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CONTENTS

PRACTICAL SECTION FOR GROWERS

Background and Objectives

The profitability of AYR chrysanthemum production is reliant upon the speed and uniformity of the winter crops. This project assessed the possibility of improving productivity by the use of modified propagation media and extending propagation times.

In the Netherlands a number of attempts have been made to produce blocking media with a more open structure using a higher than normal percentage of sphagnum peat in the blend. These blocks are considerably more expensive than conventional blocks due to the need to use a glue material to maintain the blocks in good condition during transit. As transport of blocks is not a requirement for the majority of UK growers, it may be possible to produce an equivalent or superior block from materials readily available in the UK without the need for glue and therefore at a reduced cost.

Sphagnum peat has been demonstrated to be beneficial to plant growth by suppressing *Pythium*, which is one of the major causes of unevenness in winter AYR crops. Different light and dark sphagnum peats appear to have different levels of suppressiveness to *Pythium*. Whilst sphagnum amendments may be expected to suppress *Pythium* within blocks, the effects on planting out are unknown. Peat blocks manufactured entirely from sphagnum peat tend to be fragile until sufficient root growth develops to hold them together. Dutch propagators have found that their distribution system prevents them from using more than 40% of sphagnum peat in their blocks, even when including 'glue' components. Producing blocks with a high proportion of sphagnum content is a more realistic proposition for UK growers who usually produce blocks on site. The possible improvements in air-filled porosity (AFP) and disease-suppressive biological activity could provide a cost-effective method for UK growers to improve their blocking medium composition.

The aim of this study was to assess the effect of blocking media and propagation duration on production time and on toleration of *Pythium*.

Key Results and Conclusions

The effects of 3 blocking media (Scotts 'standard', Scotts 'improved' and Masons) and 3 propagation durations (11, 15 and 20 days) on cropping time, yield and quality of AYR chrysanthemums

The experimental programme assessed two blocking media, which are currently available commercially in the UK, and compared these with a home-produced product from A J Mason. The blocking media were:

- Scotts standard
- Scotts improved
- Mason blocking

The Scotts standard medium was the B2 mix widely used by the UK industry with the exception that the blocks used in this work did not contain Aaterra. The Scotts improved medium is a new mix, blended to give a more open structure to blocks. Mason blocks are an open blend of Irish medium sphagnum peat. Blocks were prepared in two sizes, 5 x 5 x 3 cm and 6 x 6 x 3 cm (length x breadth x depth), using a Flier P1 blocking machine. The former, which may be considered the standard winter block size in the UK, was used for all 11 and 15 day propagation treatments and additionally, the 20 day propagation treatment using Mason's blocking medium. 6 cm blocks were used for the 20 day propagation treatment using Scotts standard and Scotts improved media. The plants were grown according to good commercial practice for winter grown AYR chrysanthemums.

Table A: Propagation and planting schedule for the growing trials

Propagation duration (days)	Block size (cm)	Stick date	Planting date
20*	6x6x3	04/11/99	24/11/99
15	5x5x3	04/11/99	19/11/99
11	5x5x3	08/11/99	19/11/99

** N.B. 20 day propagation treatment using Mason's medium used 5 cm blocks*

Key findings

- For any given duration of propagation, root development in the Scotts Standard blocks was markedly poorer than in either the Scotts Improved blocks or the Masons blocks. There was no obvious difference in rooting between Scotts Improved and Masons blocks when the propagation duration was 15 or 20 days, but root development in the Masons blocks was greater than in the Scotts Improved blocks when the propagation duration was only 11 days.

- Plant height, leaf number and plant fresh weight all appeared to increase in an approximately linear manner during the first 15 days of propagation. There were no obvious differences in growth between the two Scotts blocking media, but vegetative growth was slightly reduced in the Masons medium after 15 days of propagation.

- Plant height, leaf number and plant fresh weight increased exponentially between 15 and 20 days and, at 20 days, vegetative growth in the Scotts Standard treatment had outstripped that in both the Scotts Improved treatment and in the Masons treatment. This effect may have been due to the smaller blocks used in the Masons treatment, and to not adopting a more frequent irrigation regime for the two freer-draining substrates, but could also be due to different partitioning of assimilates between roots and shoots, with more root demand in the latter substrates.

- Although the 11-day and 15-day treatments were planted out at the same time in the glasshouse, the 15-day propagation treatments consistently reached the 40 cm 'stick height' stage one day ahead of the 11-day propagation treatments. This almost certainly reflects the slightly larger initial plant heights of the 15-day blocks.

- The 20-day treatments were planted out 5 days after the 11-day and 15-day treatments, but the 20-day Scotts Standard and Scotts Improved treatments reached the 40 cm stage at most only one day after the equivalent 15-day treatments and after receiving about 17% less light. The extra 5 days in propagation did, therefore, appear to translate into a roughly equivalent reduction in time spent in LD in the glasshouse.

- The 20-day Masons treatments reached the 40-cm stage two days after the 20-day Scotts treatments and after receiving 15.5% more light. This was almost certainly a result of the Masons blocks having been seriously disadvantaged during propagation because of a smaller block size.

- Sampling of individual plants showed that the average height of the 20-day block plants at the '40 cm stage' was 1-3.5 cm less than that of the 11-day and 15-day block plants. This indicates that the glasshouse LD phase for the 20-day blocks ought to have been 1-2 days longer than was actually the case, and that a more realistic estimate of the saving in LD in the glasshouse of propagating for 20 days might be only 2-3 days.

- There were no obvious differences between the treatments in average leaf number per stem, plant fresh weight or plant dry weight at the start of SD and no differences in crop uniformity. This indicates that ending the LD phase at a defined physiological stage and allowing growth to proceed for however long is required to reach this stage, effectively compensates for differences apparent in the blocked plants at planting out in the glasshouse.

- Treatments benefited rather less from interruption than might have been expected because interruption, based on average daily light integral, was given 2-3 days later than planned.

- The 15-day propagation treatments required 1-3 fewer SD to reach the harvest stage than either the 11-day or 20-day treatments. This effect appeared to be a direct consequence of initial propagation treatments rather than light receipt or other factors.

- Summing over all phases of growth in the glasshouse, the 15-day propagation treatments reached the harvest stage 2.8 days before the 11-day treatments (on average), having received about 5% less light. 20-day treatments using Scotts Standard and Scotts Improved media reached the harvest stage 5.8 days faster than the equivalent 11-day treatments, having received 6.3% less light. These also reached the harvest stage 3 days faster than the equivalent 15-day treatments, having received almost identical light integrals. It appears that in speed terms at least, much of the benefit of the longer propagation period and later planting into the glasshouse was preserved through to harvest. See Plates A, B & C.

- The 20-day Masons treatment reached the harvest stage only 2 days ahead of the equivalent 11-day treatment, and 1 day after the equivalent 15-day treatment, having received 8.8% more light! The situation may well have been different however, had the Masons 20-day treatment been stuck in 6cm blocks like the other 20-day treatments.

- The harvest durations for 11-day and 15-day propagation treatments were very similar (8-9 days). However, the harvest duration for 20-day treatments tended to be 1-2 days longer.

- 20-day propagation treatments appeared to give a higher percentage of stems (75%) in the two top weight grades than 15 or 11-day treatments, which achieved 68% each.

Plate A: The stage of development of the 11 day propagation treatments on 21/02/2000 with a stick date of 08/11/1999 and planting on 19/11/99. Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

Plate B: The stage of development of the 15 day propagation treatments on 21/02/2000 with a stick date of 04/11/1999 and planting on 19/11/99. ***Note that these plants were planted out on the same day as the 11 day propagation treatment above.*** Note the smaller leaf size and shorter pedicels compared to the 11day and 20day propagation periods; this was due to a delay in the start of light interruption for this 15day treatment. Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

Plate C: The stage of development of the 20 day propagation treatments on 21/02/2000 with a stick date of 04/11/1999 and planting on 24/11/99. ***Note that these plants were planted out 5 days later than the 11 day and 15 day propagation treatments.*** Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

The effects of 3 blocking media (Scotts 'standard', Scotts 'improved' and Masons) and 3 propagation durations (11, 15 and 20 days) on tolerance/resistance to *Pythium* root rot

- The Scotts improved medium gave the best results in *Pythium* disease challenge experiments, reducing root browning and vigour loss compared to the Scotts standard medium. The best results were achieved with the 20 day propagation, where the Scotts improved-grown plants maintained shoot heights and leaf numbers comparable to uninoculated controls after 3 weeks.

- In sand tray experiments, the dry weights of all inoculated plants were less than those of equivalent uninoculated controls in all treatments. Inoculated plants that managed to maintain equivalent heights and leaf numbers to controls often showed a smaller deficit in weight, probably resulting from reduced leaf area. An initial experiment using inoculated boxes on soil beds indicated that, if these infected plants can maintain height in the first two weeks they will still produce marketable stems.

- The good performance of plants in the Scotts improved medium appeared to be linked to this medium having a combination of a high AFP and high biological activity (FDA number), giving strong root growth and some protection from pathogens at planting (see Table B below).

Table B: Comparisons of air filled porosities (AFP) and measurements of biological activity (fluorescein diacetate (FDA)) for the Scotts standard, Scotts improved and Masons blocking media.

	Blocking medium		
	Scotts standard	Scotts improved	Masons
AFP (%)	0.63	9.92	5.62
FDA (µg/g dry wt/min)	10.62	9.01	5.31

Action Points for Growers

- Increasing the propagation time beyond 11 days has two positive effects:
    a) it decreases the time in long days by up to 2½ days and reduces the time from planting to harvest by up to 5 days.
    b) it produces a stronger root system and greatly improve a plant's resistance to *Pythium* attack at planting.

  However, it is important to note that for propagation times greater than 15 days, a larger block size (6 cm or more) is essential to achieve a good root run, and to reduce the number of plants in the tray.

- Give sufficient long days to ensure adequate stem length and sufficient maturity to allow rapid response to short days. Don't try to save time by cutting down on the long days' it will cost in the end. Follow the Langton scale for timing the interruption.

- Even if *Pythium* is only present at low levels, steaming the soil prior to planting is likely to improve cropping speed and the rate at which the 40cm stem height is attained. In the absence soil steaming, improvements in plants' tolerance to *Pythium* can be achieved with use of appropriate blocking media and block preparation (see below).

- Good strong root growth in the propagation block, with plenty of root tips exiting the block at planting, is essential for rapid establishment and growth in the first few weeks in the face of a *Pythium* challenge. Choose an open blocking compost with as much light peat as possible. Always set the blocking machine and the wetness of the mix during blocking to give the most open structure. Tolerating the nuisance of working with more fragile blocks will pay dividends if *Pythium* is usually a problem in the winter and spring months.

- In the absence of a *Pythium* challenge (i.e. good, clean, freshly-sterilised beds), the blocking media is likely to have little influence on plant establishment or on the time from planting to harvest, provided the block structure is kept reasonably open and the AFP is as high as possible. Plant out as large a plant as possible (the 'top of the tray' principle).

- For more information about *Pythium* in AYR chrysanthemums and its management/control, a summary of research carried out at HRI Efford is contained in HDC report *PC157 addendum.*

SCIENCE SECTION

Introduction

The profitability of AYR chrysanthemum production is reliant upon the speed and uniformity of the winter crops. The results of year one of this study have demonstrated that improvements in productivity are possible from the use of modified propagation media and extending the propagation time. This improvement reduced crop times and improved plants' tolerance of *Pythium* root rot, which is a major cause of grade-out losses from unevenness in winter crops and also contributes, to increased cropping and harvesting times.

In the Netherlands a number of attempts have been made to produce blocking media with a more open structure using a higher than normal percentage of sphagnum peat in the blend. These blocks are considerably more expensive than conventional blocks due to the need to use a glue material to maintain the blocks in good condition during transit.. As transport of blocks over any great distance is not a requirement for the majority of UK growers, it may be possible to produce an equivalent or superior block from materials readily available in the UK without the need for glue and therefore at a reduced cost.

Sphagnum peat has been demonstrated to be beneficial to plant growth by *Pythium* suppression (Boehm & Hoitink, 1992). Heat treatment of sphagnum peats for sterilisation reduces the efficacy of this *Pythium* suppression phenomenon indicating that it is biological in action (Hoitink & Boehm, 1999). As the age and the degree of decomposition of the peat increases, progressing from the lighter and less degraded peats to the dark mature peats, the ability of the material to suppress *Pythium* is apparently reduced (Hoitink & Boehm, 1992). This reduction is possibly linked to reductions in the available carbohydrates, which are thought to serve as a food source for a naturally occurring *Pythium* suppressive microflora (Boehm *et al.,* 1997). These studies have considered only potting media from USA sources, and no work has yet been completed on the impact of sphagnum peat added to propagation blocks. Whilst sphagnum amendments may be expected to suppress *Pythium* within blocks, the effects on planting out are unknown. Peat blocks manufactured entirely from sphagnum peat tend to be fragile until sufficient root growth develops to hold them together. As mentioned above, Dutch propagators have found that their distribution system prevents them from using more than 40% of sphagnum peat in their blocks, even when including 'glue' components. Producing blocks with a high proportion of sphagnum content is a more realistic proposition for UK growers who usually produce blocks on site. The possible improvements in air-filled porosity (AFP) and disease-suppressive biological activity could provide a cost-effective method for UK growers to improve their blocking medium composition.

The aim of this study was to further assess the effect of blocking media and propagation times on cropping time and toleration of *Pythium*. The study concentrated on three areas:

- The effect of one ‘nursery own’ and two commercially-available blocking media and three propagation times (11, 15 and 20 days) on cropping time, yield and quality.

- Assessments of the effects of the same three blocking medium, and propagation time treatments on *Pythium* root rot tolerance/resistance.

- Production and *Pythium* disease-challenge testing of a range of blocking media produced with different ratios of light and dark sphagnum peats, designed to give a range of air-filled porosities and biological activities.

Materials and Methods

The programme of work was divided into 3 sections:

Section A	-	Growing trials in propagation and on soil beds (C-block)
Section B	-	Disease trials in sand trays on enclosed sand beds and in boxes in soil beds (C-block)
Section C		Small-scale laboratory-based pathology study on the 'suppressiveness' of peat mixes to pathogenic *Pythium* spp.

Section A: Growing trials

Block treatments

The experimental programme assessed two blocking media, which are currently available commercially in the UK, and compared these with a home-produced product from A J Mason. The blocking media were:

Scotts standard
Scotts improved
Mason blocking

The Scotts standard medium was the B2 mix widely used by the UK industry with the exception that the blocks used in this work did not contain Aaterra. The Scotts improved medium is a new mix, blended to give a more open structure to blocks. Mason blocks are an open blend of Irish medium sphagnum peat. Analysis of mineral nutrient content was carried out on all three blocking media and the results of this are presented in Appendix I.

In addition, the 'biological activity' of each medium was assayed using the fluorescein diacetate hydrolysis procedure (FDA, Zelles *et al.*, 1991).

Blocks were prepared in two sizes, 5 x 5 x 3 cm and 6 x 6 x 3 cm (length x breadth x depth), using a Flier P1 blocking machine. The former, which may be considered the standard winter block size in the UK, was used for all 11 and 15 day propagation treatments and additionally, the 20 day propagation treatment using Mason's blocking medium. 6 cm blocks were used for the 20 day propagation treatment using Scotts standard and Scotts improved media.

The air filled porosity of freshly prepared blocks was determined using an adaptation of the method of Bragg and Chambers (1988). For each block assessed, a strip of stiff, corrugated polyethylene board was trimmed to a width equal to the block height and to a length equal to the combined length of the four sides of the block plus approximately 1 cm for overlap. These strips were folded at four points, matching the corners of the blocks and were wrapped around the outside of blocks and held in place with rubber elastic bands. The top and bottom of each block were covered with small squares of 100 μm nylon mesh, also secured in place with elastic bands. Covered blocks were gently submerged in tap water. Once fully saturated, blocks were taken from the water and placed in plastic weighing boats after the mesh covers had been removed. After determination of their saturated weight, blocks were placed under 20 cm tension until they reached equilibrium in terms of weight. The constant water tension was achieved by placing a 'rockwool' slab in a water reservoir and maintaining a constant 20 cm height of rockwool above the water level. Blocks were placed on the top edge of the slab. Once a constant weight was reached, this was recorded and the AFP calculated using the formula:

$$\text{AFP (\%)} = (\text{Volume of drainage water} \div \text{Volume of compost}) \times 100$$

$$= \{(a - b) \div \text{block volume}\} \times 100,$$

where a is the saturated block weight and b is the stabilised block weight at 20 cm tension.

Propagation

Plants for the studies of the propagation phase, establishment in soil beds and for pathology assessments of the three blocking media described above, were stuck following the schedule in Table 1. Clear polythene sheeting was placed over plants after sticking and removed after 6 days.

Table 1: Propagation and planting schedule for the growing trials.

Propagation duration (days)	Block size (cm)	Stick date	Planting date
20*	6x6x3	04/11/'99	24/11/'99
15	5x5x3	04/11/'99	19/11/'99
11	5x5x3	08/11/'99	19/11/'99

* *N.B. 20 day propagation treatment using Mason's medium used 5 cm blocks*

A single AYR chrysanthemum variety was used for all work described in this report. This was the same as used in year 1 of this work, and was ‘Dark Splendid Reagan’. This is a dark purple flowered variety with a response of 8.5 weeks. Planting material produced from motherstock in Kenya was purchased as unrooted cuttings from Yoder Toddington.

The cuttings were kept on heated benches in trays (40 x 60 cm, containing either eighty four 5 cm, or sixty 6 cm blocks). Whilst covered, the temperature within the peat blocks was maintained at a minimum set point of 22 ^{o}C; once uncovered, a minimum block temperature of 18^{o}C was maintained using air temperature heating set points of 18^{o}C day /19^{o}C night, with venting set at 23^{o}C.

Cyclic night break lighting was used throughout propagation to maintain vegetative growth. Incandescent lamps giving a PAR irradiance of 0.5 W/m^2 were used from 22:30 to 03:30 hrs, with a 15 minute ‘on’, 15 minute ‘off’ cycle.

The effects of the three blocking media and block size on plant establishment and development during propagation were assessed, with the standard-sized (5 cm) blocks monitored over 15 days and the larger over 20 days.

Destructive samples of ten plants were taken at 2 – 3 day intervals, starting 2 - 4 days after sticking when the cuttings were fully turgid. Samples were assessed for plant height, number of expanded leaves per plant, shoot fresh weight and root development. Plant height was defined as the distance from the upper surface of the block to the main shoot tip. Shoots were cut level with the upper surface of the block for fresh weight determinations.

Root development was assessed using a simple scoring system:

Score 0 = roots of 5 mm or more emerging around the base of the stem
Score 1 = more than 2 roots reaching the edge of the block
Score 2 = roots extending beyond the edge of the block.

Establishment and take-off on soil beds

Planting was carried out in weeks 46 and 47, on the dates detailed in Table 1. The planting density was 53/m^2 of bed, or 83% of the standard summer spacing of 64/m^2. The experimental design giving the plot layouts can be found in Appendix II. As a result of the blackout requirements dictated by the individual application of short days (SD) to each treatment (see below), experimental plots consisted of half beds in C block at HRI Efford. Consequently, the size of the plots restricted the number of replicate plots possible to two per treatment

After planting, long days (LD) continued to be applied until the length of the majority of stems within individual treatment plots had reached 40 cm from ground level. This was judged subjectively for each individual plot using centrally-placed height measurement sticks. SD were given by applying blackouts individually to each plot. Supplementary lighting was not used in any treatments.

It was planned that the timing of the interruption treatment for each plot would be according to average daily light integral received during the SD phase as described previously (Langton, 1992 - summarized in Table 2). The duration of the interruption was constant for all plots at 10 days.

Table 2: Average daily light integral received outside the glasshouse ($MJ/m^2/d$) and number of SD needing to be achieved at the start of interruption (based on Langton, 1992 for 70% transmission and assuming the variety Reagan responds as variety Delta).

Number of SD	Average daily light integral ($MJ/m^2/d$)
15	3.17
16	2.45
17	2.09
18	1.85
19	1.67
20	1.52

The heating set-points for all treatments were 18°C day and 19°C night, with ventilation at 23°C.

The target concentration for CO_2 enrichment was 1000 vpm when the vents < 5% open. This was reduced to 500 vpm when the vents were > 5% open.

A standard ADAS winter feed stock solution comprising Potassium nitrate 8.7 kg and Ammonium nitrate 5.3 kg/100 litres was made up. This stock solution was diluted for irrigation at 1/200 to give 149 N, 165 K (199 K_20) and irrigation was scheduled according to light receipt.

A programme of routine sprays was applied for the preventative control of western flower thrips (see crop diary Appendix III). This programme was supplemented with spot treatments when required to control other pests. Growth regulant was applied to all treatments on two occasions using B-Nine (1.75 g/l Daminozide, 85% a.i., water soluble powder), at between 1-3 days and 33-43 days after the start of short days. Details of actual application dates are given in the Appendices.

Section B: Disease trials

Effect of commercial blocking media and propagation time on disease severity

The same block types and propagation times as assessed above were compared for their performance under a controlled inoculation with two virulent isolates of *Pythium sylvaticum*. The experimental conditions for this study were identical to those used in the 'sand tray' inoculation work in year 1 of this project (see Carver, 2000, pages 12 & 13). The sticking and planting dates for plants were the same as those for the agronomic trials and are detailed in Table 1.

The effect of inoculation was assessed in comparison with non-inoculated controls immediately prior to planting (referred to as 0 days after planting), and at five times (3, 7, 10, 16 and 23 days) after planting. Samples of eight plants per treatment were gently removed from the sand and washed by immersion in sterile distilled water. The following parameters were then recorded on each occasion:

- Plant height from the top of the block to the growing apex (cm).
- Leaf number per plant.
- Shoot dry weight (g).
- Root growth (% coverage of the block base – 'root bulk').
- Root browning (% of the emerged roots browned).
- Confirmation of presence/absence of *Pythium* infection, 3 mm sections of root were taken with sterile forceps and plated onto selective agar (BNPRA, Pettitt & Pegg, 1991).

'Matrix' experiment

An experiment was established to assess the effect of the AFP and of the 'biological activity' as determined by FDA (see *Block treatments* page 7 above), on the performance of blocks both in the presence and absence of *Pythium* inoculum. Three components were mixed in different ratios to give 21 blends of peat. These were, the basic peat blend for Scotts B2 (supplied by Scotts Co Ltd., without lime or nutrition but containing wetter), a milled light sphagnum, and a milled dark sphagnum peat (supplied by Bullrush Peat Co Ltd and classified as H2 and H4 peats on the von Post decomposition scale (Puustjärvi & Robertson, 1975)). The light and dark sphagnum peats were selected for their high and low levels of biological activity respectively. In American research (Boehm & Hoitink, 1992), the biological activity of peats, as determined by their FDA activity, has been correlated with the suppression of

Pythium disease in a number of host plant species. In the current experiment the light and dark sphagnum peats were mixed in five ratios to give different levels of biological activity. These were:

A = 100% Light
B = 75% Light : 25% Dark
C = 50% Light : 50% Dark
D = 25% Light : 75% Dark
E = 100% Dark

These mixes of sphagnum peat were blended at four different ratios (0:100, 25:75, 50:50, 75:25) with the B2 base (referred to as ST to avoid confusion with the sphagnum blend B) in an attempt to produce a range of AFPs (see Table 3).

Table 3: Ratios of light sphagnum (H2 peat), dark sphagnum (H4 peat) and ST (Scotts B2 basic blend without mineral nutrition added) in each of the block mixes assessed in the 'Matrix' experiment.

100% A 100% light - -	**100% B** 75% light 25% dark -	**100% C** 50% light 50% dark -	**100% D** 25% light 75% dark -	**100% E** - 100% dark -
75% A, 25% ST 75% light - 25% ST	**75% B, 25% ST** 56.25% light 18.75% dark 25% ST	**75% C, 25% ST** 37.5% light 37.5% dark 25% ST	**75% D, 25% ST** 18.75% light 56.25% dark 25% ST	**75% E, 25% ST** - 75% dark 25% ST
50% A, 50% ST 50% light - 50% ST	**50% B, 50% ST** 37.5% light 12.5% dark 50% ST	**50% C, 50% ST** 25% light 25% dark 50% ST	**50% D, 50% ST** 12.5% light 37.5% dark 50% ST	**50% E, 50% ST** - 50% dark 50% ST
25% A, 75% ST 25% light - 75% ST	**25% B, 75% ST** 18.75% light 6.25% dark 75% ST	**25% c, 75% ST** 12.5% light 12.5% dark 75% ST	**25% D, 75% ST** 6.25% light 18.75% dark 75% ST	**25% E, 75% ST** - 25% dark 75% ST
100% ST - 100% ST	-	-	-	-

The pH of each of the resulting 21 peat mixes was determined and lime (as magnesium limestone) was added at rates determined following ADAS guidelines (MAFF, 1985 & ADAS, 1988) to achieve a final pH equivalent to that of ready to use B2 blocking compost (pH 5.62). These mixes were all used to produce bocks without addition of mineral nutrition. In addition, mineral nutrition was added to the following five mixes to give 26 blocking mixes in total:

100% C
75% C : 25% ST
50% C : 50% ST
25% C : 75% ST
100% ST

The nutrition was set at B2 rates (ie 150 N; 100 P and 200 K {mg/l}). This was done using Potassium nitrate (482 mg/l), Calcium nitrate (532.2 mg/l) Single super phosphate* (1352 mg/l; *in lieu of di-Calcium phosphate) and fritted trace elements (200mg/l).

Blocks were made using a Brinkmanns hand-operated blocking machine, giving blocks of dimensions 4 x 4 x 4.5 cm. These were placed in propagation trays at 60 per tray. Cuttings of var. Dark Splendid Reagan were stuck in the blocks and propagation was carried out as described above (see *Propagation*) for 14 days. Block performance was assessed 14 days after planting in inoculated sand trays as described previously (see above and Carver, 2000, pages 12 & 13). The parameters of performance were, plant height, leaf number per plant, % root vigour ('bulk') and % root browning all measured in a single destructive harvest of 8 replicate plants per treatment.

