

Project title: Improving the efficiency of labour use in tomato production – developing best practice

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Grower Summary

Headlines

Work carried out during 2004 identified several methods that could improve labour utilisation in UK tomato production. These methods were trialled on commercial nurseries of the Wight Salads Group Ltd during the 2005 cropping season.

- For new staff ringing & clipping on alternate weeks took 26% less time when compared to the target using conventional work methods (twisting). Allowing for the cost of rings and clips this gave a saving of £4,080/Ha.
- Clipping every week reduced the labour requirement by 12% when compared to the target for new staff using conventional work methods (twisting). However the cost of the clips was greater than the labour saving.
- Task separation has the potential to allow experienced staff to focus on tasks that require the highest level of skill and experience. It also allows new staff to work on simple tasks such as leaf removal and achieve an acceptable work rate relatively easily. However, complete task separation is not possible on all tomato crops.
- Task separation allows staff to work at the optimum height for each task, thereby reducing fatigue and the potential for upper limb disorders.
- A make and model of secateur commonly used on commercial nurseries (ARS 310) was shown to be preferable to a range of alternative designs which incorporated a higher degree of ergonomic design.

Background and expected deliverables

Labour costs typically account for over 30% of the unit costs of tomato production and, for most producers, it is the highest single cost of production. Data from UK growers of classic round types show labour costs to typically fall in the range of £9 to £12/m². 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 in excess of £25 million/annum.

It is therefore widely acknowledged that all businesses in the tomato sector can benefit from improvements in labour utilisation and the effects will be reduced production costs and improved business efficiency.

Work described in this report relates to the second phase of the project and focuses on the assessment on a commercial nursery of the following techniques / equipment:

- An alternative crop training method – ringing used in combination with clipping.
- The use of improved tools & equipment – hydraulic lift work platform, powered picking cart and secateurs.

Results

All the work was carried out on nurseries of the Wight Salads Group Ltd located on the Isle of Wight. The techniques trialled are described below along with a summary of the results obtained.

Alternative crop training methods

The Priva Ringmaster® comprises a base unit mounted on the work platform and a hand-tool. The hand-tool forms a wire ring around the plant stem and supporting string each time the trigger on the hand-tool is pressed. Plastic clips are still required on alternate weeks because the wire ring cannot support the weight of the plant on its own.

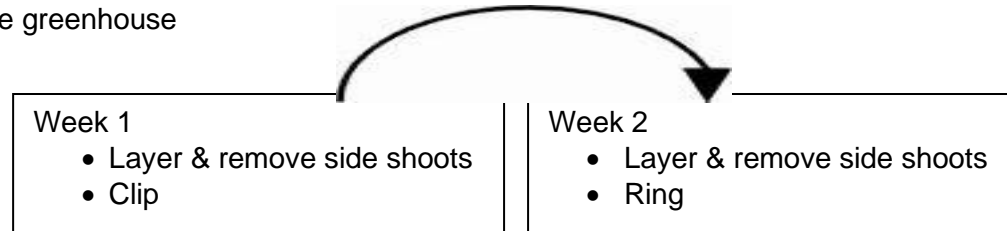


The trial work was carried out on a 1Ha block of an organic loose round crop. Ringing and clipping started in week 9 and continued through to week 37 when the crop was stopped.

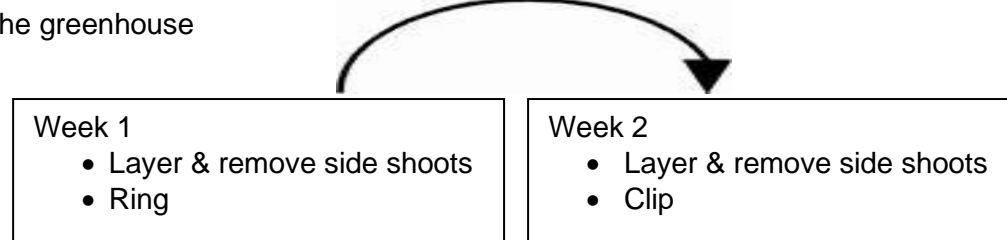


As the Ringmaster® requires the operator to use a dedicated hand-tool, it is not practical to carry out other tasks simultaneously with the ringing operation. Therefore a degree of task separation was required. The tasks were carried out in the following sequence:

One half of the greenhouse



Other half of the greenhouse



In practice, in any week, half the greenhouse was ringed and the other half clipped.

Figure 1 – Measured ring & clip work-rates

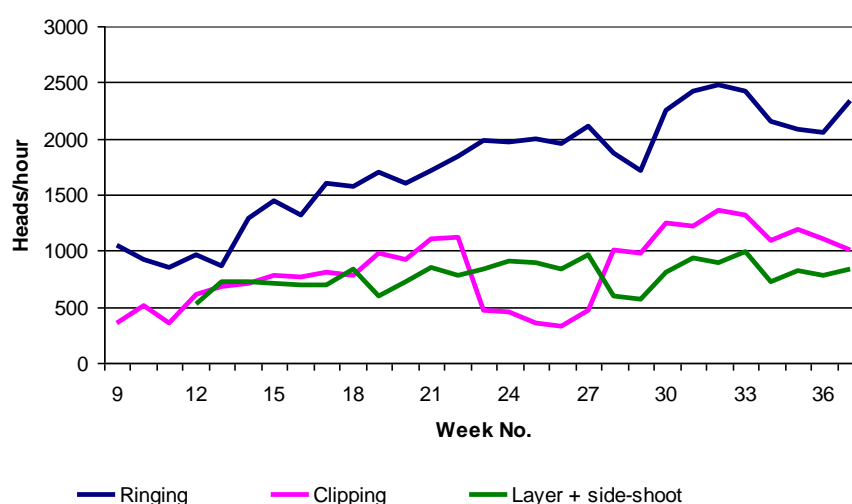


Figure 1 above shows that there was a step increase in ringing work-rate around week 13. This was due to both an increase in plant density and additional management focus. From this point onwards the ringing work-rate continued to show a steady increase as both management and staff gained experience with the technique.

The clipping operation followed a similar trend. However, a significant drop in work-rate was measured between weeks 23 and 28. This was because clipping and side-shoot removal were combined into one operation. Spot work-rate measurements showed that it was possible to achieve more than 1,000 heads/hr. However full scale application only achieved a sustained work-rate of less than 500 heads/hr.

Layering and side-shoot removal work-rates were relatively constant throughout the trial. This suggests that this was the easiest task to learn. There was a notable increase in work-rate around week 21 when the crop was allowed to grow above the string. This meant that layering and side-shoot removal were carried out at almost the same height which helped to improve the speed.

Table 1 gives the total labour hours spent working the top of the crop from week 9 to week 37 for four different scenarios.

Table 1 – Ring & clip, total labour hours

		Total hours worked	Reduction compared to new staff target (hours)
Experienced staff (measured data)	Conventional work methods (twisting)	2,356	1,087 less
New staff	Conventional work methods (twisting)	3,443 ¹	n/a
	Ring & clip	2,558	885 less
	Clip only	3,052 ²	391 less

¹ Calculated from Wight Salads Group Ltd target work-rates for new staff

² Calculated from ringing & clipping work-rate data

Although ringing & clipping took 202 hours longer than using experienced staff, it required 885 hours (26%) less than would have been expected for using new staff.

A second trial was also carried out with a cherry tomato variety (Claree). However the growth habit of this crop type was such that it had both a brittle stem and it tended to grow away from the string. The pressure point against the wire ring and marking caused by the ring meant that head breakage was high. This trial was therefore stopped.

Task separation

As previously highlighted the ring & clip trial used some of the principles of task separation. In addition, task separation was applied for a short period to several experienced staff in other greenhouses to identify additional work-rates. (see Table 2 below)

Table 2 – Individual task work-rates

Task	Average work-rate (heads/hour)
Layering alone	2,250 – 2,750
Twist + side-shoot + truss prune	450 – 525
Truss prune alone	2,400 – 3,000
Layer + side-shoot	750 - 850
Ringing	2,000 – 2,250
Clipping alone	1,000 – 1,250

In the case trialled, task separation reduced the overall work-rate of an experienced worker when she was required to complete all tasks. However this result was influenced by the growth habit of the specific variety (Aranca) which was not suited to certain aspects of task separation. The high growing density and a tendency for the plant to grow away from the string meant that it was difficult to twist. Layering at the same time as twisting means that a space is created between the plants which makes twisting easier. Separating layering from twisting removed this benefit.

Feedback from the Netherlands (where task separation is routinely applied) confirms that task separation is not viewed as a means of improving the work-rate of experienced staff. The main benefit is that experienced staff can focus on tasks that require the highest level of skill and experience e.g. twisting. With task separation new staff can start work on simple tasks such as leaf removal. This allows them to achieve an acceptable work-rate relatively easily. It also gives nursery management the opportunity to identify workers with the potential to carry out the more difficult tasks.

