Project title:	Labour use in tomato production – a commercial application of Task Separation to maximise output from seasonal staff.
Project number:	PC 217a
Project leader:	C T Pratt FEC Services Ltd, Stoneleigh Park, Kenilworth, CV8 2LS
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Date project commenced:	December 2005
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Keywords:	Tomato, labour, seasonal staff, task separation, crop work, work platform, training

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Headline

Task separation requires careful planning and consideration of change management but can result in labour savings through reduced time to train new staff and improved use of experienced staff without compromising the quality or speed of work.

Background and expected deliverables

Introduction

Labour costs typically account for over 30% of the cost of tomato production. Data from UK growers of classic round types shows labour costs typically fall in the range £9 to £12/m^2. Based on this information the total labour bill for the UK tomato sector is estimated to be over £25 million p.a.

The increased use of seasonal/temporary staff for crop work means that training has to be carried out on an annual basis. It can take up to 12 weeks for a new crop worker to achieve the same work-rate as experienced staff and in many cases this represents half of their time on the nursery. The cost of training and reduced work rates is therefore disproportionately high compared to a longer-term employee.

PC 217 identified that task separation could be a way of reducing the labour costs associated with seasonal staff and included small scale trials that were carried out on a UK nursery in 2005. This project extended the work of PC 217 and carried out a full-scale commercial trial to explore the potential for task separation in the UK.

Background to task separation

Current UK practice

The majority of crop workers on UK nurseries complete all the top of crop work (layering, training etc.) in one pass. This is referred to as all-in-one working. This approach is used because most growers think that time is saved by only having to visit the top of the plant once each week. Each crop worker is allocated a number of rows of plants in a single block on which they carry out all the crop work. The perceived benefits of this approach are:

- A minimum amount of time spent changing rows.
- A single person is responsible for all crop work carried out on a particular area within the glasshouse. This helps to ensure a sense of ownership and responsibility.

Task separation

At its extreme, task separation requires a worker to carry out one task at a time. The worker, possibly a different one, returns to the plant at another time to carry out the next task and so on until all the required tasks are completed. The claimed advantages of this approach are:

- Improved quality of work – staff can concentrate on one task at a time.
- Faster to learn – it is easier to learn a single task in isolation than when it is combined with several others.
- Improved work posture – work platforms can be set at the optimum height for the task.
- Higher work efficiencies for the specific task.
- More flexible staff organisation – experienced staff can focus on the higher skilled tasks whereas simpler tasks can be carried out by less experienced staff.

However, task separation is rarely applied on UK nurseries. The reasons for this include:

- It is thought that visiting a plant more than once to complete top of crop work is slower than all-in-one working.
- Concerns over work quality when more than one person carries out crop work on each row.
- Concerns over the need for increased staff supervision due to more complex work patterns and work quality problems.

Objectives

The objective of this project was to help tomato growers reduce the labour cost associated with crop work by demonstrating the principles of task separation on a commercial nursery.

This was achieved by:

- Applying task separation on a large scale on a commercial nursery in the UK.
- Developing and proving alternative work organisation & staff management methods to provide a more flexible and productive workforce.
- Assessing the financial implications of adopting task separation.

Results

Research method

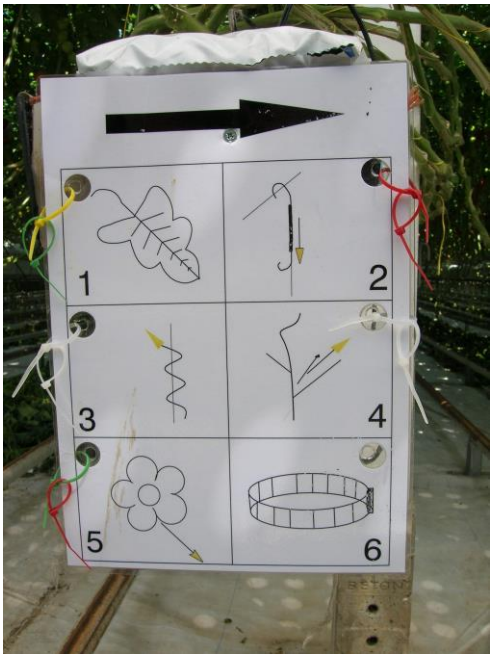
The project was carried out at G. de Lang & Sons, Mill Nurseries, East Yorkshire. The crop was the large vine variety *Classy* grown at a final density of 4.1 heads/m^2. The greenhouse was a modern Venlo design fitted with thermal screens and hanging gutters.

New workers, who had no prior tomato crop working experience, started work in Week 8. Additional new workers were brought into the trial at various stages through the year.

Supervisor aids

A major concern was the difficulty of tracking which worker had performed each task on each row of plants. To solve this graphics were developed that represented each task and a laminated copy was fixed to the end of every row. Each worker was allocated a specific colour code and was required to insert a coloured band next to the graphic of the task that they had carried out. Figure 1 below shows the graphics in situ.

Figure 1 – Row end graphics



The graphics describe the jobs as:

1. De-leafing.
2. Layering.
3. Twisting.
4. Side shooting.
5. Truss pruning.
6. Clipping.

Work organisation

In common with the majority of UK nurseries, G de Lang & Sons used weekly fixed area all-in-one working. On average experienced workers are allocated 15 rows per week (11,400 heads).

When using task separation, fixed area working can be problematic. This is because of the difficulty in synchronising the separate tasks. A more efficient approach is for workers to start at one end of the greenhouse and work

towards the far end. This ensures that work is carried out in the correct sequence and reduces non productive time spent moving from one area to another.

Next available row

At the beginning of the Week 8, all six workers started work on the first six rows of the greenhouse. As each one completed their allocated row they moved onto the next one available. All workers carried out a single task e.g. training. Once the whole block had been trained they returned to the first six rows in the block and removed side-shoots. Finally truss pruning was carried out.

Daily fixed area

A disadvantage of the next available row approach was that each worker did not necessarily return to side-shoot or truss-prune a row that they had previously trained. Therefore if one worker did a poor job that impacted on the ability to perform another task this led to conflict/dissatisfaction with other workers. Daily fixed area working was therefore introduced in Week 11. This approach required each worker to complete all the work on three rows each day. Blocks of rows were next to each other. This kept the workers close to each other which meant that supervision was easier and it maintained a 'flow through' approach.

Team working

Task separation allows skilled staff to focus on the more critical tasks. Analysis of the work-rates achieved produced the following 2-team approach:

Team 1 (3 workers)

- Train and side shoot combined as a single job.
- Truss prune as a separate task.

The target for this team was to complete 5 rows per crop worker per day,

Team 2 (2 workers)

- Layer and de-leaf carried out as separate tasks,

The target for this team was to complete 7.5 rows per crop worker per day.

Workers were allocated to each team depending on how well they performed each task. Daily fixed area working was used and Team 2 worked one day ahead of Team 1 to avoid clashes.

This approach meant that Team 1 spent all of the working day on a work platform exposed to higher temperatures whereas Team 2 were able to de-leaf in the shade during the afternoon. All the workers were paid the same rate and once warmer conditions prevailed the Team 1 workers felt they were not being adequately rewarded for carrying out more demanding work. Rather than introduce different pay scales, the team approach was modified so that all the

crop workers spent the same amount of time on a work platform. From Week 19 onwards the following work pattern was adopted:

Team 1

- Primary task - train and side shoot as a combined operation.
- The target was to complete 5 rows per crop worker per day.

Team 2

- Primary task – layer.
- The target was to complete 7.5 rows per crop worker per day.

Once the above tasks were completed both teams were then required to carry out truss pruning and finally de-leafing.

Task combinations & work-rates

The specific combination of tasks shown to be most effective during this trial was:

- Layering carried out as a single task.
- Training & side-shoot removal carried out as a combined job.
- Truss-pruning carried out as a single task.

It should be noted that the optimum level of task separation/most effective task combinations are dependent on the availability of skilled vs. unskilled labour, the growth habit of the crop and the greenhouse infrastructure. Therefore the approach detailed above will not necessarily deliver the best results on all nurseries.

Figure 2 shows the overall top of crop work rate achieved with task separation was consistently below that of all-in-one working. However, the work-rates achieved with task separation during the trial were not considered to have reached their maximum because:

- Regular changes to task combinations and work methods did not allow the workers to settle into a routine.
- The project team did not know what to expect and were therefore unable to set target work-rates.
- A piece work pay system was not used at the nursery.

Figure 2 - Top of crop work-rates

Analysis of the work-rate data at an individual worker level allowed the guideline work-rates in Table 1 below to be identified.

Table 1 - Target work rates

Job	**Work-rate Heads/hour**
Layering	2,500
Truss-pruning	2,000
Training & side-shoot removal	800
Implied overall top-of-crop	***465***

The implied overall work-rate of 465 heads/hr compares with an average top-of-crop work-rate for the all-in-one staff of 480 heads/hr. Although task separation is slower only a 3% improvement is required. This was considered to be easily achievable once a proven work method is developed.

