

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

Project number: PC217

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Annual Report: Year 1 annual report, May 2005

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Date project commenced: March 2004

Date completion due: January 2006

Keywords: Tomato, labour use, tasks, operations, tools, equipment, labour organisation.

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Grower Summary

1 *Headlines*

A critical examination of the labour organisation, tools and methods used on three UK nurseries has been carried out and compared to leading nurseries in Denmark and Holland. Specific findings from the studies are:

1. The nurseries in Holland and Denmark had better year on year staff retention. This even extended to seasonal staff. The result of this is that these nurseries had a reduced need for staff training, more consistent work rates and better quality of work.
2. In Holland, top of crop work tended to be carried out as a single task, multiple pass operation. This is in contrast to the U.K. where all the tasks are carried out in one pass.
3. Scissor lift working platforms which allow work height to be adjusted 'on the move' were common on the Danish and Dutch nurseries.
4. Twisting is without doubt the most skilled task and has the greatest impact on crop yield. Two commercially available alternatives to twisting are available. These are clipping systems and Ringmaster®.
5. Target work-rates set by the UK nurseries are readily achievable.
6. The most common factors restricting the speed of work are unnecessary distractions and 'problem plants'.
7. Collected work study data shows that the workers observed on the UK nurseries work at a similar speed to those observed in Denmark or Holland.

2 *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 £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.

The overall objective of this project is to identify and develop best practice guidelines for labour operations on UK tomato nurseries in terms of:

1. Labour organisation and management.
2. Work methods.
3. The use of simple tools and mechanical devices.
4. Optimised work rates for the key operations of crop training, de-leafing and harvesting.

Work described in this report relates to the initial phases of the project and focuses on:

- A critical examination of labour practices in current use
- Identification of the most promising areas for improvement
- Recommendations for detailed studies in year 2 of the project.

3 Summary of work to date

The work described in this report was carried out by studying working methods on three nurseries in the UK, one in Denmark and three in Holland.

The UK nurseries were:

- Arreton Valley Nursery, Arreton, Newport, Isle of Wight.
- Flavourfresh Salads Ltd, Banks, Southport, Lancashire (Aldergrove and Melrow sites).
- Mill Nurseries Ltd, Keyingham, East Yorkshire.

The Nursery in Denmark was:

- Alfred Pedersen & Son ApS, Odense, Denmark

The nurseries in Holland were:

- Three nurseries located in the Westland district of Zuid-Holland (The Greenery, Van Kester & Triomaas).

A desk based study of the individual labour tasks which are in common use in the tomato sector was also carried out. This enabled the information and data collected during the commercial nursery visits to be critically examined and the recommendations for further investigation formulated.

The key findings from the work are listed below. These findings enabled the recommendations for detailed study in year 2 of the project to be formulated.

2. The composition of the labour pool on nurseries visited in Denmark and Holland was substantially different to that found on nurseries in the UK. In general seasonal workers were used to similar degrees, however many of them returned each year. This reduced the need to train new staff at the start of every season.
3. The UK culture of combining individual tasks so that a crop worker carries out all of the operations (layer, twist, side-shoot & truss prune etc.) during a single pass through the crop is not done on many nurseries in Holland. Here a different approach is taken whereby operations are broken down into their individual components. This can mean that a crop worker passes through the crop on several occasions, first layering the crop, then twisting it and so on. It can also mean that a lower skilled worker layers the crop leaving a more skilled worker able to twist a greater area of crop. Nurseries using this approach believe that they have better workforce efficiency both in terms of speed and quality of work.
4. Where tasks are combined, the order in which they are carried out must be carefully considered. For example a top of crop worker who is carrying out lowering, twisting, side-shooting and pruning should not lower first as this is likely to mean that the remaining tasks have to be carried out outside the comfortable working zone.