It is regularly commented that a good crop worker can improve yields by as much as 30% compared to an inexperienced one. There is little doubt that this is due to the quality of all the crop work (layer, twist, side-shoot etc.). However focussing their efforts on the most skilled tasks is likely to deliver improved yield over a larger area.

The conventional UK approach of fixed area working limits the ability to realise the full benefits of task separation. The successful implementation of task separation on a large scale requires all staff to start at one end of the greenhouse and work

towards the far end together. The challenge of this approach is to maintain 'ownership' of work and therefore maintain quality. With this in mind a trial to fully implement task separation will be carried out in 2006.

The use of improved tools & equipment

Hydraulic variable height work platform

A hydraulic lift work platform was compared to a platform with manual height adjustment. All operators gave positive feedback in favour of the hydraulic version and said that it made the work easier.

However this was not reflected in increased work-rates. Several factors were thought to have affected this result:

- The height of the guard rail on the platform tested was too high and caused unnecessary obstruction to the operator. The actual height of the guard rail was 1,100mm compared to a minimum allowable height of 950mm.
- A single stop/start floor pedal restricted the ability of the operator to use the full length of the platform in combination with the easily varied speed control.

A platform has subsequently been modified to incorporate a 950mm high guard rail and improved 2-pedal control. The control pedals are located at each end of the platform. Pressing and releasing either pedal will start the platform moving when it is stationary or stop it when it is moving. Trials with this platform will continue into 2006.

Powered picking trolley

A drive unit designed to retrofit onto an existing picking trolley was trialled. The unit was a commercial prototype (B-lorry) developed and manufactured by Berg Produkt De Lier BV. The design concept for the B-lorry was that it was a cheaper alternative to buying a fully integrated picking cart and drive unit.

The unit was tested on a vine crop grown under lights. A variety of practical issues relating to both the design of the B-lorry and the specific layout of the greenhouse where it was tested meant that no improvements in work-rate were recorded. However experience gained during the test suggests that it will perform better in a loose tomato crop. Trials will continue into 2006.

Ergonomically designed secateurs

A total of 12 different designs of secateur were identified as having potential application for harvesting tomatoes on the vine. They were assessed using a panel made up of both growers and crop pickers. As a result two designs were picked as having the greatest potential. Five pairs of each design were subsequently trialled with a picking team.

Photographs of the secateurs selected are shown overleaf.



Results from the trial were that they unanimously agreed that their existing secateurs (ARS310) were preferable to the alternative designs.

Closer examination (using video) of how the secateurs were used showed that they were mainly held between the thumb and fore-finger. Therefore improved ergonomic design e.g. better handle shape, was of no benefit in practice.

Financial benefits for growers

The principal financial assessment relates to the Priva Ringmaster[®] used in combination with clipping.

The table below gives the costs for top of crop work on 1Ha between weeks 9 – 37 for a range of pay rates. For ring & clip the cost of the clips and wire are included.

These were calculated to be:

- Clips – 609,000 required @ £3.50 per 1,000 = £2,132
- Rings – 609,000 required @ £0.70 per 1,000 = £426
- Total = £2,558

Table 3 – Financial assessment of ring & clip

Labour £/hr	Experienced staff, twisting Labour only	New staff target, twisting Labour only	New staff, ring & clip Labour + consumables	Saving ring & clip vs. new staff target
6.00	£14,136	£20,658	£17,906	£2,752
7.00	£16,492	£24,101	£20,464	£3,637
8.00	£18,848	£27,544	£23,022	£4,522
9.00	£21,204	£30,987	£25,580	£5,407
10.00	£23,560	£34,430	£28,138	£6,292

Although optional, an additional cost of £700 p.a. for a maintenance contract covering the Ringmaster[®] should be included. Therefore at a typical pay rate of £7.00/hr this gives a net saving of £2,937 if the Ringmaster[®] is only used on one hectare of crop. The purchase price of a Ringmaster[®] unit is £5,500 giving a payback on investment in 23 months. However, it should be noted that a single Ringmaster[®] unit would be able to cover 4Ha if used all day.

This financial assessment has not allowed for any possible increase in crop disposal costs that may result from the higher plastic content due to the clips. Whilst non biodegradable string continues to be used and landfill is the main disposal route, clips will not be a problem. However growers should be aware of this potential limitation.

A similar assessment was carried out for clipping every week (Ringmaster® not used). However, the cost of the clips outweighed the value of the labour saving.

Conclusions

Ringling & clipping

- Is a viable alternative to twisting when inexperienced, seasonal staff are required to carry out top of crop work.
- The pressure point created by a ring on the crop stem means that varieties which tend to grow away from the string and where head breakage is high are generally not suitable.
- Marking left on the stem by the rusting metal rings did not cause disease problems in the trial area. However some concern remains. Progress is being made by the manufacturer to reduce the level of marking.
- Although the tasks carried out are simpler than twisting, staff training and attention to detail is required to achieve the best performance.

Clipping

- The cost of clips currently outweighs the labour saving when compared to twisting with new staff.

Task separation

- Will not make an experienced crop worker faster if they continue to carry out all tasks on a fixed area of crop.
- Complete task separation is not possible on all crop types. This is particularly the case with crops grown at a high density and that are known to be difficult to twist using all in one working.
- Can help to reduce fatigue by allowing the optimum work platform height to be adopted for each task. This is particularly significant for the task of layering.
- Allows skilled workers to focus on carrying out skilled tasks e.g. crop training.
- Allows unskilled workers can carry out simpler tasks that are both less critical and easier to learn.

Hydraulic lift work platforms

- Have a clear benefit in terms of ease of operation. This includes ease of getting on/off and infinitely variable on-the-move height adjustment.
- Showed no measurable improvement in work-rate. This was influenced by the specific design features of the equipment tested.
- Single pedal control (as commonly used in the UK) encourages the operator to stay close to the pedal and operate the platform in start/stop mode. This

increases wear and tear on the platform drive system and negates any potential benefits of having a long platform.

- A hydraulic platform modified to incorporate 2-pedal control received positive feedback from the operator. It did not, however, result in an increase in work-rate.

Powered picking cart

- The Berg B-lorry did not deliver any improvement in picking speed with a crop harvested on the vine. This was partly due to design limitations and partly due to the layout of the trial greenhouse.
- The unit was considered to offer greater potential in a loose tomato crop. This will be tested in 2006.

Secateurs

- A model commonly used in the UK, ARS 310, was still favoured by crop pickers after testing a variety of alternatives.
- The highly variable presentation of a truss to the picker means that secateurs are moved within the hand to give an additional degree of movement. This means that secateurs incorporating high levels of ergonomic design are of limited benefit.

Action points for growers

- Growers relying on seasonal staff to carry out crop work should trial the ring and clip method of crop training. This will allow them to ensure that the specific varieties they grow do not suffer from excessive head breakage.
- Growers carrying out their own labour trials must dedicate at least one worker full-time to the new method. It is also preferable that the worker has no prior experience. Otherwise the work-rates achieved are likely to be unrepresentative of what can be achieved with large scale application.
- Thorough staff training should continue even if simplified methods e.g. ring & clip are used.
- Growers should consider using less skilled staff to remove leaves. This will allow skilled crop workers to cover a greater top of crop area without changing their work methods.
- Consider purchasing hydraulic work platforms when replacement equipment is required. Although work-rate improvements have not been recorded, the intangible benefits such as reduced fatigue on staff retention and reduced sickness should not be underestimated.
- If not already available, offer the ARS 310 secateurs as an alternative to existing secateurs. This make and model were almost unanimously preferred by a panel of growers and a specific team of pickers.

Science Section

Introduction & background

Labour costs typically account for over 30% of the unit cost of tomato production and, for most producers, it is the highest single cost of production. Data from UK growers of classic round types show labour costs to fall in the range £9 to £12/m². 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 in excess of £25 million/annum.

It is also widely acknowledged that the recruitment and retention of permanent, skilled staff is increasingly difficult. This has led to the increased use of seasonal staff to overcome labour peaks. Seasonal staff have traditionally been used for the lower skill task of harvesting, however they are increasingly used for crop work. This places additional demands on nursery management such as:

- High demand for staff training.
- A high number of staff operating at below average work-rates due to lack of experience.
- A high demand for staff supervision to ensure acceptable standards of work.

In addition many seasonal staff are of non-UK origin and language barriers can make training and labour relations problematic. They also tend to work for one season only which means that the above points will continue to be applicable for the foreseeable future.

Although the increased use of seasonal staff highlights a variety of labour related issues, they are equally applicable to permanent staff.