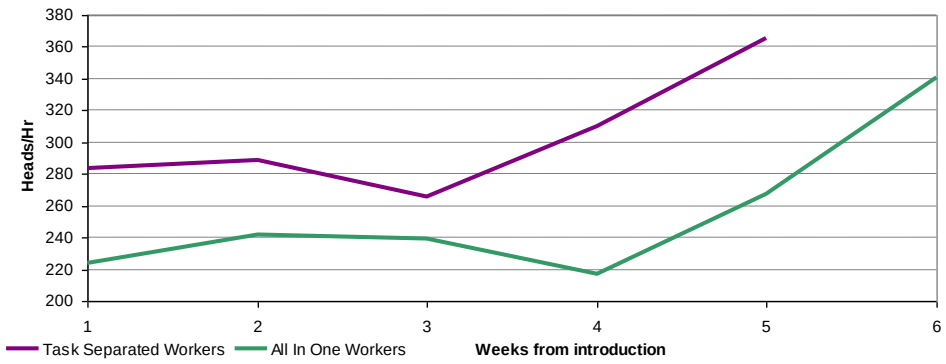
Speed of learning

Three new staff were brought into each greenhouse block once the task separation work methods had been proven.

- Layering was carried out as a single task.
- Training & side-shoot removal were carried out as a combined job.
- Truss-pruning was carried out as a single task.
- Daily fixed area working was applied.

Figure 3 below compares the combined top-of-crop work-rate during their first six weeks of crop work. It shows that a consistently higher work-rate was achieved with task separation.

Figure 3 - Mid season learning



Implementation

The introduction of new work methods in any industry can be fraught with difficulty. This is especially true when old work methods continue to be used in another area and the new method is unproven. This was clearly the case with this project.

There are many theories and strategies on change management in the workplace and it was beyond the scope of this project to explore them. However, there is no doubt that considerable planning is required before implementing changes such as these and that high levels of supervision are required whilst the alternative approach becomes proven and widely accepted.

Financial benefits for growers

Throughout the project the overall top of crop work-rates achieved with task separation were consistently lower than the all-in-one work-rates. There was no effect on crop yield or quality and therefore no crop related financial benefit or cost. Table 2 below shows the total hours per Ha required to complete the top-of-crop work from Weeks 8-35 inclusive.

Table 2 – Work hours & cost

	Task separation	**All-in-one**	**Difference**
Total hours	3,346	2,514	832
Cost at a pay rate of			
£6.00/hr	20,079	15,086	4,993
£7.00/hr	23,425	17,600	5,825
£8.00/hr	26,771	20,114	6,657

At face value task separation caused a significant increase in the top-of-crop labour cost. However, as discussed above it is believed that optimum work-rates were not achieved. In addition, within the structure of the trial it was not possible to quantify some of the benefits of task separation. Therefore task separation should not be immediately discounted.

One area that did show significant improvement was the speed of learning. Table 3 below shows the time required to complete the top-of-crop work on 1Ha during the first 5 weeks of work. The result was a saving of between £1,050 and £1,400/Ha depending on the rate of pay.

Table 3 – Financial benefit of faster learning

	Task separation	All-in-one	Difference
Total hours	668	843	175
Cost at a pay rate of			
£6.00/hr	4,007	5,057	1,050
£7.00/hr	4,675	5,900	1,225
£8.00/hr	5,343	6,743	1,400

Conclusions

Task separation can be successfully applied on UK nurseries whilst delivering work-rates comparable to traditional work methods. Many of the potential benefits have been proven at a practical level. However it has not been possible to quantify all of them due to insufficient time within the cropping year.

- With appropriate systems in place task separation does not cause a reduction in the quality of work or increase the need for worker supervision.
- During the trial task separation caused an overall reduction in work-rate. However, regular changes to work methods did not allow the workers to develop a consistent work routine and therefore reach their maximum output.
- Task separation combined with daily fixed area working reduces the time required to train new staff.
- The optimum degree of task separation is determined by the availability of skilled staff vs. new staff, the variety grown and the greenhouse infrastructure. It is therefore unique to each nursery.
- Daily fixed area working allows the benefits of task separation to be realised whilst ensuring accountability for quality of work.
- Task separation allows experienced crop workers to cover a much greater area and therefore utilise their skills much more effectively. In the trial, an experienced crop worker was able to cover 66% more crop.
- The successful implementation of task separation or any significant change to work methods requires considerable management effort and planning.

Action points for growers

Growers should:

- Introduce the principles of task separation to cover staff holidays, sickness and short-term peaks in workload to gain confidence in the technique.
- Allocate a single area for training new crop workers and train them using task separation with daily fixed area working before moving them to a permanent location.
- Identify a team of experienced crop workers open to new ideas to form the core of a task separation trial/demonstration on their own nursery.

Recommendations for further work

Whilst this trial showed that task separation can be successfully applied on a UK nursery a number of areas were not fully investigated. Therefore the full potential of task separation has yet to be realised because:

- Regular changes to the work methods throughout the trial did not allow the workers to reach their maximum work-rate.
- A number of task combinations which have the potential to improve overall work-rates were not explored.
- The benefits of applying task separation to experienced crop workers at the start of the season with the gradual introduction of seasonal staff to perform the simpler tasks were not explored.

It is therefore recommended that further work is carried out to build on the knowledge gained during PC 217a.

Science Section

Introduction & background

Introduction

Labour costs typically account for over 30% of the unit cost of tomato production. Data from UK growers of classic round types shows labour costs typically fall in the range £9 to £12/m^2. It should also be noted that speciality varieties often have unit costs of labour that are significantly higher than those for classic rounds. Based on this information the total labour bill for the UK tomato sector is estimated to be over £25 million p.a.

The availability of labour can also be problematic. Many growers aim to retain key staff on a permanent basis. However, the retention and recruitment of skilled staff can be difficult. This has led to the increased use of seasonal/temporary staff for crop work that, in the past, have been mainly used for harvesting.

As many of these temporary staff are recruited for one season only, staff training has to be carried out on an annual basis. Although there is significant variation it can take as long as 12 weeks for a new crop worker to reach the same work rates as experienced staff. In many cases this represents half of their time on the nursery. The cost of training and reduced work rates is therefore disproportionately high compared to a longer-term employee.

PC 217 identified that task separation, commonly used in the Netherlands and other Northern European countries could be a way of reducing the labour costs associated with seasonal staff. Small-scale trials were carried out on a UK nursery in 2005 within PC 217. These trials demonstrated the potential of task separation. However, they also showed that task separation could have some limitations and these should be investigated further to show if task separation is a viable work method.

This project was commissioned to fully explore the potential for task separation in the UK by carrying out full-scale commercial trials.

Background to task separation

Commercial tomato production in the UK requires crop work to be carried out on a weekly cycle. Table 4 below describes the core components of crop work.

Table 4 - Basic labour tasks

Task		Description/Comments
1	Training (twisting)	Winding the supporting string around the stem for continuing support of recent growth.
2	Layering (lowering)	Moving the top of plant along and down to accommodate recent growth.
3	Side-shooting (trimming)	Removal of side-shoots from recent growth.
4	Truss-pruning	Removal of flowers/fruit from recent growth to achieve a specific number of fruit per truss (optional, depending on market requirements).
5	De-leafing	Removing unwanted foliage from around mature/ripening fruits.

A wide range of additional 'house-keeping' tasks e.g. irrigation checks & general cleaning/tidying commonly form part of the crop work function. However, the tasks listed in Table 4above were the focus of the project.

Current UK practice

The majority of crop workers on UK nurseries carry out all the top of crop work (tasks 1-4) in one pass. This is referred to as all-in-one working. The logic behind this approach is that time is saved by only having to visit the top of the plant once each week. Bottom of crop work (de-leafing) is carried out as a separate task.

Each crop worker is allocated a single block of rows of plants according to their ability (speed & quality of work). Each crop worker is responsible for carrying out all crop work tasks to their allocated area every week.

The benefits of this system are:

- A minimum amount of time spent changing rows.
- A single person is responsible for all crop work carried out on a particular area within the glasshouse. This helps to ensure a sense of ownership and responsibility.

These are considered to deliver optimum work quality and speed whilst requiring minimal supervision.

Task separation

Unlike the UK, many nurseries in the Netherlands apply the principles of task separation. At its extreme, this means that a crop worker visits the plant to carry out one task only. He/she or possibly even a different member of staff returns to the plant at another time to carry out the next task and so on until the all the required tasks are completed. The claimed advantages of this approach are:

- Improved quality of work – workers only have to concentrate on one task at a time.
- Faster to learn – it is easier to learn a single task in isolation than when it is combined with several others.
- Improved work posture – work platforms can be set at the optimum height for the task, not a compromise to suit the combination of tasks.
- Higher work efficiencies for the specific task.
- More flexible staff organisation – experienced staff can focus on the more skilled tasks whereas simpler tasks can be carried out by less experienced staff.