Evaluation of selected 'matrix' block media on soil beds

Five block recipes were selected from the 'matrix' experiment to be compared in both steamed and unsteamed beds in the production of a commercial crop in C block at HRI Efford. The block recipes were:

i) 100% standard peat at full nutrition
ii) 100% standard peat at half nutrition
iii) 50% dark peat at full nutrition
iv) 50% dark peat at half nutrition
v) 50% light peat at full nutrition
vi) Scotts B2 peat mix.

2300 blocks of each type were prepared using a Flier P1 blocking machine. Samples of blocks of each type were taken for determinations of FDA activity and AFP using the procedures described above. All remaining blocks were stuck with cuttings of variety Dark Splendid Reagan and put into propagation for 14 days under the same conditions as those described above. At planting, heights and leaf numbers were recorded and block types were tested in eight unsteamed and two steamed plots each (for trial layout see Appendix V and for crop diary see Appendix VI). Planting was at 53 plants m^{-2}. 40 days after planting an interim assessment of plant performance was carried out on 12 plants per plot measuring plant height, leaf number, leaf area and stem fresh weight. Another height assessment was carried out on 12 plants per plot immediately prior to harvest and at harvest the number and individual weight of marketable wraps from each plot was recorded.

Evaluating box system for disease simulation in commercial soil plots

Although they provide good control of inoculum and infection, there is a problem in interpreting the results of sand tray experiments in terms of potential impacts of treatments tested on the likely final harvest. The sand tray system can only give useful information over the short-term (up to 3 weeks post planting) after which, the conditions in these systems is so unlike a commercial production bed that plant responses in them are unlikely to be representative. Often treatments appeared promising in sand tray experiments with infected plants maintaining similar heights and sometimes, even shoot fresh weights, to uninfected controls. However, it was not possible to determine whether these effects seen over the first few weeks after planting would be durable until harvest. An experimental system was therefore devised to carry out controlled inoculations within a normal soil bed and subsequently restrict the spread of pathogen within the bed so that the performance of inoculated plants in competition with their uninfected neighbours could be determined right up to harvest. This approach aimed to simulate the patchy pattern of disease normally seen in commercial systems.

Open-bottomed boxes or shutters, 30 cm deep and with an upper surface area equivalent to nine squares on the bed net (area of 225 sq. inches or 1451.6 cm^2, see Plates 6 - 8, pages 53-54), were constructed from 16mm sterling board. These boxes were positioned in the soil with approximately 1 cm proud of the soil level and were filled with soil. Eight boxes were placed in three soil beds in C block, HRI Efford (for positions of boxes see Appendix VII page 65), and were steam-sterilised *in situ* on the beds. Oatmeal/sand inoculum of a pathogenic isolate of *Pythium sylvaticum* was introduced into the soil in the inoculated boxes and equivalent amounts of autoclaved (killed) inoculum were introduced into the uninoculated control boxes.

The inoculum was mixed with the top 2 cm of soil immediately prior to planting, using a sterilised steel rod to give a final inoculum concentration of between 5000 – 6000 cfu g^{-1} dry wt soil.

Cuttings for this experiment were of variety Dark Splendid Reagan and were stuck in Scotts B2 blocks and propagated for 14 days as above. Planting was at full spacing (64 plants m^{-2}) on 18 January 2001 (for crop diary, see Appendix VIII). From the start of the experiment, irrigation was *via* drip lines and not overhead, to avoid splash dispersal of pathogen propagules. All plants in inoculated and control boxes and in four unboxed control areas per bed were numbered and their heights measured 12 days after planting. A final assessment was carried out on all numbered plants immediately prior to harvest. The final assessment consisted of measurements of individual plant height, leaf number, total leaf area and cut stem fresh weight.

Section C: **In vitro** ***screen for 'suppressiveness'***

The 21 peat mixes produced without mineral nutrition for the 'matrix' experiment, described above, were tested *in vitro* for their potential relative suppressiveness to *Pythium* growth in the absence of plants. Three replicate samples of each peat mix were weighed moist to a dry weight equivalent of 20g. Peat samples were then saturated with sterile tap water and brought to standard tension by placing them, in pots, on top of a rockwool slab set to 5 cm water tension. After 24 h, each sample was mixed with a 5 g aliquot of a standard sand/oatmeal inoculum prepared as described previously (see Carver, 2000 page 13) of *P. sylvaticum* isolate A052 and placed in a 250 ml conical flask sealed with parafilm. *Pythium* colonisation was determined by dilution plating at the start of the experiment and after 14 days, using methods described previously (Pettitt, 2001), and was expressed simply as colony forming units (cfu) per 10^{-1} dilution plate.

Results and Discussion

Section A: Growing trials

Propagation

Root development

Early root development appeared rather similar in all treatments. However, large differences were apparent by the end of the propagation phase as shown in Table 4.

Table 4: Average root development score at the end of propagation (note that 2.00 is the maximum rooting score possible)

Blocking medium	Block size	Propagation duration (days)	Root development score
Scotts Standard	5 cm	11	0.55
Scotts Improved	5 cm	11	0.86
Masons	5 cm	11	1.18
Scotts Standard	5 cm	15	0.95
Scotts Improved	5 cm	15	1.20
Masons	5 cm	15	1.20
Scotts Standard	6 cm	20	1.45
Scotts Improved	6 cm	20	2.00
Masons	5 cm	20	2.00

For all three propagation durations, root development in the Scotts Standard blocks was markedly poorer than in either of the other two block types. There was no obvious difference in rooting between Scotts Improved and Masons blocks when the propagation duration was 15 or 20 days, but root development in the Masons blocks was greater than in the Scotts Improved blocks when the propagation duration was only 11 days. As would be expected, root development increased with duration of propagation in all three block types.

Vegetative growth

Comparisons of the effects of blocking media and block size on vegetative growth are based only on data collected from the 15-day and 20-day treatments. This is because the 11-day propagation treatment was stuck after the other two, and so experienced different environmental conditions during propagation.

There were marked discontinuities when growth was plotted against time in propagation This was almost certainly due to relatively small numbers of blocks being assessed on successive occasions. For this reason, a modelling approach was adopted as shown in Figs 1-3 for plant height, leaf number and plant fresh weight (pages 19-21).

Plant height, leaf number and fresh weight all appeared to increase in an approximately linear manner to give the modelled 15-day values shown in Table 5. There appeared to be little obvious difference in growth in the two Scotts blocking media, but vegetative growth did appear to be slightly reduced in the Masons blocks after 15 days of propagation.

Growth between 15 and 20 days, where tested, increased exponentially. At 20 days, growth in the Scotts Standard blocks had outstripped that in both the Scotts Improved blocks and in the Masons blocks. However, this latter observation has to be treated with caution since the Masons blocks used in the 20-day propagation treatment were smaller than the Scotts blocks, and plants were more closely spaced. Indeed, it was observed at the end of propagation that the 20-day Masons plants were ‘drawn’ and thin, reflecting severe overcrowding in the propagation trays. Additionally, both the Masons blocks, and the Scotts Improved blocks, may have been disadvantaged by adopting the same irrigation regime for all treatments. These media are freer-draining than the Scotts standard medium and may have had rather drier conditions than would have been ideal. This is a factor which will need taking into account in any subsequent block trials

Table 5: Estimates of height, visible leaf number and fresh weight after 15 days of propagation (estimates based on modelled responses in Figs 1-3)

Blocking medium	**Height (cm)**	**Emerged leaves**	**Fresh weight (g)**
Scotts Standard	8.51	6.08	2.63
Scotts Improved	7.88	5.91	2.46
Masons	7.35	5.66	2.07

Figure 1: Effects of blocking medium, block size and propagation duration on plant height during propagation. (● = 5x5x3 cm blocks & ○ = 6x6x3 cm blocks)

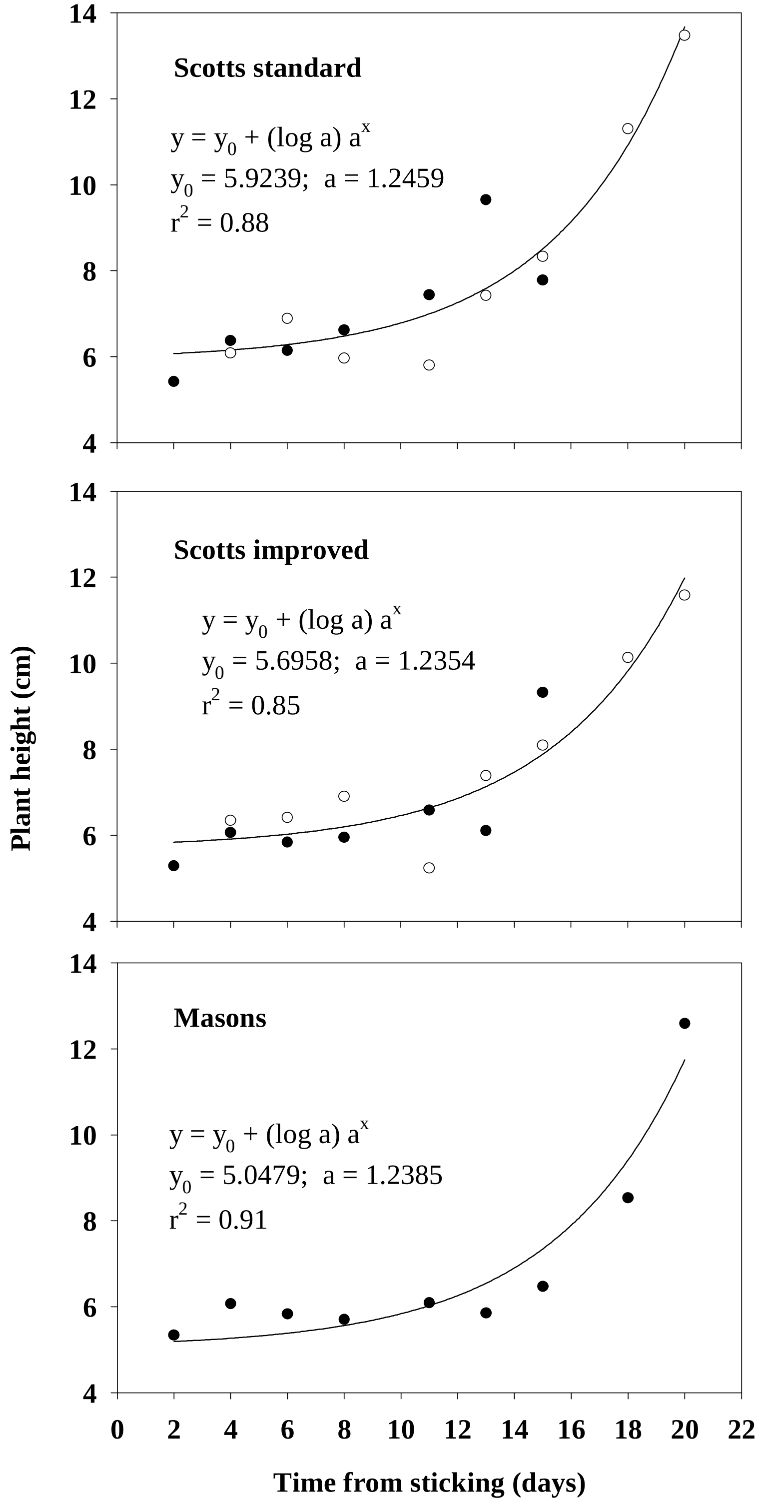


Figure 2: Effects of blocking medium, block size and propagation duration on leaf emergence during propagation. (● = 5x5x3 cm blocks & ○ = 6x6x3 cm blocks)

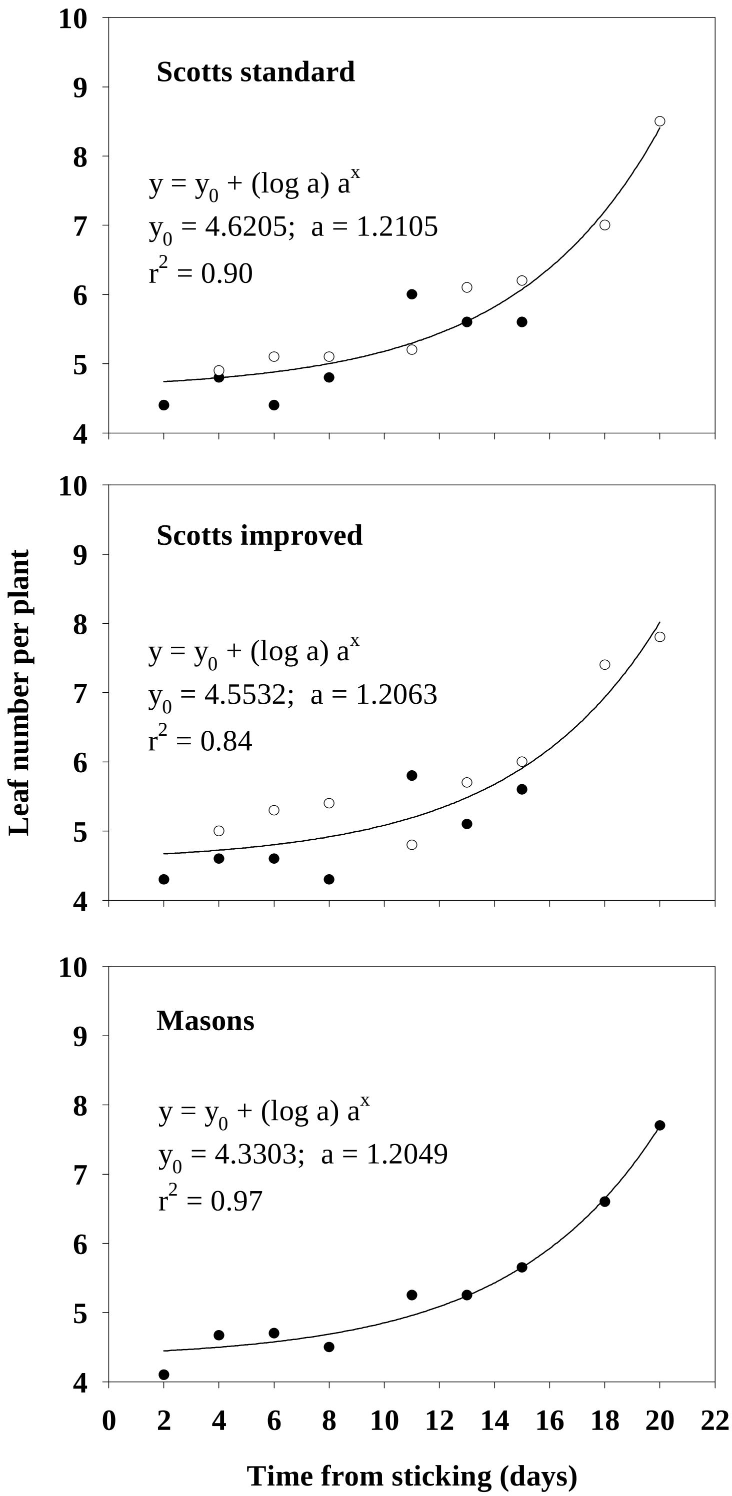
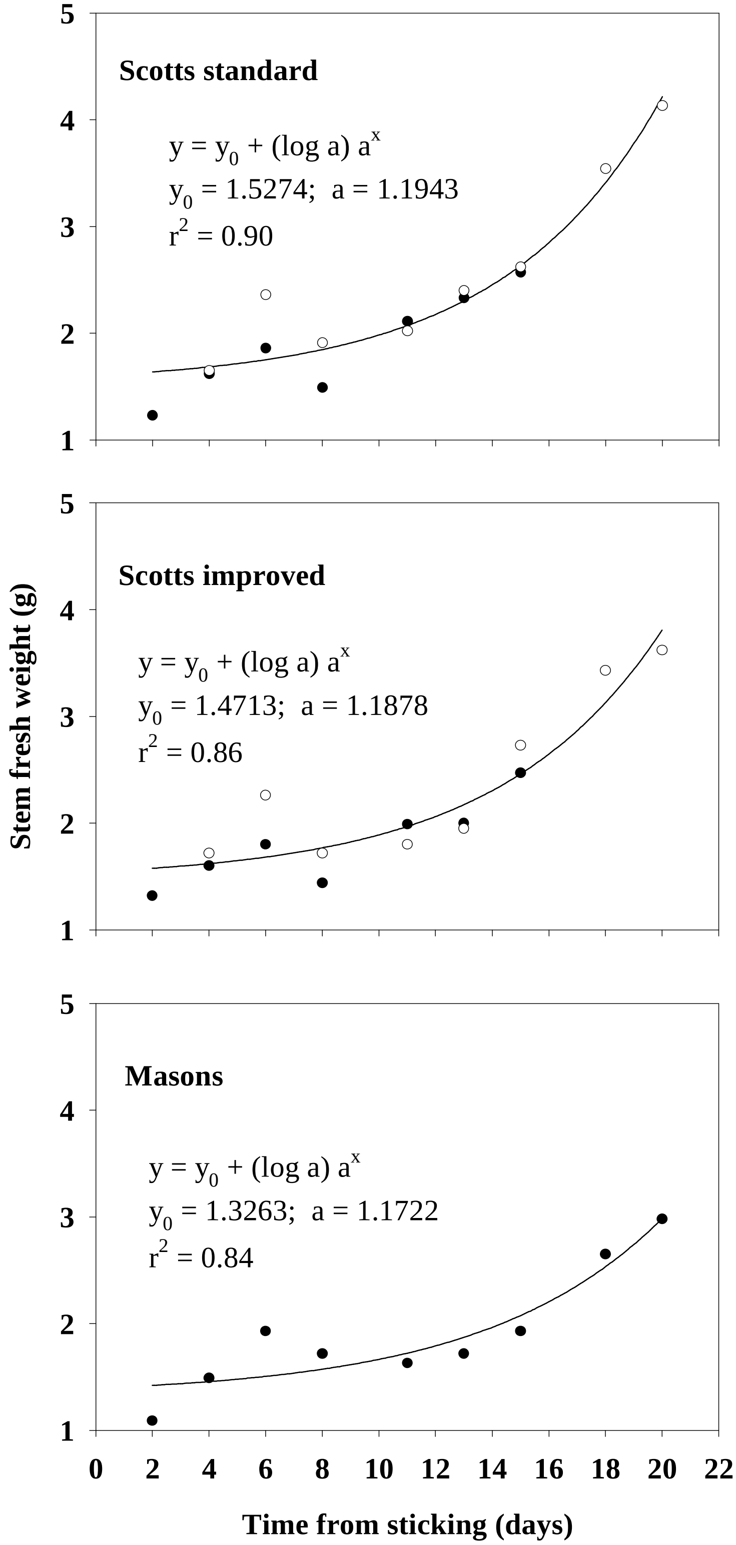


Figure 3: Effects of blocking medium, block size and propagation duration on the fresh weights of stems. (● = 5x5x3 cm blocks & ○ = 6x6x3 cm blocks)



Establishment and take-off in soil beds (LD phase)

LD duration

The LD-phase of production in the glasshouse ended for each of the plots when an average plot height of 40 cm (as judged by the use of height sticks) had been attained. The duration of this LD phase is, therefore, a useful measure of the rapidity of block establishment (rooting into the soil) and of early plant growth, albeit that the duration will also reflect light receipt during the period and initial height at planting out.

LD durations and total light receipt during LD are shown for each of the propagation treatments in Table 6. This shows that there was little obvious effect of blocking medium when the duration of propagation was 11 or 15 days. These treatments were planted out on the same day and received identical light. However the 15-day blocks consistently reached the 40 cm stage one day ahead of the 11-day blocks, probably reflecting the slightly larger size of the 15-day block plants at planting out (taller by 1-2 cm). The saving of 1 day during the glasshouse LD phase meant that the 15-day blocks reached the 40 cm stage after having received about 7% less light than the 11-day blocks (Table 6). They had, however, received about 69% more light during the 'polythene off' phase of propagation.

Table 6: Numbers of LD to the 40 cm 'height stick' stage after planting out in the glasshouse, and total light receipt recorded outside

Blocking medium / Block size	**Propagation duration**	**LD duration (days)**	**Total light receipt (MJ/m^2 – outside) since planting**
Scotts Standard 5cm	11	25	70.6
Scotts Improved 5cm	11	25-27*	70.6-79.2*
Masons 5cm	11	25	70.6
Scotts Standard 5cm	15	24	66.0
Scotts Improved 5cm	15	24-25*	66.0-70.6*
Masons 5cm	15	24	66.0
Scotts Standard 6cm	20	20	54.8
Scotts Improved 6cm	20	20	54.8
Masons 5cm	20	22	63.4

* *the 2 replicate plots of this treatment were judged to have reached the 40 cm stage at different times*

The 20-day Scotts Standard and Scotts Improved blocks reached the 40 cm stage in 4-5 fewer LD than the equivalent 15-day blocks. The extra 5 days in propagation did, therefore, appear to translate into a roughly equivalent reduction in time spent in LD in the glasshouse. In terms of light receipt, the 20-day blocks received about 17% less light than the 15-day blocks in the glasshouse, but had received 33.6% more light during the 'polythene off' phase of propagation.

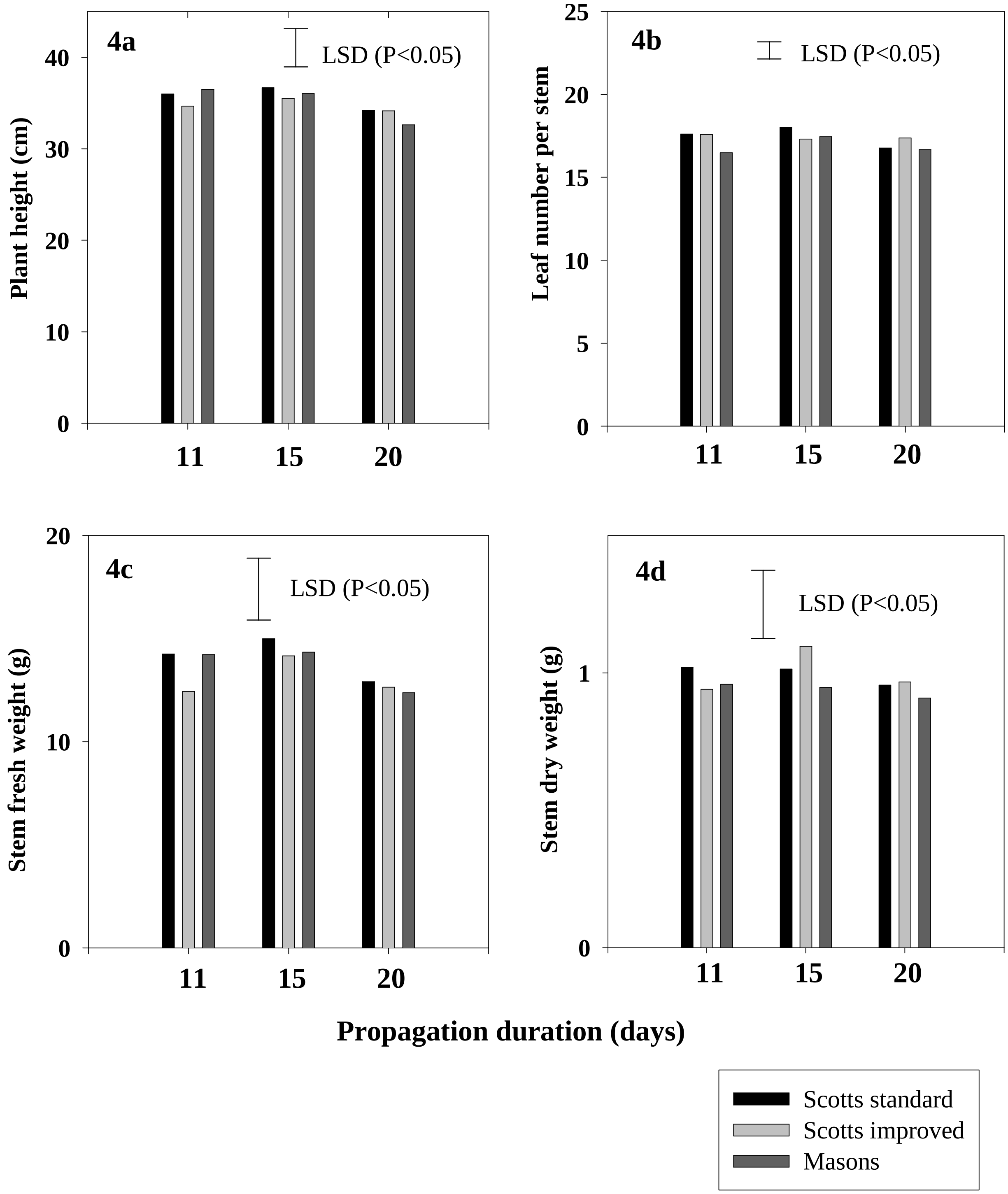
The effects of 20-days of propagation were rather less positive for the Masons blocks. These had been seriously disadvantaged during propagation because of small block size (see earlier), and reached the 40-cm stage 2 days after the 20-day Scotts blocks and after receiving 15.5% more light.

Sampling at the end of LD

Laboratory-based sampling of individual plants at the end of LD (i.e. at times determined by stage of development for each plot as shown in Table 6) showed that actual plant mean heights were nearer 35 cm than 40 cm (Fig 4a). Cut stem measurements can be expected to be shorter than height stick measurements since the latter are taken from soil level and include the height of the block. This probably explains the apparent discrepancy for 11-day and 15-day blocks. However, the average height of the 20-day block plants tended to be 1 - 3.5 cm less than the 11-day and 15-day block plants. This indicates that the glasshouse LD phase for the 20-day blocks ought to have been 1-2 days longer, and that the extra days in propagation did not fully equate to fewer LD in the glasshouse. A more realistic estimate of the saving in LD in the glasshouse, compared to 11-day blocks, might be 3 days. However, this is an estimate and it has to be borne in mind that the 20-day blocks were planted later than the others and into a different light climate. It might also be supposed that plants comprising the 20-day block plots, and particularly those in Masons medium which were the shortest of all, were probably physiologically immature when entering SD and, subsequently, the LD interruption.