Techniques developed to improve the output of seasonal staff will also benefit nurseries where the workforce is dominated by permanent staff. It is therefore widely acknowledged that all businesses in the tomato sector can benefit from improvements in labour utilisation.

This interim report describes the work that was carried out following a review of labour practices in the UK and northern Europe in Year 1 of this project (2004). The work specifically focussed on:

- Alternative crop training systems – Priva Ringmaster® & clipping.
- Task separation.
- The use of improved tools and equipment – work platforms, powered picking carts and secateurs.

Overview of work methods tested

Alternative crop training systems

The most common and long established method of crop training is twisting. This is where the supporting string is twisted (wrapped) around the stem of the plant. This requires no tools or consumables apart from the string and a work platform to ensure the worker is at the appropriate height. However, from a manual task point of view, it requires a high level of dexterity and good hand-eye coordination. Twisting is the most difficult crop working task to learn. Therefore new staff struggle to achieve

good work-rates. Of all the crop work it also has the greatest potential to damage the plant and cause significant yield loss. As a result, a number of alternative crop training systems have been developed to de-skill the task.

Ring & clip

The technique of clipping has been available for many years. Rather than twist the string around the stem, the clip grips the string and encloses the stem within its circumference (see photograph to the right).

Compared to twisting it is a much simpler task so easier to learn. It is also less likely to damage the plant. However it is not in widespread use because:

- Cost of the clips.
- Disposal of the old crop – contains plastic clips.
- Work-rate – considered to be lower than that achieved by an experienced twister.



A more recent development is the Priva Ringmaster[®]. This comprises a hand-tool which forms a metal ring around the stem and the string. With standard string the ring does not support the weight of the plant. It simply holds the stem close to the string. Rings are therefore used every two weeks, alternating with clips.

Claims made for the Ringmaster[®] are:

- Considerably higher work-rates than for clipping.
- The metal rings rust away during composting so disposal is not a problem.
- The cost per ring is much lower than for clips.

As the Ringmaster[®] is a relatively new concept there is little independent information available to verify its performance. There is also some concern regarding damage to the stem where it is in contact with the metal ring.



Task separation

On UK nurseries all top of crop work (layer, train, side-shoot removal, truss pruning) tends to be carried out in one pass through the crop. The logic behind this approach is that time is saved by only having to visit each plant once to complete all the required tasks.

In contrast, many nurseries in the Netherlands apply the principles of task separation. At its extreme, this means that a 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 all the required tasks are completed. The perceived advantages of this approach are:

- Improved quality of work – staff 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.
- Higher work efficiencies achieved for the specific task.
- Improved work posture - work platforms can be set at the optimum height for the task, not a compromise to suit the combination of tasks.
- More flexible staff organisation – allowing experienced staff to focus on the tasks which require the highest level of skill. Whereas simpler tasks can be carried out by less experienced staff.

However, little reliable work-rate data and feedback on practical implications is available from the Netherlands to form an accurate assessment of these potential benefits.

Improved tools and equipment

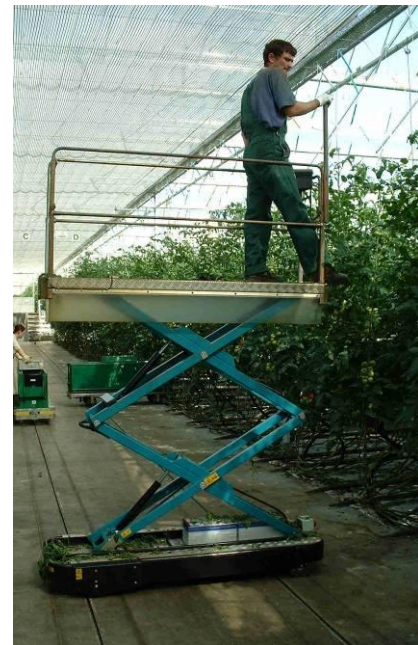
Work platforms

The working height of the majority of platforms can be adjusted to suit the task being carried out. However, most of the platforms used in the UK have mechanisms which require the worker to get off the platform to make adjustments. Workers are actively encouraged to adjust the height to suit the task in hand. However, the inconvenience associated with it means that the height is rarely adjusted as long as it is 'close' to the optimum.

This design of platform also means that the worker has to climb up to the working level and down again whenever he/she changes rows or needs to attend to a ground level problem part way along a row.

Alternative designs are available that incorporate a hydraulically powered scissor action. These allow the height to be adjusted on the move at the press of a button. This can be done whilst the worker is on the platform which means that the working height is more likely to be adjusted to the correct level. In addition, when climbing off the platform, they can be lowered to ground level. This makes the whole process easier, faster and safer. Work platforms of this design are available in the UK and some nurseries now buy them whenever replacement platforms are required. This is despite the fact that they cost around £1,000 more than a manually adjusted design.

Although the practical benefits of hydraulic platforms are clear, there is no reliable data to allow growers to make a well informed purchasing decision.



Powered picking trolleys

Standard practice on UK nurseries is for picking trolleys not to be powered i.e. they are pushed along the row by the worker as they pick fruit.

There is an increasing trend in the Netherlands towards picking trolleys that have a battery powered drive system. The most sophisticated designs include proximity sensors so that they speed up when the worker is close to them (few fruit to harvest) and slow down when the worker is further away (many fruit to harvest). This means that the worker only has to concentrate on picking fruit. In addition the effort required to push a fully laden trolley along the pipe rail should not be underestimated.

Powered picking trolleys also tend to be integrated with automated transport systems which guide the picking trolleys back to the packhouse without the need for any labour input. They are normally re-filled with empty boxes before returning to the greenhouse. This significantly reduces the down time at the end of a row where UK workers have to unload and re-load their trolleys before moving on to the next row.

In addition to the capital cost of such a system, a significant factor restricting the up-take of powered picking trolleys is the site layout on UK nurseries. Site development in the UK tends to be piecemeal which has meant that the packhouse is rarely centrally located and connected to all the greenhouses with a level, smooth, covered path. This makes the adoption of such systems difficult and/or expensive.

The benefits of a powered picking trolley appear clear even without an automated transport system. But once again little reliable information was available to allow an accurate cost benefit analysis to be carried out.

In an attempt to produce a lower cost alternative Dutch equipment manufacturer Berg Produkt De Lier BV have developed a drive unit that can be attached to a nursery's existing picking trolley. This is called the B-Lorry.



Ergonomically designed hand tools

The only hand tools that are regularly used for long periods of time are secateurs for harvesting fruit on the vine. One specific make and model which was originally designed for pruning grapes dominates the market (ARS 310). They are light, compact and have a curved blade which helps to leave the smallest possible stub on the stem. However the handle design and the angle of the cutting head relative to the handle incorporate little in the way of what is considered to be good ergonomic design.

Good ergonomic design was low on the list of purchasing criteria among UK growers and there were no such products being actively promoted by suppliers to the industry.



Objectives

The overall commercial objective of this project was to reduce labour costs in the UK tomato sector.

Specific objectives were:

- Define best practice work-rates and costs for the labour tasks of plant training, de-leafing and harvesting.
- Provide guidelines on how task separation can affect work-rate and quality of work.
- Provide recommendations on simple equipment that is cost effective and improves labour efficiency.

Research method

All the work carried out in 2005 took place at nurseries owned by the Wight Salads Group Ltd and located on the Isle of Wight. Their willingness to participate and the significant amount of time input from their staff were a vital part of this project.

Ring & Clip

Treatments

Two separate 1Ha greenhouse blocks both with a crop of loose round organic variety (Delicimo & Domatica) were compared. Both crops were grown in the soil, the gutter height was 4.0m and the crop wire was attached to the bottom of the trellis beam. The starting crop density was 2.1 heads/m² increasing to a final density of 4.2 heads/m².

House 3 - Ringing & clipping

- **Staff** - Generally of eastern European origin and with little/no previous experience of working in a tomato crop.

- **Work system** – In any week half of the block was ringed and half was clipped. This meant that the whole block was in effect ringed every other week and clipped every other week. Side-shoots and leaves were removed every week.
- **Staff organisation** – The nature of the Ringmaster® is such that it has to be carried out as a single task. Therefore the principles of task separation were applied. However each member of staff carried out all tasks on rows specifically allocated to them.

House 11 – Twisting

- **Staff** – Some of the most experienced staff on the nursery with combined crop working experience of more than 50 years.
- **Work system** – Layering, twisting and side-shoot removal were carried out weekly as one combined task. Leaves were removed every week.
- **Staff organisation** – Staff were allocated a specific number of contiguous rows on which they were responsible for all crop work tasks (standard UK approach).

The Ringmaster® was also used on a smaller area of a cherry tomato (Claree) to identify any practical issues relating to varieties that have different growth habits.