Task separation (TS) is currently applied in a limited way by some nurseries in the UK. For example when a crop worker is on holiday pickers are sometimes used for de-leafing. This releases some time from experienced crop workers who then carry out the remaining top of crop work. However, splitting the top of crop work into separate tasks is rarely done. The reasons for this are varied and include:

- It is thought that visiting a row more than once to complete top of crop work is slower than all-in-one (AIO) working.
- Concerns over work quality when more than one person carries out crop work on each row.
- Concerns over the need for increased staff supervision due to more complex work patterns and work quality problems.

If the concerns listed above can be addressed TS has the potential to deliver significant benefits especially for nurseries that are reliant on seasonal staff for crop work.

Objectives

The objective of this project was to help tomato growers reduce the labour cost associated with crop work by demonstrating the principles of TS on a commercial nursery.

Specific deliverables were:

- Apply the principles of TS on a large scale on a commercial nursery in the UK.
- Develop and prove alternative work organisation & staff management methods to provide a more flexible and productive workforce.
- Assess the financial implications of adopting TS.

Research method

Overview of location facilities and cropping

The project was carried out at G. de Lang & Sons, Mill Nurseries, East Yorkshire. The crop was the large vine variety *Classy*. The young plants were delivered to the nursery in Week 1 and planted at a density of 2.05 heads/m^2. This was increased to 4.1 heads/m^2 at the setting of the first truss (Week 8).

The glasshouse was of a modern Venlo design with thermal screens and hanging gutters. The glasshouse was split into 8 blocks each of which had its own independently controlled heating and ventilation system. There were two CO_2 enrichment systems, one supplied Blocks 15-18 and the other supplied Blocks 19-22.

TS was carried out in Blocks 15 & 16. This represented an area of 1.3 hectares comprising 75 x 55m long rows either side of the path. AIO work methods were applied in Blocks 17 & 18 (same size and layout).

Figure 4 - Nursery plan

21	**19**		**15**	**17**
Path	Path		Path	Path
22	**20**		**16**	**18**

Staff allocation

The staff that took part in the trial started work at Mill Nursery in Week 8. Although they had some experience of picking fruit they had no previous crop work experience.

In previous years it was possible to complete all the crop work in each pair of blocks within a 43 hour working week using 5 experienced staff. New staff members were expected to achieve similar work-rates within 12 weeks. Recognising the lack of experience 6 workers were allocated to each trial area. It was anticipated that the staff numbers in each block would be reduced to 5 as the work rates increased through the season.

Replacement workers were brought into the trial at various stages through the year. None of them had previous crop working experience.

Data collection

Work rates

Work rate data for both TS and AIO crop workers was collected using the nursery's PrivAssist system. This allowed work rates for each task/combination of tasks to be determined for each member of staff. FEC Services engineers downloaded data from the PrivAssist system each week using a modem connection.

Work quality

The quality of work achieved by each member of staff was assessed each week. To ensure a reliable and consistent quality score all the assessments were carried out by Chris Theron (Assistant Nursery Manager). A score out of 10 was given for:

- Training.
- Layering/spacing.
- Side-shoot removal.
- De-leafing.

The overall 'quality index' was the average score achieved. In addition to this formal assessment regular quality checks were carried out:

- By the charge-hand on an ongoing basis.
- By the grower at weekly intervals.
- By FEC during monthly visits to Mill Nursery.

Crop data

Site staff carried out weekly crop recording including:

- Growth.
- Height of flowering truss.
- Stem diameter.

Yield data was recorded daily when the fruit was picked. This was recorded as both the number of punnets and total kilograms.

In addition, the greenhouse temperature, humidity deficit and CO_2 concentration were recorded throughout the trial. This was to verify that any difference in yield was not due to different growing environments.

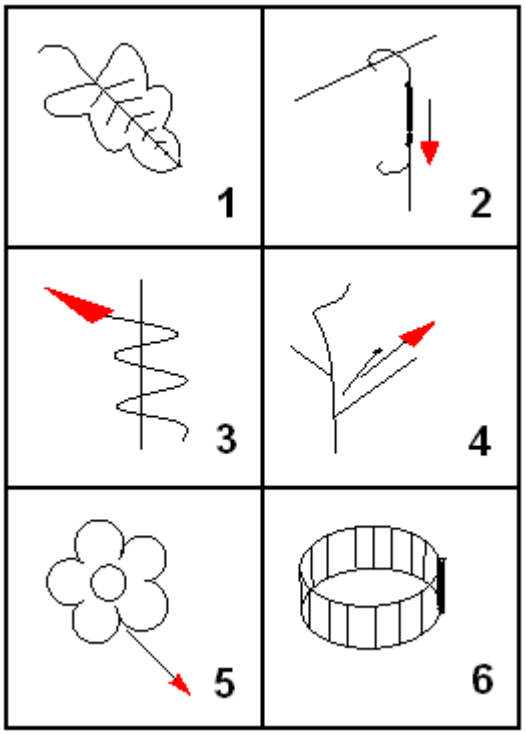
Results

Methods/tools developed to aid staff management & supervision

Task identification

PrivAssist uses numerical codes to describe each task that is recorded. Prior to the introduction of TS on the nursery job recording was limited to top of crop work, de-leafing and breaks. Therefore only 3 codes had to be remembered by staff. However, the introduction of TS and the potential for a large number of possible task combinations meant that a much more flexible yet simple to understand system had to be developed. An additional factor was that the majority of the staff did not speak English as their first language. Therefore graphical representations of each task were developed (see Figure 5 below).

Figure 5 - Job graphics



The graphics describe the jobs as:

1. De-leafing.
2. Layering.
3. Twisting.
4. Side shooting.
5. Truss pruning.
6. Clipping.

Whilst clipping did not form part of the trial it was included in the graphics as space was available and it added flexibility for future use by the nursery.

The work method and quality of work required was explained in detail during the staff induction. This was repeated as necessary during the early training phase and when work quality fell below the required standard. To support this each graphic was combined with photographs showing the required standard of work with examples of common mistakes. As the majority of the staff were from Poland text translated into Polish was also included. These were displayed in the greenhouse to allow the workers to refer to them when they were unsure about how to perform a particular task. An example of this is shown in Figure 6 below.

Figure 6 – Explanation boards for greenhouse ends

PrivAssist job codes

A unique set of job codes were required for every potential combination of tasks.

PrivAssist allows the use of 3 digit numerical job codes i.e. 001 – 999. The existing nursery job codes were all <200. The following rules were applied to the TS job codes:

- ***Digit 1*** was fixed as 2 to differentiate all the TS codes from work carried out on other parts of the nursery.
- ***Digit 2*** was the task ID number. Where two tasks were combined this was the lowest ID number.
- ***Digit 3*** where two tasks were combined this was the highest ID number. Where only one task was carried out on its own a 0 was entered.

Table 5 below shows the job codes associated with the most common tasks/combinations of tasks.

Table 5 – Example PrivAssist Job codes

Job code	Description
210	De-leafing
220	Layering
230	Twisting
240	Shoot removal
250	Prune truss
223	Layer & Twist
224	Layer & Shoot removal
*263	Twist, Shoot, Prune
270	All Top Work

* 263 was the only 3 task combination and did not follow the numbering rules.

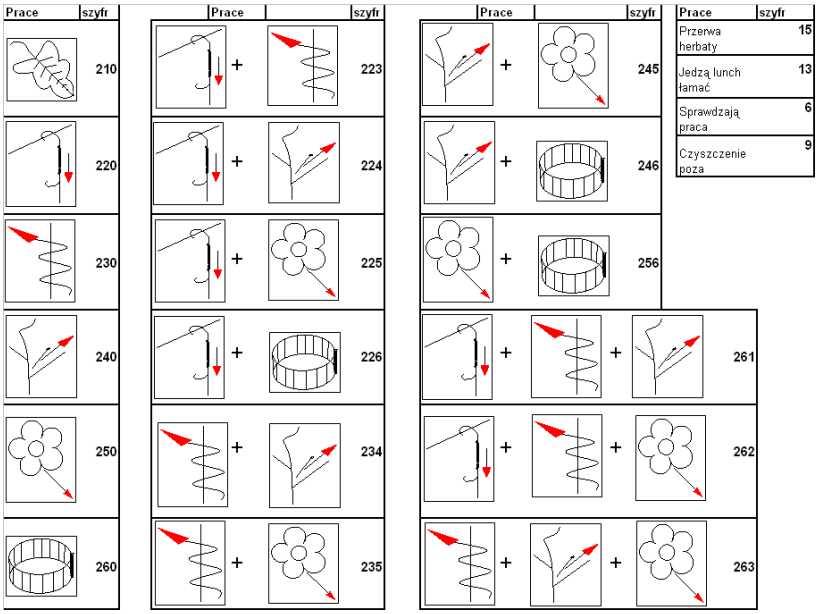
Graphical management tools

The graphics as shown in Figure 5 were also used to develop practical tools to aid job recording and staff supervision.

Job recording

The job code associated with the most common task combinations was combined with the graphics describing it on a single laminated sheet (see Figure 7 below). A copy was placed next to each PrivAssist terminal to help staff enter the correct job codes. They included some basic Polish descriptors but could be easily understood by workers of any language.

