a low white polythene tunnel within a high tunnel. Liquid feeding with 200 mg/l N : 200 mg/l K_2O 2-3 times per week commenced as soon as cuttings were removed from the mist, and continued until planting. Occasional fungicide sprays of iprodione (Rovral WP), bupirimate (Nimrod) and chlorothalonil (Repulse) were applied for protection against botrytis and powdery mildew.

Elite grade cold-stored runners were bought in and batches held in cold store, at -1°C until required for planting.

Following planting, unwanted runners were removed from cold-stored and fresh module plants at intervals from late July and on into October. Flower trusses were removed from the last four planting dates of the cold-stored runners, but blossom was retained for treatments A - D for a small late summer crop.

Pest and disease control measures were applied according to commercial practice. Fungicides used were chlorothalonil (Repulse), triadimefon (Bayleton 5), iprodione (Rovral WP), bupirimate (Nimrod), fosetyl-aluminium (Aliette), and fenarimol (Rubigan); insecticides included *Bacillus thuringiensis* (Bactospeine), pirimicarb (Pirimor), dicofol + tetradifon (Childion), demeton-S-methyl (Metasystox), and cypermethrin (Ambush C). Simazine and low rate propyzamide (Kerb 50W) herbicides were applied to the alleyways; some hand weeding was necessary in the planting holes.

The trial was not mown after the first full crop in 1990. By the time Pandora had completed cropping, it may have been too late to allow sufficient regrowth after mowing before flower initiation commenced in autumn.

Records and Analysis of Results

Fruit was picked and recorded as Large, Medium, and Small Class 1 (>35mm, 25-35mm and 18-25mm respectively), Class 2 and Waste. The derived variates total Class 1 and total crop including waste were obtained during analysis.

Size and quality graded yields were subjected to ANOVA's, each variety being analysed separately. 10%, 50% and 90% pick dates were also calculated, based on both Class 1 total, and total crop including waste.

Leaf numbers were counted on 16 November 1989 from 5 plants per plot as an indication of treatment effect on establishment and therefore plant size and crown number. The size of plant achieved by the onset of winter dormancy is related to the number of sites (crowns) which have initiated flowers and for this trial was therefore expected to be an indication of yield potential for the 1990 crop. As in trial GT11/017, the leaf counts were used in a covariate analysis with yield.

An assessment of plant height and diameter was made in December 1990 as a more appropriate measure of plant size due to the large number of leaves present at this stage. These dimensions were converted into plant volume assuming the plant to be a section of a sphere by the following formula:

$$\pi h (c^2/8 + h^2/6)$$

where c = mean spread measured in two directions

h = plant height

RESULTS AND DISCUSSION

Tables of results are presented in the Appendix.

Yield from cold-stored runners in 1989

The first four plantings of cold-stored runners which were allowed to crop produced a small yield in 1989. The results did not merit statistical analysis, but the mean yields and cropping periods are presented in the Appendix Table 1, page 24.

The second planting date gave the greatest yield for both varieties, but even this was only equivalent to a Class 1 yield of 3.6 tonnes/ha for Elsanta, and 1.1 tonnes/ha for Pandora. The 50% pick dates were from 2 to 8 days later for Pandora compared to Elsanta, but nearly all fruit was picked during July, and virtually none in early August when market prices were higher.

1990 crop

See Appendix Table 2, page 25 (Elsanta) and Table 3, page 26 (Pandora) for details of yield and grade-out. The trends for Class 1 yield are summarised in Figs. 1 & 2, page 13 respectively.

Class 1 Yield

The trend for total crop and marketable (Class 1 + 2) yields were the same as that for the Class 1 total:

Elsanta: For cold stored runners, there was no significant difference between the first three planting dates up to 1 June (mean 29.4 t/ha); these plantings gave significantly higher yields than the next three plantings 15 June - 13 July (between which there were no significant differences) and the final planting on 27 July which gave the lowest yield of 9.9 t/ha.

For fresh module plants mean yields appeared to decline with each subsequent planting from 13 July onwards, but yield differences between the first four planting dates up to 10 August were not statistically significant (mean 25.2 t/ha). The final two plantings in September gave a notably low mean yield of 4.3 t/ha and the previous planting of 24 August was intermediate (14.8 t/ha).

Pandora: Yields from cold stored runners were not significantly different for the first five plantings up to 29 June averaging 16.7 t/ha, but the last two plantings gave a significantly lower mean yield of 10.2 t/ha ($P<0.01$).

For fresh modules, mean yields were similar for the first four plantings to 10 August (averaging 16.7 t/ha), followed by a significant drop ($P<0.01$) to an average yield of 10.4 t/ha for the next two planting dates with the final planting on 21 Sept giving a further yield decline ($P<0.01$) to 5.1 t/ha. As with Elsanta however, the decline in mean yields from fresh modules from 27 July appeared to be a smoother progression than the groups of statistically similar means indicate (Figs. 1 & 2, page 13).

The mean Class 1 yields for fresh module plants for both varieties thus declined by approximately 9 g/plant for every days delay in planting after 27 July. At the spacings used in this trial, this was equivalent to 0.39 t/ha for Elsanta and 0.23 t/ha for Pandora.

Mean yields from cold-stored runners of both varieties appeared to show a small increase between the 15 June and 29 June plantings (trts D & E) but this did not prove to be significant. This corresponded to the point at which the later plantings were deblossomed and not allowed to fruit in the planting year. It is possible therefore that the yield in 1990 of some or all of the first four planting dates was adversely affected by being allowed to fruit in 1989.

Yield comparison for cold stored runners vs fresh module plants

Yields were compared for the three planting dates (treatments E, F and G) when both cold-stored and fresh module runners were planted. In each case cold-stored runners produced lower mean yields, but differences were only significant for the 27 July planting for both varieties ($P<0.001$), and 13 July for Pandora ($P<0.05$). When treatments showing similar yields were grouped between both plant types, then for each variety a pattern emerged (Figs. 1 and 2, page 13). As a general trend, cold-stored runners showing equivalent yields to fresh modules were from treatments planted approximately 6 weeks earlier.

Treaments with similar yields:

Variety	Cold-stored runners	Fresh modules
Elsanta	A - C	E - G
	D - F	H
	G	J
Pandora	A - E	E - H
	F - G	I - J

More specifically however, the latest planting dates before mean yields began to decline appreciably were as follows:

Latest planting date

Variety	Cold stored runners	Fresh modules
Elsanta	C 1 June	F 13 July
Pandora	E 29 June	G 27 July

Fruit quality and size grade out

The treatment mean proportions of Class 1 fruit for the whole cropping period ranged from 77-86% for Elsanta, and 74-88% for Pandora, but there was no obvious pattern to the variations. Overall, the amount of Waste + Class 2 was acceptable and typical of a main season crop and was caused by a combination of mechanical damage, bird pecks and slugs, disease, and malformation including that from poor pollination. For the season total, Class 2 (mainly misshapen fruit) represented a small proportion of the total crop (typically 5-6%). Closer examination showed that for Elsanta the proportion of Class 1 remained more or less constant throughout the cropping period, whereas for Pandora it started very high with 95-100% Class 1, but fell to about 50-60% for the late picks. This increase in Class 2 and Waste was attributed to insufficient overlap of flowering between the varieties leading poor pollination of the later Pandora trusses.

The mean proportion across treatments of large Class 1 berries (> 35mm) was 34% for Elsanta and 35% for Pandora. The proportion of large fruit varied between treatments and followed the typical trend that the lower yielding treatments tended to have a higher proportional weight of large fruit.