5. In the UK fixed height platforms (or variable height platforms that are difficult to adjust) dominate. In contrast scissor lift working platforms that allow the working height to be changed 'on the move' were common on the nurseries in Denmark and Holland. These scissor lift platforms are considered to be better when considering both the quality and speed of work as they give the worker the ability to easily adjust their working height according to the allocated task/s. They also have significant advantages from a health & safety perspective.
6. Twisting is without doubt the most skilled task and has the greatest impact on crop yield. Two commercially available alternatives are available. These are clipping systems and Ringmaster®. Measurements of the work rates for these approaches indicate that labour rates are broadly equivalent to an experienced crop twister. The main advantage is their simplicity compared to twisting and should result in reduced training times. Less plant damage and less variability in the rates achieved by different workers were also anticipated. Independent data on the performance and costs associated with these techniques is not available however.
7. Whilst the target work-rates set by the UK nurseries are readily achievable by experienced staff, they require that workers operate at close to their full speed. Measurements taken on commercial nurseries show that the most common factors restricting the speed of work are unnecessary distractions and 'problem plants'.
8. Collected work study data shows that the workers observed on UK nurseries work at a similar speed to those observed in Denmark or Holland.
9. Harvesting trolleys varied immensely. All the ones seen (UK, Netherlands & Denmark) had basic ergonomic flaws. Even semi-automated powered versions considered to be state of the art had fundamental ergonomic design flaws.
10. Whilst there is limited use of hand tools (e.g. knives, secateurs etc.) on UK nurseries, it was identified that the ones in use were of poor quality and had little consideration of the principles of good ergonomic design.

3.1 Recommendations for detailed investigation in year 2 of the project

The work carried out to date has successfully identified a number of areas where there is significant potential for realising improvements in labour efficiency. It is therefore proposed that the most promising areas should be studied in detail in the second year of the project. The specific recommendations are:

3.1.1 Work organisation

As previously highlighted, current practice on UK nurseries is for operatives to carry out several tasks at the same time when working the crop (e.g. layer, twist, side-shoot etc). This is in contrast to many nurseries in Holland where 'task separation' is practiced. Under this regime workers are only required to carry out one task at a time (e.g. twist only, drop only etc.). In many cases this approach requires that workers are trained to carry out only one task.

It is recommended that the implementation of work methods based task separation should be further investigated by working with UK nursery. This should involve measuring the effect on work rate and quality when compared with conventional work organisation.

3.1.2 The use of improved tools/facilities

It is proposed that a nursery should be equipped with improved tools in order that the effect on work rate and quality can be studied. It is recommended that the study should include:

- Motorised picking trolleys
- Variable height (scissor lift) work platforms
- Ergonomically superior secateurs.

3.1.3 Crop training methods

Crop twisting has been identified as one of the most critical operations on a tomato nursery. In an attempt to overcome the need for twisting and to improve work-rates, two commercially available solutions should be studied in detail. These should be:

Ringmaster® – the method developed by Priva that uses a wire ring to hold the plant to the string and support the crop.

Clips – the technique that uses a plastic clip to support the crop on the string.

Both Ringmaster® and clips should be used during the 2005 cropping season and their effectiveness compared with traditional twisting. Performance of the systems should be compared in terms of:

- Work-rate
- Capital cost
- Consumables cost
- Cropping problems introduced by the system
- Crop disposal costs.

All of the above will provide invaluable information to growers that will enable them to evaluate their current systems and integrate changes.

4 Financial benefits for growers

One major driving force behind this project was to obtain information that allows growers to contain labour costs in the future. By identifying areas with the best potential for improvement, the work to date has gone some way to meeting this requirement.

The second year work plan will investigate the recommendations in this report. It will provide invaluable information on the cost effectiveness of a number of technologies and techniques, all of which show significant potential for improving labour utilisation. Information from these trials will allow growers to make changes on their own nurseries, safe in the knowledge that cost savings and performance improvements can be achieved.

5 Action points for growers

- Growers investing in new equipment e.g. work platforms and picking trolleys should seriously consider their effect on productivity and not just the price.
- Growers with a mixture of equipment and work methods should undertake their own 'in house' comparisons to assess their performance.
- Follow the results from year 2 of the project as they become available.