Having said that the 20-day block plots may have been physiologically immature at the start of SD, sampling showed no obvious differences between the treatments in average leaf number per stem, plant fresh weight or plant dry weight at the start of SD (Fig 4b, c, d). The difference in average plant fresh weight, for example, between the treatment giving the lowest weight (12.38 g) and that giving the highest weight (14.99 g) was only 2.61 g, which is less than the 3.28 g required for significance at $P<5\%$.

Figure 4: Plant heights (a), leaf numbers (b), fresh weights (c) and dry weights (d) recorded at the end of the LD phase of production.

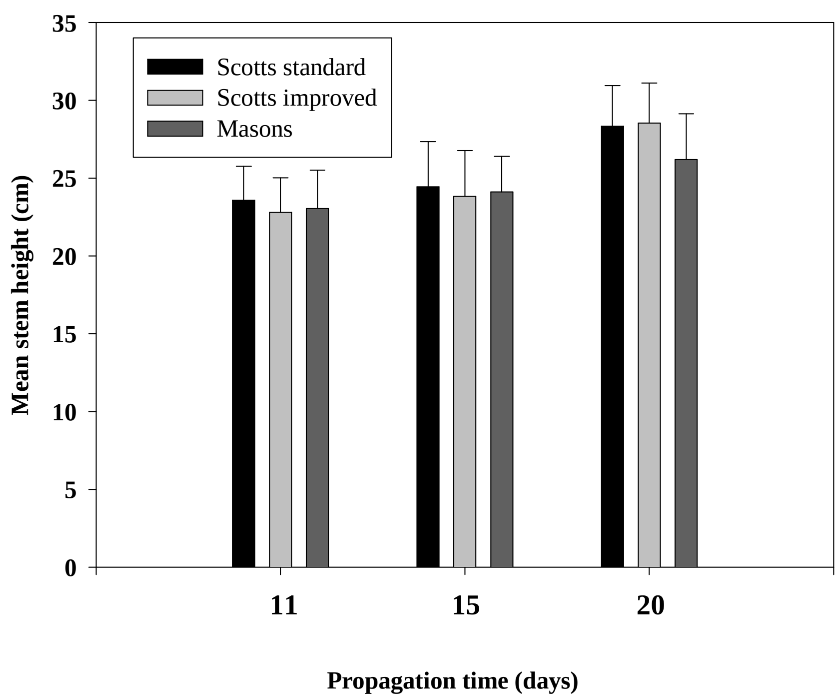


On this evidence, it does appear that ending the LD phase at a defined physiological stage and allowing growth to proceed for however long was required to reach this stage, effectively compensated for differences apparent in the blocked plants at planting out in the glasshouse. Nevertheless, the 20-day propagation plants did receive between 2 and 5 fewer LD photoperiods after planting out than the 15-day propagation plants in the same blocking medium, and between 4 and 22% less light receipt. These factors are likely to have influenced the speed of reaction to early SD.

Crop uniformity

Differences in the duration of propagation, leading to varied degrees of plant competition in the trays, allied with possible differences in establishment after planting out, might have been expected to result in differences in crop uniformity during the LD phase. This was tested by calculating standard deviations for plant height of 50 plants per treatment, two weeks after planting out when any effects of differences due to establishment ought to have been apparent. However, as shown in Fig 5 there were no obvious differences in crop uniformity. Even the 20-day Masons block treatment showed no more plant-to-plant variation than any other.

Figure 5: Assessments of the effects of blocking medium and propagation time on stem height uniformity at 2 weeks after planting out in the glasshouse.
(bars are standard deviations; n = 50)



The SD phase and final harvest

The placement of the interruption

Although the plan had been to interrupt each of the plots using the light integrals shown in Table 2 (Materials and Methods, page 10), it is apparent in retrospect that interruption occurred 2-3 days later than intended.

Table 7 shows the actual number of SD given before the start of the interruption and the consequent average daily light integral. In order to be able to compare what did happen against the intended procedure for the calculation of the start of interruption, the next four columns show the target daily light integral for the actual number of SD given, the optimum number of SD for the actual light receipt, the theoretical daily light integral for this optimum number of SD (Langton 1992) and the actual daily light integral for the optimum number of SD. The final column shows the actual average daily light integral over the first four SD for each treatment.

It will be seen that as a result of differing start days and the coincidence of good and poor light days over the period, most of the 15-day propagation treatments received about 35% more light than the majority of other treatments over SD 1 to 4 of this crucial period.

The interruption

The length of the interruption was 10 days, in line with commercial practice in early January in most years. However, as shown in Table 7a, light receipt in 2000 over the first two weeks of January was particularly good (21% above the Efford long-term average). Thus the daily light integral and the total light receipt over the period of the interruption was considerably higher than had been expected. In retrospect the length of the interruption might have been reduced so as to bring the total light receipt closer to that experienced in a more normal year.

There is little doubt that the late placement of the interruption, together with high light receipt during the interruption will have affected the performance of most if not all treatments.

The late placement will have reduced the positive effect of the interruption on the 15-day treatments, particularly those where speed of bud initiation would have been enhanced by the high daily light integral during the early SD period. Plate 4 shows that 15-day treatments exhibited very few of the benefits associated with interrupted lighting, particularly one of such duration and light sum. Leaf and flower size were

Table 7: Placement of the interruption.

Block	Propagation duration (days)	No. SD actually given	Average daily light integral ($MJ/m^2/d$)	Target daily light integral for no. SD given** ($MJ/m^2/d$)	Optimum no. SD for actual light receipt
Scotts Standard	11	20	2.29	1.52	17
Scotts Improved*	11a 11b	20 20	2.09 2.29	1.52 1.52	18 17
Masons	11	20	2.29	1.52	17
Scotts Standard	15	19	2.32	1.67	16
Scotts Improved*	15a 15b	19 20	2.29 2.32	1.67 1.52	16 17
Masons	15	19	2.32	1.67	16
Scotts Standard	20	20	2.29	1.67	17
Scotts Improved	20	20	2.29	1.67	17
Masons	20	20	2.09	1.67	18

Table 7 CONTINUED

Block	Propagation duration (days)	Theoretical daily light integral for optimum no. SD** ($MJ/m^2/d$)	Actual daily light integral for optimum no. SD ($MJ/m^2/d$)	Actual daily light integral during SD 1-4 ($MJ/m^2/d$)
Scotts Standard	11	2.09	2.22	2.60
Scotts Improved*	11a 11b	1.85 2.09	2.06 2.22	2.71 2.60
Masons	11	2.09	2.22	2.60
Scotts Standard	15	2.45	2.59	3.50
Scotts Improved*	15a 15b	2.45 2.09	2.59 2.22	3.50 2.60
Masons	15	2.45	2.59	3.50
Scotts Standard	20	2.09	2.22	2.60
Scotts Improved	20	2.09	2.22	2.60
Masons	20	1.85	2.06	2.71

** the 2 replicate plots of this treatment went into SD at different times*

*** see Table 2*

Table 7a: Light receipt and average daily light integral during the interruption, and comparison with long-term average light data for Efford

Block	Prop. duration (days)	Total light receipt during interruption (MJ/m^2)	Daily light integral during interruption ($MJ/m^2/d$)	Long-term daily light integral ($MJ/m^2/d$)	% increase, actual over long-term
Scotts Standard	11	30.81	3.08	2.34	+31.6
Scotts Improved*	11a 11b	33.24 30.81	3.32 3.08	2.61 2.34	+27.6 +31.6
Masons	11	30.81	3.08	2.34	+31.6
Scotts Standard	15	32.01	3.20	2.32	+37.9
Scotts Improved*	15a 15b	32.01 30.81	3.20 3.08	2.32 2.34	+37.9 +31.6
Masons	15	32.01	3.20	2.32	+37.9
Scotts Standard	20	30.81	3.08	2.34	+31.6
Scotts Improved	20	30.81	3.08	2.34	+31.6
Masons	20	33.24	3.32	2.61	+27.6

* *the 2 replicate plots of this treatment went into SD at different times*

not enhanced, flower development down the stem was not affected, and pedicel length was hardly increased.

In contrast, plants from the other propagation treatments, particularly those propagated for 20 days, responded essentially as expected. This is seen in plates 3 and 5; plants had larger top leaves, somewhat longer pedicels, and bud set down the stem indicating two periods of development. Most responsive to the effects of a long interruption with high light receipt was the Masons 20-day treatment. Here the lower buds on a proportion of the plants showed a form of compounding suggesting these shoots had not completely changed from the vegetative to the reproductive phase during the initial SD period. It may be regarded as unusual that plants that had been put into interruption 2 or 3 days later than the theoretical 'safe' day on the Langton scale should have behaved in this way. It is not possible to explain this with any degree of certainty, but it is noteworthy that the 20-day propagation plants went into SD before they had fully attained the 40 cm standard, and after having received a lower LD light receipt than would otherwise have been the case. As a consequence it is likely that these plants were physiologically less mature at the start of the interruption. The effect of a relatively long vegetative interruption with above average light would have been to slow bud development and widen flowering response times between plants of differing maturity.

SD duration

Given that treatments were recorded as having very similar weights at the start of SD, grew with very similar light receipts when averaged over the duration of SD, and received similar interruptions, it might reasonably be expected that all would reach the harvest stage at the same time. Table 8 indicates that this expectation was realised with regard to comparisons of blocking media, since differences between block types within propagation durations appear trivial and within the range which might be expected of a character which is determined subjectively. Although Masons 20-day plots began to be harvested after receiving similar numbers of SD as other 20-day treatment plots, they actually received about 6.9% more light during this phase of production.

Table 8: Average numbers of SD and light receipt (including the interruption) up to the start of harvest

Block	Propagation duration (days)	No. SD	Total light receipt (MJ/m^2)
Scotts Standard	11	62	282.3
Scotts Improved*	11	62.5	292.0
Masons	11	62	282.3
Scotts Standard**	15	60	269.7
Scotts Improved*	15	61.5	280.6
Masons**	15	60	269.7
Scotts Standard	20	62	282.3
Scotts Improved	20	62	282.3
Masons	20	63	301.7

* the 2 replicate plots of this treatment went into SD at different times, and the date of day 1 of harvest differed.

** the 2 replicate plots of this treatment went into SD at the same time, but the date of day 1 of harvest differed.

In contrast to the effects of blocking media, propagation duration did appear to have a clear influence on SD cropping duration. Thus, treatments receiving 15 days of propagation consistently required 1-2 fewer SD to reach the harvest stage than 11-day treatments (Table 8). The 15-day propagation treatments had been judged to be 1-2 days ahead of the 11-day treatments at the start of SD, and it appears that this benefit stemming from larger size at planting out was maintained right through to final harvest. The 15-day blocks did receive higher light levels than the 11-day blocks during SD 1-4 (Table 7) and this probably ensured that the speed advantage of the 15-

day blocks was maintained. On the other hand, the 15-day blocks received an average of about 4% less light in total than the 11-day blocks during the SD phase (Table 8).

The 11-day and 20-day propagation treatments received very similar total light receipts during SD (averages of 285.5 and 288.8 MJ/m^2), and there appeared no obvious difference in SD cropping duration.

Overall cropping time

Overall cropping time in the glasshouse to the start of harvest for each of the treatments, and total light receipt, are shown in Figs 6 and 7 respectively, and a more comprehensive summary of light receipt is given in the Appendix. The faster cropping of 15-day propagation treatments compared to 11-day treatments, averaging 2.8 days, is clearly apparent. These treatments were planted out at the same time, but the 15-day blocks went into SD about 1 day earlier, into the interruption about 2 days earlier, and reached harvest stage about 3 days earlier than the 11-day blocks having received about 5% less light in total. Planting out larger plants clearly benefits production, at least to the harvest stage.

The 20-day treatments gave an even greater saving in time spent in the glasshouse, with the 20-day Scotts Standard and Scotts Improved blocks reaching the harvest stage 5.8 days faster than the equivalent 11-day treatments, and having received 6.3% less light. These also reached the harvest stage 3 days faster than the equivalent 15-day treatments, having received slightly less light (337.1 MJ/m^2 against 342.3 MJ/m^2 for 15-day treatments). It appears that in speed terms at least, much of the benefit of the longer propagation period and later planting into the glasshouse was preserved through to harvest. This is not the case, however, for the 20-day Masons treatment. This reached the harvest stage 2 days ahead of the equivalent 11-day treatment having received about 3.5% more light, but reached the harvest stage 1 day after the equivalent 15-day treatment, having received 8.8% more light! The situation may well have been different however, had the Masons 20-day treatment been stuck in 6cm blocks. Plates 1-5 show the appearance of plots on 21 February when harvesting of the earliest plots began.

Harvest duration and yield

Figs 8a, c and d show that there were no significant differences in plant height, plant fresh weight and plant dry weight at final harvest. However, Masons 10- and 15-day treatments reduced the number of leaves per stem compared to other 10- and 15-day treatments (Fig 8b). The reason for this is not known.

Figure 6: Total cropping time from sticking to harvest for all treatments. A, Scotts standard, B, Scotts improved and D, Mason. 11, 15 and 20 are propagation times in days (Zero denotes the date on which blocks were planted out in the glasshouse).

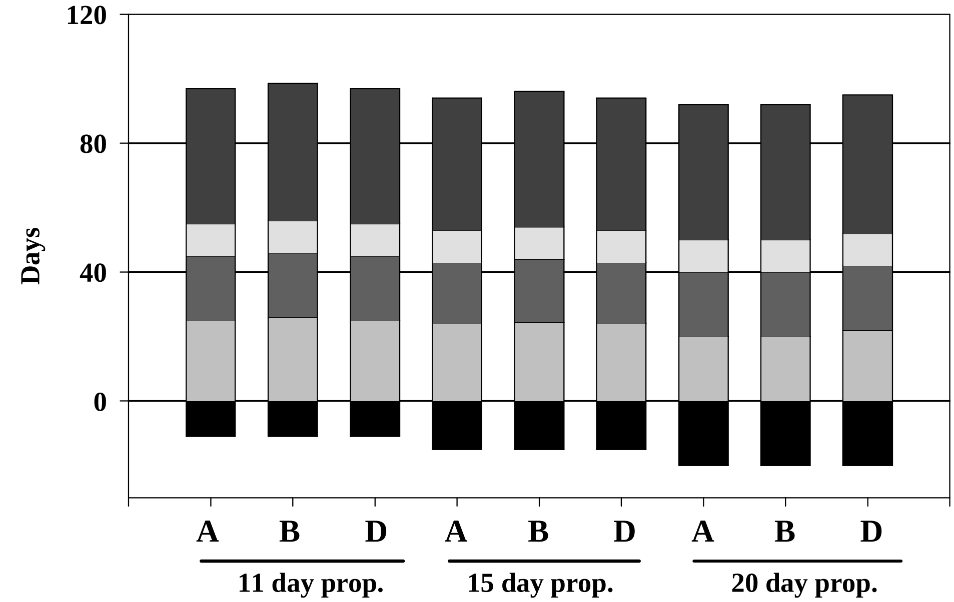
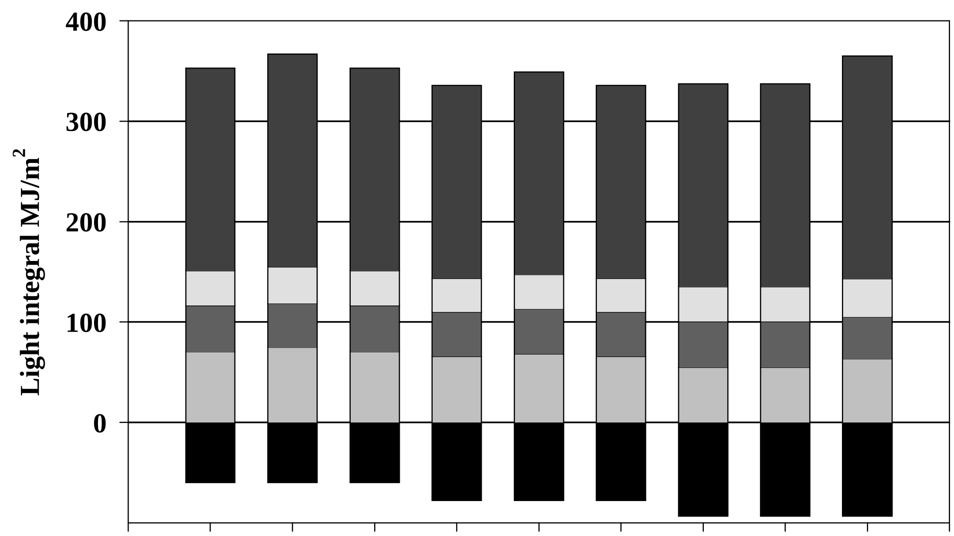


Figure 7: Total light integral from sticking to harvest for all treatments. A, Scotts standard, B, Scotts improved, D, Mason. 11, 15 and 20 are propagation times in days.(The zero line denotes the time at which blocks were planted out in the glasshouse).



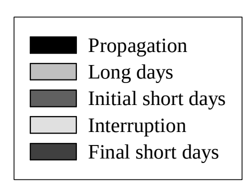
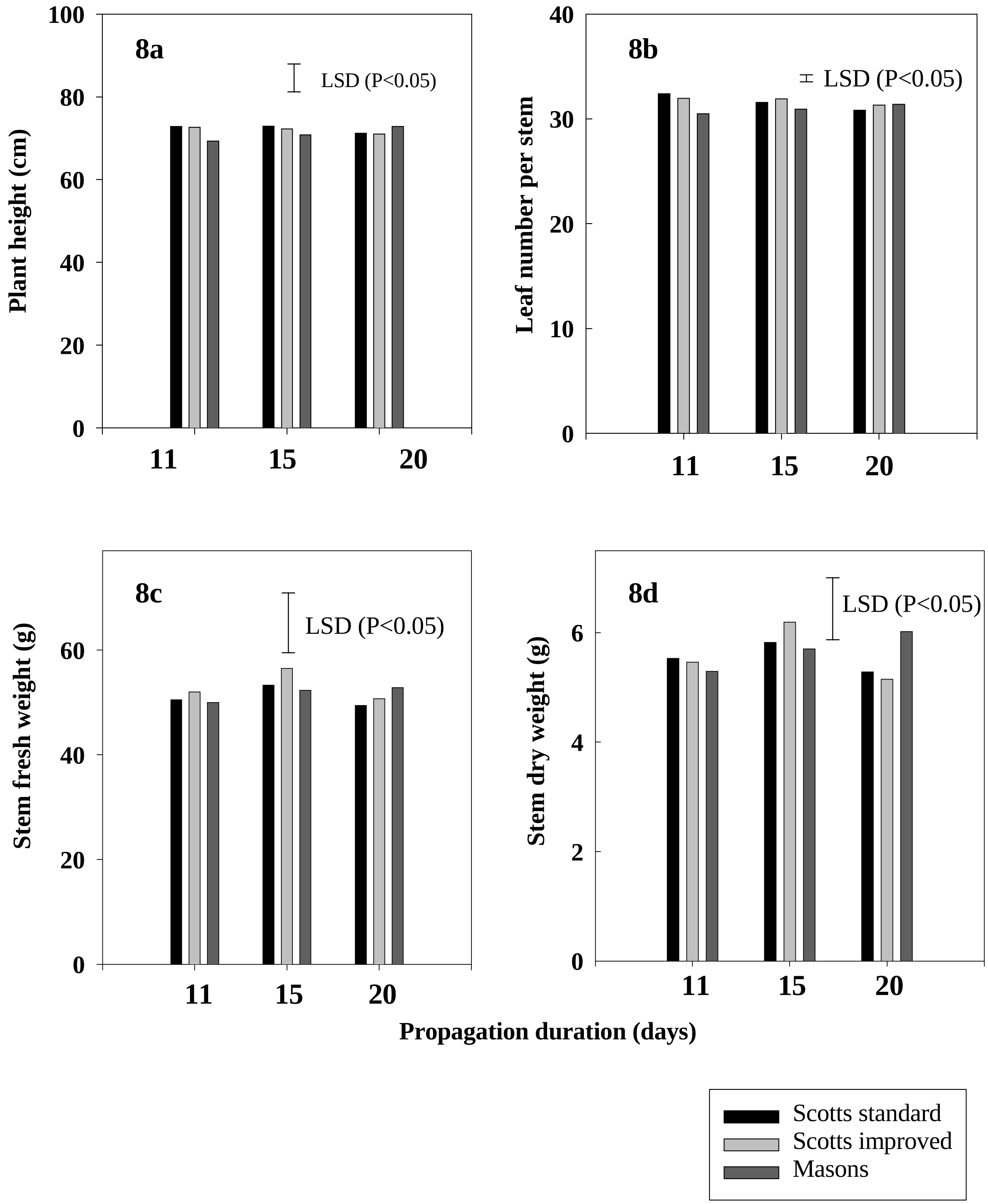


Figure 8: Average plant heights (a), leaf numbers (b), fresh weights (c) and dry weights (d), recorded at the start of harvest.



Harvest duration for each of the treatments, average daily light integral during the harvest period and final harvested yield (expressed as the percentage of stems in four weight categories) are shown in Table 9a. The question arises: does the faster cropping of 15-day propagation blocks compared to 11-day blocks carry through to a shorter harvest duration? Table 9a indicates that the harvest duration of 15-day blocks was, on average, marginally faster than for the 11-day blocks, even though the average daily light integral associated with the harvest of the 15-day blocks was slightly less than that associated with the 11-day blocks. There may, therefore, have been a slight benefit of propagating for 15 days on harvest duration. However, there appeared no obvious advantage of 15-day propagation in terms of harvested yield.

The relationship between cropping speed in the glasshouse and harvest duration did not carry through to the 20-day propagation treatments since these averaged 10.7 days for complete harvest against 8.3 days for the 15-day treatments and 9 days for the 11-day treatments. This was in spite of a higher daily light integral during the harvest of the 20-day blocks. The 20-day treatments did, however, give a higher proportion of stems in the top two weight grades. 74.8% against an average of 68.0% for the 11 and 15-day treatments.

Table 9a: Effect of treatment on harvest duration and final harvested yield (expressed as the percentage of stems in each of 4 weight categories, including waste)

Propagation treatment	Harvest Duration (days)	Average daily light integral ($MJ/m^2/d$)	% >325g	% 225-325g	% <225g	% Waste	Total stems cut
Scotts Standard 11 days	9.5	7.35	5.4	63.0	27.1	4.5	738
Scotts Improved 11 days	10.5	7.06	6.9	64.0	26.1	3.0	727
Masons 11 days	7.0	7.21	2.1	59.9	34.5	3.5	710
Scotts Standard 15 days	8.0	6.77	7.1	60.8	27.6	4.5	707
Scotts Improved 15 days	9.0	6.70	3.5	67.6	25.8	3.1	717
Masons 15 days	8.0	6.77	2.8	64.6	28.7	3.9	712
Scotts Standard 20 days	11.0	7.59	6.3	73.1	18.1	2.5	718
Scotts Improved 20 days	11.0	7.59	3.5	67.4	26.0	3.1	712
Masons 20 days	10.0	8.36	8.3	65.9	22.5	3.3	721

Table 9b indicates that there was no essential difference between the 11-day treatments and the 15-day treatments in the proportions of stems that could be cut during the early harvest period. Thus, for both propagation durations the 50% harvest point was reached in 4-5 days. In contrast, the 50% harvest stage for the 20-day treatments was reached in about 6 days, so planting out a larger plant did not appear necessarily to give a shorter harvest duration. Harvest duration will largely be determined by crop uniformity and at no stage did any one treatment appear better than any other in this regard.

Table 9b has been constructed by taking the first day of harvest for each replicate of each treatment as day 1. This aids interpretation of harvest duration but tends to conceal the fact that day 1 for the 15-day treatments is actually 2-3 days ahead of day 1 for the 11-day treatments (see Figure 6). Day 1 for the 20-day treatments was actually after day 1 for the 15-day treatments, but this was only because the 20-day blocks were planted out 5 days after the 11 and 15-day blocks. In terms of glasshouse utilisation, the 20-day and 15-day treatments were rather similar, with the latter showing a longer cropping time but a shorter harvest duration. It remains speculation as to how this would have affected had the interruption been given as planned.

Table 9b Cumulative percentage of saleable wraps harvested over time from the start of harvest*

Propagation treatment	**Days after the start of harvest**											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Scotts Standard 11 days	14.9	-	-	53.2	-	73.1	-	90.8	-	-	100	
Scotts Improved 11 days	14.9	-	23.4	42.6	52.5	61.0	-	78.0	-	88.7	100	
Masons 11 days	21.9	-	-	64.2	-	88.3	-	100				
Scotts Standard 15 days	5.2	-	34.8	-	56.3	69.6	-	100				
Scotts Improved 15 days	10.8	-	28.1	46.0	-	68.3	-	92.1	-	100		
Masons 15 days	3.7	-	28.5	-	49.0	59.9	-	100				
Scotts Standard 20 days	4.3	-	-	34.3	-	59.3	-	72.1	-	-	100	
Scotts Improved 20 days	5.1	-	-	29.7	-	51.4	-	70.3	-	-	100	
Masons 20 days	7.2	-	30.1	-	44.5	-	-	68.9	-	100		

* Note that this table sums the numbers of wraps harvested over the two replicates of each treatment. To do this, the first day of harvest of each replicate has been called day 1 even when these fall on different days. The total length of harvest is thus the length of the harvest in the slowest replicate rather than the average of the two replicates as in Table 9a.

Plate 1: General view of the propagation trial on the first day of harvesting (21/02/2000).

Plate 2: Photograph taken on 21/02/2000, when the first harvesting occured. This was in the 15 day propagation treatment in Scotts standard and improved blocking media. These treatments were more advanced at harvest as illustrated here and in the following plates.