Effect of planting date on plant size and relationship to subsequent yield

Leaf numbers counted in November 1989 gave a measure of plant size after establishment and showed a clear downward trend with lateness of planting (Figs.1 & 2, page 13). An initial analysis showed that for both varieties leaf numbers were variable, and since variances were not homogeneous between treatments data required log transformation (Table 4, Appendix, page 27).

Differences in leaf number between plant types and between planting dates within plant types were highly significant ($P<0.001$). By the November after planting, cold-stored runners had produced much larger plants than fresh modules over the range of planting dates used. Total crop yield was reanalysed using the log transformed leaf number data as a covariate. For Elsanta, the yield differences between planting dates for each plant type were then not significant, indicating that yield was largely related to the log of leaf number recorded the previous autumn. For Pandora, a similar analysis showed that although yield was related to leaf number, there was additional variation that could not be attributed to this factor.

Clearly in order to produce a given yield the following season, plants from cold-stored runners needed to be larger than those from fresh modules. It was not possible to use this analysis to correlate absolute yield with leaf number, but a proportional increase in leaf number was responsible for a given increase in yield. Thus a doubling in the number of leaves contributed to an extra yield of 176 g/plant (SE ± 70 g/plant) for Elsanta, and 211 g/plant (SE ± 38 g/plant) for Pandora.

Cropping season

Appendix Table 5, page 28 gives the 10%, 50% and 90% pick dates and the cropping period from 10 - 90% pick. The 50% pick date for Pandora was about 19 days later than Elsanta for cold stored runners and 16 days later for fresh module plants. There was very little difference in cropping season between cold stored and fresh plants within Elsanta, although fresh module Pandora were about 3 days later than cold stored Pandora. The length of the 10 - 90% picking period was also shorter for Pandora varying from 2 to 3 weeks compared to 3 to 4 weeks for Elsanta.

Planting date did not have a large effect on picking season except for the latest plantings which gave earlier 50% picks. This was largely related to the low yields from these treatments. The fruit on these treatments would have arisen mainly from a small number of flower trusses initiated late the previous autumn and were therefore the first to emerge.

1991 Crop

The trial was affected by Red Core (*Phytophthora fragariae*) in 1991, but symptoms only appeared late in the picking season. There was a variation in severity across the trial, and although both varietes were infected, symptoms appeared worse on Pandora. Plots were scored for Red Core, and a high score did show some correlation with lower yields, but probably because the disease showed up most severely once most fruit had been picked. Regression analysis indicated that the treatment trends were little affected.

Yield and grade-out in second season

See Appendix Table 6, page 29 (Elsanta) and Table 7, page 30 (Pandora) for details of yield and grade-out; the trends for Class 1 yield are summarised in Figs.3 & 4, page 14 respectively.

Comparison of Figs. 1 & 2, page 13 with Figs 3 & 4, page 14 show that for both varieties, the downward trend in yield with later planting dates in 1990 had largely disappeared by 1991. There was some variation in mean yields for the 1991 crop. For fresh modules, the final two plantings of Elsanta still appeared lower yielding than the earlier plantings, while with Pandora, the first three plantings appeared higher yielding. These trends were not statistically significant; they suggest a small carry over effect from the previous year but in general the yields had levelled out across treatments by the second crop.

The overall mean quality grade-out for Elsanta was 74% Class 1, 6% Class 2 and 20% Waste; for Pandora it was 73% Class 1, 8% Class 2 and 19% Waste. There was variability between planting date means (70 - 81% Class 1 for Elsanta and 66 - 79% for Pandora), but as in 1990 there was no clear trend with treatments. Overall, the pattern for Class 1 yields is therefore representative of that for the total crop.

There was little effect of treatments on the fruit size. Cold stored runner treatments D and E of Elsanta did yield more large fruit than treatment B and C, but absolute yield differences were small and of little practical significance. There was no difference in fruit size grade-out between cold stored runner and fresh module treatments. Overall, large fruit > 35mm formed 14% of the Class 1 Elsanta yield and 19% for Pandora as a mean across treatments, which was about half the proportion of the 1990 crop. Fruit size is always smaller from second cropping year plants but it may have been reduced further in 1991 by the presence of Red Core.

Fig 1 Effect of Planting Date on Leaf No. and Yield
Cold stored runners and Fresh modules ELSANTA
Leaves counted Nov 1989; Class 1 yield 1990

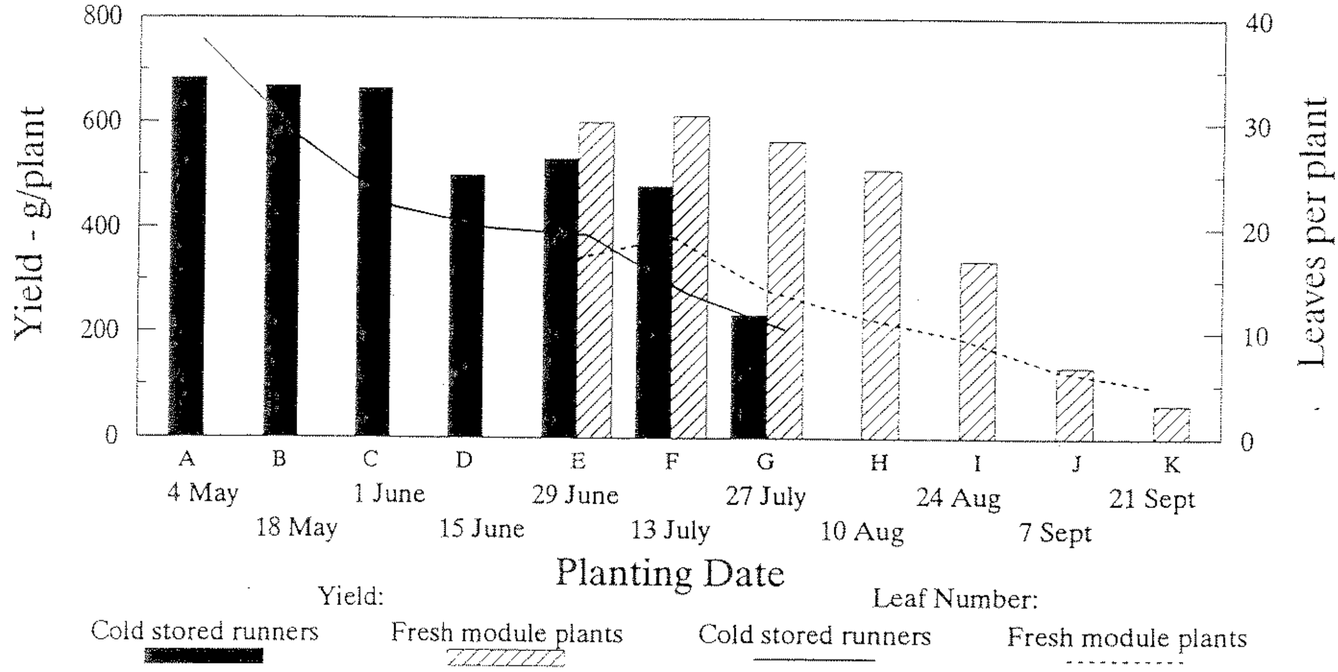


Fig 2 Effect of Planting Date on Leaf No. and Yield
Cold stored runners and Fresh modules PANDORA
Leaves counted Nov 1989; Class 1 yield 1990