Figure 7 - Example code sheet



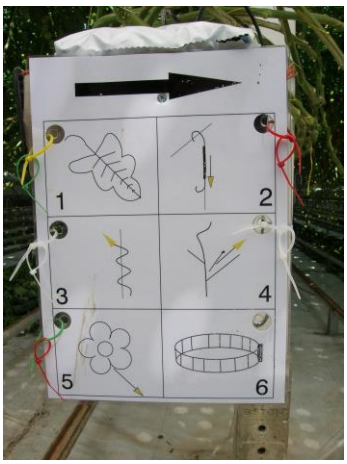
Row-end recording

The graphics were placed at the end of every row (see Figure 8 below).

Each worker was also allocated a specific colour of cable tie which they inserted next to the graphic representing the work that they carried out to each row. This allowed supervisory staff to easily see who had performed a particular task on each row and to give immediate feedback on the quality of work when required. This was necessary because, unlike fixed area working, each worker could potentially perform any task to any row.

Without this system the supervisor would have had to check everything on the PrivAssist system which can be time consuming. It also helped to promote a sense of 'ownership' of the work done to each row which is considered to be a major benefit of fixed area working.

Figure 8 - Row-end record board



Staff incentives and pay scheme

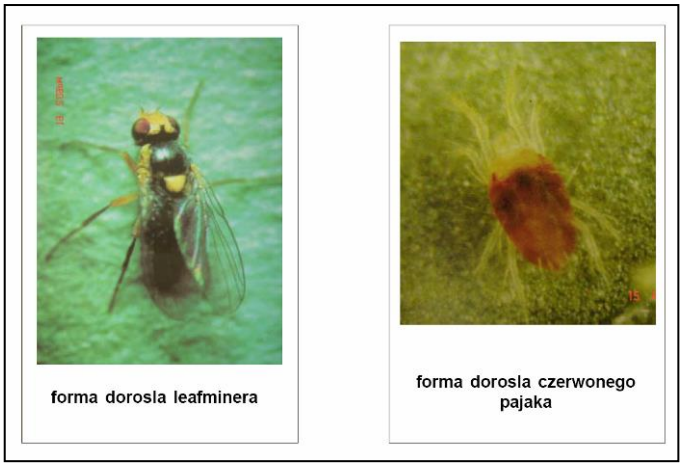
Many nurseries operate a bonus/piece rate type pay system to encourage staff to work faster. This is normally operated in conjunction with a quality monitoring system to ensure that quality does not suffer at the expense of speed.

Such a system was not used at G de Lang & Sons. Staff were simply paid a fixed hourly rate. With AIO work methods nursery management knew the work-rates that were achievable and therefore what to expect from crop workers. However, the work-rates when applying TS were unknown. To provide some motivation and identify optimum work-rates an incentive scheme was established. The scheme ensured that if workers completed their crop work early and achieved satisfactory quality they would still be paid for a 43 hour week and given extra work paid at an overtime rate.

Disease and pest control

Experienced crop workers can easily identify a wide range of pests and diseases as they work. To help new crop workers identify the most common pests and diseases, information sheets were put up at greenhouse ends. As with the task identification the emphasis was photographs rather than words. An example of one of these sheets is shown in Figure 9 below.

Figure 9 - Example of pest control information sheet



Work organisation

As on the majority of UK nurseries, G de Lang & Sons used fixed area AIO working as discussed in section 9.2.1. On average experienced workers are allocated 15 rows per week (11,400 heads).

However, when applying TS fixed area working can be problematic. This is best explained with an example.

- Two workers only do training & side-shoot removal.

- They can complete 43 rows each per week.
- Fixed area working is used.
- Layering is carried out by one person who can do 86 rows per week.

The person who layers therefore has to synchronise with the people doing training & side-shoot removal and ensure that layering is completed before the crop is trained. This means that person layering has to continually move between two 'fixed areas'. A more efficient approach is for all staff to start at one end of the greenhouse and work towards the far end. Thereby helping to ensure that work is carried out in the correct sequence and reducing non productive time spent moving from one area to another.

Next available row

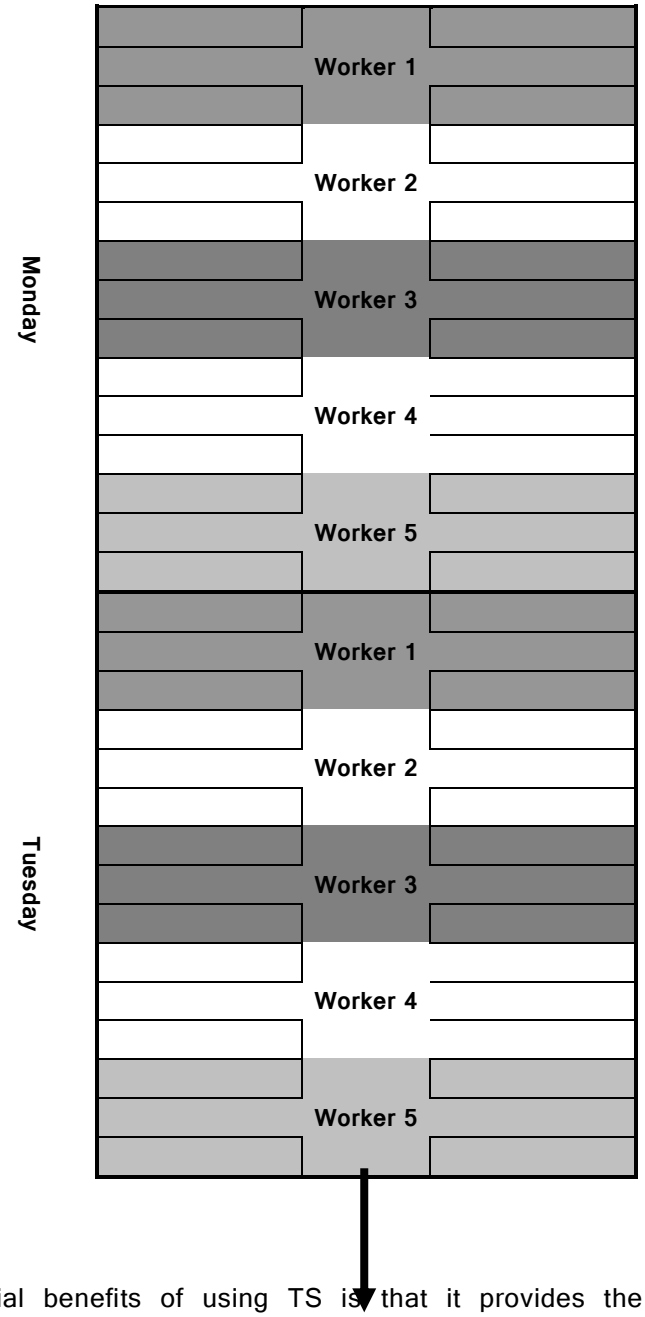
Starting in Week 8 the TS crop workers were managed on a row by row basis. At the beginning of the week all six workers started work on the first 6 rows of the greenhouse. As each one completed their row they moved to the next available row. They all carried out a single task e.g. training. Once the whole block had been trained they returned to the first 6 rows in the block and removed side-shoots and finally completed truss pruning. The row tagging system as described in section 12.1.3 meant that supervisors could easily check who had carried out each task to each row.

Daily fixed area

A disadvantage of the next available row approach was that each worker did not necessarily return to side-shoot or truss-prune a row that they had trained. When one worker did a poor job that impacted on the ability to perform another task this caused some conflict/dissatisfaction amongst the other workers and was ultimately de-motivating.

Daily fixed area working was therefore introduced in Week 11. Each worker was responsible for completing all the work on a single block of 3 rows each day. These blocks of rows were all adjacent to each other keeping all the workers close to each other and maintaining the 'flow through' approach.

Figure 10 - Daily fixed area working



Team working

One of the potential benefits of using TS is that it provides the flexibility to allow the efforts of skilled staff to be concentrated on the more critical tasks. Analysis of the work-rates achieved showed that it was possible for three crop workers to complete all the training and side-shoot removal in the whole block (Team 1). The remaining operations (layering and truss pruning) were carried out by two crop workers (Team 2).

The work-rates achieved by all five crop workers were assessed to identify those who were best at carrying out the Team 1 work (speed & quality). The remaining workers were allocated to Team 2. The following work pattern was adopted in Week 17:

Team 1

- 3 crop workers.
- Training and side shooting carried out as a combined job.
- Truss pruning carried out as a single task.
- Target 5 rows completed per crop worker per day.

Team 2

- 2 crop workers.
- Layering and de-leafing were carried out as separate tasks.
- Target 7.5 rows per crop worker per day.

Daily fixed area working was used.

Week 19

The approach adopted in Week 18 worked well. Team 2 essentially worked one day ahead of Team 1 to avoid row clashes. As the Team 2 workers had previously performed all tasks they appreciated the impact of poor layering on the ability to train the crop and the work quality was generally good.