Science Section

1 Introduction

The availability of labour in tomato production in the UK is often problematic. Whilst many growers retain key staff on a permanent basis, skilled staff is hard to find and the recruitment of suitable personnel can be difficult when vacancies arise.

Most nurseries also recruit seasonal staff to overcome labour peaks. In many cases this temporary labour is of non-UK origin and language barriers can often make training and labour relations problematic. As most of this seasonal staff is recruited for one season only, training has to be carried out on an annual basis.

Even on the most efficient nurseries, work-rates and labour costs can be highly variable. This can affect several areas of the business including:

- **Staff costs** – the area that one member of staff can manage can be highly variable thus affecting production costs across a nursery.
- **Timeliness** – the standard of crop training and de-leafing work can affect plant health, crop quality and the ease (and cost) of picking.
- **Health & Safety** – the repetitive nature of many manual operations means that health & safety issues relating to upper limb disorders have to be taken into consideration.

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 coupled to improved business efficiency.

This interim report describes the work that has been carried out to date to study the efficiency of labour use on tomato nurseries and develop recommendations to improve working practices. The overall aims of the project are to identify and develop best practice guidelines for labour operations on UK tomato nurseries in terms of:

1. Labour organisation and management.
2. Work methods.
3. The use of simple tools and mechanical devices.
4. Optimised work rates for the key operations of crop training, de-leafing and harvesting.

Specific work detailed in this report concentrates on the initial phases of the work programme and focuses on 'fact finding' studies that were carried out to:

- Give a detailed insight into labour use practices
- Identify the most promising areas for improvement
- Allow the specific work programme for year 2 of the project (2005) to be formulated.

2 Key Features of Tomato Labour in the UK

2.1 Task analysis

In order that a critical examination of the various labour issues could be carried out, all the discrete tasks involved in training tomato plants and harvesting fruits have been identified. This analysis also allowed an assessment of the scope for changing procedures or deployment of staff (particularly with a view to improving labour efficiency) to be performed.

A total of 14 tasks have been identified and these are summarised in Table 1 below.

Table 1: Basic labour tasks in use for commercial tomato production in the UK

Task		Description / Comments
1	Lowering/ layering	Terms, used interchangeably, for moving top of plant along and down (to accommodate recent growth).
2	Twisting	To wind the supporting string around the stem (not <i>vice versa</i>) for continuing support of recent growth. In some nurseries, this has been superseded by "clipping" and/or use of the Ringmaster™ from Priva.
3	Trimming/side-shooting	Removing the side-shoots near the top of the plant to encourage growth on the main stem only.
4	Pruning	Removing flowers or fruits at early stage of formation to achieve specific truss shapes and/or sizes. Optional, depending on marketing requirements.
5	De-leafing	Removing unwanted foliage from around mature/nearly mature fruits. Usually done 3 at a time.
6	Clearing floor	Taking away debris from ground level after removal of shoots and leaf trusses. This may include monitoring plant support at the lower levels.
7	Picking individual fruits	Simple harvesting involving limited quality control on size (weight), colour and integrity of fruits (e.g. no splitting).
8	Picking vines	Harvesting a complete truss (or parts of it), generally using secateurs, and, if necessary, trimming off unwanted material.
9	Putting fruit in crates	Putting marketable fruits and fruits of poorer quality into their respective crates / containers on the trolley.
10	Placing vines in punnets	Putting vines and parts of vines in their containers for marketing; arranging these containers in their crates. This may also involve putting reject fruit into different containers.
11	Monitoring plant health	Maintaining an awareness of the state of (usually) the stems and foliage for symptoms of pests & disease. May also include the application of biological control agents. Carried out as a distinct individual task.
12	Dealing with diseased or broken plants	Following instructions given in the Nursery procedures.
13	Spraying	Protecting the plants against disease either chemically or with biological predators (as a precaution or a treatment). This is a distinct individual operation that is carried out by designated staff.
14	Checking irrigation etc	Making sure that there are no problems with the plant feeding and drainage systems.

All of the above tasks are based on the observations and recordings made at the nurseries that were visited as part of this project. Therefore, they are not necessarily representative of all commercial tomato production enterprises in the UK as other facilities may carry out some additional operations.