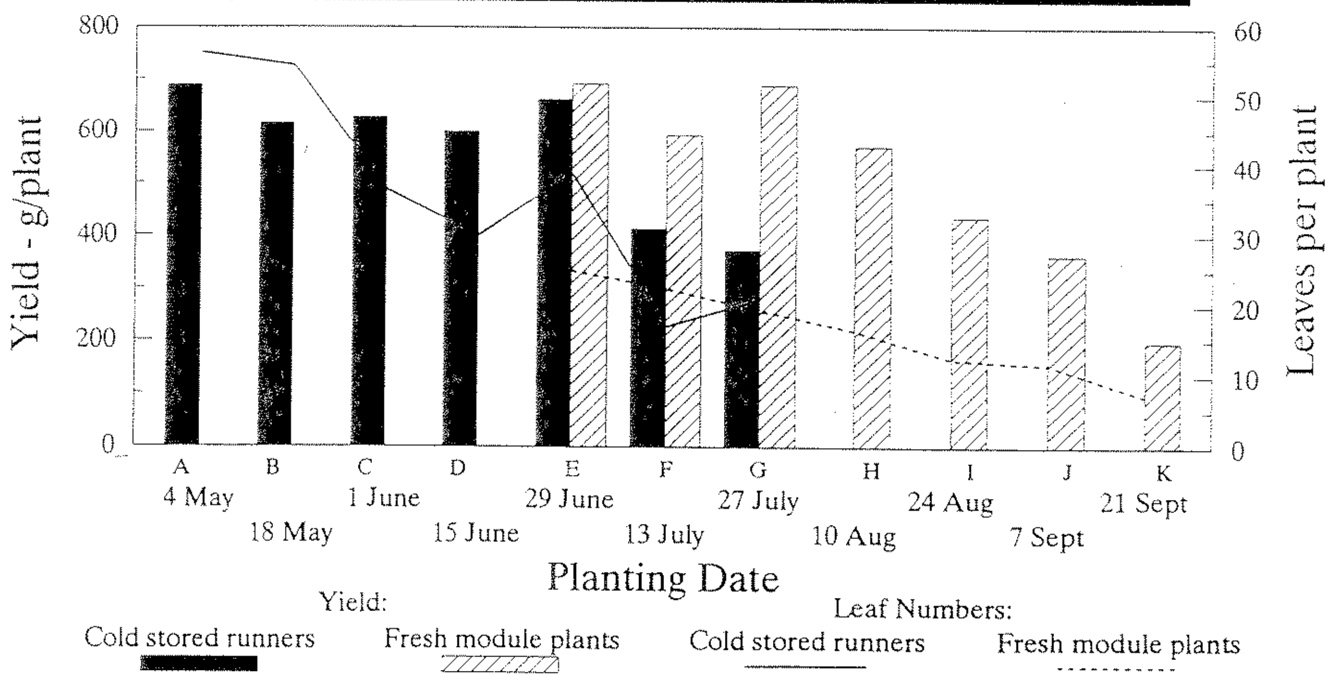


Fig 3 Effects in second season on plant size and yield

Cold stored runners and Fresh modules ELSANTA

Plants measured Dec 1990; Class 1 yield 1991

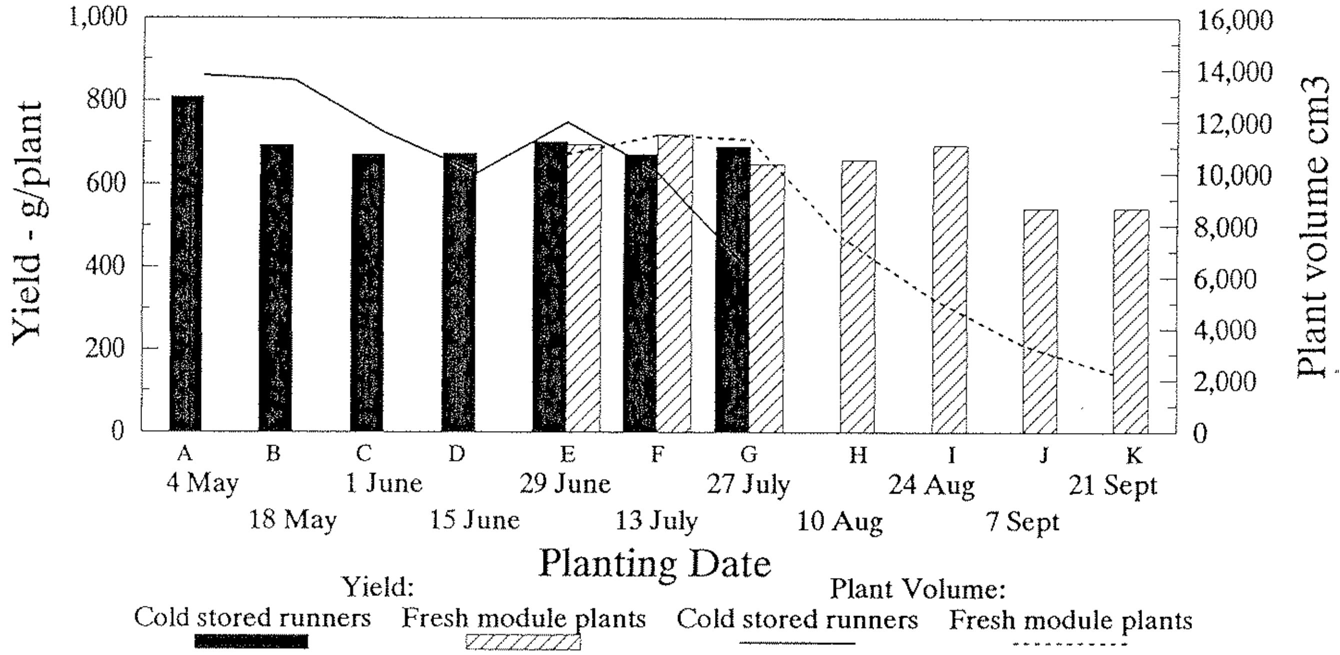
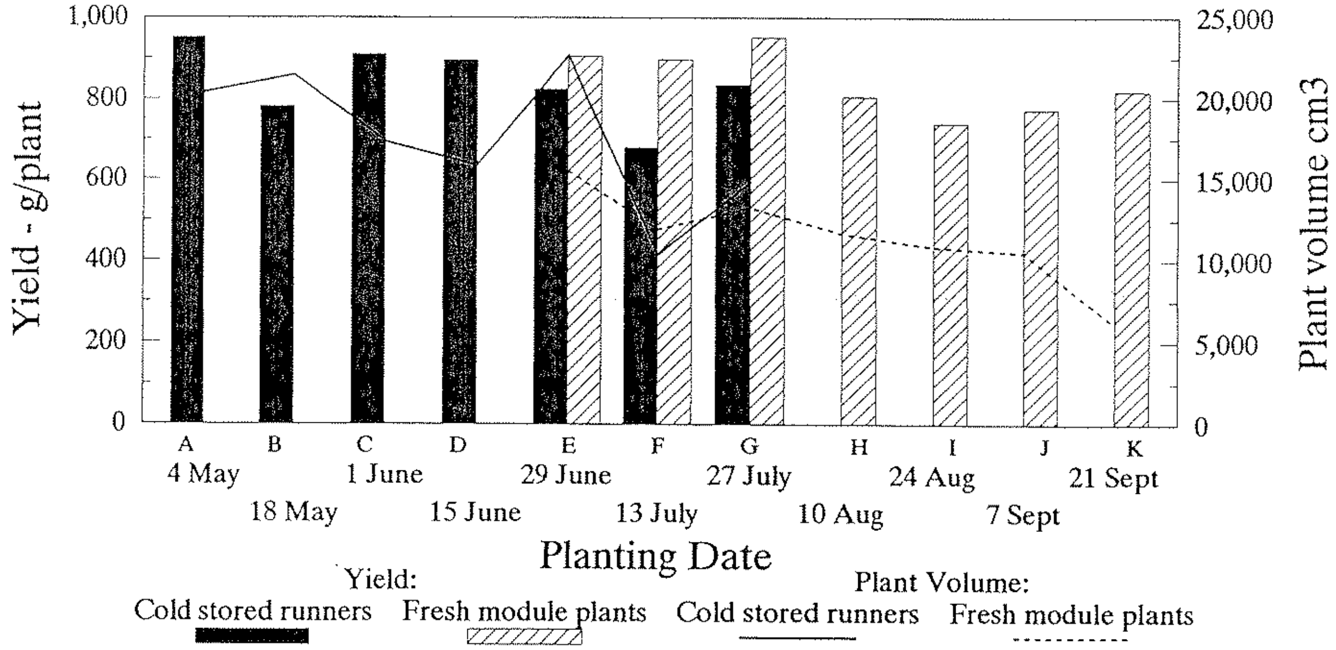