Data collection

Work-rate data

Work-rate data was collected via the nursery's Hoogendoorn Nomad labour recording system and delivered as weekly data to FEC consultants for further analysis.

Quality of work

Quality of work was formally assessed on a monthly basis by Wight Salads Group Ltd. This used a long-established system used in part to determine bonus payments and gave a score of 0–10 (0 = poor, 10 = good). It covered 29 different aspects split into 2 groups:

1. Training.
2. De-leafing.

Task separation

The principles of task separation were applied in the Ringmaster® and clipping part of this project. It therefore provided the majority of the information required to assess the potential impact of task separation. However two common tasks were not carried out in the ring & clip trial, these were:

1. Twisting.
2. Truss pruning.

To provide work-rate data for these tasks and to help identify any practical considerations, task separation was also applied to specific experienced workers. Work-rate data was collected via the nursery's Nomad system.

Improved tools & equipment

Powered picking trolley

Berg de Lier B.V. loaned the project a development version of their B-Lorry for testing. The plan was to:

- Wait until crop development, yield and therefore picking rates had stabilised. This was towards the end of June.
- Allocate the B-Lorry to a worker whose picking rate was below average and record the effect.
- Allocate the B-lorry to a worker whose picking rate was above average and record the effect.

Once again all work-rate data was recorded by the nursery's Nomad system.

Ergonomic secateurs

Research into the benefit of ergonomic secateurs was carried out as follows:

- Commercially available secateurs which incorporated good ergonomic design were identified and purchased.
- A panel of growers ranked the secateurs according to a range of factors.
- A group of pickers ranked the secateurs according to a range of factors.
- The secateurs which ranked highest were field tested and their effect recorded.

Hydraulic variable height work platforms

Testing followed the same structure as that used for the powered picking trolley.

For all parts of this project ongoing support and advice was provided throughout by FEC consultants and an independent tomato labour consultant, Paulus Verzuu. This included regular site visits to ensure that practical observations and comments by both greenhouse management and workers were recorded and acted upon if required.

Results

Ring & clip

Staff organisation

As this was a completely new method of crop training and task organisation it was considered desirable to ensure that all the work carried out on a specific row was done by a single person. This helped to retain the level of ownership and accountability that is considered to be a significant advantage of fixed area, all-in-one crop work. It also gave work-rate data for each task from four different workers. This helped to ensure that a true average work-rate was recorded and that variability between workers was accounted for.

Guidance from Priva and work-rates that were available from the Netherlands suggested that a single Ringmaster® unit was capable of carrying out all the work on 4Ha of tomatoes. Therefore only one unit was used in this trial.

The normal UK method of fixed area working, with all top of crop tasks carried out in one pass through the crop, requires around four workers per hectare (including de-leafing). Their work areas would have been allocated as shown in Figure 2 below.

Figure 2 – Normal fixed area allocation



The Ringmaster[®] comprises two parts. The base unit which is located on the work platform and the hand-tool unit.

For ease of reloading with new spools of wire it was best to mount the base unit on a hydraulic scissor-lift work platform.

Adopting the normal method of fixed area allocation would have meant considerable movement of the Ringmaster[®] from one end of the greenhouse to the other each day. This would have incurred considerable down-time and a reduction in work-rate.

Therefore work areas were allocated as shown in Figure 3 overleaf.



Figure 3 – Ring & clip trial, work area allocation plan

	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	
	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	
	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	
	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	
	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	
	Worker 1	
	Worker 2	
	Worker 3	
	Worker 4	

This meant that all crop workers progressed along the greenhouse through the week and were rarely far apart. This ensured that the Ringmaster[®] was always close by when needed. The work-rate achieved with the Ringmaster[®], combined with the fact that it alternated with clipping meant that it was capable of covering an area of 4Ha. Therefore it was only 25% utilised in the trial and it was easy for the crop workers to synchronise with each other to ensure that they did not have to wait for it.

From a management point of view the area allocation system used in the ring & clip trial made it easier to track work progress according to schedule. This was because all work up to a certain row number should have been completed each day. This contrasts with the need to check how far each individual worker has progressed when using the area allocation approach as shown in Figure 2.

A simple and cheap system to help identify which rows were allocated to each worker was to use coloured sticky tape on the crop wire at the end of each row.

Task organisation

As the Ringmaster[®] requires the use of a bulky hand-tool, applying all-in-one working would have required the worker to pick up and put down the hand-tool each time a single ring was applied. This would clearly have been an inefficient way of working. In addition it would also have meant that each worker would have required their own Ringmaster[®] and utilisation of the equipment would have been very low. Therefore ringing was carried out as a single task operation.

In any given week half the greenhouse was ringed and half was clipped. It was considered beneficial from an organisational point of view to ensure that the remaining tasks followed a constant work pattern regardless of whether the crop was ringed or clipped.

The remaining top of crop tasks included layering and side-shoot removal. These two tasks took place at a similar work height and movement from one to the next followed a natural, flowing path. It was therefore decided to combine these into a single job. Each head was layered and the side-shoots were removed before moving on to the next head.

Work-rates

Work-rates presented as the average number of heads per hour in each week are shown in Figures 4 and 5 below.

Ringling

Figure 4 – Ringling



After a slow start (1,000 heads/hr) the work-rate made a significant

step increase in week 14 and showed continuous improvement throughout the season. The reason for the step increase in week 14 was attributed to several contributing factors:

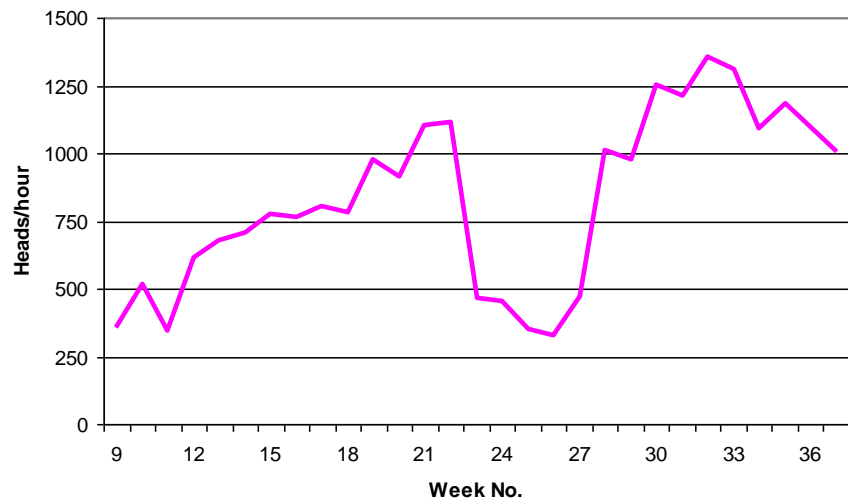
- Density increased from 2.1 to 4.2 heads/m². This meant that there was less distance to travel between heads.
- Increased work pressure due to higher density.
- Increased focus on labour efficiency by management once the plant density was fully established.

Short term dips in work-rate were normally due to a focus on work quality following feedback from management.

The work-rate quoted by Priva for the Ringmaster® was 1,500 heads/hr. This was shown to be easily achieved and an experienced worker can be expected to achieve a work-rate of over 2,000 heads/hr. During the last 10 weeks the fastest worker achieved an average of 2,414 heads/hr compared to the slowest at 1,883 heads/hr (28% more).

Clipping

Figure 5 – Clipping
work rate



This showed a steady increase to 750 heads/hr. There was however little improvement from week 15 to week 18. Following a site visit and some suggested improvements the work-rate reached 1,000 heads/hr. These improvements focussed on clip supply:

- Clips were originally in a box mounted at one end of the work platform. This meant that when travelling in one direction clips were first picked up with the left hand and then transferred into the right hand before application. Moving the box so that it was always to the right hand side of the worker, regardless of direction of travel, eliminated this non-productive transfer between hands.
- The addition of a waist mounted bag to hold clips reduced hand movement even further.

These may seem to be simple, even obvious considerations but they highlight the effect of poor workplace organisation. In addition, although clipping requires a lower skill level than twisting, it demands the same attention to detail otherwise work-rates will suffer.

A significant and prolonged drop in work-rates occurred between weeks 22 and 27. This was due to a change in work method. Considering the relative location of each task, clipping and side-shoot removal take place very close together.

Paulus Verzuu demonstrated that on a single row he could achieve a work-rate of over 1,000 heads/hr when clipping and side-shooting as a single job. This work method was applied between weeks 22 and 27 with the expectation that a work-rate of 800 – 900 heads/hr could be achieved. In practice a work-rate of only 410 heads/hr was achieved. The reasons for this could not be explained and a second visit by Paulus Verzuu was arranged.