However, warm, sunny weather in Week 18 highlighted a factor that had to be taken account of when using team working. Team 1 spent all of the working day on a work platform exposed to the sun and higher greenhouse temperatures. Team 2 arguably had the more physical task of layering to complete. However, they were able to complete all their layering before mid-day while temperatures were lower and de-leaf in the shade during the afternoon. On balance the Team 1 workers felt that they had the most difficult working conditions but were being paid the same amount as Team 2.

Rather than introduce different pay scales the team approach was modified so that all the crop workers spent the same amount of time on a work platform.

From Week 19 onwards the following work pattern was adopted:

Team 1

- 3 crop workers.
- Primary task - training and side shooting carried out as a combined job.
- Target 5 rows completed per crop worker per day.

Team 2

- 2 crop workers.
- Primary task – layering.
- Target 7.5 rows per crop worker per day.

Both teams

- Truss prune when their primary tasks were completed.

- De-leafing only when all truss pruning was completed.

This approach worked successfully until Week 28 when new crop workers were introduced and the work method was changed.

Equipment

Work platforms

Figure 10 shows the type of work platform used by crop workers in this trial. It was possible to adjust the working height to suit the specific task being carried out. However, this was a manual process rather than 'push button' as is common on newer hydraulic work platforms.

Figure 10 - A typical work platform

PC 217 identified that crop workers in the UK tend to use work platforms in a stop/start manner. The control pedal is depressed briefly to move the work platform forward by a small amount after completing the required task on each plant. In addition to causing unnecessary wear & tear to the drive system, stop/start operation was considered to reduce work-rates. Slow but continuous movement is the preferred mode of operation in the Netherlands where TS is used.

To allow non-stop operation the work platforms at the nursery had to be modified to:

- Reduce their speed.
- Improve the controls.

Work platform speed

A mechanical gearing system allowed the maximum speed of the work platform to be reduced by a factor of 10. However, this was still too fast to allow non-stop movement for the slowest task. The gearing therefore had to be modified. See Table 6 below.

Table 6 - Work platform speeds

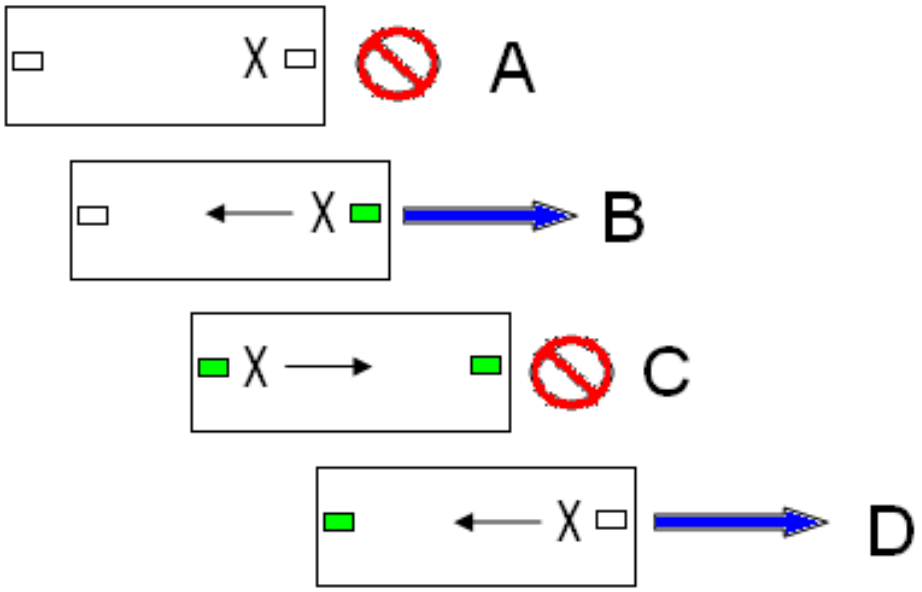
	Heads/hour	Metres/hour
Minimum speed	425	126
Maximum speed	4000	1205

Work platform controls

The work platforms had a single control pedal at one end. The pedal could be operated in 'brake' or 'accelerator' mode. Brake operation allows the work platform to move continuously until the pedal is pressed and held down, it starts moving again as soon as the pedal is released. Accelerator operation only allows the work platform to move when the pedal is pressed down; it stops as soon as the pedal is released. They were normally used in accelerator mode on the nursery.

Brake mode could have been used for non-stop operation meaning that the pedal was only pressed when a 'problem plant' was encountered. However, this requires the worker to remain close to the pedal just in case they need to stop. This does not allow the crop worker to 'buffer' the variation in work rate by moving along the work platform due to the possibility of being too far away from the pedal when he/she wants to stop. The work platforms were therefore modified to include two pedals, one at each end of the platform. The worked in one touch stop, one touch to start mode. Figure 11 below shows how this works in practice.

Figure 11 - Work platform controls



- A: Work platform is stationary at the beginning of the row.
- B: Rightmost pedal pressed, the work platform moves to the right. If plants require more time than the speed allows, the crop worker moves along the platform to the left.
- C: If the plants still require more attention and the left hand end of the trolley is reached the pedal is pressed to halt motion. The worker then works along the plants to the right until reaching the rightmost end of the platform.
- D: The rightmost pedal is pressed and the trolley moves to the right once again.

The speed of the work platform was adjusted to match the work-rate so that the pedals were only used as a last resort without being so slow as to reduce the overall work-rate achieved.

Speedometers

The work platforms did not have a speedometer or graduated dial allowing the workers to easily gauge their work-rate at any moment in time and to easily adjust to the correct speed when changing tasks. They were therefore fitted with speed and time trip computers. A table that related speed to work-rate in heads per hour was also attached to the work platform.

Figure 12 - Trolley trip computer speed table

Figure 13 - Trolley

The AIO workers were also given similar tools to ensure that any difference in overall work-rate recorded was due to TS and not changes in equipment.

Green waste disposal

Side-shoot removal and truss-pruning produce a significant amount of green waste. Simply dropping this waste is not considered to be good practice as it can land on the plant and encourage disease development as it decays. Normal practice at the nursery was to put the waste in plastic bins placed on the bed of the trolley. The adoption of two-pedal (non-stop) control meant that the bins were in the way and an alternative approach had to be developed.

New bins that could be hung on the work platform guard rails and easily moved were provided. Although they allowed the workers to move more freely along the work platform the limited space between the top rails meant that the bins were smaller. They therefore required more frequent emptying.

Work rates achieved

Many changes to work methods and task combinations were made throughout the season. Tables 7 and 8 below list the major changes that took place during the trial and the date they occurred.

Table 7 - Events diary for TS workers

Date (2006)	Week No	Event
14th February	7	Crop planted
20th February	8	Crop work begun (all tasks carried out separately)
9th March	10	Top de-leafing begun
9th March	10	Daily fixed area management
13th March	11	Twisting and side shooting combined
3rd April	14	Layering started
24th April	18	Worker organisation changed to team approach
8th May	19	Team approach refined
25th May	21	Worker numbers reduced
29th May	22	New worker introduced
4th July	27	Worker fully trained
6th July	27	Trialled combined truss prune and layer
10th July	28	New workers introduced, skilled workers moved on
11th August	33	Twist, Side Shoot and Truss prune combined as one task
4th September	36	Crop stopped

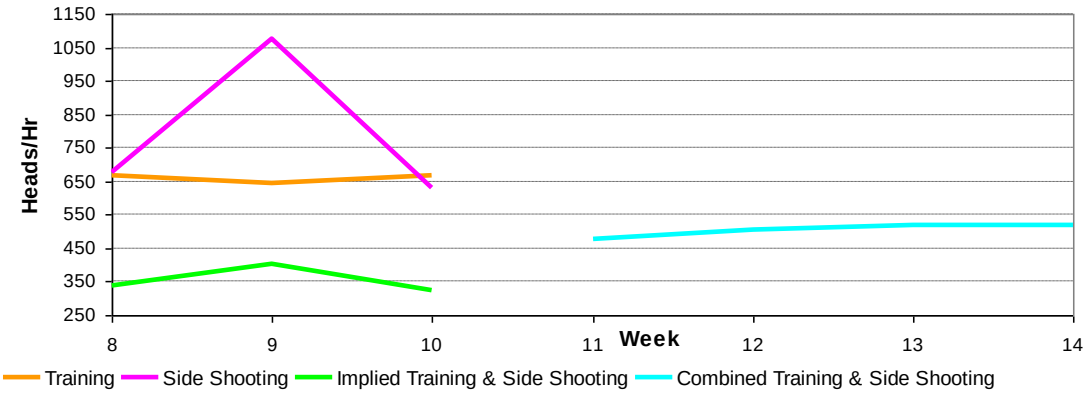
Table 8 - Events diary for AIO workers

Date (2006)	Week No	Event
14th February	7	Crop started
20th February	8	Crop work begun
9th March	10	Top de-leafing begun
3rd April	14	Layering begun
29th May	22	New workers introduced
4th September	36	Crop stopped

Weeks 8 - 14

This phase covers a period from when the crop workers started work (Week 8) up to the point at which layering started (Week 15).