Fig 4 Effects in second season on plant size and yield

Cold stored runners and Fresh modules PANDORA

Plants measured Dec 1990; Class 1 yield 1991



Plant size

Appendix Table 8, page 31 and Figs. 3 & 4, page 14, show the mean plant sizes for each treatment at the stage after all flowers would have been initiated for the second crop the following season. Fig 5, page 16 shows the relationship between plant volume and leaf number for a small sample of plants of both varieties. This illustrates firstly that Pandora tended to have a denser leaf canopy than Elsanta, and that for both varieties plant sizes had greatly increased compared to the previous years record (Figs. 1 & 2, page 13). Despite the overall increase in plant sizes, means for each treatment followed a remarkably similar pattern to the previous year. The general downward trend with later planting dates was still evident even though some levelling out had occurred, and plants from cold stored runners were still larger than those from fresh modules. Nevertheless yields were fairly even across the range of plant sizes apart from slightly lower yields from the last two plantings of Elsanta. This suggests that a minimum plant size for full cropping potential had been reached by all but these two treatments by the autumn preceding the final crop. Also, fruit size was largely unaffected by plant size; the large cold stored runner plants giving a similar fruit size grade-out to those from fresh modules. Thus fruit size appears to depend more on the cultivar, plant age and total yield the plant is supporting, not on the plant size *per se*.

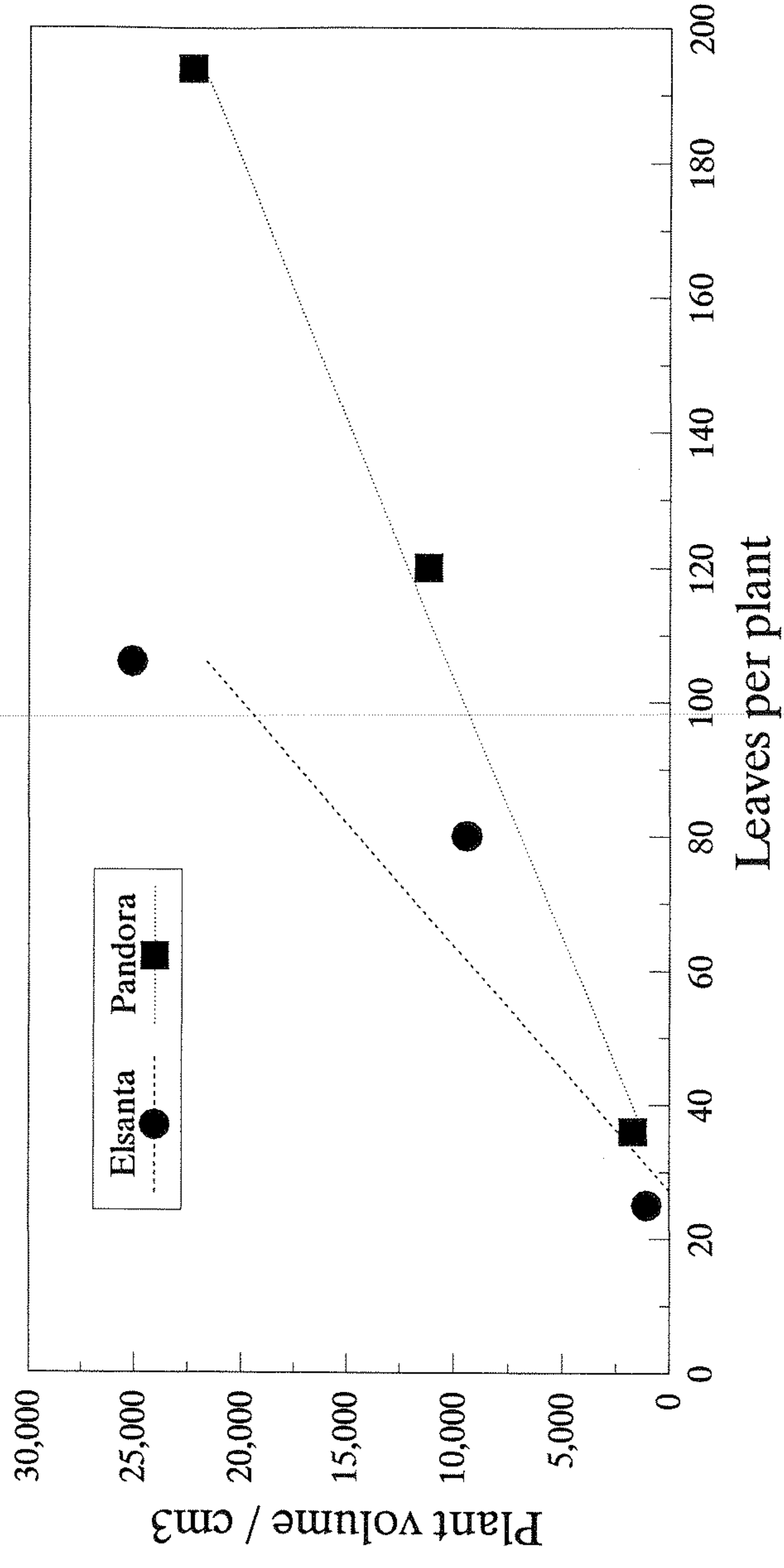
Cropping season

As in 1990, there was no significant effect of plant type or planting date on cropping season. The pick dates for both varieties are summarised below.

	10% pick	50% pick	90% pick	10 - 90% pick period
Elsanta	22 June	1 July	10 July	18 days
Pandora	6 July	15 July	24 July	18 days

1991 was a more typical season for temperatures compared to the very warm April in 1990 which advanced the crop that year, and the 1991 crop was some 2 weeks later. Nevertheless, warm temperatures during July accelerated ripening and the picking period was quite short. In 1991 50% pick was 2 weeks later for Pandora compared to Elsanta. The cropping period was condensed to about 3 weeks for both varieties.