During this visit he worked with each crop worker individually. This showed that a work-rate of 750 heads/hr was possible. It was suggested that as the crop workers had become used to clipping as a separate task that any change to their work method had become difficult to implement. Therefore the old work routine was continued until the end of the season.

As a guide, for clipping alone, a work-rate of 750 heads/hr should be easily achieved with minimal experience. An experienced worker should be able to achieve over 1,000 heads/hr. During the last five weeks the fastest worker achieved an average of 1,138 heads/hr compared to the slowest at 963 heads/hr (18% more).

Layer & side-shoot

Figure 6 –
Layer and
side-shoot
work rate



With virtually no learning time the average work-rate achieved was 700–750 heads/hr. Following a dip in week 19 due to a focus on quality there was a significant rise to 800–850 heads/hr. This coincided with a change in crop height in week 20. Prior to week 21 the crop was grown up to the wire but not above it. However growing the crop above the wire is possible when the crop is not twisted. This was done from week 21 onwards to raise the height of the fruit being harvested. A secondary benefit was to bring the working height of layering and side-shoot removal closer together which helped to improve the work-rates by 100 heads/hr.

The drop in work-rate around week 29 was also due to a focus on quality.

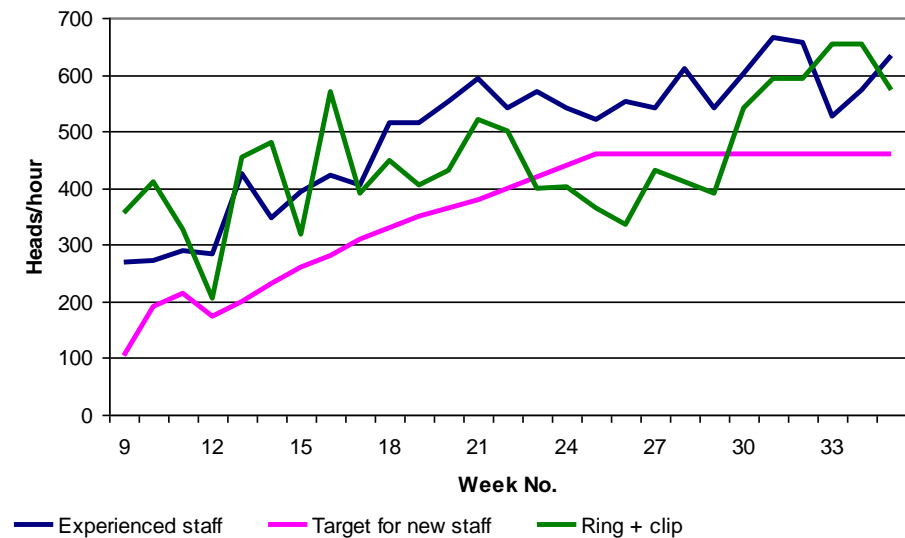
The work-rate appears to have fallen from week 34 onwards. This was due to a reduction in density. However, although the amount of side-shoots to remove was reduced, the heads that were stopped still required layering. These figures are therefore misleading.

As a guide, for layering and side-shooting combined, a work-rate of 700 heads/hr should be easily achieved with minimal experience. An experienced worker should be able to achieve over 800 heads/hr.

During the last five weeks the fastest worker achieved an average of 944 heads/hr compared to the slowest at 855 heads/hr (10% more).

Combined work-rates

Figure 7 – Top of crop work combined



Ring & clip vs experienced workers

The overall combined work-rate for top of crop work with ring & clip was compared with two other scenarios:

1. The work-rate actually achieved by experienced workers carrying out twisting, layering and side-shoot removal as a single job.
2. The Wight Salads Group Ltd target for new staff carrying out twisting, layering and side-shoot removal as a single job.

Figure 7 above shows how all three scenarios compare as the season progressed.

During the first three weeks ring & clip appeared to be faster than the experienced workers. This was a false figure as slight differences in sowing dates meant that the ring & clip crop was not being layered. The work-rate dropped significantly in week 12 when additional heads were taken. Observations and comments received showed that tying in an extra head was more difficult in the ring & clip area. This appeared to be due to the fact that the string and stem were no longer a single intertwined item but tended to be separate. This formed an additional barrier to negotiate when tying in the new shoot.



There was some degree of variability in overall work-rate whilst work methods stabilised. By week 18 ring & clip had stabilised at approximately 100 heads/hr lower than the work-rate achieved by the experienced staff. However, further refinements in technique, as discussed earlier, closed the gap to less than 50 heads/hr. The big difference from week 22 – 27 was due to alternative work practices being tested. From week 30 onwards work-rates were similar at around 600 heads/hr.

Ring & clip vs Target for new staff

Apart from the period between weeks 22–27 when alternative work methods were tested, ring & clip was always faster than the target for new staff.

Figure 8 –
Total hours
worked

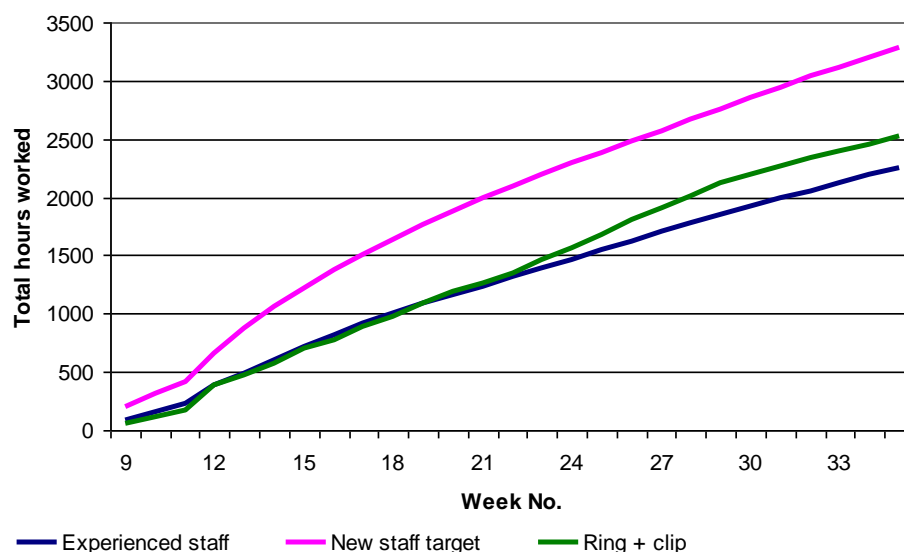


Figure 8 above shows the total hours of top of crop work in each scenario. Ring & clip was consistently less than the new staff target. It was almost identical to the experienced staff until the change in work method in week 22 where it consistently took longer until week 28 when the previous work method was reinstated.

The total time spent carrying out top of crop work from week 9 to week 37 inclusive is shown in Table 4 below. Additional data, ring & clip (clean data), has been added for clarity. This removes the unsuccessful work method applied from weeks 22 – 27 from the analysis. Data for clipping every week i.e. not used, was calculated using the recorded work-rates.

Table 4 – Top of crop work, total hours

	Total hours worked	As % of experienced staff hours	Difference compared to experienced staff (hours)
Experienced staff (all in one work, twisting)	2,356	69%	1,087 less
New staff target (all in one work, twisting)	3,443	100%	n.a.
Ring & Clip (new staff, raw data)	2,669	78%	774 less
Ring & Clip (new staff, clean data)	2,558	74%	885 less
Clip only (new staff)*	3,052	89%	391 less

* Calculated from recorded data

Quality of work

Table 5 – Ring & clip work quality

	Worker A	Worker B	Worker C	Worker D	Average
Training	9.3	8.8	9.4	9.1	9.2
De-leafing	9.8	10.0	9.9	9.5	9.8
Average	9.6	9.4	9.6	9.3	9.5

Table 6 – Conventional work quality

	Worker A	Worker B	Worker C	Worker D	Average
Training	9.8	9.6	9.7	9.0	9.5
De-leafing	9.8	9.7	9.8	9.4	9.7
Average	9.8	9.7	9.8	9.2	9.6

Note – 0 = bad, 10 = good

Training

The average quality of work for the workers using ring & clip was slightly lower than those using conventional work methods. Closer investigation showed that the most significant factor contributing to this was the quality score for side and mid shoot removal. The average score for ring & clip was 7.8 compared to 8.3 for conventional working. Considering the potential causes of this there was little evidence to suggest that this was caused directly by ringing & clipping.

In contrast, the average score for head breakage was 9.5 for ring & clip compared to 9.1 for conventional work methods. This supports the belief that ring & clip should cause less head breakage. This is because the plant is handled to a much lesser extent than when twisting.