Figure 14 - Results Week 11 – 14



In the TS block training, side-shoot removal and truss-pruning were carried out as three separate tasks until Week 10.

- Training - there was little variation in work-rate, the average was 650 heads/hr.
- Side-shoot removal - there was a significant increase in the work rate in Week 9. However, the quality of work was poor. Although the work-rate fell in Week 10 the quality of work was significantly better.
- The average combined work rate for Weeks 8 – 10 was 350 heads/hr (no layering).

Although side-shoot removal quality had improved in Week 10 it was still not carried out to the required standard. This was thought to be due to workers rushing to get down the rows quickly and therefore missing side shoots. From Week 11 onwards training and side shoot removal were carried out as a single task. Training requires the worker to focus on all the new growth of each individual stem which is also required when searching for side-shoots. Combining these tasks allowed the workers to identify side-shoots whilst training and return to them immediately to remove them. Therefore from Week 11 onwards training and side-shoot removal were combined as a single job. Over the period from Week 11 – 14 the combined training and side-shooting work rate increased steadily from 470 heads/hr to 520 heads/hr. The quality of the side shooting also reached an acceptable standard.

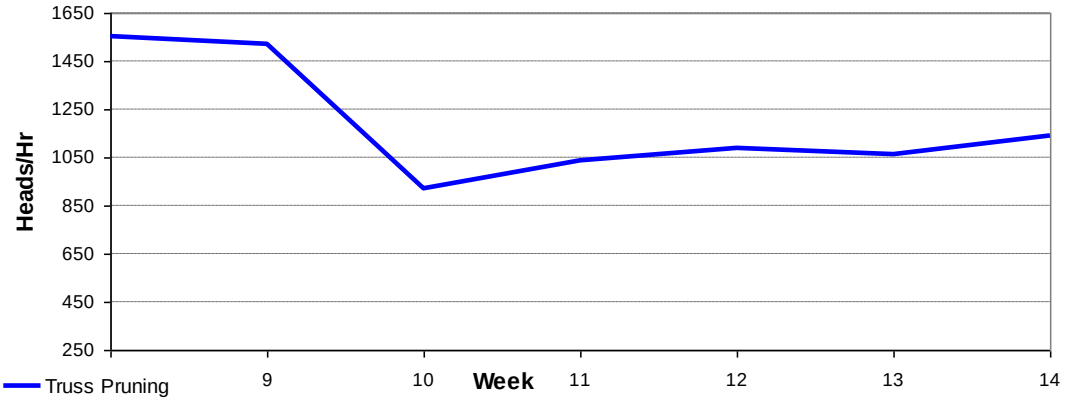


Figure 15 - Weeks 8 – 14 Truss pruning

Truss pruning was carried out as a separate task for the whole of this period. The initial work-rate was over 1500 heads/hr. This fell to 900 heads/hr in Week 10. This was partly due to an increased focus on quality of work in Week 10 but also because the crop was growing faster thereby increasing the workload per row. As the work-rate was calculated by dividing the number of heads per row by the time taken, the impact of slow growth early in the season gave an artificially high work-rate.

Figure 16 - Weeks 8 – 14 AIO vs. TS workers

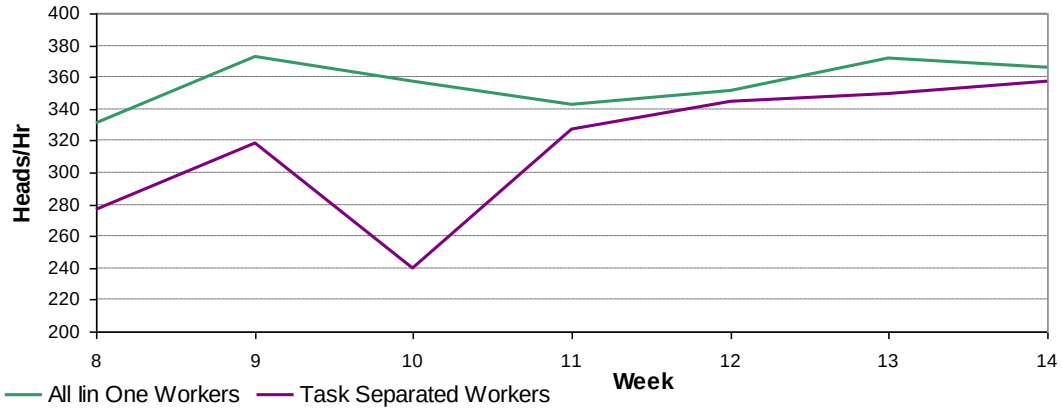


Figure 16 above shows the top-of-crop work-rate achieved by the new staff using AIO worker methods compared to the overall top-of-crop work-rate for the TS staff from Weeks 8 – 14.

- Up to Week 10 the AIO workers were significantly faster than the TS workers (average 350 heads/hr vs 280 heads/hr).
- From Week 11 onwards the work rates were similar.

The lower work rates and greater fluctuations in performance of the TS workers were due in part to:

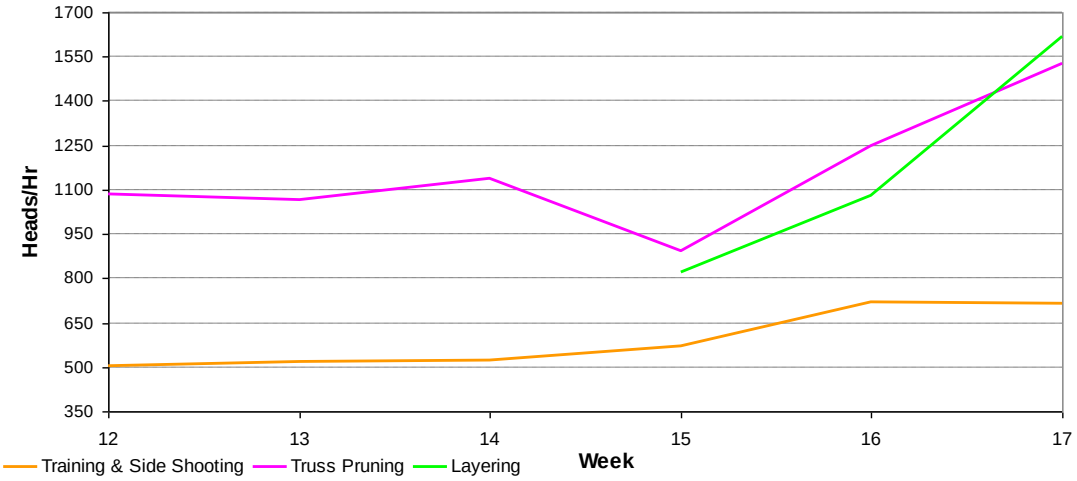
- The project team (managers, supervisors etc.) were also learning how best to apply TS.
- Regular changes to the work methods did not allow the workers to settle into a work routine.
- The poor performance of one worker impacted on the work-rate of all workers whilst 'next available row' was used. Daily fixed area working (introduced in Week 11) helped to resolve this issue.

Weeks 15 – 17

Layering was required from Week 15 onwards. The tasks were broken down as follows:

- Layering was carried out as a single task.
- Training & truss pruning were carried out together.
- Truss-pruning was carried out as a single task.

Figure 17 - Weeks 12 – 17



During the short period from Week 15 to Week 17:

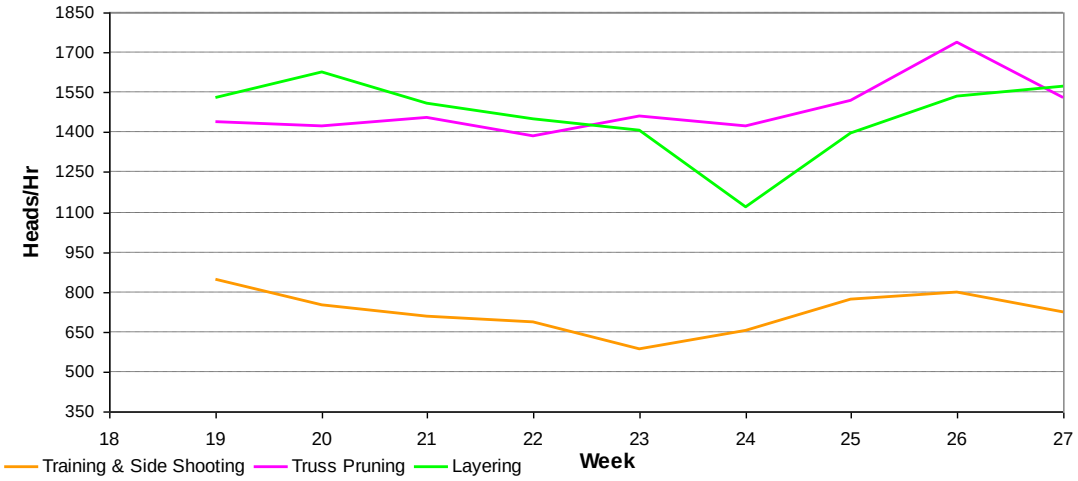
- Layering quickly increased from 800 heads/ hr to 1600 heads/ hr.
- Training and side-shooting increased from 570 heads/ hr to 720 heads/ hr.
- Truss-pruning increased from 890 heads/hr to 1500 heads/hr.