Fig 5 Relationship between Plant Volume and Leaf Number before second cropping season Plants measured December 1990



Combined yield 1990 + 1991

Appendix Tables 9 & 10, pages 32 and 33 give details of the combined yields for both years which are summarised for Class 1 fruit in Figs. 6 & 7, page 18. Because of plant variability, yield differences between treatment means of 390 g/plant for Elsanta, and 350 g/plant for Pandora, are required for statistical significance at P <0.05.

Nevertheless, while the combined 2 seasons' yields are only significantly different between the earliest and latest planting dates for each plant type, the pattern of decline observed in the first season was still obvious.

Fig 6 Combined Class 1 yields for 1990 + 1991
ELSANTA

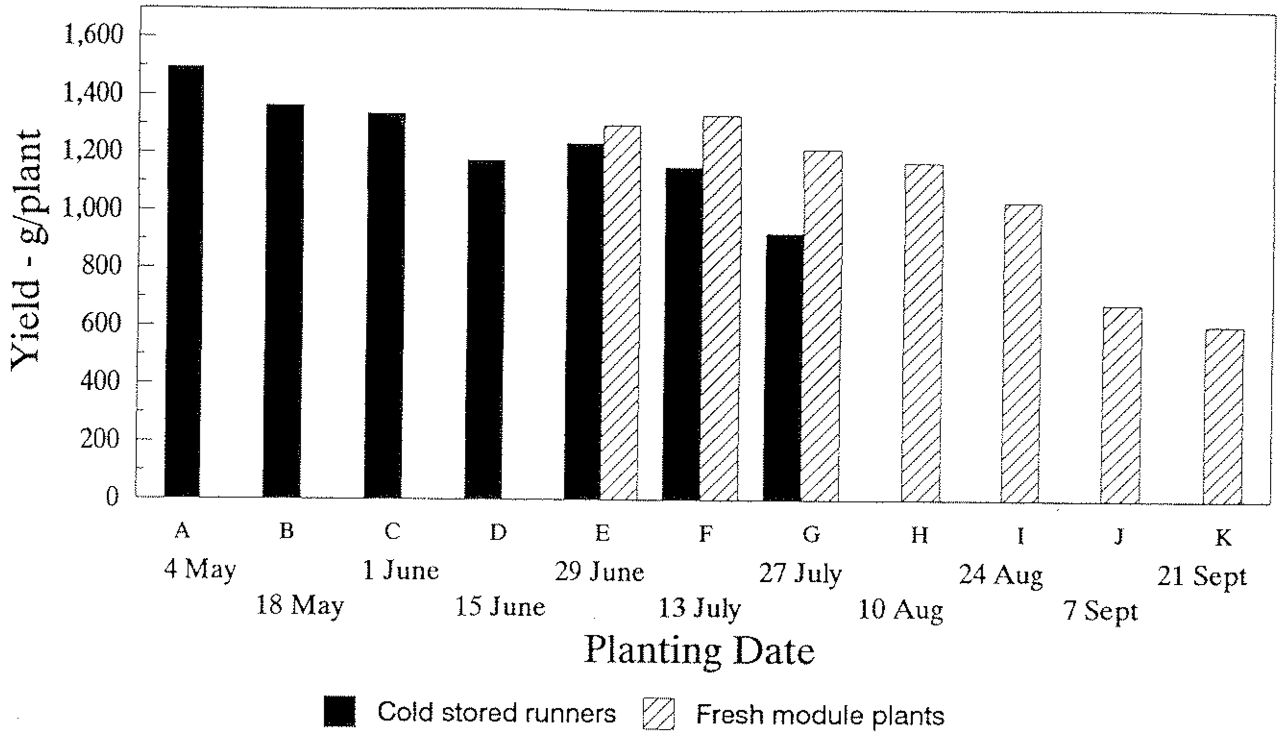
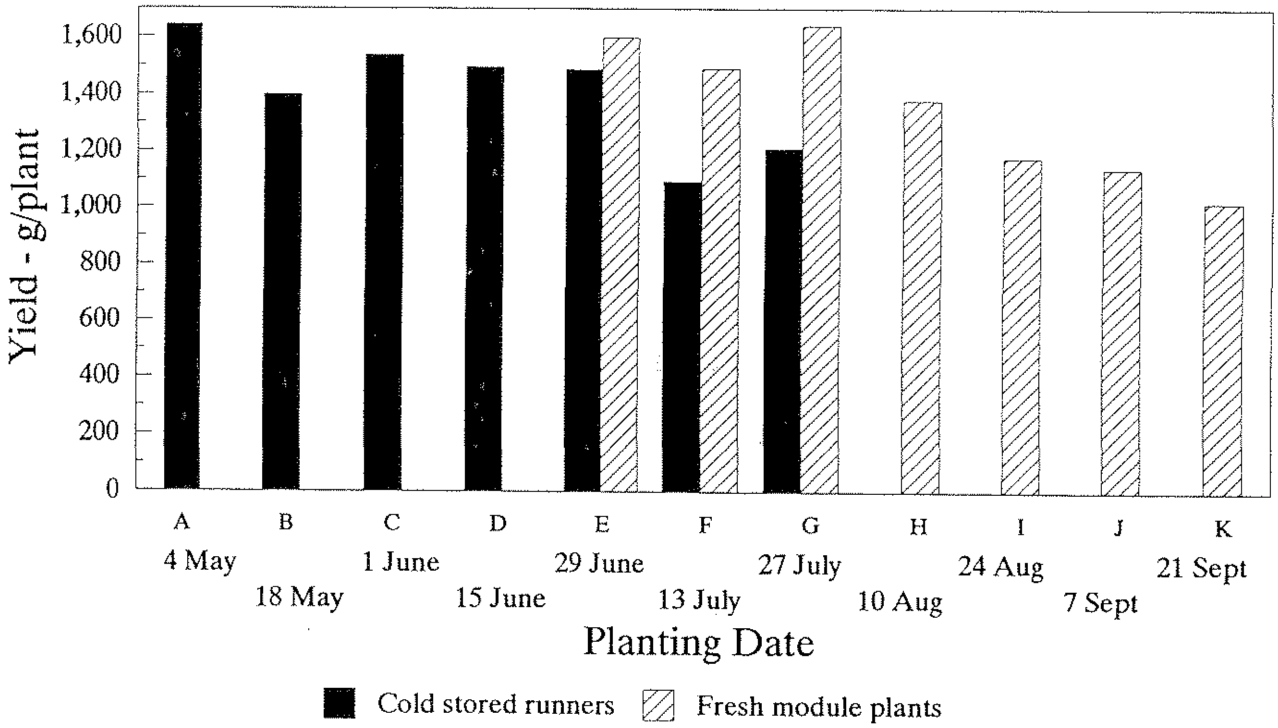


Fig 7 Combined Class 1 yields for 1990 + 1991
PANDORA



This study has not attempted a full commercial interpretation of these results, but has provided quantitative yield data to help enable various planting options to be assessed. Fruit prices applicable to the particular cropping season would obviously be a key factor in determining how much yield loss from a full potential yield could be tolerated by delaying planting. Annual cropping is becoming increasingly part of new intensive cropping systems and clearly also requires a high maiden yield to be successful. However this trial has shown that there can be some carry over effect to a second year from the latest planting dates, and even where there is a good second crop, it may not sufficiently compensate for a poor maiden crop.