Plate 3: The stage of development of the 11 day propagation treatments on 21/02/2000. Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

Plate 4: The stage of development of the 15 day propagation treatments on 21/02/2000. Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

Plate 5: The stage of development of the 20 day propagation treatments on 21/02/2000. Left to right the treatments are: Scotts standard (A), Scotts improved (B) and Mason (D)

Sections B & C: Disease trials and* in vitro *screen for 'suppressiveness'

Effect of the commercial blocking media and propagation time on disease severity

In the face of a *Pythium* challenge, all of the block and propagation time treatments suffered some degree of vigour loss in relation to their uninoculated controls. The best levels of disease tolerance were seen with the Scotts improved medium and in the longer propagation times. The most promising performance was with plants grown in blocks of Scotts improved medium with a 20 day propagation. This is well illustrated by the significant increase in root vigour compared to the other blocking media (Figure 9). Root vigour ('bulk' of emergent root) was also reasonable with the 15 and 11 day propagation treatments in the Scotts improved medium as well as the Masons medium. However, plants growing in the Masons medium did not perform well in the 20 day propagation treatment, possibly as a result of the comparatively smaller block size used for this treatment. The roots in both the Scotts improved and the Masons 20 day-propagated treatments appeared vigorous at planting with high rooting scores (see Figure 9). This was probably a result of the high AFPs of these two media (Table 10). Plants growing in the Mason medium suffered more root browning than those in the Scotts improved medium (Figure 10). These results also indicate a high percentage root browning for the Scotts standard treatment, although this may just be a function of the much small amounts of root produced in this medium (Figures 9 & 10).

One reason for the lower levels of root browning in the Scotts improved medium may be the higher levels of biological activity seen in this medium (Table 10) giving a measure of disease suppression. The combination of a high AFP and high FDA activity may explain the comparative success of this medium.

Table 10: Comparisons of air filled porosities (AFP) and measurements of biological activity by FDA for the Scotts standard, Scotts improved and Masons blocking media.

	Blocking medium		
	Scotts standard	Scotts improved	Masons
AFP (%)	0.63	9.92	5.62
FDA (µg/g dry wt/min)	10.62	9.01	5.31

Figure 9: Effect of propagation time and blocking medium on the rate of increase in root 'bulk' or vigour as determined by the increase in the relative amount of root emergence and root system size over the first four weeks after planting on control and *Pythium*-inoculated sand trays..

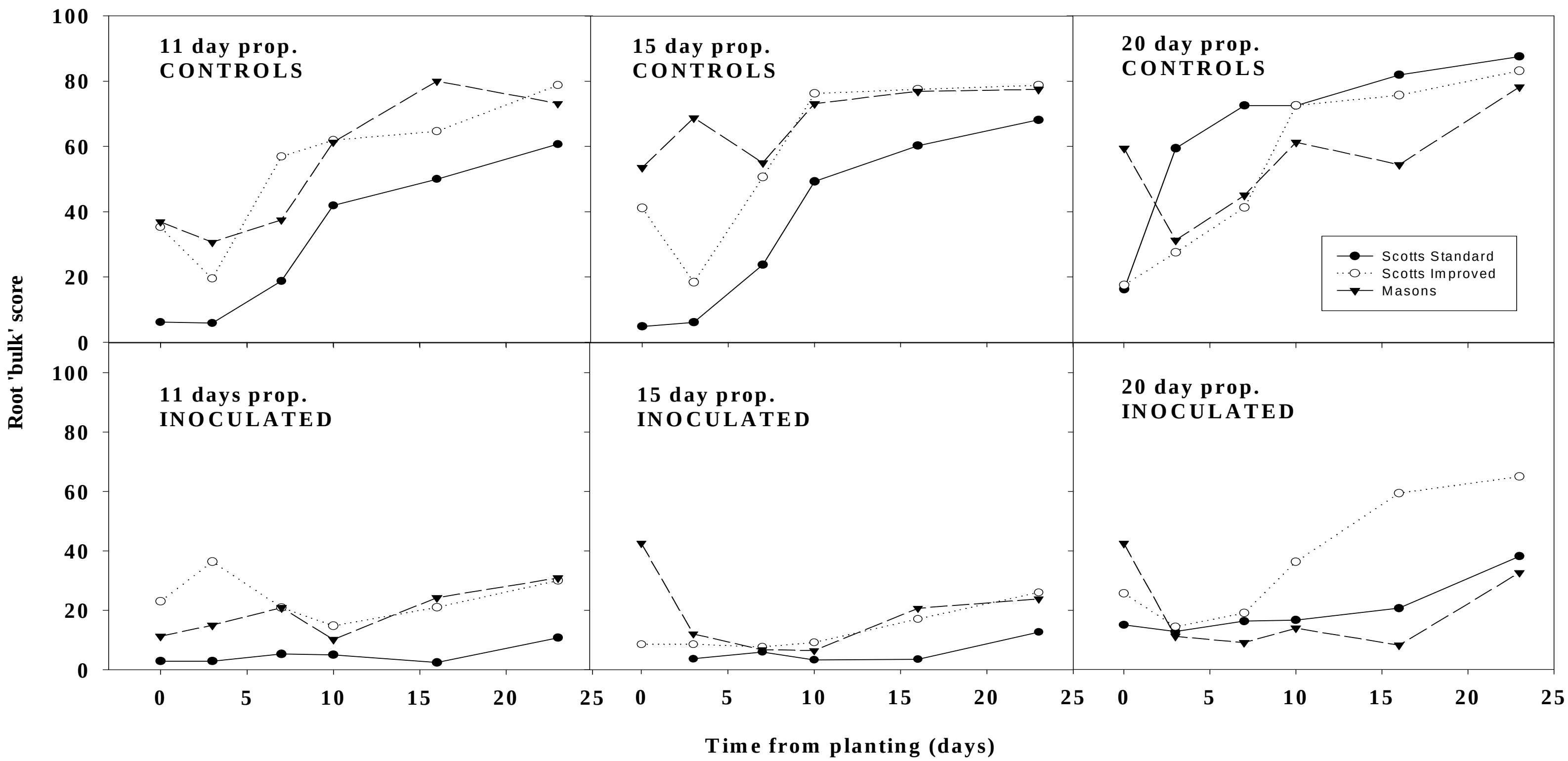
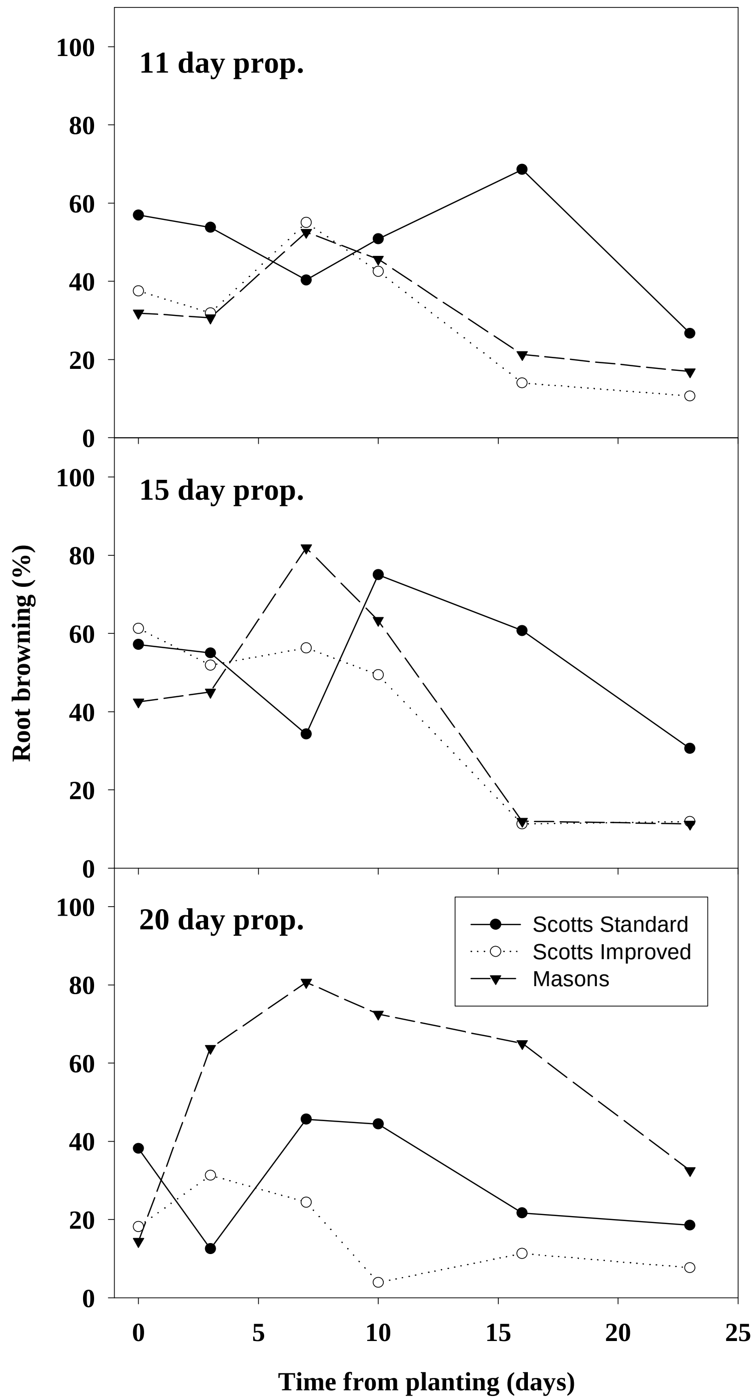


Figure 10: Effect of propagation time and blocking medium on the rate of increase in root browning caused by *Pythium* spp. over the first four weeks after planting on *Pythium*-inoculated sand trays.



In Figure 10 the level of root browning was seen to decline over time. This may be due to a high degree of root rot, which, when advanced would cause the badly affected browned roots to disintegrate and thereby cause the percentage of browned root to decline (Pettitt, 2001). However, in the current study the level of root browning was correlated with root vigour (Figure 11), with root vigour declining with increasing root browning. This shows that any reductions in root browning seen in this experiment can be confidently considered as beneficial.

The parameters of plant stem growth and development; dry weight, stem height and leaf number, all gave results similar to those seen with root browning and vigour (Figures 12 – 14). The best growth in the face of pathogen challenge was seen in plants grown in the Scotts improved medium with a 20 day propagation. Plant heights and leaf numbers in this treatment were comparable with uninoculated controls (Figures 13 & 14). However, the shoot dry weights were slightly lower than controls (Figure 12), although they were significantly better than those of the uninoculated Masons 20 day-propagated plants.

Matrix experiment

The blending of different ratios of light and dark sphagnum peat with the Scotts standard mix gave a useful range of AFP values from 2.93 to 10.62% (Table 11, page 44). Similarly, a range of biological activities as determined by FDA hydrolysis was generated. In keeping with previous observations (Boehm & Hoitink, 1992), the levels of FDA hydrolysis were amongst highest in the 100% light sphagnum (3.59 μg/g/min) and the 100% Scotts B2 peat (4.19 μg/g/min) and the lowest was in the 100% dark sphagnum peat (0.56 μg/g/min). The levels of FDA hydrolysis in the various mixes reflected the proportions of these components (Table 11).

The AFP was reduced in all of the peat mixes containing added mineral nutrition except the Scotts B2 peat (Table 11). There was also a substantial reduction in the FDA hydrolysis in all of these peat mixes, including the Scotts B2 peat, which was reduced from 4.19 to 1.98 μg/g/min.

The results of the disease challenge were disappointing. The experiment was inoculated in early Autumn and a similar inoculum load (approximately 7000 cfu/g of sand) of the same isolate (A052) was used as the successful sand tray experiment in week 47 of year 1 of the project. However, the amount of *Pythium* root rot disease seen was very small with a maximum percentage root browning of 4% (Table 11).

Figure 11: Relationship between root browning and vigour ('bulk') under *Pythium* disease challenge; data considered independently of blocking medium and propagation time.

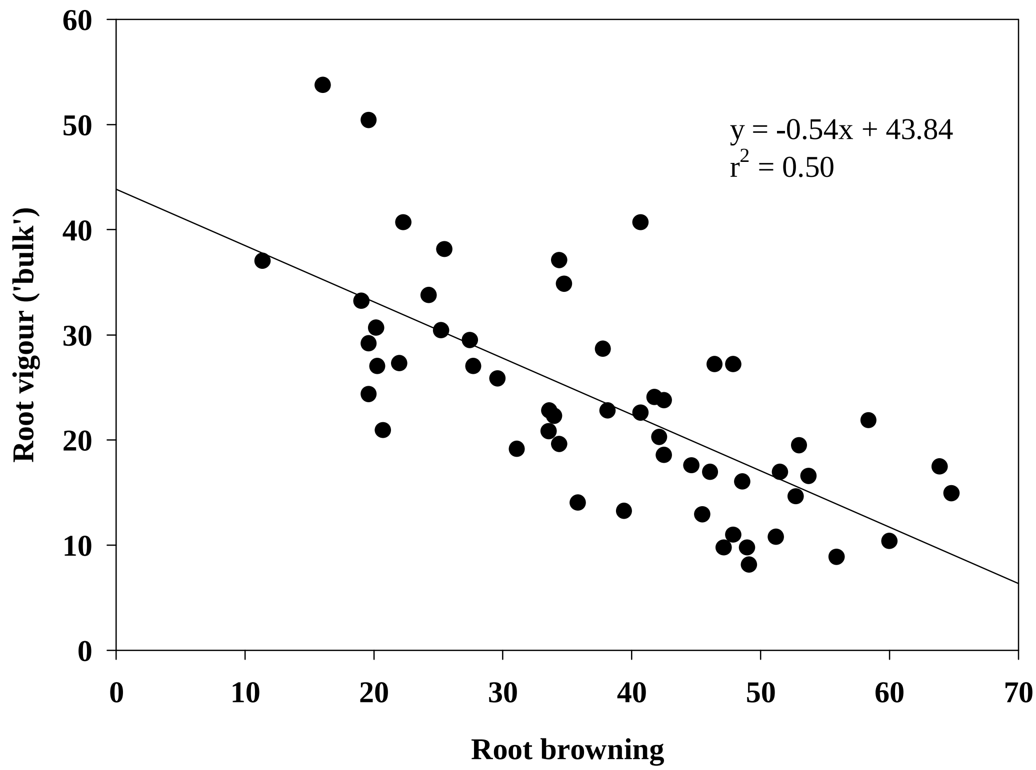


Figure 12: Effect of propagation time and blocking medium on the rate of increase in shoot dry weight over the first four weeks after planting on control and *Pythium*-inoculated sand trays.

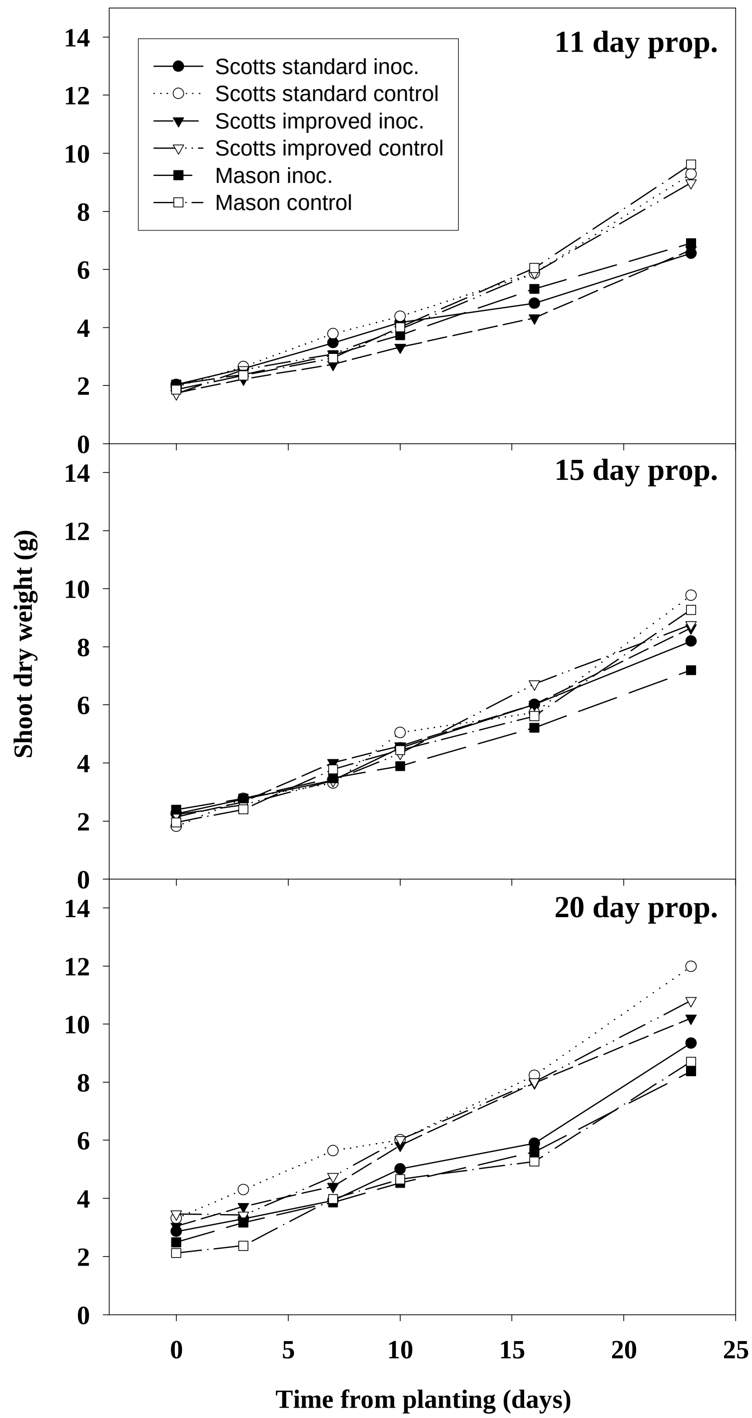


Figure 13: Effect of propagation time and blocking medium on the rate of increase in plant height (measured from the top of the block to the growing tip) over the first four weeks after planting on control and *Pythium*-inoculated sand trays.

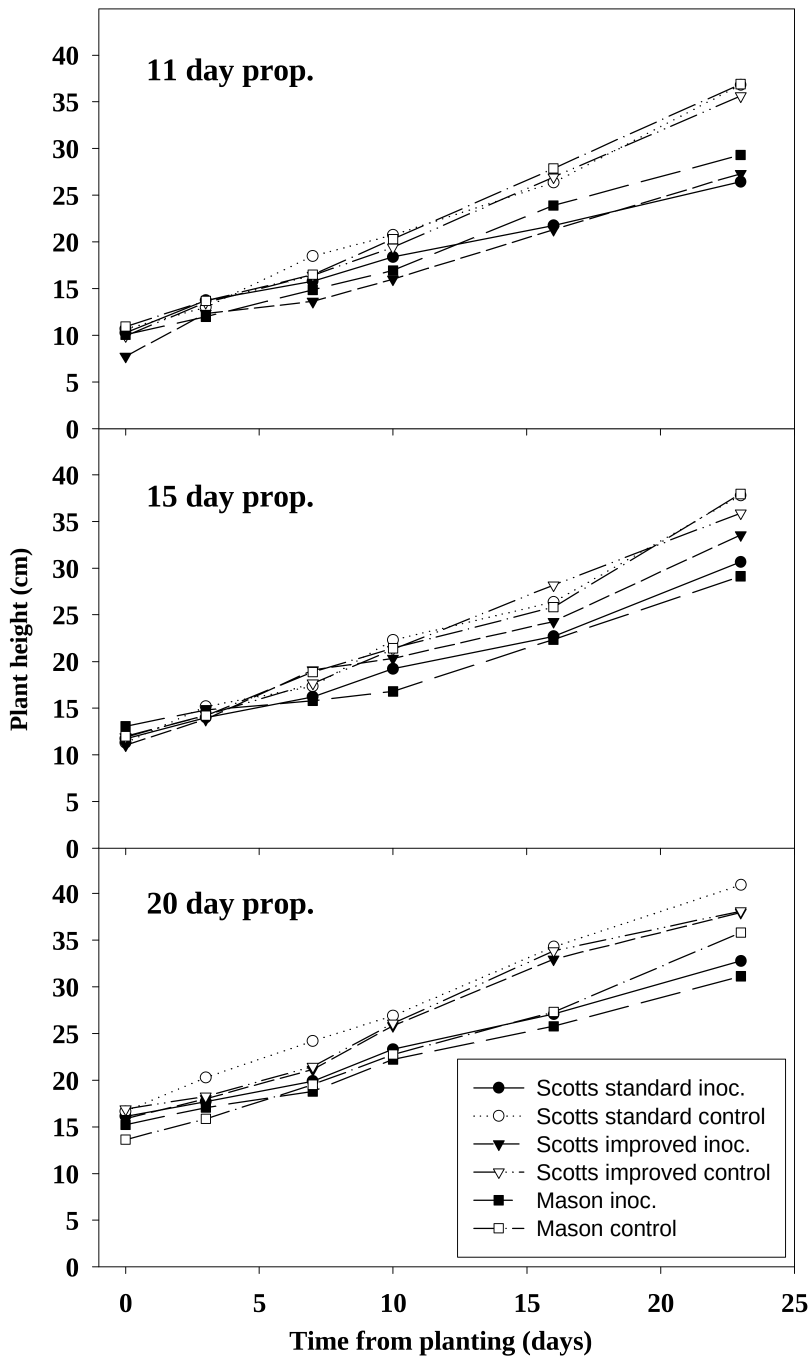


Figure 14: Effect of propagation time and blocking medium on the rate of increase in the leaf number per plant over the first four weeks after planting on control and *Pythium*-inoculated sand trays.

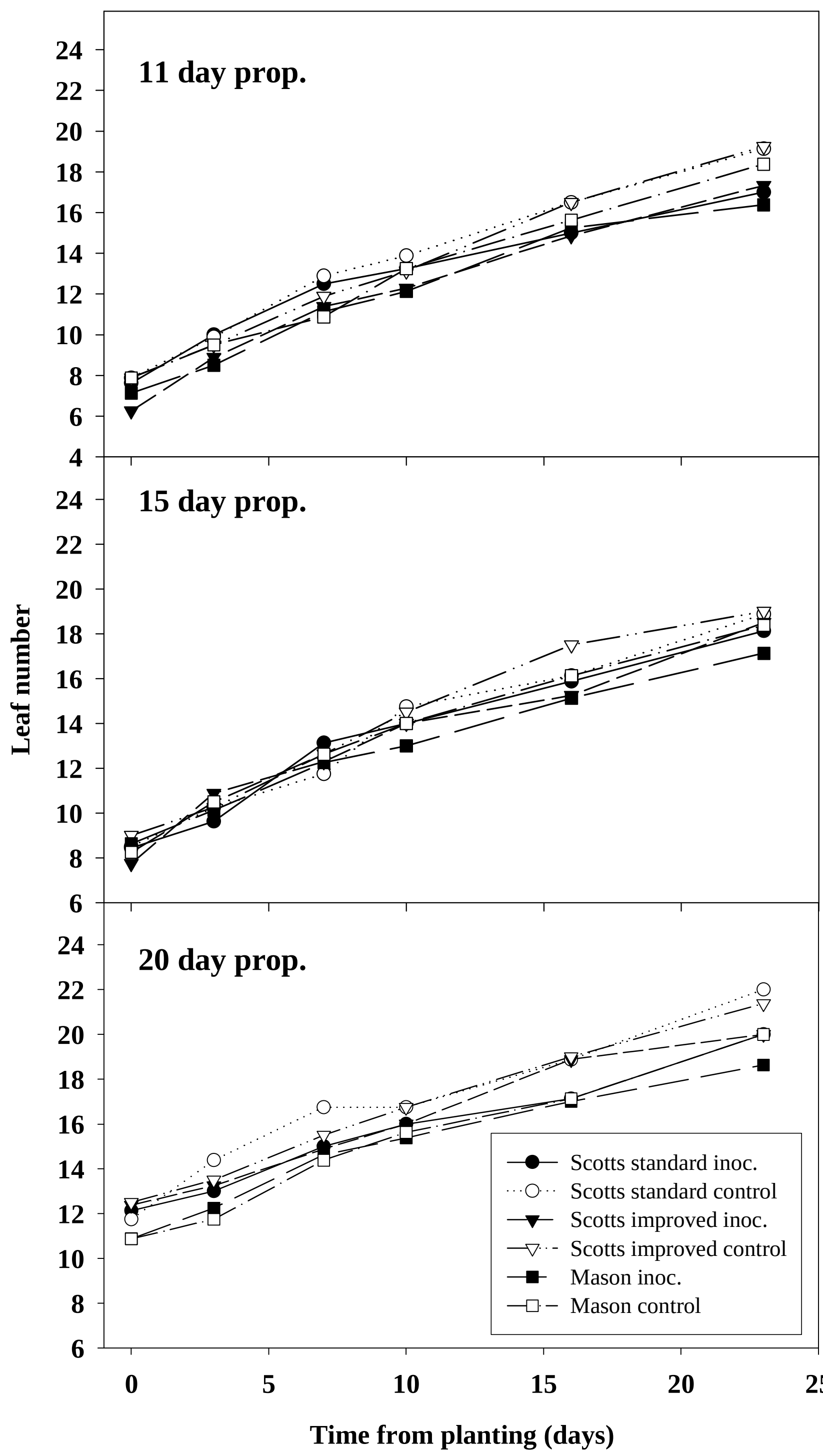


Table 11: Air-filled porosity (%), biological activity measured by FDA hydrolysis, *in vitro* suppression of *Pythium* and root browning caused in tray inoculation tests with chrysanthemums for the range of sphagnum peat mixes tested in the 'matrix' experiment.