De-leafing

The average quality of de-leafing was slightly higher in the ring & clip area. Prior to the trial it was suggested that de-leafing would be more difficult and likely to leave stubs because the clip would be an obstruction. No such effect was noted.

Miscellaneous practical and plant observations

The copper coated wire from which the rings are formed caused slight marking where they made contact with the stem of the plant (see photograph opposite).

This initially caused some concern in the 1Ha trial with the loose round crop. However, it did not prove to be a problem. There was no stem breakage or botrytis associated with these marks. However, the stem of the cherry type variety trialled (Claree) had the tendency to grow away from the string. It was also known to be brittle and prone to head breakage. The level of head breakage using ring and clip with this crop proved to be so high that the trial was stopped.



A plastic coated wire is under development to try and reduce damage of the type shown in the photograph above.

Priva are also testing a development called 'gap cord'. This is a replacement for conventional string which holds the ring and allows it to support the weight of the plant. A small area of gap cord was tested but the ring tended to cut into the stem so the trial was stopped.



Priva 'Gap Cord'

Task separation

A number of the aspects of task separation were tested as part of the ring & clip trial. To obtain further information with other tomato varieties and tasks, task separation was applied to an additional worker.

To fully test the potential and limitations of task separation it was decided to test the approach with a variety that was known to be difficult to work with (Aranca). It was also decided that a worker with physical strength limitations should be included. This would show how removing the most physically demanding tasks would affect performance.

For the reasons explained above the worker used for the study was an experienced crop worker who had a history of back and shoulder problems. To isolate the most physically demanding task i.e. layering, the top of crop work was split into two passes as detailed below:

- Job 1 - Layering alone.
- Job 2 - Twist + side-shoot + truss prune.

To encourage the optimum work height to be adopted for each task a hydraulic scissor lift work platform was used.

Data for this modified work method was collected over a period of six weeks. This allowed the crop worker to get used to the new approach and reach a stable work-rate.

Table 7 – Average work-rates achieved

	Work-rate – heads/hour
All-in-one (layer, twist, side-shoot, truss prune)*	457
Layer alone	2,469
Twist + side-shoot + truss prune	470
Combined	395

* Average of previous three weeks before task separation was applied

Layer alone

In the first week the work-rate was 2,090 heads/hr. This gradually increased to 2,752 heads/hr by the sixth week.

A notable comment made by the worker was that even though she was still layering the same number of heads each day she did not experience the same level of fatigue at the end of the day and her shoulders were less stiff. This was attributed to the following:

- The height of the platform was always adjusted to the correct height for layering alone and no compromise was required to account for other tasks being carried out at the same time.
- Although all-in-one working gives continuous variation in tasks, the frequency of rotation (approximately 7 seconds) is not enough to allow the muscles to relax and recover from the previous layering movement. In contrast applying task separation gives significant breaks between periods of layering.

Twist, side-shoot, truss prune

The work-rate achieved for this task combination was relatively stable at around 470 heads/hr with little improvement over the six week period. The work-rate achieved was only slightly higher (13 heads/hr more) than the all-in-one work-rate. This was due to:

- Growth habit of the plant – it tended to grow away from the string.
- Density – 4 heads/m².

The growth habit of the plant made it an inherently difficult plant to twist without excessive head breakage. All-in-one working meant that, as each plant was layered, a space was created within the row. This meant that there was less chance of the head of the plant snagging or being damaged on neighbouring plants during the twisting operation. Layering as a separate task meant that this space no longer existed, therefore making the twisting task more difficult. In addition the number of broken heads was greater thereby increasing the time required to tie in new shoots.

The relatively high density compared to many Dutch growers further compounded this problem.



Truss pruning

A separate trial was carried out to determine the work-rate for truss pruning alone. This gave results that varied from 2,400 to 3,000 heads/hr.

A possible additional benefit of truss pruning as a separate task could be improved accuracy of pruning. Rather than pruning a one week old truss, they could be left for longer. This would allow fruit set to be more accurately assessed. A possible limitation of this approach is that, when left for longer, it is more difficult to cleanly remove the excess fruit using the thumb and forefinger. This is likely to increase the time taken to complete the operation. However, the benefits resulting from improved accuracy of truss pruning such as faster picking and packing could be worth it for specific markets.

Task order

With the crop of Aranca it was found that, if layering was carried out first, the new growth on the plant leant out further into the path. This made it prone to mechanical damage as the work platform returned along the path. It was therefore necessary to twist the crop before layering was carried out.

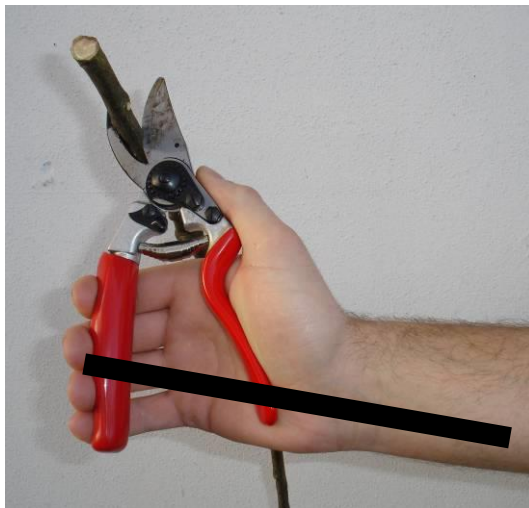
Improved tools & equipment

Secateurs

Twelve alternative designs of commercially available secateurs were identified as having some features of potential benefit / interest. Specific focal points were:

- Handle design – shape, size, texture / material.
- Handle to cutting head orientation.
- Cutting head design – size & shape.

The objective was to improve the ergonomic standard of the equipment used whilst at least retaining the current work-rate.



The photographs above demonstrate a number of these features. The handles are shaped to ensure a good fit within the palm and for the fingers. This feature spreads the force of the cutting action across the whole hand and reduces pressure points.

The black lines show the alignment of the wrist and hand. The photograph on the right hand side shows bad wrist position. Here the wrist and hand are not aligned. Where significant, repeated cutting force is required this position can lead to wrist strain. The photograph on the left shows the hand and wrist alignment following an almost straight line. This position is least likely to cause strain. To aid the adoption of this posture the cutting head is angled relative to the handles.

The 12 secateurs short-listed for assessment incorporated a number of these features. These secateurs, plus an assessment form, were given to a group of growers and crop pickers for evaluation. The outcome of this exercise was that the following two pairs showed the greatest potential.



Darlac Ergonomic Snips

Bahco P129 Snips

Five pairs of each of these secateurs were purchased and given to a picking team to use. The result was unanimously negative. Their existing secateurs (ARS 310) see below, were considered to be superior. It is possible that the result was affected by the fact that the staff were used to their existing secateurs and were therefore predisposed to preferring them. However, detailed analysis of the way the secateurs were used showed that they were rarely held fully in the palm of the hand. In practice the tendency was to hold them between the tips of the thumb and one or two fingers. This allowed an additional degree of freedom when aligning the cutting head with the truss. Therefore the shape of the handle was of little consequence and as the cutting force was low, the need to align the hand and wrist to avoid strain was minimal.



The dominant factors behind choice of secateurs for harvesting vines of tomatoes were:

- Light and compact.
- Low-force spring opening – easy operation with just thumb and one finger.
- Short handles – greater flexibility on position in the hand.

A design feature of the ARS 310 secateurs that was considered by many growers to be a significant advantage was the curved cutting surface. This meant that when harvesting a truss a clean finish without a stub end was left on the stem. This was considered to present a lower disease risk.

Hydraulic variable height work platform

A crop worker who achieved average work-rates was allocated a hydraulic scissor lift platform to work with and his work-rates were monitored. A number of features of the hydraulic lift platform were found to be limiting.

Guard rail height

All-in-one working was used and truss pruning was required. With this work method it became immediately apparent that the height of the guard rail on the new work platform was higher (1,100mm) than the previous one (910mm). Combined with the

specific worker's height it caused significant restrictions on the way work was carried out. When the platform height was correctly adjusted for layering and twisting, the guard rail tended to obstruct truss pruning in the lower part of the work zone. Slight variations in crop height and the height of the truss to be pruned meant that the worker had to work both above and below the guard rail. The net effect was that the new work platform actually reduced work-rates.

To address this situation the following two approaches were taken:

- Truss prune as a separate task.
- Investigate the health and safety requirements for guard rail height.

By carrying out truss pruning as a separate task and allowing the height of the platform to be changed to suit, work-rates of 2,400 heads/hr (variety Temptation) and 3,000 heads/hr (variety Campari) were achieved. The work-rate for the remaining tasks (layer, twist, side-shoot) was 447 heads/hr in both cases. This gave a combined work-rate of 377 heads/hr and 389 heads/hr respectively. This compared to an initial work-rate of 410 heads/hr before work platforms were changed. Truss pruning every other week was tested but this was limited by the inability to cleanly remove fruit from the oldest truss using the thumb and forefinger.