There is no doubt that the increase in work-rates was due to the workers becoming more experienced. The work method was also unchanged during this period which allowed them to settle into a routine. The increase in total workload due to the introduction of layering was also considered to have had a positive effect on work-rates. This was also seen in PC 217 where crop workers with many years experience worked faster in response to an increasing workload.

The combined top-of-crop work-rate achieved by the TS workers at the end of Week 17 was 375 heads/ hr including layering. This compared to 435 heads/hr achieved by the AIO workers.

Week 18 – 27

Figure 18 - Weeks 18 – 27



Week 18 saw the introduction of the team approach. The approach was refined in Week 19 because of concerns expressed by the workforce and the nursery management that workers were spending long periods of time on the trolleys during the hottest parts of the day.

Data was unavailable for Week 18 because of technical difficulties with the recording system. The period Weeks 19 – 27 gave the workers a chance to settle into a work pattern without changes in work methods. It was felt by the nursery management and FEC that the workers would benefit from having a consistent work practice.

The work rates showed that there were small fluctuations in the work rates for training & side shooting and for truss pruning. Layering decreased sharply in Week 24 from 1400 heads/ hr to 1100 heads/hr. There did not seem to be a discernible reason for this and the following weeks showed work rates for layering increasing again.

Week 22 – 32

New staff were brought into the AIO block and the TS block to identify any difference in the speed of learning once the TS work methods had been proven and the workload was high. Due to staff availability three new workers were brought into the AIO block in Week 22 and three into the TS block in Week 28.

In the TS block all staff carried out all tasks to give more reliable average work-rate data.

- Layering was carried out as a single task.
- Training & side-shoot removal were carried out as a combined job.
- Truss-pruning was carried out as a single task.
- Daily fixed area working was applied.

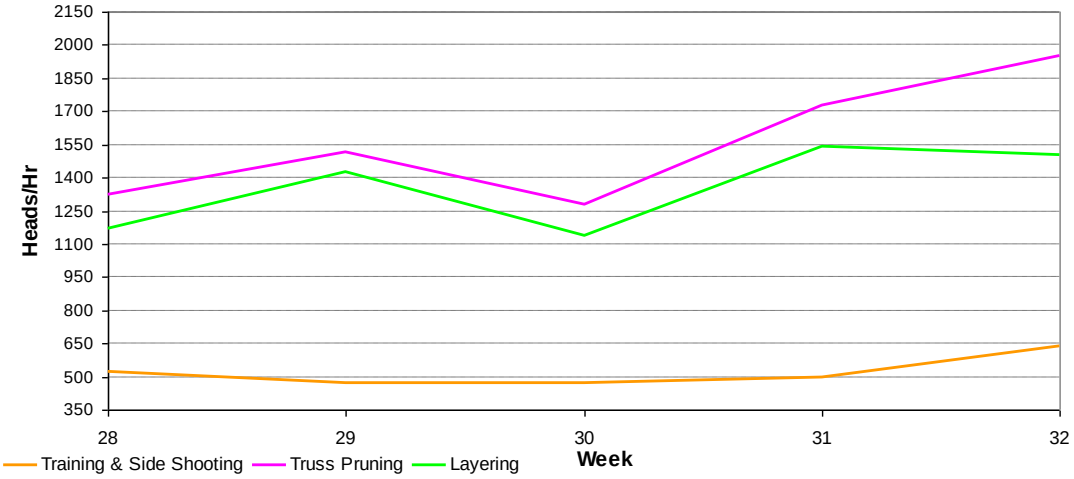
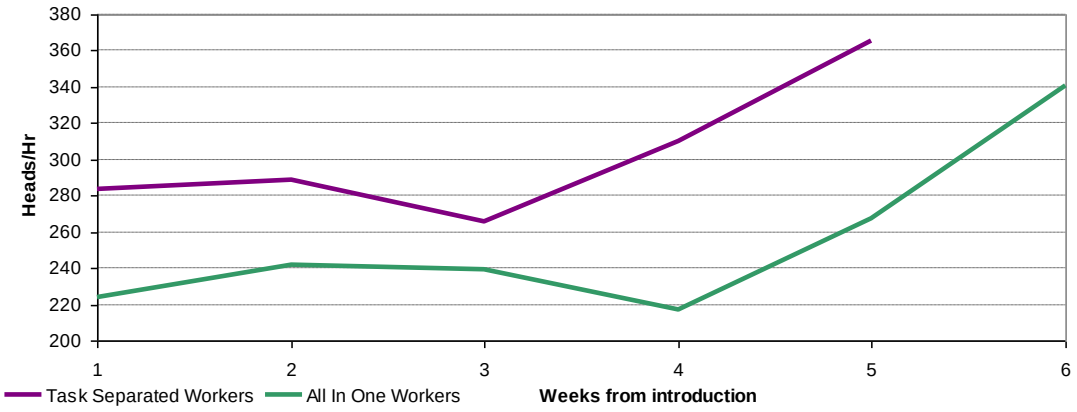


Figure 19 - Weeks 28 -32

Figure 19 above shows how the work-rates in the TS block changed over the initial 4 week period. At the end of this period the nursery management considered that the workers were fully trained (acceptable work-rates & quality). The combined top-of-crop work rate was 390 heads/hr.

Figure 20 below compares the combined top-of-crop work-rate achieved by the three new TS workers introduced in Week 28 with the three new AIO workers introduced in Week 22 during their first six weeks of crop work. It shows that the three new TS crop workers achieved a higher combined work rate than the three new AIO workers throughout this period. The nursery management considered the speed of learning and quality of work carried out by the TS workers to be much better than they would normally expect for AIO workers.

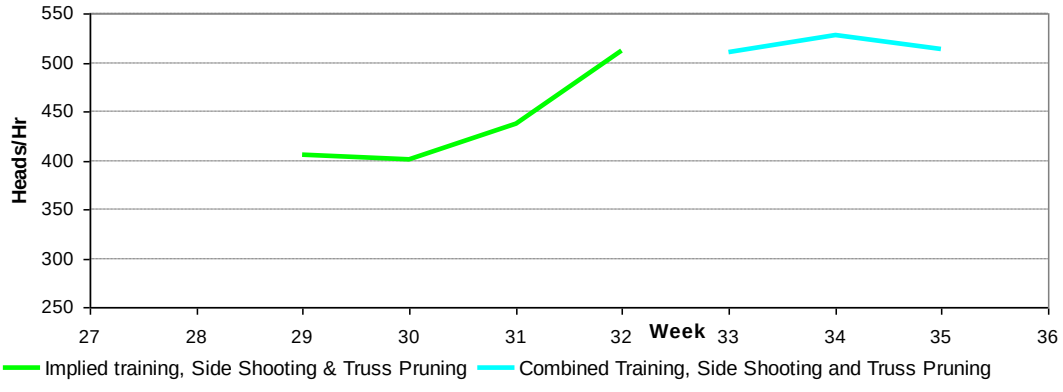
Figure 20 - Mid season learning



Week 33

The tasks of training, side-shoot removal and truss pruning were combined into a single job in Week 33. Figure 21 shows that there was a slight improvement in overall top-of-crop work-rates when twisting, side shooting and truss pruning were combined. However, the increase in work rate was too small to conclusively state that it was due to the change in work practice and not just increased experience.

Figure 21 - Combined work rate trial



Modified work platforms

Two pedal trolleys as described in section 12.3.3 were brought into the trial in Week 21. No improvements in work-rate were recorded but the following benefits resulted.

1. Workers travelled more smoothly along the rows.
2. Feedback from the workers was positive and nursery management felt they were a benefit.
3. The background noise level in the glasshouse was reduced due to a reduction in stop/start drive train noise.
4. A reduction in breakdowns due to reduced mechanical stress associated with less frequent stop/start cycling.

A disadvantage was that the batteries had to be charged twice as often.

Season overview

Overall work-rate

Figure 21 below shows the combined top-of-crop work-rate achieved by the TS workers and the AIO workers over the whole season. It shows that the TS workers were always slower than the AIO workers. There were two periods when the work-rate achieved by the TS workers was similar to the AIO workers. The first period was before layering was required. It coincided with a short time when the TS work methods were unchanged thereby allowing the workers to develop a stable work routine. The second period was when some new staff were introduced into the AIO block thereby reducing the average work-rate achieved.

During the remainder of the season the work methods being used by the TS workers were regularly changing. Although there was no way of accounting for this, there is little doubt that the work-rates achieved were negatively affected due to the lack of a stable routine.

Figure 21 - Season work rates

Target work-rates

The trial showed that complete separation of all tasks was possible. The quality of work was acceptable and with the staff management/organisation tools developed they did not require additional supervision compared to AIO workers. However, a degree of job combination delivered the best results. The following task combinations were found to provide the best results on the trial nursery:

1. Layering – as a single task.
2. Truss-pruning – as a single task.
3. Training & side-shoot removal – as a combined task.