Blocking medium mix (see page 13)	AFP (%)	FDA (µg/g/min)	*In vitro* suppression of *Pythium*[a]	Root browning (%) in inoculated blocks
100% A	5.07	3.59	9.5	4.00
100% B	10.62	1.79	8.0	3.00
100% C	5.42	1.42	5.5	1.72
100% D	6.77	1.01	4.0	1.81
100% E	2.93	0.56	3.5	0.75
100% ST	3.56	4.19	9.0	1.25
75% A	5.86	3.83	9.5	1.88
75% B	8.73	3.15	7.0	1.53
75% C	6.79	2.36	5.0	1.34
75% D	4.36	1.97	7.0	1.13
75% E	6.53	2.10	0.0	0.88
50% A	5.65	5.10	9.5	2.44
50% B	5.70	5.34	2.0	1.72
50% C	6.39	3.57	5.0	1.78
50% D	7.58	3.30	4.0	1.13
50% E	6.46	2.37	6.0	1.59
25% A	5.83	3.88	8.5	1.41
25% B	5.81	3.59	8.0	2.03
25% C	4.58	3.35	4.0	1.56
25% D	6.18	2.77	6.0	1.91
25% E	4.61	2.52	2.5	1.59
Media with mineral nutrition added				
100% C + N	4.69	0.73	-	1.13
75% C + N	5.00	1.43	-	2.34
50% C + N	6.39	1.99	-	2.47
25% C + N	4.26	1.73	-	0.97
!00% ST + N	5.54	1.98	-	1.53

[a] Numbers of colony-forming units per plate in a 10^{-1} dilution series. The lower the number, the greater the suppression.

When compared with previous sand tray inoculations, the low level of disease can be appreciated: in week 47 , 1998 the root browning in the inoculated Scotts standard medium after 14 days ranged from approximately 45 to 68% and in week 12, 2000, with a smaller initial inoculum dose (approximately 4800 cfu/g of sand), the range of root browning was between 8 and 30% (Carver, 2000).

Although there was a small decline in the root vigour or percentage root bulk in most inoculated plants, there was only a significant decline in the 100% A and 100% B peat mixes (A = 100% light sphagnum and B = 100% of a mixture of 75% light sphagnum and 25% dark sphagnum). The 100% A gave 4% root browning with a 37.7% root vigour score, and 100% B gave 3% root browning with a root vigour score of 41.6%. The only other decline in root vigour was in the 25% D medium (for explanations of block recipes see Table 3, page 13), where 1.9% root browning was associated with a root vigour score of 52.2%. The mean root vigour score for all of the inoculated treatments combined was 58.31% compared to 73.6% for the controls, where no root browning was observed (Table 12).

There was no relationship between the low level of root browning and plant height and no effect of the marginally higher levels of browning mentioned above was observed. However, there was still a slight reduction in both the mean height of inoculated plants and in the mean number of leaves per stem in comparison with non-inoculated controls (Table 12).

A measure of *Pythium* suppression was obtained from an *in vitro* assay which determined the level of colonisation of inoculated peat mix samples (Table 11). The higher the number of cfu per plate, the lower the suppression. Interestingly the amount of observed root browning was related to the amount of suppression , with the highest levels of root browning associated with the highest rates of colonisation. This observation agrees with previous findings with colonisation of inoculated sands and of nursery soils and *Pythium* root rot symptoms (Carver, 2000; Pettitt, 2001). However, neither the amount of *Pythium* colonisation, nor of root browning appeared to be reduced in media with high FDA hydrolysis activities. This result contradicts previous findings (Boehm & Hoitink, 1992, Pettitt & Wainwright, 2000, unpublished; Petch & Pettitt, 2001, unpublished).

An increased amount of root browning and infection might be explained in a pure mix of a less degraded light sphagnum peat, when the ‘hot’ nature of the medium might cause some degree of stress to the roots. Unfortunately, this does not explain the apparently higher levels of *Pythium* colonisation in the more biologically active media. This area requires further work and is the subject of strategic studies in a

MAFF-funded project on disease suppression. The MAFF-funded work may provide some further media that might be exploited for *Pythium* suppression in blocking medium mixes.

Table 12: Table showing means across all blocking medium mix treatments for the matrix experiment together with their standard deviations in brackets, illustrating the small difference between treatments and between controls and inoculated plants.

Disease challenge treatment	**'Disease-indicating' parameters of plant growth & development**			
	Root browning (%)	**Root vigour (%, 'emergent bulk')**	**Plant height (cm)**	**Leaf no. per stem**
Inoculated	1.74 (0.74)	58.31 (7.06)	21.67 (0.97)	13.44 (0.45)
Controls	0.00 (-)	73.60 (5.06)	23.82 (0.71)	14.11 (0.36)

When the effects of AFP were considered, no relationships were observed with any of the four parameters of disease (% root browning, % root vigour, plant height and leaf number) considered in either inoculated or uninoculated plants.

In conclusion, considering the small amount of disease achieved, the results of the matrix experiment need to be treated with caution. However, the dark sphagnum peat appeared the most suppressive to *Pythium* colonisation and to root browning and the light sphagnum the least so. The Scotts B2 base mix showed little or no *Pythium* suppression, but, paradoxically, also showed comparatively a low level of root browning.

Evaluation of selected 'matrix' block media on soil beds

Comparisons of AFP and FDA activity for the six media selected for assessment are shown in Table 13. There was little variation in AFP with the lowest (6.46%) for the 50% A with full nutrients and highest (9.31%) for the 50% E with full nutrients medium (see Table 3, page 13, for full media recipes). FDA activity appeared to be influenced by the level of mineral nutrition in blocks and was higher in both 100% ST and 50% E media containing half nutrients (Table 13).

Table 13: Results of AFP and FDA hydrolysis activity assessments carried out on blocks of the six media prepared for soil bed comparisons.

Blocking medium*	**AFP (%)**	**FDA (µg/g/min.)**
100% ST -.full nutrients	8.02	166.9
100% ST - half nutrients	8.41	219.3
50% E – full nutrients	9.31	88.5
50% E – half nutrients	8.30	126.6
50% A – full nutrients	6.46	179.8
Scotts B2	9.08	76.4

* for full explanation of recipes see Table 3, page 13 , and for rates of added mineral nutrients see page 14.

In this experiment the largest treatment difference was between steamed and unsteamed plots. Plants growing in all six media were behind in the unsteamed plots by the time of the interim growth assessment carried out 40 days after planting (Table 14). There was no real effect of blocking medium on plant performance on steamed beds, with only the 50% A medium falling slightly behind in terms of mean height (Table 14) and no obvious effect of block nutrition. All treatments received the same number of long days (34 days) and were transferred to short days when a majority of the plots had reached a 40 cm plant height. Only very small differences in grade-out quality were seen on the steamed beds with possibly an increase in numbers of wraps and mean wrap weight with the half rate block nutrition (Table 15).

Plants from unsteamed beds were generally about 10% shorter and gave approximately 5% lighter wraps at harvest than those on steamed beds. Although still small, there were differences between the blocking medium treatments, with the

Scotts B2 and the 50% E plus full nutrients media giving consistently the smallest plants and poorest yield (Tables 14, 15 and Appendix IX). The largest plants

Table 14: Effect of soil steaming and propagation blocking medium on plant heights and leaf numbers.

Blocking medium*	**At Planting**		**Interim (40 days after planting)**				**At Harvest**	
			Steamed		**Unsteamed**		**Steamed**	**Unsteamed**
	Ht. (cm)	***Leaf No.***	**Ht. (cm)**	***Leaf No***	**Ht. (cm)**	***Leaf No***	**Ht. (cm)**	**Ht. (cm)**
100% ST -.full nutrients	11.5	*6.5*	49.2	*23.4*	43.5	*22.1*	95.2	87.6
100% ST - half nutrients	9.3	*6.1*	49.3	*24.2*	43.5	*22.0*	95.0	85.3
50% E – full nutrients	12.5	*6.8*	47.1	*23.0*	43.2	*21.7*	94.1	87.0
50% E – half nutrients	11.7	*6.8*	48.6	*23.5*	43.7	*22.0*	94.7	85.1
50% A – full nutrients	12.0	*6.6*	50.7	*22.6*	44.4	*22.5*	91.8	88.0
Scotts B2	10.9	*6.4*	46.7	*21.3*	42.7	*21.5*	94.6	83.7

Table 15: Effect of soil steaming and propagation blocking medium on yield of wraps and their quality in terms of weight.

Blocking medium*	**Steamed**		**Unsteamed**	
	Total No. of wraps ***(mean per plot)***	**Mean wrap weight (± SE)**	**Total No. of wraps** ***(mean per plot)***	**Mean wrap weight (± SE)**
100% ST -.full nutrients	35 *(17.5)*	303.9 (± 5.90)	142 *(17.8)*	296.5 (± 2.37)
100% ST - half nutrients	38 *(19.0)*	320.1 (± 6.49)	137 *(17.1)*	292.8 (± 2.60)
50% E – full nutrients	33 *(16.5)*	315.8 (± 6.68)	128 *(16.0)*	300.4 (± 2.57)
50% E – half nutrients	34 *(17.0)*	324.4 (± 6.41)	137 *(17.1)*	298.0 (± 2.53)
50% A – full nutrients	35 *(17.5)*	310.8 (± 4.54)	135 *(16.9)*	302.0 (± 2.86)
Scotts B2	33 *(16.5)*	318.6 (± 6.99)	119 *(14.9)*	296.8 (± 2.85)

* for full explanation of recipes see Table 3, page 13, and for rates of added mineral nutrients see page 14.

and the highest wrap weights in unsteamed beds were from the 50% A plus full nutrients treatment, although the highest yield of wraps was obtained with plants grown in 100% ST plus full nutrition blocks. The two poorest performances were from the blocking media with the lowest FDA hydrolysis activity (Table 13). However, as in the work reported above, high FDA activity did not necessarily correlate with good performance in the face of a disease challenge; as stated above, the presence and efficacy of biological suppression of *Pythium* requires further study. Low levels of *Pythium* infection were confirmed in all unsteamed beds by isolations from small numbers of root segments (< 30 per plot) and no infections were detected in root segments taken from the steamed plots. Overall, these results confirm that steaming beds prior to planting improves plant performance and that even rather low levels of *Pythium* infection can reduce plant vigour. The fact that differences between blocking media were only apparent on the unsteamed beds reaffirms previous observations (Pettitt, 2001 and results of sections B and C of this report) that the main benefit from improving blocking media appears to be improving tolerance of plants to *Pythium* attack.

Evaluating box system for disease simulation in commercial soil plots

Table 16 shows mean data for plant heights, leaf numbers, leaf areas and stem fresh weights at harvest for the three treatments in this experiment. An interruption was not used for this experiment (see crop diary, Appendix VIII), consequentially the plant heights overall are somewhat less than would be expected for a spring-grown crop. There were no differences between uninoculated control plants, whether situated within a box or elsewhere in a bed, showing that the box system did not impair the normal development of plants.

Table 16: Effects of growing in inoculated and uninoculated boxes within soil beds on plant yield at harvest.

	Plant height (cm)	**Leaf number**	**Stem fresh weight**	**Total leaf area**
Inoculated box plants	74.83 (± 1.57)	26.37 (± 0.47)	54.24 (± 3.47)	616.0 (± 5.25)
Uninoculated box plants	75.17 (± 1.13)	27.38 (± 0.58)	60.52 (± 0.30)	697.3 (± 13.26)
Controls from outside boxes	75.14 (± 0.99)	27.19 (± 0.98)	57.33 (± 5.41)	665.4 (± 39.86)

Isolations from soil from inside and outside inoculated boxes demonstrated that the pathogen had not spread from inoculated boxes to the surrounding soil. Isolations were also carried out from the roots of all plants and these showed that all plants present in inoculated boxes show some degree of root infection by *Pythium sylvaticum*. Inoculation with *Pythium* reduced the mean plant size. However, the main reason for this experiment was to try to provide a link between results from sand tray experiments with *Pythium* inoculum, and realistic final yield expectations. Plants were grouped into categories based on their heights at 14 days after planting to determine whether infected plants that were able to maintain a competitive height after 2 weeks could sustain this performance until harvest.

Table 17: Effect of stem height at 14 days after planting on stem height at harvest in inoculated (infected) and uninoculated plants in boxes within soil beds.

14 day height category (cm)	Inoculated plants		Uninoculated controls	
	Final height	No of stems	Final height	No of stems
10-12	63.37 (± 7.23)	3	-	-
12-14	69.28 (± 0.80)	9	71.04 (± 1.85)	10
14-16	74.84 (± 0.58)	68	74.89 (± 0.65)	47
16-18	77.55 (± 0.63)	26	75.93 (± 0.55)	42
18-20	81.25 (± 1.25)	2	77.62 (± 0.94)	9

When plant heights are considered in terms of 14 day height categories (Table 17), it becomes clear that plants that perform well in the early stages of the crop, whether infected or not, do maintain height until harvest. However, many infected plants were smaller, particularly in terms of leaf area, than uninoculated plants as can be seen in comparisons between Plates 6, 7 and 8. This smaller leaf area generally resulted in lower stem fresh weights in infected plants in all categories except those that attained a competitive height of 14 – 16 cm in the first two weeks after planting (Table 18). Infected plants that reached a height of 14 cm or above 13 days after planting all produced stems of greater than 50 g fresh weight. This indicates that treatments in inoculated sand tray experiments, which produce plants that can maintain their height relative to uninoculated controls, have strong possibilities for producing marketable stems and reducing uneveness in contaminated soil beds.

The lack of pathogen spread from the boxes, and the realism achieved during this experiment demonstrate that this simple technique will be of great use in future work with *Pythium* root rot. In particular, it may have potential for use in on-nursery trials using indigenous *Pythium* isolates. The technique would also have potential in future biocontrol experiments for example examining the potential for- and yield consequences of incorporating micro-organism preparations into blocks to give protection to plants in the first few weeks on production beds.

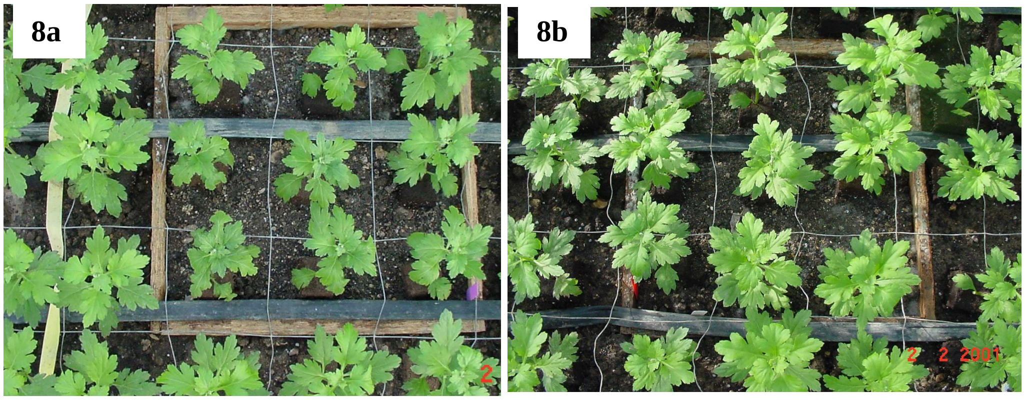
Table 18: Effect of stem height at 14 days after planting on stem fresh weight at harvest in inoculated (infected) and uninoculated plants in boxes within soil beds.

Interim height category (cm)	**Inoculated plants**		**Uninoculated controls**	
	Final fresh weight	**No of stems**	**Final fresh weight**	**No of stems**
10-12	27.17 (± 9.67)	3	-	-
12-14	34.87 (± 2.44)	9	42.46 (± 6.99)	10
14-16	58.51 (± 6.83)	68	57.15 (± 2.25)	47
16-18	53.04 (± 2.3)	26	64.68 (± 2.40)	42
18-20	52.80 (± 3.00)	2	78.77 (± 6.87)	9

Plate 6: Uninoculated control box within soil bed 6 days after planting. (NB The apparent yellowing of the leaves is due to reflected sunlight).

Plate 7: Inoculated box (all plants infected with *P. sylvaticum*) 6 days after planting, showing reduction in plant size and some reversible wilting. (NB. The apparent yellowing is due to reflection of sun – sunny weather is also responsible for inducing wilting!).

Plate 8: Inoculated (a) and control (b) boxes 15 days after planting



Conclusions

- For any given duration of propagation, root development in the Scotts Standard blocks was markedly poorer than in either the Scotts Improved blocks or the Masons blocks. There was no obvious difference in rooting between Scotts Improved and Masons blocks when the propagation duration was 15 or 20 days, but root development in the Masons blocks was greater than in the Scotts Improved blocks when the propagation duration was only 11 days.

- Plant height, leaf number and plant fresh weight all appeared to increase in an approximately linear manner during the first 15 days of propagation. There were no obvious differences in growth between the two Scotts blocking media, but vegetative growth did appear to be slightly reduced in the Masons medium after 15 days of propagation.

- Plant height, leaf number and plant fresh weight increased exponentially between 15 and 20 days and, at 20 days, vegetative growth in the Scotts Standard treatment had outstripped that in both the Scotts Improved treatment and in the Masons treatment. This effect may have been due to the smaller blocks used in the Masons treatment, and to not adopting a more frequent irrigation regime for the two freer-draining substrates, but could also be due to different partitioning of assimilates between roots and shoots, with more root demand in the latter substrates.

- Although the 11-day and 15-day treatments were planted out at the same time in the glasshouse, the 15-day propagation treatments consistently reached the 40 cm ‘stick height’ stage one day ahead of the 11-day propagation treatments. This almost certainly reflects the slightly larger initial plant heights of the 15-day blocks.

- The 20-day treatments were planted out 5 days after the 11-day and 15-day treatments, but the 20-day Scotts Standard and Scotts Improved treatments reached the 40 cm stage at most only one day after the equivalent 15-day treatments and after receiving about 17% less light. The extra 5 days in propagation did, therefore, appear to translate into a roughly equivalent reduction in time spent in LD in the glasshouse.

- The 20-day Masons treatments reached the 40-cm stage two days after the 20-day Scotts treatments and after receiving 15.5% more light. This was almost certainly a result of the Masons blocks having been seriously disadvantaged during propagation because of a smaller block size.

- Sampling of individual plants showed that the average height of the 20-day block plants at the '40 cm stage' was 1-3.5 cm less than that of the 11-day and 15-day block plants. This indicates that the glasshouse LD phase for the 20-day blocks ought to have been 1-2 days longer than was actually the case, and that a more realistic estimate of the saving in LD in the glasshouse of propagating for 20 days might be only 2-3 days.

- There were no obvious differences between the treatments in average leaf number per stem, plant fresh weight or plant dry weight at the start of SD and no differences in crop uniformity. This indicates that ending the LD phase at a defined physiological stage and allowing growth to proceed for however long is required to reach this stage, effectively compensates for differences apparent in the blocked plants at planting out in the glasshouse.

- Treatments benefited rather less from interruption than might have been expected because interruption, based on average daily light integral, was given 2-3 days later than planned.

- The 15-day propagation treatments required 1-3 fewer SD to reach the harvest stage than either the 11-day or 20-day treatments. This effect appeared to be a direct consequence of initial propagation treatments rather than light receipt or other factors.

- Summing over all phases of growth in the glasshouse, the 15-day propagation treatments reached the harvest stage 2.8 days before the 11-day treatments (on average), having received about 5% less light. 20-day treatments using Scotts Standard and Scotts Improved media reached the harvest stage 5.8 days faster than the equivalent 11-day treatments, having received 6.3% less light. These also reached the harvest stage 3 days faster than the equivalent 15-day treatments, having received almost identical light intrgrals. It appears that in speed terms at least, much of the benefit of the longer propagation period and later planting into the glasshouse was preserved through to harvest.

- The 20-day Masons treatment reached the harvest stage only 2 days ahead of the equivalent 11-day treatment, and 1 day after the equivalent 15-day treatment, having received 8.8% more light! The situation may well have been different however, had the Masons 20-day treatment been stuck in 6cm blocks like the other 20-day treatments.

- The harvest durations for 11-day and 15-day propagation treatments were very similar (8-9 days). However, the harvest duration for 20-day treatments tended to be 1-2 days longer.

- 20-day propagation treatments appeared to give a higher percentage of stems in the two top weight grades than 15 or 11-day treatments.

- The Scotts improved medium gave the best results in *Pythium* disease challenge experiments, reducing root browning and vigour loss compared to the Scotts standard medium. The best results were achieved with the 20 day propagation, where the Scotts improved-grown plants maintained shoot heights and leaf numbers comparable to uninoculated controls after 3 weeks.

- In sand tray experiments, the dry weights of all inoculated plants were less than those of equivalent uninoculated controls in all treatments. Inoculated plants that managed to maintain equivalent heights and leaf numbers to controls often showed a smaller deficit in weight, probably resulting from reduced leaf area. An initial experiment using inoculated boxes on soil beds indicated that, if these infected plants can maintain height in the first two weeks they will still produce marketable stems

- The good performance of plants in the Scotts improved medium appeared to be linked to this medium having a combination of a high AFP and high biological activity, giving strong root growth and some protection from pathogens at planting.

- A 'matrix' of different peat mixes was generated to produce a set of media with a range of AFP and biological activities. These were compared in a disease challenge experiment. Unfortunately a poor inoculation gave disappointing and confounded results.

- An *In vitro* disease suppression study indicated that in the mixes generated in the 'matrix' experiment, the existence of high biological activity, as determined by the FDA assay, did not necessarily indicate a *Pythium*-suppressive medium, although in the absence of high FDA values, biological suppression would be unlikely. This indicates that FDA alone may not be a good indicator of disease-suppressive activity. This area requires more confirmatory results.

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Appendix I: Table showing mineral analysis of samples of the blocking media used in the establishment/take-off experiment in C block, HRI Efford, taken at, and three times after planting and in the first month of the crop.

Blocking Medium	**Scotts standard (A)**				**Scotts improved (B)**				**Masons (D)**			
Sample Date	**8.11.99**	**19.11.99**	**24.11.99**	**30.11.99**	**8.11.99**	**19.11.99**	**24.11.99**	**30.11.99**	**8.11.99**	**19.11.99**	**24.11.99**	**30.11.99**
Bulk density g/l	0.385	0.318	0.314	0.335	0.471	0.333	0.299	0.340	0.330	0.324	0.279	0.320
PH	5.1	5.2	4.8	4.8	5.4	5.1	4.9	4.9	5.5	5.8	5.7	5.5
Conductivity µS/20cm	277	159	512	300	352	325	603	646	348	396	648	635
Mineral analyses (mg/l)												
Nitrate N	88	6	81	48	84	44	82	43	19	105	24	33
Ammonium N	28.2	13.5	31.5	13.6	49.7	9.7	7.4	1.6	98.6	74.7	123.3	31.9
Potassium	89	41	223	155	138	91	294	628	256	188	390	443
Calcium	61	49	195	191	87	119	251	319	191	139	251	421
Magnesium	47	41	177	108	83	121	214	274	51	36	82	233
Phosphorus	40	31	47	38	71	58	52	60	94	69	85	52
Iron	0	0	0	0	0	0	0	0	0	0	0	0
Zinc	0.41	0.42	1.31	3.86	0.52	0.31	0.96	2.94	0.6	0.38	0.84	2.53
Manganese	0.17	0.12	0.84	0.93	0.19	0.31	0.90	1.61	0.22	0.12	0.75	1.48
Copper	0.1	0.25	0.18	2.32	0.10	0.04	0.36	0.89	0	0	0.42	0.67
Boron	0.08	0.29	0.32	0.18	0	0	0.18	0	0	0	0	0
Sodium	96	48	84	66	60	42	72	96	66	48	72	108
Sulphate	32	22	160	173	83	71	284	525	223	167	194	474

NB. In the Masons medium the ammonium nitrogen levels were higher than the nitrate N. However this does not appear to have had an effect on the substrate pH, which would be expected to decrease with increased ammonium nitrogen exploitation by the plants. Also, later values for the nutrition in all of the media show the impact of liquid feeding.

Appendix II: Plan for the trial assessing the effects of propagation time and blocking media on the speed, uniformity and yield of winter AYR crops. (Each plot consisted of one half bed in ‘C block’, HRI Efford).