Other important factors include the availability of land and labour for planting, and a reliable supply of plants. Using fresh plants does allow the possibility of replanting the same site in late July following a June / early July crop. If an earlier protected crop is taken, it should also be possible to sterilise the site before replanting. At present the limited availability of fresh plants in July, whether bare root or module raised, is a major factor restricting their uptake in the UK for this intensive cropping option. Commercial systems of module runner raising have been developed to supply plants before bare root runners become available, but module runner raising is a specialised operation and it appears that most propagators and growers still need confirmation of its benefits before it is adopted on a large scale. While there is still a significant demand for traditionally propagated but late fresh dug runners, there is little incentive for propagators to change.

Cold stored runners may be a suitable and less expensive alternative, but to obtain a good maiden yield they need planting before mid June for Elsanta or late June for Pandora. This precludes a previous crop from that site in that cropping year. A small crop is often taken from cold stored runners some 60 days after planting. This can be worthwhile when it falls into a high price period from late July onwards, but only if it does not jeopardize establishment and flower initiation for the following years crop when significant yield losses will almost certainly outweigh the return from a relatively small late summer crop.

CONCLUSIONS

1. Planting date can have a marked effect on the maiden yields of both cold stored and fresh module plants. Both plant types can produce equally good maiden yields, but for the largest crops cold stored runners require planting by early to late June and fresh modules by mid to late July for Elsanta and Pandora respectively. Module rooted cuttings should be an attractive alternative to fresh dug runners as the latter are largely unavailable until late August - early September by which time their maiden yield potential has already greatly declined.

2. Cold stored runners are less expensive than module plants and may be more suitable where land is available and it is not essential to follow a strawberry crop with a new planting in the same year. It is not clear from this trial alone whether or not it is worth retaining blossom for a small crop in the planting year.

3. Second year yields largely appear to level out across the range of planting dates used. Nevertheless the combined yields for two years still suggest that planting date will affect the profitability of two year as well as annually replanted crops.

4. Cold stored runners planted 4 - 6 weeks earlier than fresh module plants were much larger but gave similar yields. This appeared to have little effect on fruit size or quality in this trial, but larger plants could slow down picking. Fruit size appears to depend more on the age of the plant and the yield the plant is supporting rather than plant size *per se*.

5. The size of dormant plants after flower initiation of the maiden crop can give some indication of relative yield potential between different planting dates, but only within a given plant type. Plant size had no correlation with second year yield.

6. Planting date had little effect on cropping season except where yields were low from the late plantings in the first year. Typically the picking period here was shorter and the crop restricted to one or two trusses initiated late and therefore first to emerge from the crown.

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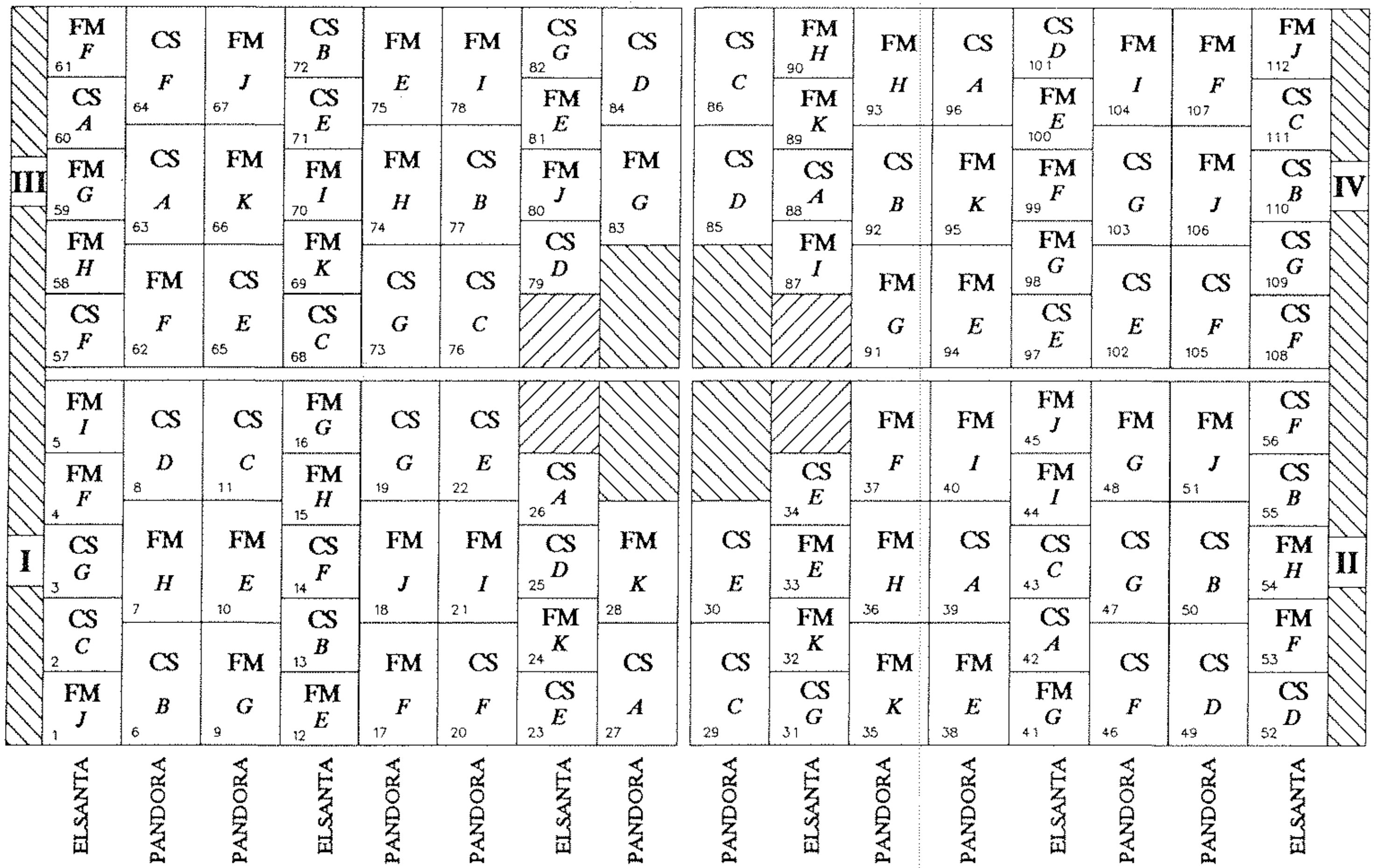
APPENDIX

Trial Plan and Plot Layout in Field

Effect of Planting Date on Cold-stored and Fresh Module Plants of Elsanta & Pandora 1989/90/91



Field S7

N

Treatments

Planting time

Week no.	Date 1989	
A - 18	4/5	CS
B - 20	18/5	CS
C - 22	1/6	CS
D - 24	15/6	CS
E - 26	29/6	CS / FM
F - 28	13/7	CS / FM
G - 30	27/7	CS / FM
H - 32	10/8	FM
I - 34	24/8	FM
J - 36	7/9	FM
K - 38	21/9	FM

Plant type

CS - Cold stored runners

FM - Fresh module plants

24 Plants per plot. Double rows on mulched raised beds at 1.52 m wheelings.

Elsanta 30 cm between rows x 30 cm in-row staggered = 3.6 m plot length.

Pandora 40 cm between rows x 50 cm in-row staggered = 6.0 m plot length.