More detailed descriptions of the activities at each nursery visited are given in annexes 1 to 5. The tasks referred to in these annexes are coded according to the task identification numbers given in Table 1. The code numbers are given in square [] brackets. Annexes 5a, 5b and 5c resulted from the visits to nurseries in Holland. In some cases the information provided by these sites was less detailed. This means that Annexes 5a to 5c are less comprehensive than Annexes 1 to 4.

2.2 Tools and equipment

The tools and equipment used for the tasks listed in Table 1 are shown in Table 2 below.

Table 2. Tools and equipment used for crop training and harvesting in commercial tomato production in the UK

Task		Tools and equipment
1	Lowering/ layering	No specific tools. Exact nature of task depends on design of bobbin used to carry string supporting the plant stem.
2	Twisting	No tools used.
3	Trimming	No tools used. Shoots pinched using usually thumb and first finger.
4	Pruning	Flower or fruit usually pinched out using thumb and first finger; secateurs may be used.
5	De-leafing	Tools rarely used. There are contradictory opinions on the use of knives and whether they make plants more susceptible to botrytis or less. Ideally leaf trusses should be snapped off with a (manual) action that leaves no stump and no tear down the stem.
6	Clearing floor	Various types of brush and basket. Some nurseries have a suction machine akin to a vacuum cleaner. Some nurseries leave all the leaf material under the hanging gutter until the end of the season.
7	Picking individual fruits	No tools used.
8	Picking vines	Secateurs to remove both truss from plant and unwanted fruits from truss.
9	Putting fruit in crates	No tools used.
10	Placing vines in punnets	In conjunction with task no. 8; no extra tools needed.
11	Monitoring plant health	No tools used.
12	Dealing with diseased or broken plants	Secateurs and extra string and bobbins as appropriate. Tape may occasionally be used to help plant stems recover from damage/injury.
13	Spraying	Knapsack type sprayer or "spraying robot" which simply has to be transferred from row to row.
14	Checking irrigation etc	No tools used.

2.2.1 Working platforms

Work at the top of the crop (tasks [1] to [4]) requires the operator to work just below the roof of the greenhouse. An elevated working platform is provided for this purpose. The main differences between the designs of these mobile platforms, which are all propelled along the floor heating pipes by (rechargeable) battery powered electric motors, is the means of raising (and lowering) the working platform. On the latest models, the working platforms are supported on a powered scissor jack mechanism (see Fig. 1). The height of this platform can be altered by operating a switch located on the guard rail surrounding the area on which the worker stands. This encourages regular operation that ensures the worker is in the most suitable position to carry out the task/s.

In contrast, earlier designs require that raising and lowering is done by operation of a hand mechanism. The most widespread design uses a screw thread to alter the vertical position of the worker's platform. Operation of this design is not very convenient to use and it is rare to find the platform height being adjusted even by a few centimetres. Consequently crop workers access the platform by climbing up the incorporated step ladder. It is very rare for the platform height to be adjusted to meet postural needs when working at the top of the crop.



Fig 1: Scissor-lift platform

2.2.2 Picking Trolleys

When harvesting, the pickers push trolleys carrying crates and/or boxes and/or punnets along the heating pipes into which the fruits (including rejects) are deposited. The specific nature of these containers depends on management policy and the customers' requirements. These trolleys may also carry the trash containers used when clearing up plant debris. For working close to ground level, these trolleys are often equipped with a small seat for the operator. As a rule, these trolleys are not self-propelled but are moved by the operator either leaning into them when in an erect posture or working his/her feet on the ground when seated. Unless the pipes are covered with accumulated plant debris there is no serious resistance to movement. Therefore, level pipes that are clear of debris are needed if workers are to operate in an unhindered way and achieve good work rates. With this in mind there is scope for automating movement of picking trolleys.

Automated movement of the fruit containers (full or empty) to a central loading / unloading facility was also seen at some of the nurseries visited in this study. This ensures that pickers always have a trolley with empty containers waiting for them at the end of a row and do not have to spend time unloading & re-loading them. On most UK nurseries pickers have to unload their trolleys, stacking the full containers on pallets or carts. They then have to re-load their trolley with empty containers before starting to pick fruit again. This practice leads to a large amount of non-picking time and potential distraction for operatives.