The Work at Height Regulations were updated in March 2005. Any work platforms purchased or modified after this date have to comply with the new regulations. Within these regulations mobile work platforms are required to have a guard rail that is a minimum of 950mm (previously 910mm) and a maximum of 1,100mm above the height of the platform itself. Therefore the guard rail on the work platform used in this trial could have its height reduced to 950mm whilst still complying with the Work at Height Regulations.

Controls

The control system commonly used on work platforms in the UK has a single, foot operated pedal at one end. The pedal can normally be configured to either move or stop the work platform when pressed. The common choice is to use 'move when pressed'. The majority of UK crop workers operate their work platform in 'start-stop' mode i.e. they press the pedal briefly to move the work platform after they have completed the work on each plant. This means that they have to stay next to the pedal.

One perceived benefit of a long work platform is that it allows greater freedom of movement for the crop worker. This allows the worker to move along the platform and deal with problem plants without the need to stop the platform moving. However the one pedal control system restricts their ability to do this because whenever the platform has to be stopped they may be too far away from the pedal. With this in mind the challenge is to:

- Allow the platform to move continuously.
- Give the worker the freedom to move on the platform.
- Allow the platform to be easily stopped wherever the worker is stood.

The solution developed to meet these requirements was two pedals, one at each end of the work platform with the following mode of operation:

- Press either pedal to start the platform moving. Motion continues when the pedal is released.

- Press either pedal to stop the platform. The platform remains stationary when the pedal is released.

A work platform was modified to incorporate two pedal control as described above. In addition the guard rail height was changed to 950mm. This enabled both these improvements to be tested.

Due to the late start of this part of the project (and unforeseen delays in completing the modifications including a safety inspection) reliable comparative work-rate data could not be recorded. However, the work platform has continued to be used in a winter crop of tomatoes grown under supplementary lighting. Comments from the crop worker have been positive from a work method point of view but an increase in work-rate has not resulted.

Powered picking trolley

A pre-production prototype of the B-lorry as described in Section 2.3 was delivered to the nursery in September 2005. This late arrival date did not allow definitive work-rate comparisons to be made because of the rapidly reducing yield. Despite this some useful feedback has been received from tests carried out in a winter tomato crop.

Initial reactions were that it was bulky and occupied a significant amount of space between the already restricted rows of plants and pipes. In practice this proved not to be a major problem.

However, several other practical issues were evident, the most problematic of which were:

- When changing direction the control box has to be moved from one end of the trolley to the other. The spring loaded cable return mechanism made this difficult, as did the limited space to move around the trolley.
- The sensor which tracks the location of the picker was difficult to position and set correctly. The effect was especially important when trying to place a vine neatly in a box as the trolley continues to move when it is approached.

Some of the problems relating to space and contact with the crop were exaggerated as the tests were carried out on a crop that was inter-planted.

On balance it was concluded that the B-lorry was likely to be most suitable for use with a loose round crop. This is because accurate placement in a tray is not critical with this crop type. Tests will be carried out in 2006 with a normal season loose round crop.

Financial assessment

Ring & clip

Costs provided by Priva are as follows:

- Ringmaster® unit purchase cost £5,500 each

- Maintenance contract £700 p.a.
- Wire £0.70 per 1,000 rings

In addition clips need to be purchased. Non biodegradable clips were used in this trial at a cost of £3.50 per 1,000 clips.

During the early part of the season it was assumed that the crop was twisted as there is generally enough skilled labour available. On this basis it is assumed that ringing & clipping starts on week 9 and continues to week 37.

Assuming that the crop is clipped / ringed on alternate weeks and a density of 4.2 heads/m² is used throughout:

- Total number of clips required on 1Ha = 609,000 (£2,131)
- Total number of rings required on 1Ha = 609,000 (£426)

The results shown in Table 8 below show the total cost at various rates of pay (see Appendix 1 for more detail). In the case of ring & clip the cost of rings and clips has been added. However the initial capital cost and ongoing maintenance cost have not been included as this is dependent on the area of crop that the Ringmaster® is used on.

Table 8 – Ring & clip cost comparison (labour + consumables)

Labour £/hr	Total cost for different rates of pay			Saving - ring & clip vs. new staff target
	Experiment staff twisting	New staff target twisting	New staff ring and clip	
5.00	11,780	17215	15348	1867
5.50	12958	18937	16627	2310
6.00	14136	20658	17906	2752
6.50	15314	22380	19185	3195
7.00	16492	24101	20464	3637
7.50	17670	25823	21743	4080
8.00	18848	27544	23022	4522
8.50	20026	29266	24301	4965
9.00	21204	30987	25580	5407
9.50	22382	32709	26859	5850
10.00	23560	34430	28138	6292

Table 9 – Ring & clip, saving after maintenance cost

Labour £/hr	Saving - ring & clip vs. new staff twisting	Saving after maintenance cost			
		1Ha	2Ha	3Ha	4Ha
5.00	1867	1167	1517	1634	1692

5.50	2310	1610	1960	2076	2135
6.00	2752	2052	2402	2519	2577
6.50	3195	2495	2845	2961	3020
7.00	3637	2937	3287	3404	3462
7.50	4080	3380	3730	3846	3905
8.00	4522	3822	4172	4289	4347
8.50	4965	4265	4615	4731	4790
9.00	5407	4707	5057	5174	5232
9.50	5850	5150	5500	5616	5675
10.00	6292	5592	5942	6059	6117

Table 9 shows the final saving per hectare after an allowance for the maintenance cost for areas from 1 to 4Ha. With a typical pay rate of £7.50/hr and 1Ha of crop a net saving of £3,380 is achieved. This gives a payback on investment of 20 months.

However, in all cases experienced staff using conventional work methods cost less than new staff using ring & clip.

Note that these costs are only for top of crop work for the period from week 9 to week 37. They do not include any other labour requirement for the tomato crop.

Clipping

The labour requirement for a crop that has been clipped every week has been calculated using the work-rate data recorded in the ring and clip trial. For the period from week 9 to week 37 a total of 3,052 hours would have been required for 1Ha.

Under this scenario the purchase cost of the Ringmaster®, maintenance and wire are eliminated. However twice as many clips are required and the total increases to 1.2 million. The total cost of these clips (£3.50 per 1,000) is £4,263.

Table 10 overleaf gives a summary of the cost of clipping every week. Regardless of the hourly rate paid, clipping was always more expensive than the alternatives of new staff twisting and ring & clip. For example at a typical rate of £7.50/hr clipping was £1,330/Ha more expensive than twisting.

Table 10 – Clipping cost comparison

Labour £/hr	Total cost – labour + consumables		
	New staff - twisting	New staff - ring & clip	New staff - clip only
5.00	17215	15348	19523

5.50	18937	16627	21049
6.00	20658	17906	22575
6.50	22380	19185	24101
7.00	24101	20464	25627
7.50	25823	21743	27153
8.00	27544	23022	28679
8.50	29266	24301	30205
9.00	30987	25580	31731
9.50	32709	26859	33257
10.00	34430	28138	34783

Discussion

2.2 Ring & Clip

Ring and clipping on alternate weeks achieved work-rates comparable with experienced staff using conventional work methods. Most importantly it was significantly higher (36%) than the target for new staff using conventional crop training methods. However, experience with the cherry variety Claree clearly showed that it was not suitable for all tomato varieties. Varieties that have brittle, easily broken stems that grow away from the string tend to be unsuitable for ringing as excessive head breakage can occur.

Ring & clip made significant labour savings compared to the new staff target during the first 10 weeks. This highlighted the ease with which the task could be learnt compared to twisting. It should be noted that the block supervisor and grower manager were also learning how to apply ring & clip for the first time. It was felt that had they been more experienced at the start, training new staff would have been faster therefore delivering an even better result. It also became clear that even though the tasks were less complex and easier to learn, time invested in training new staff should not be reduced. The benefits of a focus on technique and workplace organisation were demonstrated by an increase in work-rates following early site visits.

Even in the loose round crop there was some initial concern about marks left on the stem by the metal rings. It was thought that they would increase the likelihood of broken stems. This was proven on the cherry variety Claree but not on the organic loose round variety Delicimo. It was also thought that the marks would serve as a point of entry for disease. There was no evidence to suggest that this was the case. Priva continue to develop the Ringmaster[®] and one recent development is a plastic coated wire. This is intended to reduce the marking left by the rings on the stems.

Clipping

The total hours for clipping alone were calculated using the work-rate data recorded during the ring & clip trial. This showed a saving of 391 hours (11%) compared to the new staff target for twisting. However the cost of the clips was greater than the labour saving even at the maximum pay rate assumed in the calculations (£10/hr).