Frequent changes to work methods and workers meant that it was not possible to quantify long-term average work-rates for each of the above jobs. However, the work-rates achieved by specific staff and results obtained in PC 217 (2005) allowed some guideline figures to be produced (see Table 9 below).

Table 9 - Target work rates

Job	**Work-rate Heads/hour**
Layering	2,500
Truss-pruning	2,000
Training & side-shoot removal	800
Implied overall top-of-crop	***465***

This compares with an average top-of-crop work-rate for the AIO staff of 480 heads/hr between Weeks 19 – 35 for top of crop work. Although these figures suggest that TS is slower only a slight improvement is required (3%).

Yield / work quality

There were periods when specific aspects of the quality of work in the TS block were unsatisfactory. However, similar work quality problems also occurred in the AIO block. Overall the quality of work carried out by the TS workers was considered to be the same standard as that achieved by the AIO workers.

Proof of the quality of work and ultimately the key output is the yield of the crop. Table 10 below shows that the yield in the TS block was almost identical to the yield in the AIO block. Therefore TS had no effect, either positive or negative, on yield.

Table 10 – Yield data

	TS block	AIO block
Yield kg/m^2	38.5	38.4
Difference	+0.4%	

Discussion

Overall work-rate and quality

The principles of task separation have been successfully applied on a UK nursery. Although the overall work-rate achieved with TS was lower than with AIO working throughout the whole season. The following factors contributed to this:

1. Regular changes to work methods were required to address problems as they occurred and to test the effect of alternatives. This caused considerable disruption to the workers and did not allow them to develop a consistent work routine.
2. Unlike AIO working, the project team did not know the work-rates that could be expected with TS. It was therefore difficult to set realistic targets.
3. A piece-work type pay structure was not used. This would have helped to counter the effect of point 2 above by providing the workers with additional motivation.

During the periods when the TS workers were not subject to changes in their work methods the work-rate achieved was close to that of the AIO workers. This shows that work rates comparable to those for all-in-one working can be achieved when TS is applied.

Speed of learning

When the workers first entered the greenhouse in Week 8 the work-rate achieved with TS was less than with AIO working. On face value this suggests that TS was more difficult to learn. However, this was affected by the same factors that affected the overall work-rate as discussed in section 13.1 above.

Speed of learning was assessed a second time when new workers were brought into the trial later in the season. At this time many of these influencing factors had been resolved. This showed that in their first week the TS workers were significantly faster than the AIO workers. In addition it took

the AIO workers an extra week to achieve satisfactory work-rates. This is because:

- TS allows a worker to focus on one task at a time.
- Daily fixed area working meant that all the workers were close together. This meant that the supervisor could more easily find them and train them as a group. This increased the amount of training time per worker without increased input from the supervisor.

Task combinations

Various combinations of tasks were trialled during the project. Although every possible combination was not tested the preferred combinations were:

- Twist and side shoot as a combined job.
- Truss prune as a separate job.
- Layering as a separate job.
- De-leafing as a separate job.

The degree of task separation and the most effective task combinations are dependent on both the skills available in the workforce and the greenhouse infrastructure. For example, if only one of the five crop workers was new to the job it may be necessary to layer as a separate task to provide sufficient unskilled work. Layering and side-shoot removal were not trialled in 2006 but they were successfully combined in PC 217 (2005) as part of the Ringmaster™ trial. One of keys to the successful application of task separation is to develop as simple a work pattern as possible especially if the team approach to staff management is adopted.

The project did not consider the range of supplementary tasks commonly included in the crop work role. These include general tidying and placement of biological control. Many of these can be allocated to non crop worker staff thereby releasing more time for experienced staff to carry out the more critical tasks.

In PC 217 (2005) layering had to be carried out before training because the crop was grown above the crop wire. This was not the case in 2006, in fact it was preferable to train the crop first because it meant that the plant was better supported during layering and that the heads were more organised which helped the quality of truss-pruning.

Staff organisation

Weekly fixed area working as commonly used in the UK was not appropriate for the level of task separation applied in this trial. The 'next available row' approach is the ultimate in terms of work flow and minimising movement within the greenhouse. However, a drawback of next available row was proven to be the negative impact that one poor worker could have on the whole team. Changing to daily fixed area with all workers carrying out all tasks on their allocated rows solved this problem. The daily fixed area approach allowed

supervisors to easily locate all staff and provide group training unlike the weekly fixed area approach. This was seen as a major benefit independently of task separation.

The introduction of team working allowed the workers who were better at specific tasks (principally training) to focus their skills accordingly. This meant that the person who carried out layering did not train the crop. There was therefore the potential for conflict if the layering was done badly as was the case with the next available row approach. However, this was not the case. The daily fixed area approach was retained which made the quality of work of an individual worker more visible to both workers and supervisors and there were no work quality problems. The downfall of the initial two team approach was that the higher temperature associated with working in the top of the crop all day was not rewarded financially and the work pattern was therefore altered to accommodate it.

Team working was also found to have a number of both positive and negative benefits depending on the psychology of specific crop workers:

Positive

- Working in close proximity promotes competition and therefore motivation to work faster.
- It provides peer support for those workers who are struggling and require extra help.

Negative

- There is increased opportunity for socialising whilst working, reducing the level of concentration and therefore work-rate & quality.
- Team members may slow down to the pace of the slowest worker.

The negative effects of team working could be addressed through the use of a piece-work pay system either per individual or per team. The host nursery strongly believed that piece-work was detrimental to quality and did not use it. However, many UK nurseries successfully use piece-work pay systems.

There is no doubt that the daily fixed area, team work approach was the best solution for applying task separation on the host nursery.

Management tools

A number of management tools were developed to help organise the work and the crop workers throughout the season. Although potentially less significant, their benefits are equally applicable to traditional UK work methods. The row end boards proved to be the most important management tool for task separation. They allowed the supervisor to easily and quickly identify who had carried out each task to each row.

The unique job codes and the associated sheets that were fixed to the PrivAssist terminals helped to reduce errors when entering job codes. This was especially significant with the wide range of task combinations associated with task separation.

The benefits of the job descriptor and pest and disease boards were mainly at the beginning of the season and on the introduction of new staff. Graphical representations and language free communication were an important part of the success of this approach.

Equipment

The work platforms were modified to allow no-stop movement along the rows. Although no clear improvement in work-rate was recorded feedback from the workers was positive. There was also a reduction in break-downs due to reduced drive train fatigue.

The speed and time displays on the work platforms were most useful to the workers as a clock and stopwatch. This speed function did not appear to be used. This may have been due to the lack of a target work-rate and/or piece work pay system.

Implementation

The introduction of new work methods in any industry can be fraught with difficulty. This is especially true when old work methods continue to be used in another area and the new method is unproven. The challenge is to motivate staff to want any change to succeed rather than fail. The staff involved in the Ringmaster trial (PC 217, 2005) were without doubt highly motivated and contributed significantly to its success. The staff involved in the task separation trial were at best neutral and were easily de-motivated when they felt that they were put at a disadvantage compared to traditional work methods.

There are many theories and strategies on change management in the workplace and it was beyond the scope of this project to explore them. However, there is no doubt that the wrong approach can make the best ideas fail. When testing or proving any changes the selection of people with the right approach combined with adequate incentives to succeed are vital.

Conclusions

Task separation can be successfully applied on UK nurseries and work-rates comparable to traditional work methods can be acheived. Most of the potential benefits have been proven at a practical level. However it has not been possible to quantify all of them due to insufficient time within the cropping year.

- With appropriate systems in place task separation does not cause a reduction in the quality of work or increase the need for worker supervision.
- Task separation combined with daily fixed area working reduces the time required to train new staff.
- The optimum degree of task separation is determined by the availability of skilled staff vs. new staff, the variety grown and the greenhouse infrastructure. It is therefore unique to each nursery.
- Daily fixed area working allows the benefits of task separation to be realised whilst ensuring accountability for quality of work.
- Task separation allows experienced crop workers to cover a much greater area and therefore utilise their skills much more effectively. In the trial, an experienced crop worker was able to cover 66% more crop.
- The successful implementation of task separation or any significant change to work methods requires considerable management effort and planning.

Recommendations

Growers should:

- Introduce the principles of task separation to cover staff holidays, sickness and short-term peaks in workload to gain confidence in the technique.
- Allocate a single area for training new crop workers and train them using task separation with daily fixed area working before moving them to a permanent location.
- Identify a team of experienced crop workers open to new ideas to form the core of a task separation trial/demonstration on their own nursery.

Further work

Whilst this trial showed that task separation can be successfully applied on a UK nursery a number of areas were not fully investigated because:

- Regular changes to the work methods throughout the trial did not allow the workers to reach their maximum work-rate.
- A number of task combinations which have the potential to improve overall work-rates were not explored.
- The benefits of applying task separation to experienced crop workers at the start of the season with the gradual introduction of seasonal staff to perform the simpler tasks were not explored.

The full potential of task separation has yet to be fully quantified. It is therefore recommended that further work is carried out to build on the knowledge gained during PC 217a.

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