2.3 Labour organisation

Greenhouse labour is nominally divided into two groups –‘crop workers’ and ‘pickers’. Crop workers are generally responsible for the more demanding tasks as their duties are centred on taking care of the plants and ensuring that they are in optimum condition. The duties of the pickers centre on removing the fruits from the plants as carefully and quickly as possible. The allocation of responsibility for quality control varies between the pickers and the graders/packers according to decisions taken by the nursery management. Supervisory responsibilities within these two groups of workers are also decided locally by the nursery management.

The senior crop workers may be salaried or hourly paid. In contrast pickers are almost exclusively paid on a piece-work system. The weight picked is the major parameter but there may be other considerations (i.e. based on variety or maturity of the crop) which can introduce weighting factors. For example, it would take longer to pick 100kg of a small speciality variety than 100kg of classic rounds.

On UK nurseries there is a growing dependence on seasonal labour, much of which is provided by students from Eastern Europe. These workers are employed for about six months. Most workers of this type only work on a nursery for one season. Only in exceptional cases do they return. Typically, such imported labour makes up 80 to 90% of the pickers and up to 20% of the crop workers. However, because of the need for skilled crop workers, more seasonal labour is being used for crop work. This can lead to difficulties with staff training.

2.4 Rates of work

All the UK nurseries visited have target work rates for the individual tasks or specific combinations of combined tasks shown in Table 1. Work rates for tasks [11] to [14] may be less explicit and simply included in the daily or weekly job schedules of the crop workers. For example a crop worker may have to look after 7000 plants on a weekly (39 hours) cycle (see Annex 4). Some nurseries are more flexible with regard to allowing crop workers to organise their time, provided the job is done satisfactorily. Others are more regimented. Workers of either group (but probably more so the pickers) cause problems for the nursery if they do not work fast enough. With this in mind many nurseries use a system by which workers may face penalties or even dismissal if they do not achieve the necessary work rates. On the other hand workers who exceed target rates (less so pickers if they are on piece-work) may be eligible for bonuses.

Most nurseries collect work rate data on their recording systems (e.g. “Nomad”, “Privassist” etc). This information is then available to the nursery management should they wish to use it for labour analysis.

3 Research Methods

The work described in this report was carried out by studying working methods on nurseries in the UK, Denmark and Holland.

3.1 Participating UK nurseries

These nurseries were:

- Arreton Valley Nursery, Arreton, Newport, Isle of Wight.
- Flavourfresh Salads Ltd, Banks, Southport, Lancashire (Aldergrove and Melrow sites).
- Mill Nurseries Ltd, Keyingham, East Yorkshire.

The procedure with each of the participating nurseries was as follows:

1. Interview key members of nursery management team to determine their approach to labour management and discuss any key labour related issues.
2. Carry out an introductory 'walk round' selected greenhouses on the nursery and observe labour organisation and working practices.
3. Work with an area supervisor to carry out a detailed analysis of the work practices and activities that were taking place on the nursery at the time of the visit.
4. Spend some time with individual crop workers and pickers discussing with them how they approached and carried out their jobs and collecting some work study data by simple, direct observation.

At the end of the visit have a further meeting with the same management team members as in 1 above to discuss the observations and raise any further issues needing clarification.

With all of the participating UK nurseries, a high level of cooperation was experienced. Staff at all of the sites demonstrated a willingness to assist and openly talk about all aspects of their work. It is therefore recognised that this approach made a major contribution to the initial phases of the project as reported in this document.

3.2 Participating Nurseries in Denmark and Holland

In order that UK practices could be compared with those used on leading nurseries in northern Europe, visits were made to Alfred Pedersen & Son ApS, Odense, Denmark and 3 nurseries located in the Westland district of Holland (The Greenery, Van Kester & Triomaas).