Compared to ring & clip, clipping alone took 494 hours longer. Savings would be made on the purchase and maintenance costs for the Ringmaster®. However, these were easily outweighed by the additional cost of the clips.

Task separation

Due to the nature of the ringing task, task separation had to be applied as part of the ring & clip trial. This provided valuable information and experience relating to the concept of task separation. As all crop workers carried out all tasks it was possible to compare individual work-rates for different tasks / combinations of tasks. Differences of up to 28% were recorded and the fastest worker for one task was not necessarily the fastest for all tasks. Developing the concept of task separation further would have allowed the workers to focus their efforts on what they did best. A conservative estimate suggests that an improvement in overall work-rate of 10% could have been achieved. However, it is not generally practical (or desirable) for one worker to carry out a single repetitive task all the time. In addition to simple boredom and tiredness (due to constant use of the same muscles), health and safety issues relating to upper limb disorders also need to be considered.

One benefit of task separation is that the working height can be optimised for each individual task. This contrasts with the practice of operating at a compromise height as is often the case for all-in-one working. This was demonstrated in the trial when a crop worker continued to carry out the full range of tasks on rotation but noted a significant reduction in fatigue at the end of each day.

Task separation was applied to an experienced crop worker. She continued to carry out all tasks and the result was that her overall work-rate reduced. However, the result was affected by limitations relating to plant density / growth habit. This demonstrated that, although some degree of task separation is possible for all crop types, complete task separation may not be possible.

Discussions with growers in the Netherlands confirm that task separation is not viewed primarily as a means of reducing the total labour requirement in terms of hours. More important is the benefit realised by using inexperienced staff to carry out the lower skill / less critical tasks. This allows experienced staff to focus on skilled tasks such as twisting. This appears to be of even greater potential benefit to UK growers where seasonal staff are used for crop work to an even greater extent.

Although not tested it was clear that applying task separation in this way whilst continuing with experienced staff working in a single block of adjacent rows would be difficult. This is because it would require the lesser skilled staff to almost continuously move around the greenhouse working on a few rows at a time for each skilled worker. This would be both difficult to manage and could create conflicts if work was not completed on time ready for the next worker. Discussions with Paulus Verzuu coupled with experience gained with the ring & clip trials suggest that adopting a similar row allocation pattern would alleviate many of these problems.

Hydraulic lift work platforms

There is little doubt that hydraulic lift work platforms deliver a variety of benefits even when operated with a single pedal in stop / start mode. For example they are:

- Easier & safer for operators to get on and off.

- Easier to adjust to the correct working height.

However, limitations relating to the guard rail height meant that the work carried out towards the end of the 2005 season failed to record any improvement in work-rate.

The work platform that was modified to have the correct guard rail height of 950mm and two-pedal control has produced positive feedback from the member of staff using it. However complications relating to an inter-planted crop meant that a reliable work-rate comparison was not possible.

This aspect of the work will continue to be pursued in 2006.

Powered picking cart

The retrofit power unit supplied by Berg Produkt De Lier BV (the B-lorry) suffered significant delays during development and was only delivered to site towards the end of the normal cropping season. Trial work in a crop grown with supplementary lighting revealed the following limitations:

- Reduced working space between the pipe rails.
- The control system increases the trolley speed when the worker is close to the sensor. This makes it difficult to accurately place a truss in its individual tray.

Unfortunately the first point is not easily overcome as it is inherent in the design of the B-lorry. However, it should be possible to reduce the impact of the second point by modifying and fine tuning the control system. It was believed that in its current format the B-lorry offered the greatest potential with a loose tomato crop.

Purpose built powered picking carts, such as those used in the Netherlands, are regularly combined with automatic transport systems. These use a system to guide the cart back to the packhouse. In many cases they are automatically unloaded and reloaded with empty boxes before they return to the greenhouse. In addition to removing the need to physically push the picking cart along the rows, using these systems mean that crop pickers do not have to load / unload their carts at the end of each row (as is the norm in the UK). The response of UK growers to this system tends to be that it is not practical to implement on their nurseries. This is because UK nurseries tend to be much more fragmented than nurseries in the Netherlands. As a consequence they do not benefit from a single, level path connecting the greenhouse to the packhouse. Therefore automatic guidance back to the packhouse is, at best, difficult and expensive to implement. This generally means that the complete system is considered to be expensive and impractical and it is therefore ruled out.

The B-lorry was trialled because it was believed that it had the potential to increase picking rates and it did not need the greenhouse to packhouse guidance system. Therefore it would be reasonable to assume that a purpose built powered picking cart has the potential to increase picking rates. A purpose built powered picking cart would also address some of the practical issues encountered whilst trialling the B-lorry.

Secateurs

The secateurs commonly used for harvesting vine tomatoes incorporate little in the way of good ergonomic design. However, the highly variable location / presentation of the truss to the worker meant that, in practice, the secateurs were constantly repositioned in the hand. This gives an extra degree of movement and helps to avoid awkward hand-wrist positions. The force required to cut a truss was small which

reduced the potentially harmful effect of applying the cutting force through only the thumb and index finger. Therefore, when compared to the different designs of secateur assessed and tested, the design already in common use (ARS 310) was found to be the most satisfactory by grower managers and crop pickers.

Conclusions

Ring & clip

- Is a viable alternative to twisting when inexperienced, seasonal staff are required to carry out top of crop work.
- The pressure point created by a ring means that varieties which tend to grow away from the string and/or where head breakage is high are generally not suitable.
- Marking left on the stem by the rusting metal rings did not cause disease problems in the trial area. However some concerns remain. Progress is being made by the manufacturer to reduce the level of marking.
- Although the tasks carried out are simpler than twisting, staff training and attention to detail is required to achieve the best performance.

Clipping

- The cost of clips currently outweighs the labour saving compared to twisting even when inexperienced staff are carrying out the work

Task separation

- Will not make an experienced crop worker faster if they continue to carry out all tasks on a fixed area of crop.
- Complete task separation is not possible on all crop types. This is especially the case for crops grown at a high density that are known to be more difficult to train using conventional working.
- Allows the operator to work at the ideal height for each specific task. This was shown to reduce fatigue when a crop worker continued to carry out all tasks (albeit separated).
- Will allow skilled workers to focus their efforts on carrying out skilled tasks e.g. crop training. This allows unskilled workers to carry out simpler tasks that are both less critical and easier to learn.

Hydraulic lift work platforms

- Have a clear benefit in terms of ease of operation i.e. getting on/off and infinite variable on-the-move height adjustment. However no measurable improvement in work-rate was recorded. This was confused by other factors.
- Single pedal control, as commonly used in the UK, does not encourage operators to use the full length of the work platform. This is because they have to stay close to the pedal to operate the platform in start / stop mode.
- A hydraulic platform that was modified to operate with 2-pedal control received positive feedback from the operator. It did not however result in an increase in work-rate.

Powered picking cart

- The Berg B-lorry did not deliver any improvement in picking speed with a crop harvested on the vine. This was partly due to design limitations and partly due to specific circumstances in the trial greenhouse.
- The B-lorry was considered to offer greater potential in a loose tomato crop. This will be tested in 2006.

Secateurs

- After testing alongside a variety of alternatives, a model in common use in the UK (ARS 310) was still favoured by crop pickers after testing a variety of alternatives.
- The highly variable presentation of a truss to the picker means that secateurs are moved within the hand to give an additional degree of movement. This means that secateurs incorporating high levels of ergonomic design are of limited benefit.

Technology Transfer

HDC News

- Feature article March 2006
- Feature article November 2006

HDC Events

- Tomato Conference 2005
- Tomato Conference 2006

Appendix 1 – Detailed ring & clip cost analysis

	Experienced staff, twisting	New staff target, twisting	New staff, ring & clip				
Total hours	2356	3443	2558	←From Table 4			
Labour £/hr	Total cost for different rates of pay			Consumables (ring & clip only)	Total ring & clip cost (labour + consumables)	Saving - ring & clip vs. new staff target	Saving as % of new staff target
5.00	11,780	17215	12790	2558	15348	1867	15%
5.50	12958	18937	14069	2558	16627	2310	16%
6.00	14136	20658	15348	2558	17906	2752	18%
6.50	15314	22380	16627	2558	19185	3195	19%
7.00	16492	24101	17906	2558	20464	3637	20%
7.50	17670	25823	19185	2558	21743	4080	21%
8.00	18848	27544	20464	2558	23022	4522	22%
8.50	20026	29266	21743	2558	24301	4965	23%
9.00	21204	30987	23022	2558	25580	5407	23%
9.50	22382	32709	24301	2558	26859	5850	24%
10.00	23560	34430	25580	2558	28138	6292	25%