	D plot 2	**A** plot 4	*B* plot 6	*D* plot 8	*D* plot 10	**B** plot 12	**A** plot 14	**B** plot 16	**A** plot 18
	A plot 1	**D** plot 3	**D** plot 5	**B** plot 7	**A** plot 9	**D** plot 11	**B** plot 13	**A** plot 15	**B** plot 17
Propagation duration =	11 days BED5	20 days BED 6	15 days BED 7	20 days BED 8	15 days BED 9	11 days BED 10	15 days BED 11	20 days BED 12	11 days BED 13

Appendix III: **Crop diary for the establishment/take-off experiment in C block, HRI Efford.**

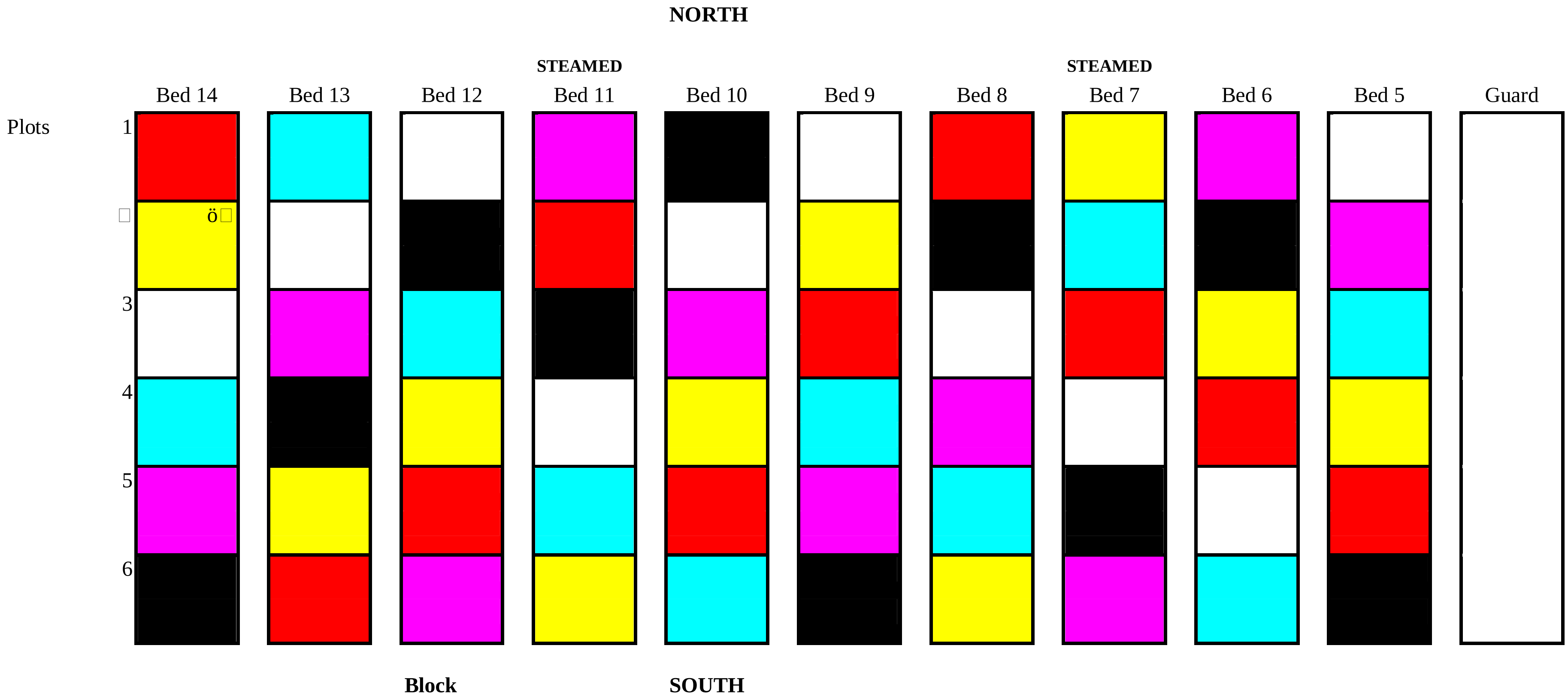
Date	Event
04.11.99	Stuck 15 and 20 day propagation treatments
04.11.99	Rovral (1.0 g/l)
08.11.99	Stuck 11 day propagation treatments
08.11.99	Rovral (1.0 g/l) on 11 day propagation treatments
18.11.99	Rovral (1.0 g/l)
19.11.99	Planted 11 and 15 propagation treatments (Long days)
23.11.99	Rovral (1.0 g/l)
24.11.99	Planted 20 day propagation treatment (Long days)
28.11.99	Malathion (1.8 ml/l) + Beehappy (1.0 ml/l)
05.12.99	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
12.12.99	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
14.12.99	Plots 5, 6, 9, 10 & 14 into short days
15.12.99	Plots 1, 2, 4, 7, 11, 13, 15, 16, 17, 18, into short days
16.12.99	Plots 1, 2, 4, 5, 6, 7, 9, 10, 11, 13, 14, 15, 16, 17 & 18 B-Nine (1.75 g/l)*
17.12.99	Plots 3, 8 & 12 into short days
18.12.99	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
20.12.99	Plots 3, 8 & 12 B-Nine (1.75 g/l)*
02.01.00	Plots 5, 6, 9, 10 & 14 start interruption
04.01.00	Plots 1, 2, 4, 7, 11, 13, 15, 16, 17 & 18 start interruption
06.01.00	Plots 3, 8 & 12 start interruption
09.01.00	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
12.01.00	Plots 5, 6, 9, 10 & 14 recommence short days
14.01.00	Plots 1, 2, 4, 7, 13, 15, 16, 17 & 18 recommence short days
16.01.00	Malathion (1.8 ml/l) + Beehappy (1.0 ml/l)
19.01.00	Plots 2, 3, 6, 5, 8, 9,10, 12,13, 14, 15, 16 & 18 B-Nine (1.75 g/l)*
23.01.00	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
27.01.00	Plots 1,4,7, 11 & 17 B-Nine (1.75 g/l)*
30.01.00	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
02.02.00	Disbudded
06.02.00	Nemolt (0.5 ml/l) + Malathion (1.5 ml/l)
13.02.00	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
20.02.00	Dichlorvos (1.0 ml/l) + Beehappy (1.0 ml/l)
21.02.00	Harvest started
08.03.00	Harvest completed

* see **Appendix IV** for B-Nine

Appendix IV: Application schedule for applications of daminozide as B-Nine to the establishment/take-off experiment in C block, HRI Efford (see also Appendix II & III).

Plot number	**Treatment**	**Number of days after start of SD**	
		to first application	**to second application**
1	A11	1	43
2	D11	1	35
3	D20	3	33
4	A20	1	43
5	D15	2	36
6	B15	2	36
7	B20	1	43
8	D20	3	33
9	A15	2	36
10	D15	2	36
11	D11	1	43
12	B11	3	33
13	B15	1	35
14	A15	2	36
15	A20	1	35
16	B20	1	35
17	B11	1	43
18	A11	1	35

Appendix V: Trial diagram showing planting positions for the 5 'matrix' block types plus the Scotts B2 in the C block comparison experiment planted in November 2000.



Block recipes

A — STANDARD PEAT **FULL** NUTRITION

B — STANDARD PEAT **HALF** NUTRITION

C — 50% DARK PEAT **FULL** NUTRITION

D — 50% DARK PEAT **HALF** NUTRITION

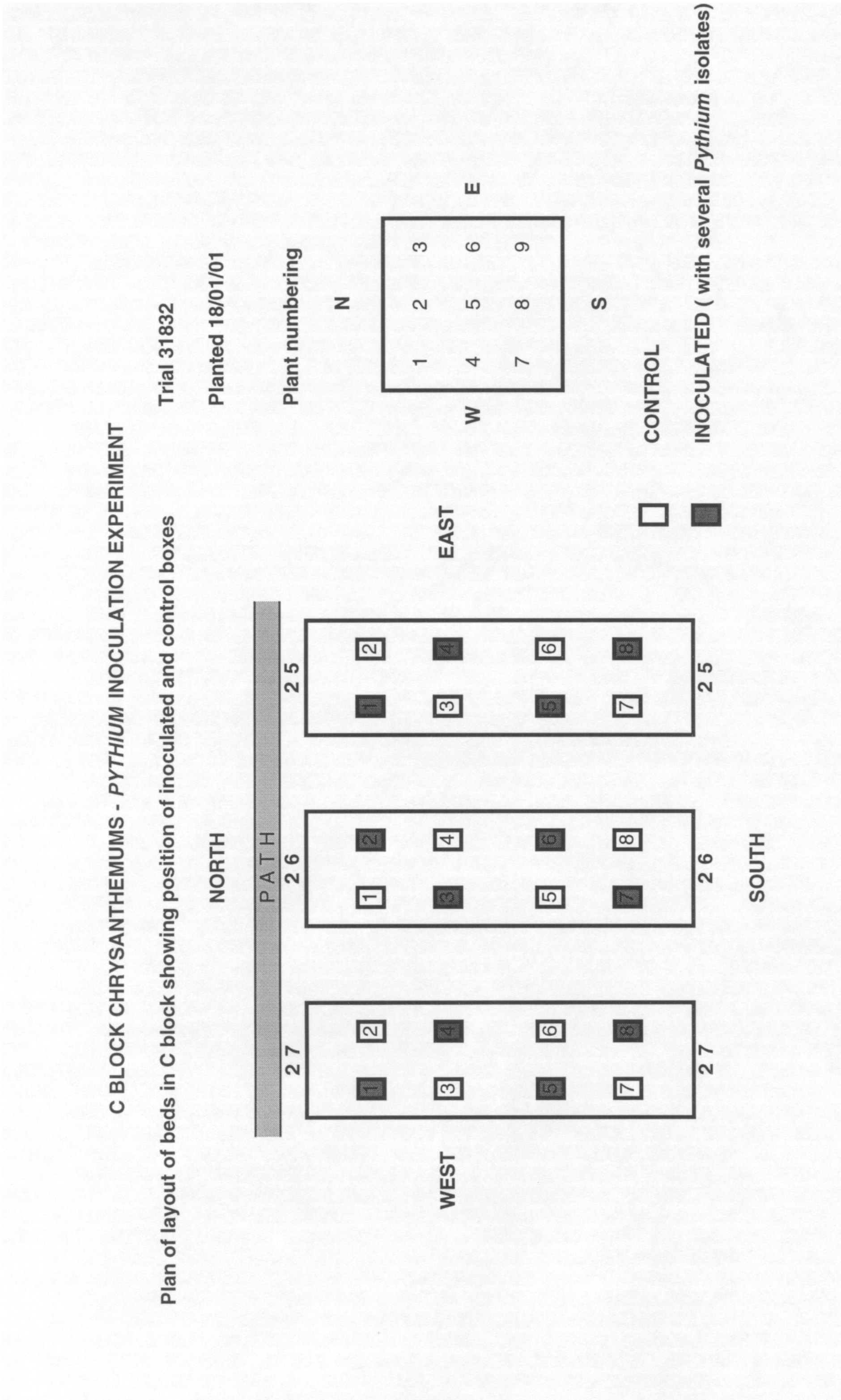
E — 50% LIGHT PEAT **FULL** NUTRITION

F — SCOTTS B2

Appendix VI: **Crop diary for the 'matrix' blocking media assessment trial in C block, HRI Efford.**

Date	**Event**
25.10.00	Made blocks
27.10.00	All plants stuck
27.10.00	Mycotal (1 g/l): Vertilec (2 g/l)
06.11.00	Covers off
09.11.00	Rovral (1 ml/l)
10.11.00	Planted all beds/ Lights on
12.11.00	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
19.11.00	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
26.11.00	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
01 12.00	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
09.12.00	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
14.12.00	Start of SD: Lights off
15.12.00	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
24.12.00	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
29.12,00	Start of interruption
29.12.00	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
04.01.01	B-Nine (2 g/l)
05.01.01	End of interruption
05.01.01	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
12.01.01	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
19.01.01	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
26.01.01	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
02.02.01	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
05.02.01	Aphox (1 g/l)
12.02.01	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
20.02.01	Start of harvest

Appendix VII: Trial plan for the box experiment in C Block, Efford



Appendix VIII: Crop diary for the inoculation box experiment in C block, HRI Efford.

Date	**Event**
18.01.01	All plots planted/ Lights on in C block
19.01.01	Dynamec (0.5 ml/l): Beehappy (1.0 ml/l)
26.01.01	Dichlorvos (1.0 ml/l): Beehappy (1.0 ml/l)
01.02.01	B-Nine (1 ml/l)
02.02.01	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
08.02.01	Start of SD (Lights off)
12.02.01	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
18.02.01	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
25.02.01	Dynamec (0.5 ml/l): Beehappy (1 ml/l)
02.03.01	Malathion (1.8 ml/l): Nemolt (0.5 ml/l): Beehappy (1 ml/l)
13.03.01	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
23.03.01	Dichlorvos (1 ml/l): Beehappy (1 ml/l)
09.04.01	Harvest started

Appendix Table IX: Effect of soil steaming and propagation blocking medium (‘matrix’ block recipes) on total leaf area per plant and cut stem fresh weight 40 days after planting.

Blocking medium	**Leaf Area**		**Stem fresh weight**	
	Steamed	**Unsteamed**	**Steamed**	**Unsteamed**
100% ST -.full nutrients	430.8	326.0	22.8	16.9
100% ST - half nutrients	430.2	311.3	22.7	16.3
50% E – full nutrients	391.8	315.8	20.6	16.2
50% E – half nutrients	430.3	327.6	21.8	17.2
50% A – full nutrients	422.4	334.7	22.4	17.5
Scotts B2	392.7	331.6	20.3	16.3

NB. This table illustrates that the main differences occur between steamed and unsteamed treatments. The differences seen between block-types within the steamed and unsteamed treatments were not statistically significant. Also of interest is that treatments 100% ST with full nutrients and Scotts B2 are essentially the same blocking medium (see pages 13-16).

Appendix X: Comprehensive tables of light integrals for the 1999 blocks vs propagation time trial held in C block, HRI Efford. Treatments are labelled A (Scotts standard), B (Scotts Improved) and D (Masons) for blocking media followed by the number of days in propagation (11, 15 or 20). In treatments B11 and B15 the two replicate plots went into short days at different times and are therefore considered separately in this table and labelled a and b.

A11		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
08/11	2.7453	0				
09/11	6.7913	1		6.7913	6.7913	6.79
10/11	3.1448	2		4.97	9.94	9.94
11/11	4.8303	3		4.92	14.77	14.77
12/11	5.6285	4		5.10	20.39	20.39
13/11	6.7093	5		5.42	27.10	27.10
14/11	2.0898	6		4.87	29.19	29.19
15/11	5.3324	1		5.33	5.33	5.33
16/11	5.5739	2		5.45	10.91	10.91
17/11	6.1841	3		5.70	17.09	17.09
18/11	4.7229	4		5.45	21.81	21.81
19/11	6.0232	5		5.57	27.84	27.84
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	25	25	2.83	70.63	70.63
15/12	4.6512	1	26	4.65	4.65	75.28
16/12	3.9138	2	27	4.28	8.57	79.19
17/12	0.7635	3	28	3.11	9.33	79.96
18/12	1.0888	4	29	2.60	10.42	81.05
19/12	4.7167	5	30	3.03	15.13	85.76
20/12	4.2599	6	31	3.23	19.39	90.02
21/12	0.2413	7	32	2.81	19.64	90.26
22/12	0.4042	8	33	2.50	20.04	90.67
23/12	3.298	9	34	2.59	23.34	93.97
24/12	0.643	10	35	2.40	23.98	94.61
25/12	2.1734	11	36	2.38	26.15	96.78
26/12	1.5064	12	37	2.31	27.66	98.29
27/12	0.9384	13	38	2.20	28.60	99.23

28/12	3.9804	14	39	2.33	32.58	103.21
29/12	4.1952	15	40	2.45	36.77	107.40
30/12	0.5432	16	41	2.33	37.32	107.95
31/12	0.4321	17	42	2.22	37.75	108.38
01/01	1.5968	18	43	2.19	39.35	109.97
02/01	1.874	19	44	2.17	41.22	111.85
03/01	4.5035	20	45	2.29	45.72	116.35
04/01	2.3187	1	46	2.32	2.32	118.67
05/01	2.2933	2	47	2.31	4.61	120.96
06/01	2.7893	3	48	2.47	7.40	123.75
07/01	3.652	4	49	2.76	11.05	127.40
08/01	4.626	5	50	3.14	15.68	132.03
09/01	5.0053	6	51	3.45	20.68	137.04
10/01	4.1353	7	52	3.55	24.82	141.17
11/01	0.8131	8	53	3.20	25.63	141.98
12/01	1.4594	9	54	3.01	27.09	143.44
13/01	3.714	10	55	3.08	30.81	147.16
14/01	4.079	1	56	4.079	4.079	151.24
15/01	2.9653	2	57	3.52	7.04	154.20
16/01	4.6517	3	58	3.90	11.70	158.85
17/01	2.8404	4	59	3.63	14.54	161.69
18/01	3.6581	5	60	3.64	18.19	165.35
19/01	1.9523	6	61	3.36	20.15	167.30
20/01	0.8385	7	62	3.00	20.99	168.14
21/01	2.1002	8	63	2.89	23.09	170.24
22/01	4.5688	9	64	3.07	27.65	174.81
23/01	5.6634	10	65	3.33	33.32	180.48
24/01	4.9846	11	66	3.48	38.30	185.46
25/01	6.9361	12	67	3.77	45.24	192.40
26/01	6.9778	13	68	4.02	52.22	199.37
27/01	7.2015	14	69	4.24	59.42	206.58
28/01	2.914	15	70	4.16	62.33	209.49
29/01	2.8929	16	71	4.08	65.22	212.38
30/01	3.7967	17	72	4.06	69.02	216.18
31/01	5.8873	18	73	4.16	74.91	222.07
01/02	1.5274	19	74	4.02	76.44	223.59
02/02	7.1792	20	75	4.18	83.62	230.77
03/02	2.5535	21	76	4.10	86.17	233.33
04/02	1.3366	22	77	3.98	87.51	234.66
05/02	4.3818	23	78	4.00	91.89	239.05
06/02	1.2688	24	79	3.88	93.16	240.31
07/02	1.2126	25	80	3.77	94.37	241.53
08/02	4.9454	26	81	3.82	99.31	246.47
09/02	6.2162	27	82	3.91	105.53	252.69
10/02	3.2167	28	83	3.88	108.75	255.90
11/02	8.662	29	84	4.05	117.41	264.57
12/02	6.3511	30	85	4.13	123.76	270.92
13/02	7.9067	31	86	4.25	131.67	278.82
14/02	2.2398	32	87	4.18	133.91	281.06
15/02	4.4972	33	88	4.19	138.40	285.56
16/02	9.316	34	89	4.34	147.72	294.88
17/02	8.0829	35	90	4.45	155.80	302.96
18/02	6.1076	36	91	4.50	161.91	309.07
19/02	7.2964	37	92	4.57	169.21	316.36
20/02	10.227	38	93	4.72	179.43	326.59
21/02	9.7365	39	94	4.85	189.17	336.33
22/02	8.4449	40	95	4.94	197.61	344.77
23/02	3.499	41	96	4.91	201.11	348.27
24/02	4.6816	42	97	4.90	205.80	352.95
25/02	12.358	1	98	12.358	12.358	365.31
26/02	8.5204	2	99	10.44	20.88	373.83
27/02	7.0745	3	100	9.32	27.95	380.91
28/02	1.083	4	101	7.26	29.04	381.99
29/02	4.4787	5	102	6.70	33.51	386.47
01/03	11.241	6	103	7.46	44.76	397.71
02/03	3.9518	7	104	6.96	48.71	401.66
03/03	7.4931	8	105	7.03	56.20	409.15
04/03	12.606	9	106	7.65	68.81	421.76
05/03	12.419	10	107	8.12	81.23	434.18
06/03	2.2102	11	108	7.59	83.44	436.39

B11(a)		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
08/11	2.75	0				
09/11	6.79	1		6.79	6.79	6.79
10/11	3.14	2		4.97	9.94	9.94
11/11	4.83	3		4.92	14.77	14.77
12/11	5.63	4		5.10	20.39	20.39
13/11	6.71	5		5.42	27.10	27.10
14/11	2.09	6		4.87	29.19	29.19
15/11	5.33	1		5.33	5.33	5.33
16/11	5.57	2		5.45	10.91	10.91
17/11	6.18	3		5.70	17.09	17.09
18/11	4.72	4		5.45	21.81	21.81
19/11	6.02	5		5.57	27.84	27.84
20/11	4.21	1	1	4.21	4.21	4.21
21/11	4.02	2	2	4.11	8.23	8.23
22/11	1.83	3	3	3.35	10.06	10.06
23/11	2.52	4	4	3.15	12.58	12.58
24/11	3.22	5	5	3.16	15.80	15.80
25/11	2.72	6	6	3.09	18.52	18.52
26/11	1.86	7	7	2.91	20.38	20.38
27/11	4.94	8	8	3.17	25.32	25.32
28/11	2.87	9	9	3.13	28.19	28.19
29/11	0.49	10	10	2.87	28.68	28.68
30/11	2.56	11	11	2.84	31.24	31.24
01/12	3.27	12	12	2.88	34.51	34.51
02/12	4.37	13	13	2.99	38.88	38.88
03/12	1.33	14	14	2.87	40.21	40.21
04/12	4.68	15	15	2.99	44.90	44.90
05/12	4.25	16	16	3.07	49.15	49.15
06/12	1.62	17	17	2.99	50.76	50.76
07/12	2.95	18	18	2.98	53.72	53.72
08/12	0.82	19	19	2.87	54.53	54.53
09/12	3.62	20	20	2.91	58.16	58.16
10/12	3.29	21	21	2.93	61.45	61.45
11/12	0.69	22	22	2.82	62.14	62.14
12/12	2.47	23	23	2.81	64.62	64.62
13/12	1.34	24	24	2.75	65.96	65.96
14/12	4.67	25	25	2.83	70.63	70.63
15/12	4.65	26	26	2.90	75.28	75.28
16/12	3.91	27	27	2.93	79.19	79.19
17/12	0.76	1	28	0.76	0.76	79.96
18/12	1.09	2	29	0.93	1.85	81.05
19/12	4.72	3	30	2.19	6.57	85.76
20/12	4.26	4	31	2.71	10.83	90.02
21/12	0.24	5	32	2.21	11.07	90.26
22/12	0.40	6	33	1.91	11.47	90.67
23/12	3.30	7	34	2.11	14.77	93.97
24/12	0.64	8	35	1.93	15.42	94.61
25/12	2.17	9	36	1.95	17.59	96.78
26/12	1.51	10	37	1.91	19.10	98.29
27/12	0.94	11	38	1.82	20.03	99.23
28/12	3.98	12	39	2.00	24.01	103.21
29/12	4.20	13	40	2.17	28.21	107.40
30/12	0.54	14	41	2.05	28.75	107.95
31/12	0.43	15	42	1.95	29.18	108.38
01/01	1.60	16	43	1.92	30.78	109.97
02/01	1.87	17	44	1.92	32.66	111.85
03/01	4.50	18	45	2.06	37.16	116.35
04/01	2.32	19	46	2.08	39.48	118.67
05/01	2.29	20	47	2.09	41.77	120.96
06/01	2.79	1	48	2.79	2.79	123.75
07/01	3.65	2	49	3.22	6.44	127.40
08/01	4.63	3	50	3.69	11.07	132.03
09/01	5.01	4	51	4.02	16.07	137.04
10/01	4.14	5	52	4.04	20.21	141.17

11/01	0.81	6	53	3.50	21.02	141.98
12/01	1.46	7	54	3.21	22.48	143.44
13/01	3.71	8	55	3.27	26.19	147.16
14/01	4.08	9	56	3.36	30.27	151.24
15/01	2.97	10	57	3.32	33.24	154.20
16/01	4.65	1	58	4.65	4.65	158.85
17/01	2.84	2	59	3.75	7.49	161.69
18/01	3.66	3	60	3.72	11.15	165.35
19/01	1.95	4	61	3.28	13.10	167.30
20/01	0.84	5	62	2.79	13.94	168.14
21/01	2.10	6	63	2.67	16.04	170.24
22/01	4.57	7	64	2.94	20.61	174.81
23/01	5.66	8	65	3.28	26.27	180.48
24/01	4.98	9	66	3.47	31.26	185.46
25/01	6.94	10	67	3.82	38.19	192.40
26/01	6.98	11	68	4.11	45.17	199.37
27/01	7.20	12	69	4.36	52.37	206.58
28/01	2.91	13	70	4.25	55.29	209.49
29/01	2.89	14	71	4.16	58.18	212.38
30/01	3.80	15	72	4.13	61.98	216.18
31/01	5.89	16	73	4.24	67.86	222.07
01/02	1.53	17	74	4.08	69.39	223.59
02/02	7.18	18	75	4.25	76.57	230.77
03/02	2.55	19	76	4.16	79.12	233.33
04/02	1.34	20	77	4.02	80.46	234.66
05/02	4.38	21	78	4.04	84.84	239.05
06/02	1.27	22	79	3.91	86.11	240.31
07/02	1.21	23	80	3.80	87.32	241.53
08/02	4.95	24	81	3.84	92.27	246.47
09/02	6.22	25	82	3.94	98.49	252.69
10/02	3.22	26	83	3.91	101.70	255.90
11/02	8.66	27	84	4.09	110.36	264.57
12/02	6.35	28	85	4.17	116.72	270.92
13/02	7.91	29	86	4.30	124.62	278.82
14/02	2.24	30	87	4.23	126.86	281.06
15/02	4.50	31	88	4.24	131.36	285.56
16/02	9.32	32	89	4.40	140.68	294.88
17/02	8.08	33	90	4.51	148.76	302.96
18/02	6.11	34	91	4.55	154.87	309.07
19/02	7.30	35	92	4.63	162.16	316.36
20/02	10.23	36	93	4.79	172.39	326.59
21/02	9.74	37	94	4.92	182.13	336.33
22/02	8.44	38	95	5.02	190.57	344.77
23/02	3.50	39	96	4.98	194.07	348.27
24/02	4.68	40	97	4.97	198.75	352.95
25/02	12.36	41	98	5.15	211.11	365.31
26/02	8.52	42	99	5.23	219.63	373.83
27/02	7.07	43	100	5.27	226.70	380.91
28/02	1.08	1	101	1.08	1.08	381.99
29/02	4.48	2	102	2.78	5.56	386.47
01/03	11.24	3	103	5.60	16.80	397.71
02/03	3.95	4	104	5.19	20.75	401.66
03/03	7.49	5	105	5.65	28.25	409.15
04/03	12.61	6	106	6.81	40.85	421.76
05/03	12.42	7	107	7.61	53.27	434.18
06/03	2.21	8	108	6.94	55.48	436.39
07/03	1.02	9	109	6.28	56.50	437.41
08/03	8.29	10	110	6.48	64.79	445.70

B11(b)