18 beds @ 1.52 m = 27.4 m wide x 37 m long = 1014 m^2

[hatched] = Guards and dummy plots Pandora

[hatched] = Dummy plots Elsanta

} Cold-stored runners planted Week 20

Table 1. Mean Yield and Cropping Period of first 4 plantings of cold stored runners in 1989

Treatment/ Planting date	Yield g/plant* Total Class 1	Yield g/plant* Total Crop	% Class 1 > 25 mm	Cropping Period: Period picked	Cropping Period: Days	Cropping Period: 50% Pick date
ELSANTA						
A. 4 May	43	59	41	3/7-31/7	29	10 July
B. 18 May	83	105	43	3/7-3/8	32	13 July
C. 1 June	46	61	39	10/7-7/7	29	19 July
D. 15 June	24	30	38	20/7-7/7	19	27 July
PANDORA						
A. 4 May	25	38	42	7/7-31/7	25	12 July
B. 18 May	40	49	47	10/7-31/7	22	18 July
C. 1 June	18	25	44	20/7-7/8	19	24 July
D. 15 June	7	8	48	31/7-7/8	8	4 August

* For tonnes/ha divide by 22.8 (Elsanta) or 38.0 (Pandora).

Table 2. Yield of ELSANTA, 1990

Treatment/ Planting Date	Tonnes/ha Class 1 Lge	Med	Sml	Total	Class 2	Waste	Total Crop	g/plant Class 1
Cold Stored								
A. 4 May	7.9	18.9	3.0	29.7	1.4	6.0	37.1	685
B. 18 May	6.8	19.8	2.8	29.4	1.9	6.7	38.0	670
C. 1 June	9.1	17.9	2.2	29.2	1.9	5.0	36.1	666
D. 15 June	7.5	13.0	1.5	22.0	1.1	3.5	26.6	501
E. 29 June	8.7	13.4	1.3	23.4	1.4	3.8	28.6	533
F. 13 July	9.5	11.0	0.6	21.1	1.0	2.5	24.6	481
G. 27 July	4.4	5.2	0.2	9.9	0.4	1.3	11.6	234
Fresh modules								
E. 29 June	9.7	14.8	2.0	26.4	1.7	3.7	31.8	602
F. 13 July	6.4	18.2	2.4	27.0	2.1	5.9	35.0	615
G. 27 July	7.8	14.8	2.2	24.9	1.5	4.1	30.5	567
H. 10 August	7.0	13.4	2.0	22.4	1.8	3.5	27.7	512
I. 24 August	5.5	8.3	1.0	14.8	0.9	1.9	17.6	338
J. 7 September	2.8	2.8	0.2	5.8	0.2	1.2	7.2	135
K. 21 September	1.1	1.6	0.1	2.8	0.2	0.8	3.8	64
SED (39 df)	*1.95*	*2.19*	*0.36*	*3.94*	*0.33*	*n/a*	*4.70*	*89.8*

Table 3. Yield of PANDORA, 1990

Treatment/ Planting Date		Tonnes/ha Class 1						g/plant Class 1
	Lge	Med	Sml	Total	Class 2	Waste	Total Crop	
Cold Stored								
A. 4 May	6.1	10.6	1.1	17.7	2.1	6.0	23.1	689
B. 18 May	5.6	9.8	0.8	16.2	1.4	6.7	21.8	616
C. 1 June	5.5	10.2	0.7	16.5	1.4	5.0	21.3	627
D. 15 June	5.6	9.7	0.5	15.8	0.9	3.5	20.9	600
E. 29 June	7.2	9.6	0.6	17.4	1.2	3.8	21.6	661
F. 13 July	4.5	6.0	0.4	10.9	0.4	2.5	12.8	413
G. 27 July	4.6	4.4	0.4	9.5	0.3	1.3	11.0	372
Fresh modules								
E. 29 June	5.2	11.6	1.4	18.2	0.9	3.7	21.5	691
F. 13 July	5.3	8.9	1.3	15.6	9.8	5.9	19.0	593
G. 27 July	7.0	10.7	0.4	18.1	0.8	4.1	22.5	689
H. 10 August	3.3	10.7	1.0	15.0	0.4	3.5	17.9	571
I. 24 August	3.8	6.8	0.8	11.4	0.2	1.9	13.7	435
J. 7 September	2.6	6.4	0.5	9.5	0.2	1.2	11.2	362
K. 21 September	2.0	2.9	0.2	5.1	0.1	0.8	5.8	198
SED (39 df)	*0.95*	*1.41*	*0.35*	*1.94*	*0.24*	*n/a*	*2.22*	*73.6*

Table 4. Mean Leaf number per plant (November 1989). Original and log transformed data.

Treatment/ Planting Date	ELSANTA Leaves/plant	ELSANTA Natural log transform	PANDORA Leaves/plant	PANDORA Natural log transform
Cold stored				
A. 4 May	37.6	3.60	56.3	4.02
B. 18 May	28.6	3.31	54.5	3.97
C. 1 June	22.2	3.10	36.5	3.57
D. 15 June	20.2	2.99	30.0	3.38
E. 29 June	19.7	2.92	39.0	3.64
F. 13 July	14.4	2.66	17.0	2.74
G. 27 July	11.09	2.37	20.9	3.02
Fresh modules				
E. 29 June	17.1	2.82	25.2	3.21
F. 13 July	19.4	2.89	22.4	3.03
G. 27 July	14.0	2.63	19.2	2.86
H. 10 August	11.4	2.43	16.4	2.75
I. 24 August	9.4	2.24	12.4	2.51
J. 7 September	6.4	1.82	11.6	2.44
K. 21 September	4.8	1.55	7.1	1.96
Mean Cold stored	**22.0**	**2.99**	**36.3**	**3.49**
Mean Fresh modules	**11.8**	**2.34**	**16.3**	**2.68**
SED (39 df) to compare dates	-	*0.154*	-	*0.184*
SED (39 df) to compare plant types	-	*0.058*	-	*0.070*

Table 5. Cropping season 1990, Class 1 Fruit

Treatment/ Planting Date		10% pick	50% pick	90% pick	Days between 10-90% pick
Cold stored			**ELSANTA**		
A.	4 May	3 June	19 June	30 June	27
B.	18 May	2 June	19 June	30 June	28
C.	1 June	1 June	17 June	1 July	30
D.	15 June	1 June	16 June	27 June	26
E.	29 June	31 May	15 June	27 June	27
F.	13 July	2 June	16 June	26 June	24
G.	27 July	30 May	12 June	23 June	24
Fresh modules					
E.	29 June	1 June	17 June	29 June	28
F.	13 July	2 June	19 June	30 June	28
G.	27 July	1 June	18 June	29 June	29
H.	10 August	2 June	19 June	29 June	28
I.	24 August	30 May	16 June	28 June	29
J.	7 September	29 May	14 June	25 June	27
K.	21 September	27 May	7 June	18 June	22
Cold stored			**PANDORA**		
A.	4 May	28 June	6 July	13 July	17
B.	18 May	28 June	7 July	13 July	18
C.	1 June	29 June	7 July	14 July	20
D.	15 June	28 June	7 July	13 July	21
E.	29 June	28 June	6 July	14 July	21
F.	13 July	24 June	2 July	12 July	16
G.	27 July	27 June	5 July	13 July	23
Fresh modules					
E.	29 June	26 June	4 July	11 July	17
F.	13 July	24 June	3 July	11 July	14
G.	27 July	26 June	4 July	13 July	16
H.	10 August	26 June	4 July	11 July	15
I.	24 August	26 June	4 July	12 July	18
J.	7 September	26 June	3 July	11 July	19
K.	21 September	22 June	29 June	8 July	22