		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
08/11	2.7453	0				
09/11	6.7913	1		6.79	6.79	6.79
10/11	3.1448	2		4.97	9.94	9.94
11/11	4.8303	3		4.92	14.77	14.77
12/11	5.6285	4		5.10	20.39	20.39
13/11	6.7093	5		5.42	27.10	27.10
14/11	2.0898	6		4.87	29.19	29.19
15/11	5.3324	1		5.33	5.33	5.33
16/11	5.5739	2		5.45	10.91	10.91
17/11	6.1841	3		5.70	17.09	17.09
18/11	4.7229	4		5.45	21.81	21.81
19/11	6.0232	5		5.57	27.84	27.84
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	25	25	2.83	70.63	70.63
15/12	4.6512	1	26	4.65	4.65	75.28
16/12	3.9138	2	27	4.28	8.57	79.19
17/12	0.7635	3	28	3.11	9.33	79.96
18/12	1.0888	4	29	2.60	10.42	81.05
19/12	4.7167	5	30	3.03	15.13	85.76
20/12	4.2599	6	31	3.23	19.39	90.02
21/12	0.2413	7	32	2.81	19.64	90.26
22/12	0.4042	8	33	2.50	20.04	90.67
23/12	3.298	9	34	2.59	23.34	93.97
24/12	0.643	10	35	2.40	23.98	94.61
25/12	2.1734	11	36	2.38	26.15	96.78
26/12	1.5064	12	37	2.31	27.66	98.29
27/12	0.9384	13	38	2.20	28.60	99.23
28/12	3.9804	14	39	2.33	32.58	103.21
29/12	4.1952	15	40	2.45	36.77	107.40
30/12	0.5432	16	41	2.33	37.32	107.95
31/12	0.4321	17	42	2.22	37.75	108.38
01/01	1.5968	18	43	2.19	39.35	109.97
02/01	1.874	19	44	2.17	41.22	111.85
03/01	4.5035	20	45	2.29	45.72	116.35
04/01	2.3187	1	46	2.32	2.32	118.67
05/01	2.2933	2	47	2.31	4.61	120.96
06/01	2.7893	3	48	2.47	7.40	123.75
07/01	3.652	4	49	2.76	11.05	127.40
08/01	4.626	5	50	3.14	15.68	132.03
09/01	5.0053	6	51	3.45	20.68	137.04
10/01	4.1353	7	52	3.55	24.82	141.17

11/01	0.8131	8	53	3.20	25.63	141.98
12/01	1.4594	9	54	3.01	27.09	143.44
13/01	3.714	10	55	3.08	30.81	147.16
14/01	4.079	1	56	4.079	4.079	151.24
15/01	2.9653	2	57	3.52	7.04	154.20
16/01	4.6517	3	58	3.90	11.70	158.85
17/01	2.8404	4	59	3.63	14.54	161.69
18/01	3.6581	5	60	3.64	18.19	165.35
19/01	1.9523	6	61	3.36	20.15	167.30
20/01	0.8385	7	62	3.00	20.99	168.14
21/01	2.1002	8	63	2.89	23.09	170.24
22/01	4.5688	9	64	3.07	27.65	174.81
23/01	5.6634	10	65	3.33	33.32	180.48
24/01	4.9846	11	66	3.48	38.30	185.46
25/01	6.9361	12	67	3.77	45.24	192.40
26/01	6.9778	13	68	4.02	52.22	199.37
27/01	7.2015	14	69	4.24	59.42	206.58
28/01	2.914	15	70	4.16	62.33	209.49
29/01	2.8929	16	71	4.08	65.22	212.38
30/01	3.7967	17	72	4.06	69.02	216.18
31/01	5.8873	18	73	4.16	74.91	222.07
01/02	1.5274	19	74	4.02	76.44	223.59
02/02	7.1792	20	75	4.18	83.62	230.77
03/02	2.5535	21	76	4.10	86.17	233.33
04/02	1.3366	22	77	3.98	87.51	234.66
05/02	4.3818	23	78	4.00	91.89	239.05
06/02	1.2688	24	79	3.88	93.16	240.31
07/02	1.2126	25	80	3.77	94.37	241.53
08/02	4.9454	26	81	3.82	99.31	246.47
09/02	6.2162	27	82	3.91	105.53	252.69
10/02	3.2167	28	83	3.88	108.75	255.90
11/02	8.662	29	84	4.05	117.41	264.57
12/02	6.3511	30	85	4.13	123.76	270.92
13/02	7.9067	31	86	4.25	131.67	278.82
14/02	2.2398	32	87	4.18	133.91	281.06
15/02	4.4972	33	88	4.19	138.40	285.56
16/02	9.316	34	89	4.34	147.72	294.88
17/02	8.0829	35	90	4.45	155.80	302.96
18/02	6.1076	36	91	4.50	161.91	309.07
19/02	7.2964	37	92	4.57	169.21	316.36
20/02	10.227	38	93	4.72	179.43	326.59
21/02	9.7365	39	94	4.85	189.17	336.33
22/02	8.4449	40	95	4.94	197.61	344.77
23/02	3.499	41	96	4.91	201.11	348.27
24/02	4.6816	42	97	4.90	205.80	352.95
25/02	12.358	1	98	12.358	12.358	365.31
26/02	8.5204	2	99	10.44	20.88	373.83
27/02	7.0745	3	100	9.32	27.95	380.91
28/02	1.083	4	101	7.26	29.04	381.99
29/02	4.4787	5	102	6.70	33.51	386.47
01/03	11.241	6	103	7.46	44.76	397.71
02/03	3.9518	7	104	6.96	48.71	401.66
03/03	7.4931	8	105	7.03	56.20	409.15
04/03	12.606	9	106	7.65	68.81	421.76
05/03	12.419	10	107	8.12	81.23	434.18
06/03	2.2102	11	108	7.59	83.44	436.39

D11	D11	Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
08/11	2.7453	0				
09/11	6.7913	1		6.79	6.79	6.79
10/11	3.1448	2		4.97	9.94	9.94
11/11	4.8303	3		4.92	14.77	14.77
12/11	5.6285	4		5.10	20.39	20.39
13/11	6.7093	5		5.42	27.10	27.10
14/11	2.0898	6		4.87	29.19	29.19
15/11	5.3324	1		5.33	5.33	5.33
16/11	5.5739	2		5.45	10.91	10.91
17/11	6.1841	3		5.70	17.09	17.09
18/11	4.7229	4		5.45	21.81	21.81
19/11	6.0232	5		5.57	27.84	27.84
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	25	25	2.83	70.63	70.63
15/12	4.6512	1	26	4.65	4.65	75.28
16/12	3.9138	2	27	4.28	8.57	79.19
17/12	0.7635	3	28	3.11	9.33	79.96
18/12	1.0888	4	29	2.60	10.42	81.05
19/12	4.7167	5	30	3.03	15.13	85.76
20/12	4.2599	6	31	3.23	19.39	90.02
21/12	0.2413	7	32	2.81	19.64	90.26
22/12	0.4042	8	33	2.50	20.04	90.67
23/12	3.298	9	34	2.59	23.34	93.97
24/12	0.643	10	35	2.40	23.98	94.61
25/12	2.1734	11	36	2.38	26.15	96.78
26/12	1.5064	12	37	2.31	27.66	98.29
27/12	0.9384	13	38	2.20	28.60	99.23
28/12	3.9804	14	39	2.33	32.58	103.21
29/12	4.1952	15	40	2.45	36.77	107.40
30/12	0.5432	16	41	2.33	37.32	107.95
31/12	0.4321	17	42	2.22	37.75	108.38
01/01	1.5968	18	43	2.19	39.35	109.97
02/01	1.874	19	44	2.17	41.22	111.85
03/01	4.5035	20	45	2.29	45.72	116.35
04/01	2.3187	1	46	2.32	2.32	118.67
05/01	2.2933	2	47	2.31	4.61	120.96
06/01	2.7893	3	48	2.47	7.40	123.75
07/01	3.652	4	49	2.76	11.05	127.40
08/01	4.626	5	50	3.14	15.68	132.03
09/01	5.0053	6	51	3.45	20.68	137.04
10/01	4.1353	7	52	3.55	24.82	141.17

11/01	0.8131	8	53	3.20	25.63	141.98
12/01	1.4594	9	54	3.01	27.09	143.44
13/01	3.714	10	55	3.08	30.81	147.16
14/01	4.079	1	56	4.08	4.08	151.24
15/01	2.9653	2	57	3.52	7.04	154.20
16/01	4.6517	3	58	3.90	11.70	158.85
17/01	2.8404	4	59	3.63	14.54	161.69
18/01	3.6581	5	60	3.64	18.19	□□□□□□□□
19/01	1.9523	6	61	3.36	20.15	167.30
20/01	0.8385	7	62	3.00	20.99	168.14
21/01	2.1002	8	63	2.89	23.09	170.24
22/01	4.5688	9	64	3.07	27.65	174.81
23/01	5.6634	10	65	3.33	33.32	180.48
24/01	4.9846	11	66	3.48	38.30	185.46
25/01	6.9361	12	67	3.77	45.24	192.40
26/01	6.9778	13	68	4.02	52.22	199.37
27/01	7.2015	14	嘱□□□.2	4.24	59.42	206.58
28/01	2.914	15	70	4.16	62.33	209.49
29/01	2.8929	16	71	4.08	65.22	212.38
30/01	3.7967	17	72	4.06	69.02	216.18
31/01	5.8873	18	73	4.16	74.91	222.07
01/02	1.5274	19	74	4.02	76.44	223.59
02/02	7.1792	20	75	4.18	83.62	230.77
03/02	2.5535	21	76	4.10	86.17	233.33
04/02	1.3366	22	77	3.98	87.51	234.66
05/02	4.3818	23	78	4.00	91.89	239.05
06/02	1.2688	24	79	3.88	93.16	240.31
07/02	1.2126	25	80	3.77	94.37	241.53
08/02	4.9454	26	81	3.82	99.31	246.47
09/02	6.2162	27	82	3.91	105.53	252.69
10/02	3.2167	28	83	3.88	108.75	255.90
11/02	8.662	29	84	4.05	117.41	264.57
12/02	6.3511	30	85	4.13	123.76	270.92
13/02	7.9067	31	86	4.25	131.67	278.82
14/02	2.2398	32	87	4.18	133.91	281.06
15/02	4.4972	33	88	4.19	138.40	285.56
16/02	9.316	34	89	4.34	147.72	294.88
17/02	8.0829	35	90	4.45	155.80	302.96
18/02	6.1076	36	91	4.50	161.91	309.07
19/02	7.2964	37	92	4.57	169.21	316.36
20/02	10.227	38	93	4.72	179.43	326.59
21/02	9.7365	39	94	4.85	189.17	336.33
22/02	8.4449	40	95	4.94	197.61	344.77
23/02	3.499	41	96	4.91	201.11	348.27
24/02	4.6816	42	97	4.90	205.80	352.95
25/02	12.358	1	98	12.36	12.36	365.31
26/02	8.5204	2	99	10.44	20.88	373.83
27/02	7.0745	3	100	9.32	27.95	380.91
28/02	1.083	4	101	7.26	29.04	381.99
29/02	4.4787	5	102	6.70	33.51	386.47
01/03	11.241	6	103	7.46	44.76	397.71
02/03	3.9518	7	104	6.96	48.71	401.66
03/03	7.493	8	105	7.03	56.20	409.15

A15	A15	Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.059	1.059	1.059
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	1	26	4.67	4.67	70.63
15/12	4.6512	2	27	4.66	9.32	75.28
16/12	3.9138	3	28	4.41	13.23	79.19
17/12	0.7635	4	29	3.50	14.00	79.96
18/12	1.0888	5	30	3.02	15.09	81.05
19/12	4.7167	6	31	3.30	19.80	85.76
20/12	4.2599	7	32	3.44	24.06	90.02
21/12	0.2413	8	33	3.04	24.30	90.26
22/12	0.4042	9	34	2.75	24.71	90.67
23/12	3.298	10	35	2.80	28.01	93.97
24/12	0.643	11	36	2.60	28.65	94.61
25/12	2.1734	12	37	2.57	30.82	96.78
26/12	1.5064	13	38	2.49	32.33	98.29
27/12	0.9384	14	39	2.38	33.27	99.23
28/12	3.9804	15	40	2.48	37.25	103.21
29/12	4.1952	16	41	2.59	41.44	107.40
30/12	0.5432	17	42	2.47	41.99	107.95
31/12	0.4321	18	43	2.36	42.42	108.38
01/01	1.5968	19	44	2.32	44.01	109.97
02/01	1.874	1	45	1.87	1.87	111.85
03/01	4.5035	2	46	3.19	6.38	116.35
04/01	2.3187	3	47	2.90	8.70	118.67
05/01	2.2933	4	48	2.75	10.99	120.96
06/01	2.7893	5	49	2.76	13.78	123.75

07/01	3.652	6	50	2.91	17.43	127.40
08/01	4.626	7	51	3.15	22.06	132.03
09/01	5.0053	8	52	3.38	27.06	137.04
10/01	4.1353	9	53	3.47	31.20	141.17
11/01	0.8131	10	54	3.20	32.01	141.98
12/01	1.4594	1	55	1.46	1.46	143.44
13/01	3.714	2	56	2.59	5.17	147.16
14/01	4.079	3	57	3.08	9.25	151.24
15/01	2.9653	4	58	3.05	12.22	154.20
16/01	4.6517	5	59	3.37	16.87	158.85
17/01	2.8404	6	60	3.28	19.71	161.69
18/01	3.6581	7	61	3.34	23.37	165.35
19/01	1.9523	8	62	3.17	25.32	167.30
20/01	0.8385	9	63	2.91	26.16	168.14
21/01	2.1002	10	64	2.83	28.26	170.24
22/01	4.5688	11	65	2.98	32.83	174.81
23/01	5.6634	12	66	3.21	38.49	180.48
24/01	4.9846	13	67	3.34	43.48	185.46
25/01	6.9361	14	68	3.60	50.41	192.40
26/01	6.9778	15	69	3.83	57.39	199.37
27/01	7.2015	16	70	4.04	64.59	206.58
28/01	2.914	17	71	3.97	67.51	209.49
29/01	2.8929	18	72	3.91	70.40	212.38
30/01	3.7967	19	73	3.90	74.19	216.18
31/01	5.8873	20	74	4.00	80.08	222.07
01/02	1.5274	21	75	3.89	81.61	223.59
02/02	7.1792	22	76	4.04	88.79	230.77
03/02	2.5535	23	77	3.97	91.34	233.33
04/02	1.3366	24	78	3.86	92.68	234.66
05/02	4.3818	25	79	3.88	97.06	239.05
06/02	1.2688	26	80	3.78	98.33	240.31
07/02	1.2126	27	81	3.69	99.54	241.53
08/02	4.9454	28	82	3.73	104.49	246.47
09/02	6.2162	29	83	3.82	110.70	252.69
10/02	3.2167	30	84	3.80	113.92	255.90
11/02	8.662	31	85	3.95	122.58	264.57
12/02	6.3511	32	86	4.03	128.93	270.92
13/02	7.9067	33	87	4.15	136.84	278.82
14/02	2.2398	34	88	4.09	139.08	281.06
15/02	4.4972	35	89	4.10	143.58	285.56
16/02	9.316	36	90	4.25	152.89	294.88
17/02	8.0829	37	91	4.35	160.98	302.96
18/02	6.1076	38	92	4.40	167.08	309.07
19/02	7.2964	39	93	4.47	174.38	316.36
20/02	10.227	40	94	4.62	184.61	326.59
21/02	9.7365	1	95	9.74	9.74	336.33
22/02	8.4449	2	96	9.09	18.18	344.77
23/02	3.499	3	97	7.23	21.68	348.27
24/02	4.6816	4	98	6.59	26.36	352.95
25/02	12.358	5	99	7.74	38.72	365.31
26/02	8.5204	6	100	7.87	47.24	373.83
27/02	7.0745	7	101	7.76	54.31	380.91
28/02	1.083	8	102	6.92	55.40	381.99
29/02	4.4787	9	103	6.65	59.88	386.47
01/03	11.241	10	104	7.11	71.12	397.71

Note replicate plots 1 and 2 reached harvest 2 days apart

B15(a)		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.059	1.059	1.059
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	1	25	4.67	4.67	70.63
15/12	4.6512	2	26	4.66	9.32	75.28
16/12	3.9138	3	27	4.41	13.23	79.19
17/12	0.7635	4	28	3.50	14.00	79.96
18/12	1.0888	5	29	3.02	15.09	81.05
19/12	4.7167	6	30	3.30	19.80	85.76
20/12	4.2599	7	31	3.44	24.06	90.02
21/12	0.2413	8	32	3.04	24.30	90.26
22/12	0.4042	9	33	2.75	24.71	90.67
23/12	3.298	10	34	2.80	28.01	93.97
24/12	0.643	11	35	2.60	28.65	94.61
25/12	2.1734	12	36	2.57	30.82	96.78
26/12	1.5064	13	37	2.49	32.33	98.29
27/12	0.9384	14	38	2.38	33.27	99.23
28/12	3.9804	15	39	2.48	37.25	103.21
29/12	4.1952	16	40	2.59	41.44	107.40
30/12	0.5432	17	41	2.47	41.99	107.95
31/12	0.4321	18	42	2.36	42.42	108.38
01/01	1.5968	19	43	2.32	44.01	109.97
02/01	1.874	1	44	1.87	1.87	111.85
03/01	4.5035	2	45	3.19	6.38	116.35
04/01	2.3187	3	46	2.90	8.70	118.67
05/01	2.2933	4	47	2.75	10.99	120.96
06/01	2.7893	5	48	2.76	13.78	123.75

07/01	3.652	6	49	2.91	17.43	127.40
08/01	4.626	7	50	3.15	22.06	132.03
09/01	5.0053	8	51	3.38	27.06	137.04
10/01	4.1353	9	52	3.47	31.20	141.17
11/01	0.8131	10	53	3.20	32.01	141.98
12/01	1.4594	1	54	1.4594	1.4594	143.44
13/01	3.714	2	55	2.59	5.17	147.16
14/01	4.079	3	56	3.08	9.25	151.24
15/01	2.9653	4	57	3.05	12.22	154.20
16/01	4.6517	5	58	3.37	16.87	158.85
17/01	2.8404	6	59	3.28	19.71	161.69
18/01	3.6581	7	60	3.34	23.37	165.35
19/01	1.9523	8	61	3.17	25.32	167.30
20/01	0.8385	9	62	2.91	26.16	168.14
21/01	2.1002	10	63	2.83	28.26	170.24
22/01	4.5688	11	64	2.98	32.83	174.81
23/01	5.6634	12	65	3.21	38.49	180.48
24/01	4.9846	13	66	3.34	43.48	185.46
25/01	6.9361	14	67	3.60	50.41	192.40
26/01	6.9778	15	68	3.83	57.39	199.37
27/01	7.2015	16	69	4.04	64.59	206.58
28/01	2.914	17	70	3.97	67.51	209.49
29/01	2.8929	18	71	3.91	70.40	212.38
30/01	3.7967	19	72	3.90	74.19	216.18
31/01	5.8873	20	73	4.00	80.08	222.07
01/02	1.5274	21	74	3.89	81.61	223.59
02/02	7.1792	22	75	4.04	88.79	230.77
03/02	2.5535	23	76	3.97	91.34	233.33
04/02	1.3366	24	77	3.86	92.68	234.66
05/02	4.3818	25	78	3.88	97.06	239.05
06/02	1.2688	26	79	3.78	98.33	240.31
07/02	1.2126	27	80	3.69	99.54	241.53
08/02	4.9454	28	81	3.73	104.49	246.47
09/02	6.2162	29	82	3.82	110.70	252.69
10/02	3.2167	30	83	3.80	113.92	255.90
11/02	8.662	31	84	3.95	122.58	264.57
12/02	6.3511	32	85	4.03	128.93	270.92
13/02	7.9067	33	86	4.15	136.84	278.82
14/02	2.2398	34	87	4.09	139.08	281.06
15/02	4.4972	35	88	4.10	143.58	285.56
16/02	9.316	36	89	4.25	152.89	294.88
17/02	8.0829	37	90	4.35	160.98	302.96
18/02	6.1076	38	91	4.40	167.08	309.07
19/02	7.2964	39	92	4.47	174.38	316.36
20/02	10.227	40	93	4.62	184.61	326.59
21/02	9.7365	41	94	4.74	194.34	336.33
22/02	8.4449	42	95	4.83	202.79	344.77
23/02	3.499	1	96	3.499	3.499	348.27
24/02	4.6816	2	97	4.09	8.18	352.95
25/02	12.358	3	98	6.85	20.54	365.31
26/02	8.5204	4	99	7.26	29.06	373.83
27/02	7.0745	5	100	7.23	36.13	380.91
28/02	1.083	6	101	6.20	37.22	381.99
29/02	4.4787	7	102	5.96	41.70	386.47
01/03	11.241	8	103	6.62	52.94	397.71
02/03	3.9518	9	104	6.32	56.89	401.66
03/03	7.493	10	105	6.44	64.38	405.61

B15(b)		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.059	1.059	1.059
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.69396	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	25	25	2.83	70.63	70.63
15/12	4.6512	1	26	4.65	4.65	75.28
16/12	3.9138	2	27	4.28	8.57	79.19
17/12	0.76346	3	28	3.11	9.33	79.96
18/12	1.0888	4	29	2.60	10.42	81.05
19/12	4.7167	5	30	3.03	15.13	85.76
20/12	4.2599	6	31	3.23	19.39	90.02
21/12	0.24126	7	32	2.81	19.64	90.26
22/12	0.40421	8	33	2.50	20.04	90.67
23/12	3.298	9	34	2.59	23.34	93.97
24/12	0.643	10	35	2.40	23.98	94.61
25/12	2.1734	11	36	2.38	26.15	96.78
26/12	1.5064	12	37	2.31	27.66	98.29
27/12	0.93836	13	38	2.20	28.60	99.23
28/12	3.9804	14	39	2.33	32.58	103.21
29/12	4.1952	15	40	2.45	36.77	107.40
30/12	0.54317	16	41	2.33	37.32	107.95
31/12	0.4321	17	42	2.22	37.75	108.38
01/01	1.5968	18	43	2.19	39.35	109.97
02/01	1.874	19	44	2.17	41.22	111.85
03/01	4.5035	20	45	2.29	45.72	116.35
04/01	2.3187	1	46	2.32	2.32	118.67
05/01	2.2933	2	47	2.31	4.61	120.96
06/01	2.7893	3	48	2.47	7.40	123.75

07/01	3.652	4	49	2.76	11.05	127.40
08/01	4.626	5	50	3.14	15.68	132.03
09/01	5.0053	6	51	3.45	20.68	137.04
10/01	4.1353	7	52	3.55	24.82	141.17
11/01	0.8131	8	53	3.20	25.63	141.98
12/01	1.4594	9	54	3.01	27.09	143.44
13/01	3.714	10	55	3.08	30.81	147.16
14/01	4.079	1	56	4.079	4.079	151.24
15/01	2.9653	2	57	3.52	7.04	154.20
16/01	4.6517	3	58	3.90	11.70	158.85
17/01	2.8404	4	59	3.63	14.54	161.69
18/01	3.6581	5	60	3.64	18.19	165.35
19/01	1.9523	6	61	3.36	20.15	167.30
20/01	0.83853	7	62	3.00	20.99	168.14
21/01	2.1002	8	63	2.89	23.09	170.24
22/01	4.5688	9	64	3.07	27.65	174.81
23/01	5.66336	10	65	3.33	33.32	180.48
24/01	4.9846	11	66	3.48	38.30	185.46
25/01	6.9361	12	67	3.77	45.24	192.40
26/01	6.9778	13	68	4.02	52.22	199.37
27/01	7.2015	14	69	4.24	59.42	206.58
28/01	2.914	15	70	4.16	62.33	209.49
29/01	2.8929	16	71	4.08	65.22	212.38
30/01	3.7967	17	72	4.06	69.02	216.18
31/01	5.8873	18	73	4.16	74.91	222.07
01/02	1.5274	19	74	4.02	76.44	223.59
02/02	7.1792	20	75	4.18	83.62	230.77
03/02	2.5535	21	76	4.10	86.17	233.33
04/02	1.3366	22	77	3.98	87.51	234.66
05/02	4.3818	23	78	4.00	91.89	239.05
06/02	1.2688	24	79	3.88	93.16	240.31
07/02	1.2126	25	80	3.77	94.37	241.53
08/02	4.9454	26	81	3.82	99.31	246.47
09/02	6.2162	27	82	3.91	105.53	252.69
10/02	3.2167	28	83	3.88	108.75	255.90
11/02	8.662	29	84	4.05	117.41	264.57
12/02	6.3511	30	85	4.13	123.76	270.92
13/02	7.9067	31	86	4.25	131.67	278.82
14/02	2.2398	32	87	4.18	133.91	281.06
15/02	4.4972	33	88	4.19	138.40	285.56
16/02	9.316	34	89	4.34	147.72	294.88
17/02	8.0829	35	90	4.45	155.80	302.96
18/02	6.1076	36	91	4.50	161.91	309.07
19/02	7.2964	37	92	4.57	169.21	316.36
20/02	10.227	38	93	4.72	179.43	326.59
21/02	9.7365	39	94	4.85	189.17	336.33
22/02	8.4449	40	95	4.94	197.61	344.77
23/02	3.499	41	96	4.91	201.11	348.27
24/02	4.6816	42	97	4.90	205.80	352.95
25/02	12.358	1	98	12.358	12.358	365.31
26/02	8.5204	2	99	10.44	20.88	373.83
27/02	7.0745	3	100	9.32	27.95	380.91
28/02	1.083	4	101	7.26	29.04	381.99
29/02	4.4787	5	102	6.70	33.51	386.47
01/03	11.241	6	103	7.46	44.76	397.71
02/03	3.9518	7	104	6.96	48.71	401.66
03/03	7.493	8	105	7.03	56.20	409.15