Table 6. Yield of ELSANTA, 1991

Treatment/ Planting Date	Tonnes/ha Class 1 Lge	Med	Sml	Total	Class 2	Waste	Total Crop	g/plant Class 1
Cold stored								
A. 4 May	3.8	29.4	2.3	35.5	3.3	8.9	47.8	809
B. 18 May	2.9	25.3	2.2	30.4	2.4	9.9	42.8	693
C. 1 June	2.8	24.4	2.2	29.4	2.6	8.0	39.9	670
D. 15 June	5.2	22.6	1.8	29.5	3.3	9.4	42.2	673
E. 29 June	5.6	23.5	1.7	30.8	3.0	8.0	41.8	702
F. 13 July	4.8	22.7	1.9	29.4	2.6	9.7	41.8	671
G. 27 July	4.2	23.7	2.3	30.2	2.4	8.3	40.9	690
Fresh modules								
E. 29 June	3.2	25.4	1.9	30.5	2.8	9.0	42.3	695
F. 13 July	3.3	26.4	1.9	31.5	3.5	8.8	43.8	718
G. 27 July	3.8	23.0	1.6	28.4	3.0	8.5	39.9	647
H. 10 August	4.0	22.2	2.6	28.8	2.4	6.7	37.8	657
I. 24 August	3.4	24.5	2.5	30.4	2.0	5.2	37.6	693
J. 7 September	3.6	18.5	1.7	23.8	1.8	5.9	31.5	542
K. 21 September	3.6	17.8	2.4	23.7	2.1	4.7	30.5	541
SED (39 df)	*0.83*	*4.40*	*0.59*	*5.22*	*0.67*	*n/a*	*6.24*	*119.0*

Table 7. Yield of PANDORA, 1991

Treatment/ Planting Date	Tonnes/ha Class 1 Lge	Med	Sml	Total	Class 2	Waste	Total Crop	g/plant Class 1
Cold stored								
A. 4 May	4.4	18.4	2.3	25.0	2.2	4.7	32.0	951
B. 18 May	4.2	14.6	1.8	20.6	2.0	5.5	28.1	781
C. 1 June	3.9	17.4	2.6	23.9	2.0	5.3	31.2	909
D. 15 June	4.0	17.1	2.4	23.6	2.4	4.5	30.4	895
E. 29 June	5.1	14.6	2.0	21.7	3.0	6.7	31.4	825
F. 13 July	3.6	12.2	2.1	17.9	2.2	5.6	25.7	679
G. 27 July	4.0	15.2	2.8	22.0	3.1	5.5	30.6	836
Fresh modules								
E. 29 June	4.2	17.3	2.4	23.8	2.1	5.0	31.0	905
F. 13 July	4.6	16.5	2.5	23.6	2.4	4.8	30.9	897
G. 27 July	5.6	17.6	1.9	25.0	2.8	6.4	34.2	951
H. 1 August	4.0	14.8	2.5	21.2	1.8	6.0	29.0	806
I. 24 August	3.9	13.7	1.9	19.4	3.0	6.3	28.8	739
J. 7 September	3.5	15.2	1.6	20.3	1.5	5.7	27.6	773
K. 21 September	3.6	16.0	1.9	21.5	2.0	4.8	28.4	819
SED (39 df)	*0.78*	*2.99*	*0.48*	*3.51*	*0.57*	*n/a*	*4.35*	*133.4*

Table 8. **Mean Plant Volume per plant (5 plants/plot x 4 replicates) measured December 1990 prior to second cropping year.**

Treatment/ Planting Date	Plant Volume/cm^3 ELSANTA	PANDORA
Cold stored		
A. 4 May	13757	20410
B. 18 May	13593	21497
C. 1 June	11566	17345
D. 15 June	10005	15859
E. 29 June	11989	22728
F. 13 July	10040	10357
G. 27 July	6247	14841
Fresh modules		
E. 29 June	10747	15535
F. 13 July	11501	11955
G. 27 July	11310	13266
H. 10 August	7590	11661
I. 24 August	5185	10851
J. 7 September	3372	10490
K. 21 September	2259	6119

Table 9. Yield of ELSANTA, 1990 + 91

Treatment/ Planting Date		Tonnes/ha Class 1 Lge	Med	Sml	Total	Class 2	Waste	Total Crop	g/plant Class 1
Cold stored									
A.	4 May	11.8	48.5	5.3	65.6	4.8	15.0	85.3	1495
B.	18 May	9.7	45.1	5.0	59.8	4.3	16.7	80.8	1363
C.	1 June	11.9	42.3	4.4	58.6	4.4	13.0	76.1	1337
D.	15 June	12.6	35.5	3.3	51.5	4.5	12.8	68.8	1175
E.	29 June	14.3	36.9	3.0	54.2	4.4	11.8	70.4	1235
F.	13 July	14.3	33.7	2.6	50.6	3.7	12.2	66.4	1153
G.	27 July	8.8	29.2	2.5	40.5	2.8	9.6	52.9	924
Fresh modules									
E.	29 June	12.9	40.1	3.9	56.9	4.5	12.7	74.1	1298
F.	13 July	9.7	44.6	4.2	58.5	5.6	14.7	78.8	1333
G.	27 July	11.6	37.9	3.8	53.3	4.5	12.7	70.4	1214
H.	10 August	11.0	35.7	4.6	51.3	4.1	10.1	65.6	1169
I.	24 August	8.9	32.9	3.4	45.3	2.9	7.1	55.3	1032
J.	7 September	6.4	21.4	1.9	29.7	2.0	7.1	38.9	678
K.	21 September	4.7	19.4	2.4	26.5	2.2	5.5	34.3	605
SED (39 df)		*2.44*	*6.10*	*0.70*	*8.38*	*0.81*	*n/a*	*10.13*	*191.1*

Table 10. Yield of PANDORA, 1990 + 91

Treatment/ Planting Date	Tonnes/ha Class 1 Lge	Med	Sml	Total	Class 2	Waste	Total Crop	g/plant Class 1
Cold stored								
A. 4 May	10.5	29.2	3.4	43.2	4.4	8.1	55.6	1641
B. 18 May	10.0	24.3	2.7	36.8	3.4	9.7	49.9	1398
C. 1 June	9.4	27.7	3.3	40.4	3.5	8.6	52.5	1536
D. 15 June	9.6	26.8	2.9	39.3	3.3	8.7	51.3	1495
E. 29 June	12.2	24.3	2.6	39.1	4.1	9.7	53.0	1487
F. 13 July	8.1	18.2	2.5	28.8	2.6	7.1	38.5	1093
G. 27 July	8.8	19.8	3.2	31.8	3.4	6.7	41.9	1209
Fresh modules								
E. 29 June	9.4	28.9	3.7	42.0	3.1	7.4	52.5	1597
F. 13 July	10.0	25.5	3.8	39.2	3.3	7.4	49.9	1491
G. 27 July	12.6	28.3	2.3	43.2	3.5	10.1	56.8	1640
H. 10 August	7.3	25.4	3.5	36.3	2.2	8.4	47.0	1378
I. 24 August	7.7	20.5	2.7	30.9	2.3	8.3	42.5	1174
J. 7 September	6.2	21.7	2.0	29.9	1.7	7.2	38.8	1136
K. 21 September	5.7	19.0	2.1	26.8	2.2	5.4	34.4	1017
SED (39 df)	*1.49*	*3.64*	*0.70*	*4.62*	*0.63*	*n/a*	*5.56*	*175.6*