D15

		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.06	1.06	1.06
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	1	1	4.21	4.21	4.21
21/11	4.0229	2	2	4.11	8.23	8.23
22/11	1.8278	3	3	3.35	10.06	10.06
23/11	2.5243	4	4	3.15	12.58	12.58
24/11	3.2234	5	5	3.16	15.80	15.80
25/11	2.7167	6	6	3.09	18.52	18.52
26/11	1.8613	7	7	2.91	20.38	20.38
27/11	4.9419	8	8	3.17	25.32	25.32
28/11	2.8654	9	9	3.13	28.19	28.19
29/11	0.4899	10	10	2.87	28.68	28.68
30/11	2.5631	11	11	2.84	31.24	31.24
01/12	3.2709	12	12	2.88	34.51	34.51
02/12	4.3651	13	13	2.99	38.88	38.88
03/12	1.3316	14	14	2.87	40.21	40.21
04/12	4.6846	15	15	2.99	44.90	44.90
05/12	4.2534	16	16	3.07	49.15	49.15
06/12	1.615	17	17	2.99	50.76	50.76
07/12	2.953	18	18	2.98	53.72	53.72
08/12	0.815	19	19	2.87	54.53	54.53
09/12	3.624	20	20	2.91	58.16	58.16
10/12	3.2933	21	21	2.93	61.45	61.45
11/12	0.694	22	22	2.82	62.14	62.14
12/12	2.473	23	23	2.81	64.62	64.62
13/12	1.344	24	24	2.75	65.96	65.96
14/12	4.668	1	25	4.67	4.67	70.63
15/12	4.6512	2	26	4.66	9.32	75.28
16/12	3.9138	3	27	4.41	13.23	79.19
17/12	0.7635	4	28	3.50	14.00	79.96
18/12	1.0888	5	29	3.02	15.09	81.05
19/12	4.7167	6	30	3.30	19.80	85.76
20/12	4.2599	7	31	3.44	24.06	90.02
21/12	0.2413	8	32	3.04	24.30	90.26
22/12	0.4042	9	33	2.75	24.71	90.67
23/12	3.298	10	34	2.80	28.01	93.97
24/12	0.643	11	35	2.60	28.65	94.61
25/12	2.1734	12	36	2.57	30.82	96.78
26/12	1.5064	13	37	2.49	32.33	98.29
27/12	0.9384	14	38	2.38	33.27	99.23
28/12	3.9804	15	39	2.48	37.25	103.21
29/12	4.1952	16	40	2.59	41.44	107.40
30/12	0.5432	17	41	2.47	41.99	107.95
31/12	0.4321	18	42	2.36	42.42	108.38
01/01	1.5968	19	43	2.32	44.01	109.97
02/01	1.874	1	44	1.87	1.87	111.85
03/01	4.5035	2	45	3.19	6.38	116.35
04/01	2.3187	3	46	2.90	8.70	118.67
05/01	2.2933	4	47	2.75	10.99	120.96
06/01	2.7893	5	48	2.76	13.78	123.75

07/01	3.652	6	49	2.91	17.43	127.40
08/01	4.626	7	50	3.15	22.06	132.03
09/01	5.0053	8	51	3.38	27.06	137.04
10/01	4.1353	9	52	3.47	31.20	141.17
11/01	0.8131	10	53	3.20	32.01	141.98
12/01	1.4594	1	54	1.46	1.46	143.44
13/01	3.714	2	55	2.59	5.17	147.16
14/01	4.079	3	56	3.08	9.25	151.24
15/01	2.9653	4	57	3.05	12.22	154.20
16/01	4.6517	5	58	3.37	16.87	158.85
17/01	2.8404	6	59	3.28	19.71	161.69
18/01	3.6581	7	60	3.34	23.37	165.35
19/01	1.9523	8	61	3.17	25.32	167.30
20/01	0.8385	9	62	2.91	26.16	168.14
21/01	2.1002	10	63	2.83	28.26	170.24
22/01	4.5688	11	64	2.98	32.83	174.81
23/01	5.6634	12	65	3.21	38.49	180.48
24/01	4.9846	13	66	3.34	43.48	185.46
25/01	6.9361	14	67	3.60	50.41	192.40
26/01	6.9778	15	68	3.83	57.39	199.37
27/01	7.2015	16	69	4.04	64.59	206.58
28/01	2.914	17	70	3.97	67.51	209.49
29/01	2.8929	18	71	3.91	70.40	212.38
30/01	3.7967	19	72	3.90	74.19	216.18
31/01	5.8873	20	73	4.00	80.08	222.07
01/02	1.5274	21	74	3.89	81.61	223.59
02/02	7.1792	22	75	4.04	88.79	230.77
03/02	2.5535	23	76	3.97	91.34	233.33
04/02	1.3366	24	77	3.86	92.68	234.66
05/02	4.3818	25	78	3.88	97.06	239.05
06/02	1.2688	26	79	3.78	98.33	240.31
07/02	1.2126	27	80	3.69	99.54	241.53
08/02	4.9454	28	81	3.73	104.49	246.47
09/02	6.2162	29	82	3.82	110.70	252.69
10/02	3.2167	30	83	3.80	113.92	255.90
11/02	8.662	31	84	3.95	122.58	264.57
12/02	6.3511	32	85	4.03	128.93	270.92
13/02	7.9067	33	86	4.15	136.84	278.82
14/02	2.2398	34	87	4.09	139.08	281.06
15/02	4.4972	35	88	4.10	143.58	285.56
16/02	9.316	36	89	4.25	152.89	294.88
17/02	8.0829	37	90	4.35	160.98	302.96
18/02	6.1076	38	91	4.40	167.08	309.07
19/02	7.2964	39	92	4.47	174.38	316.36
20/02	10.227	40	93	4.62	184.61	326.59
21/02	9.7365	1	94	9.74	9.74	336.33
22/02	8.4449	2	95	9.09	18.18	344.77
23/02	3.499	3	96	7.23	21.68	348.27
24/02	4.6816	4	97	6.59	26.36	352.95
25/02	12.358	5	98	7.74	38.72	365.31
26/02	8.5204	6	99	7.87	47.24	373.83
27/02	7.0745	7	100	7.76	54.31	380.91
28/02	1.083	8	101	6.92	55.40	381.99
29/02	4.4787	9	102	6.65	59.88	386.47
01/03	11.241	10	103	7.11	71.12	397.71

Note replicate plots 1 and 2 reached harvest 2 days apart

A20		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.06	1.06	1.06
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	10		5.13	51.30	51.30
21/11	4.0229	11		5.03	55.32	55.32
22/11	1.8278	12		4.76	57.15	57.15
23/11	2.5243	13		4.59	59.68	59.68
24/11	3.2234	14		4.49	62.90	62.90
25/11	2.7167	1	1	2.72	2.72	2.7167
26/11	1.8613	2	2	2.29	4.58	4.58
27/11	4.9419	3	3	3.17	9.52	9.52
28/11	2.8654	4	4	3.10	12.39	12.39
29/11	0.4899	5	5	2.58	12.88	12.88
30/11	2.5631	6	6	2.57	15.44	15.44
01/12	3.2709	7	7	2.67	18.71	18.71
02/12	4.3651	8	8	2.88	23.07	23.07
03/12	1.3316	9	9	2.71	24.41	24.41
04/12	4.6846	10	10	2.91	29.09	29.09
05/12	4.2534	11	11	3.03	33.34	33.34
06/12	1.615	12	12	2.91	34.96	34.96
07/12	2.953	13	13	2.92	37.91	37.91
08/12	0.815	14	14	2.77	38.73	38.73
09/12	3.624	15	15	2.82	42.35	42.35
10/12	3.2933	16	16	2.85	45.64	45.64
11/12	0.694	17	17	2.73	46.34	46.34
12/12	2.473	18	18	2.71	48.81	48.81
13/12	1.344	19	19	2.64	50.16	50.16
14/12	4.668	20	20	2.74	54.82	54.82
15/12	4.6512	1	21	4.65	4.65	59.47
16/12	3.9138	2	22	4.28	8.57	63.39
17/12	0.7635	3	23	3.11	9.33	64.15
18/12	1.0888	4	24	2.60	10.42	65.24
19/12	4.7167	5	25	3.03	15.13	69.96
20/12	4.2599	6	26	3.23	19.39	74.22
21/12	0.2413	7	27	2.81	19.64	74.46
22/12	0.4042	8	28	2.50	20.04	74.86
23/12	3.298	9	29	2.59	23.34	78.16
24/12	0.643	10	30	2.40	23.98	78.80
25/12	2.1734	11	31	2.38	26.15	80.98
26/12	1.5064	12	32	2.31	27.66	82.48
27/12	0.9384	13	33	2.20	28.60	83.42
28/12	3.9804	14	34	2.33	32.58	87.40
29/12	4.1952	15	35	2.45	36.77	91.60
30/12	0.5432	16	36	2.33	37.32	92.14
31/12	0.4321	17	37	2.22	37.75	92.57
01/01	1.5968	18	38	2.19	39.35	94.17
02/01	1.874	19	39	2.17	41.22	96.04
03/01	4.5035	20	40	2.29	45.72	100.55
04/01	2.3187	1	41	2.32	2.32	102.87
05/01	2.2933	2	42	2.31	4.61	105.16
06/01	2.7893	3	43	2.47	7.40	107.95

07/01	3.652	4	44	2.76	11.05	111.60
08/01	4.626	5	45	3.14	15.68	116.23
09/01	5.0053	6	46	3.45	20.68	121.23
10/01	4.1353	7	47	3.55	24.82	125.37
11/01	0.8131	8	48	3.20	25.63	126.18
12/01	1.4594	9	49	3.01	27.09	127.64
13/01	3.714	10	50	3.08	30.81	131.35
14/01	4.079	1	51	4.08	4.08	135.43
15/01	2.9653	2	52	3.52	7.04	138.40
16/01	4.6517	3	53	3.90	11.70	143.05
17/01	2.8404	4	54	3.63	14.54	145.89
18/01	3.6581	5	55	3.64	18.19	149.55
19/01	1.9523	6	56	3.36	20.15	151.50
20/01	0.8385	7	57	3.00	20.99	152.34
21/01	2.1002	8	58	2.89	23.09	154.44
22/01	4.5688	9	59	3.07	27.65	159.01
23/01	5.6634	10	60	3.33	33.32	164.67
24/01	4.9846	11	61	3.48	38.30	169.66
25/01	6.9361	12	62	3.77	45.24	176.59
26/01	6.9778	13	63	4.02	52.22	183.57
27/01	7.2015	14	64	4.24	59.42	190.77
28/01	2.914	15	65	4.16	62.33	193.68
29/01	2.8929	16	66	4.08	65.22	196.58
30/01	3.7967	17	67	4.06	69.02	200.37
31/01	5.8873	18	68	4.16	74.91	206.26
01/02	1.5274	19	69	4.02	76.44	207.79
02/02	7.1792	20	70	4.18	83.62	214.97
03/02	2.5535	21	71	4.10	86.17	217.52
04/02	1.3366	22	72	3.98	87.51	218.86
05/02	4.3818	23	73	4.00	91.89	223.24
06/02	1.2688	24	74	3.88	93.16	224.51
07/02	1.2126	25	75	3.77	94.37	225.72
08/02	4.9454	26	76	3.82	99.31	230.67
09/02	6.2162	27	77	3.91	105.53	236.88
10/02	3.2167	28	78	3.88	108.75	240.10
11/02	8.662	29	79	4.05	117.41	248.76
12/02	6.3511	30	80	4.13	123.76	255.11
13/02	7.9067	31	81	4.25	131.67	263.02
14/02	2.2398	32	82	4.18	133.91	265.26
15/02	4.4972	33	83	4.19	138.40	269.76
16/02	9.316	34	84	4.34	147.72	279.07
17/02	8.0829	35	85	4.45	155.80	287.16
18/02	6.1076	36	86	4.50	161.91	293.26
19/02	7.2964	37	87	4.57	169.21	300.56
20/02	10.227	38	88	4.72	179.43	310.79
21/02	9.7365	39	89	4.85	189.17	320.52
22/02	8.4449	40	90	4.94	197.61	328.97
23/02	3.499	41	91	4.91	201.11	332.47
24/02	4.6816	42	92	4.90	205.80	337.15
25/02	12.358	1	93	12.36	12.36	349.51
26/02	8.5204	2	94	10.44	20.88	358.03
27/02	7.0745	3	95	9.32	27.95	365.10
28/02	1.083	4	96	7.26	29.04	366.18
29/02	4.4787	5	97	6.70	33.51	370.66
01/03	11.241	6	98	7.46	44.76	381.90
02/03	3.9518	7	99	6.96	48.71	385.86
03/03	7.4931	8	100	7.03	56.20	393.35
04/03	12.606	9	101	7.65	68.81	405.96
05/03	12.419	10	102	8.12	81.23	418.37
06/03	2.2102	11	103	7.59	83.44	420.58

B20		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.06	1.06	1.06
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	10		5.13	51.30	51.30
21/11	4.0229	11		5.03	55.32	55.32
22/11	1.8278	12		4.76	57.15	57.15
23/11	2.5243	13		4.59	59.68	59.68
24/11	3.2234	14		4.49	62.90	62.90
25/11	2.7167	1	1	2.72	2.72	2.7167
26/11	1.8613	2	2	2.29	4.58	4.58
27/11	4.9419	3	3	3.17	9.52	9.52
28/11	2.8654	4	4	3.10	12.39	12.39
29/11	0.4899	5	5	2.58	12.88	12.88
30/11	2.5631	6	6	2.57	15.44	15.44
01/12	3.2709	7	7	2.67	18.71	18.71
02/12	4.3651	8	8	2.88	23.07	23.07
03/12	1.3316	9	9	2.71	24.41	24.41
04/12	4.6846	10	10	2.91	29.09	29.09
05/12	4.2534	11	11	3.03	33.34	33.34
06/12	1.615	12	12	2.91	34.96	34.96
07/12	2.953	13	13	2.92	37.91	37.91
08/12	0.815	14	14	2.77	38.73	38.73
09/12	3.624	15	15	2.82	42.35	42.35
10/12	3.2933	16	16	2.85	45.64	45.64
11/12	0.694	17	17	2.73	46.34	46.34
12/12	2.473	18	18	2.71	48.81	48.81
13/12	1.344	19	19	2.64	50.16	50.16
14/12	4.668	20	20	2.74	54.82	54.82
15/12	4.6512	1	21	4.65	4.65	59.47
16/12	3.9138	2	22	4.28	8.57	63.39
17/12	0.7635	3	23	3.11	9.33	64.15
18/12	1.0888	4	24	2.60	10.42	65.24
19/12	4.7167	5	25	3.03	15.13	69.96
20/12	4.2599	6	26	3.23	19.39	74.22
21/12	0.2413	7	27	2.81	19.64	74.46
22/12	0.4042	8	28	2.50	20.04	74.86
23/12	3.298	9	29	2.59	23.34	78.16
24/12	0.643	10	30	2.40	23.98	78.80
25/12	2.1734	11	31	2.38	26.15	80.98
26/12	1.5064	12	32	2.31	27.66	82.48
27/12	0.9384	13	33	2.20	28.60	83.42
28/12	3.9804	14	34	2.33	32.58	87.40
29/12	4.1952	15	35	2.45	36.77	91.60
30/12	0.5432	16	36	2.33	37.32	92.14
31/12	0.4321	17	37	2.22	37.75	92.57
01/01	1.5968	18	38	2.19	39.35	94.17
02/01	1.874	19	39	2.17	41.22	96.04
03/01	4.5035	20	40	2.29	45.72	100.55
04/01	2.3187	1	41	2.32	2.32	102.87
05/01	2.2933	2	42	2.31	4.61	105.16
06/01	2.7893	3	43	2.47	7.40	107.95

07/01	3.652	4	44	2.76	11.05	111.60
08/01	4.626	5	45	3.14	15.68	116.23
09/01	5.0053	6	46	3.45	20.68	121.23
10/01	4.1353	7	47	3.55	24.82	125.37
11/01	0.8131	8	48	3.20	25.63	126.18
12/01	1.4594	9	49	3.01	27.09	127.64
13/01	3.714	10	50	3.08	30.81	131.35
14/01	4.079	1	51	4.08	4.08	135.43
15/01	2.9653	2	52	3.52	7.04	138.40
16/01	4.6517	3	53	3.90	11.70	143.05
17/01	2.8404	4	54	3.63	14.54	145.89
18/01	3.6581	5	55	3.64	18.19	149.55
19/01	1.9523	6	56	3.36	20.15	151.50
20/01	0.8385	7	57	3.00	20.99	152.34
21/01	2.1002	8	58	2.89	23.09	154.44
22/01	4.5688	9	59	3.07	27.65	159.01
23/01	5.6634	10	60	3.33	33.32	164.67
24/01	4.9846	11	61	3.48	38.30	169.66
25/01	6.9361	12	62	3.77	45.24	176.59
26/01	6.9778	13	63	4.02	52.22	183.57
27/01	7.2015	14	64	4.24	59.42	190.77
28/01	2.914	15	65	4.16	62.33	193.68
29/01	2.8929	16	66	4.08	65.22	196.58
30/01	3.7967	17	67	4.06	69.02	200.37
31/01	5.8873	18	68	4.16	74.91	206.26
01/02	1.5274	19	69	4.02	76.44	207.79
02/02	7.1792	20	70	4.18	83.62	214.97
03/02	2.5535	21	71	4.10	86.17	217.52
04/02	1.3366	22	72	3.98	87.51	218.86
05/02	4.3818	23	73	4.00	91.89	223.24
06/02	1.2688	24	74	3.88	93.16	224.51
07/02	1.2126	25	75	3.77	94.37	225.72
08/02	4.9454	26	76	3.82	99.31	230.67
09/02	6.2162	27	77	3.91	105.53	236.88
10/02	3.2167	28	78	3.88	108.75	240.10
11/02	8.662	29	79	4.05	117.41	248.76
12/02	6.3511	30	80	4.13	123.76	255.11
13/02	7.9067	31	81	4.25	131.67	263.02
14/02	2.2398	32	82	4.18	133.91	265.26
15/02	4.4972	33	83	4.19	138.40	269.76
16/02	9.316	34	84	4.34	147.72	279.07
17/02	8.0829	35	85	4.45	155.80	287.16
18/02	6.1076	36	86	4.50	161.91	293.26
19/02	7.2964	37	87	4.57	169.21	300.56
20/02	10.227	38	88	4.72	179.43	310.79
21/02	9.7365	39	89	4.85	189.17	320.52
22/02	8.4449	40	90	4.94	197.61	328.97
23/02	3.499	41	91	4.91	201.11	332.47
24/02	4.6816	42	92	4.90	205.80	337.15
25/02	12.358	1	93	12.36	12.36	349.51
26/02	8.5204	2	94	10.44	20.88	358.03
27/02	7.0745	3	95	9.32	27.95	365.10
28/02	1.083	4	96	7.26	29.04	366.18
29/02	4.4787	5	97	6.70	33.51	370.66
01/03	11.241	6	98	7.46	44.76	381.90
02/03	3.9518	7	99	6.96	48.71	385.86
03/03	7.4931	8	100	7.03	56.20	393.35
04/03	12.606	9	101	7.65	68.81	405.96
05/03	12.419	10	102	8.12	81.23	418.37
06/03	2.2102	11	103	7.59	83.44	420.58

D20		Day no by phase	Crop days from planting	Daily light integral by phase	Cumulative light receipt by phase	Cumulative light receipt of crop
04/11	5.6752	0				
05/11	1.059	1		1.06	1.06	1.06
06/11	7.8806	2		4.47	8.94	8.94
07/11	3.1268	3		4.02	12.07	12.07
08/11	2.7453	4		3.70	14.81	14.81
09/11	6.7913	5		4.32	21.60	21.60
10/11	3.1448	6		4.12	24.75	24.75
11/11	4.8303	1		4.83	4.83	4.83
12/11	5.6285	2		5.23	10.46	10.46
13/11	6.7093	3		5.72	17.17	17.17
14/11	2.0898	4		4.81	19.26	19.26
15/11	5.3324	5		4.92	24.59	24.59
16/11	5.5739	6		5.03	30.16	30.16
17/11	6.1841	7		5.19	36.35	36.35
18/11	4.7229	8		5.13	41.07	41.07
19/11	6.0232	9		5.23	47.09	47.09
20/11	4.2064	10		5.13	51.30	51.30
21/11	4.0229	11		5.03	55.32	55.32
22/11	1.8278	12		4.76	57.15	57.15
23/11	2.5243	13		4.59	59.68	59.68
24/11	3.2234	14		4.49	62.90	62.90
25/11	2.7167	1	1	2.72	2.72	2.72
26/11	1.8613	2	2	2.29	4.58	4.58
27/11	4.9419	3	3	3.17	9.52	9.52
28/11	2.8654	4	4	3.10	12.39	12.39
29/11	0.4899	5	5	2.58	12.88	12.88
30/11	2.5631	6	6	2.57	15.44	15.44
01/12	3.2709	7	7	2.67	18.71	18.71
02/12	4.3651	8	8	2.88	23.07	23.07
03/12	1.3316	9	9	2.71	24.41	24.41
04/12	4.6846	10	10	2.91	29.09	29.09
05/12	4.2534	11	11	3.03	33.34	33.34
06/12	1.615	12	12	2.91	34.96	34.96
07/12	2.953	13	13	2.92	37.91	37.91
08/12	0.815	14	14	2.77	38.73	38.73
09/12	3.624	15	15	2.82	42.35	42.35
10/12	3.2933	16	16	2.85	45.64	45.64
11/12	0.694	17	17	2.73	46.34	46.34
12/12	2.473	18	18	2.71	48.81	48.81
13/12	1.344	19	19	2.64	50.16	50.16
14/12	4.668	20	20	2.74	54.82	54.82
15/12	4.6512	21	21	2.83	59.47	59.47
16/12	3.9138	22	22	2.88	63.39	63.39
17/12	0.7635	1	23	0.76	0.76	64.15
18/12	1.0888	2	24	0.93	1.85	65.24
19/12	4.7167	3	25	2.19	6.57	69.96
20/12	4.2599	4	26	2.71	10.83	74.22
21/12	0.2413	5	27	2.21	11.07	74.46
22/12	0.4042	6	28	1.91	11.47	74.86
23/12	3.298	7	29	2.11	14.77	78.16
24/12	0.643	8	30	1.93	15.42	78.80
25/12	2.1734	9	31	1.95	17.59	80.98
26/12	1.5064	10	32	1.91	19.10	82.48
27/12	0.9384	11	33	1.82	20.03	83.42
28/12	3.9804	12	34	2.00	24.01	87.40
29/12	4.1952	13	35	2.17	28.21	91.60
30/12	0.5432	14	36	2.05	28.75	92.14
31/12	0.4321	15	37	1.95	29.18	92.57
01/01	1.5968	16	38	1.92	30.78	94.17
02/01	1.874	17	39	1.92	32.66	96.04
03/01	4.5035	18	40	2.06	37.16	100.55
04/01	2.3187	19	41	2.08	39.48	102.87
05/01	2.2933	20	42	2.09	41.77	105.16
06/01	2.7893	1	43	2.79	2.79	107.95

07/01	3.652	2	44	3.22	6.44	111.60
08/01	4.626	3	45	3.69	11.07	116.23
09/01	5.0053	4	46	4.02	16.07	121.23
10/01	4.1353	5	47	4.04	20.21	125.37
11/01	0.8131	6	48	3.50	21.02	126.18
12/01	1.4594	7	49	3.21	22.48	127.64
13/01	3.714	8	50	3.27	26.19	131.35
14/01	4.079	9	51	3.36	30.27	135.43
15/01	2.9653	10	52	3.32	33.24	138.40
16/01	4.6517	1	53	4.65	4.65	143.05
17/01	2.8404	2	54	3.75	7.49	145.89
18/01	3.6581	3	55	3.72	11.15	149.55
19/01	1.9523	4	56	3.28	13.10	151.50
20/01	0.8385	5	57	2.79	13.94	152.34
21/01	2.1002	6	58	2.67	16.04	154.44
22/01	4.5688	7	59	2.94	20.61	159.01
23/01	5.6634	8	60	3.28	26.27	164.67
24/01	4.9846	9	61	3.47	31.26	169.66
25/01	6.9361	10	62	3.82	38.19	176.59
26/01	6.9778	11	63	4.11	45.17	183.57
27/01	7.2015	12	64	4.36	52.37	190.77
28/01	2.914	13	65	4.25	55.29	193.68
29/01	2.8929	14	66	4.16	58.18	196.58
30/01	3.7967	15	67	4.13	61.98	200.37
31/01	5.8873	16	68	4.24	67.86	206.26
01/02	1.5274	17	69	4.08	69.39	207.79
02/02	7.1792	18	70	4.25	76.57	214.97
03/02	2.5535	19	71	4.16	79.12	217.52
04/02	1.3366	20	72	4.02	80.46	218.86
05/02	4.3818	21	73	4.04	84.84	223.24
06/02	1.2688	22	74	3.91	86.11	224.51
07/02	1.2126	23	75	3.80	87.32	225.72
08/02	4.9454	24	76	3.84	92.27	230.67
09/02	6.2162	25	77	3.94	98.49	236.88
10/02	3.2167	26	78	3.91	101.70	240.10
11/02	8.662	27	79	4.09	110.36	248.76
12/02	6.3511	28	80	4.17	116.72	255.11
13/02	7.9067	29	81	4.30	124.62	263.02
14/02	2.2398	30	82	4.23	126.86	265.26
15/02	4.4972	31	83	4.24	131.36	269.76
16/02	9.316	32	84	4.40	140.68	279.07
17/02	8.0829	33	85	4.51	148.76	287.16
18/02	6.1076	34	86	4.55	154.87	293.26
19/02	7.2964	35	87	4.63	162.16	300.56
20/02	10.227	36	88	4.79	172.39	310.79
21/02	9.7365	37	89	4.92	182.13	320.52
22/02	8.4449	38	90	5.02	190.57	328.97
23/02	3.499	39	91	4.98	194.07	332.47
24/02	4.6816	40	92	4.97	198.75	337.15
25/02	12.358	41	93	5.15	211.11	349.51
26/02	8.5204	42	94	5.23	219.63	358.03
27/02	7.0745	43	95	5.27	226.70	365.10
28/02	1.083	1	96	1.08	1.08	366.18
29/02	4.4787	2	97	2.78	5.56	370.66
01/03	11.241	3	98	5.60	16.80	381.90
02/03	3.9518	4	99	5.19	20.75	385.86
03/03	7.4931	5	100	5.65	28.25	393.35
04/03	12.606	6	101	6.81	40.85	405.96
05/03	12.419	7	102	7.61	53.27	418.37
06/03	2.2102	8	103	6.94	55.48	420.58
07/03	1.019	9	104	6.28	56.50	421.60
08/03	8.291	10	105	6.48	64.79	429.89