Whilst every effort was made to collect data that was of comparable quality to that obtained on the participating UK nurseries, these sites were not as forthcoming with detailed information. On that basis the information obtained was of a poorer quality. Having said that, the opportunity to take spot measurements of work-rates and observe/discuss working practices proved to be invaluable in assessing the performance of UK based facilities.

4 Results and discussion

4.1 Task analysis

The focus of this project was the effective implementation of task No's 1 to 10 of Table 1. Based on this analysis, the approach taken was to regard each of these tasks as the fundamental operations which may be put together in different ways to create the various greenhouse procedures observed at the participating nurseries. Within a single nursery there are likely to be different procedures in different greenhouses according to factors such as the variety being grown, customer requirements etc.

Although each nursery combined the basic tasks to form slightly or considerably different working practices, without exception they all split their labour forces into people who train/tend plants and people who pick fruits. It would be rare for a crop worker to be involved in picking and very rare for a picker to undertake crop work. This was particularly the case with lowering, twisting and trimming. Therefore, in general, the tasks of lowering, twisting, trimming, pruning and de-leafing are the responsibility of the crop workers and picking combined with placing the fruit in crates and/or punnets are the pickers' responsibility. Pruning is done only when vines of a particular configuration or uniform ripeness are required and, although usually done by crop workers, may be done by pickers. In some nurseries cleaning staff are employed, avoiding the need for either crop workers or, occasionally, pickers to carry out debris clearing from the greenhouse floor.

Tasks including monitoring plant health, dealing with diseased plants, spraying and tending to irrigation drippers are also the crop workers' responsibility. However, these are carried out less overtly than twisting which directed manual action at least once a week. Monitoring of plant health is an ongoing activity, usually combined with one or more of the other crop training tasks, and dealing with damaged plants is an intermittent activity carried out as the need arises.

It seems customary at all the UK nurseries visited for lowering, twisting, trimming and pruning (when necessary) to be combined and carried out on each plant at virtually the same time as the crop worker moves on the platform through the top of the crop. The justification for this working practice seems to be that, because time must not be wasted, it is more efficient to carry out the tasks in this manner. The logic behind this is that the more times a crop worker visits the top of the crop the greater the "down time" spent not attending to the crop and, hence, the efficiency of carrying out these tasks drops. On the other hand, in the Danish and Dutch nurseries visited, the management had less of a preoccupation with temporal efficiency and was more concerned that each of these tasks was performed as well as possible, or to the best of the crop workers' ability. In their judgement this was more likely to be achieved by the crop worker visiting the top of the crop to carry out only a single task, or certainly not combining more than two tasks, each time. For the time being, this must remain a matter of opinion, but the efficacy of these two approaches must depend on a number of factors including the rate of plant growth, the customer requirements and, probably most importantly, the experience, abilities and motivation of the crop workers. The UK nurseries should certainly consider whether combining these 'top of crop' tasks in the quest for temporal efficiency may not prejudice the quality with which each of these tasks is carried out and, hence, ultimately affect yield.

When 'top of the crop' tasks are combined, is there a recommended sequence for carrying out these tasks? From the observations at the UK nurseries, it would seem that the crop workers have some freedom in choosing their *modus operandi* and this is accepted provided that the work rate met (or exceeded) the local targets. The prevailing trend would seem to be that the crop workers lower and then twist before

attending to trimming and pruning (when this is necessary). From an ergonomics point of view, it would seem more logical to do trimming and pruning before lowering then twisting. This is related to the worker's work envelope (comfortable reach zones). In a working environment where the crop worker can not readily change the height of his/her platform (see 4.2 below), the height is adjusted for the (widely accepted) most crucial lowering and twisting tasks and so is relatively high in the crop. If the heads are lowered before trimming and pruning then the optimal work envelope for these tasks is likely to be adversely affected. For each plant this may only amount to a fraction of a second but, for a worker attending to 7000 plants a week, it may make a substantial difference.

Of all the tasks in the commercial tomato greenhouse, lowering and twisting are recognised as the most important to the success of the business. If these are done badly, heads are lost (generally equivalent to three trusses of fruit), plants are stressed and yields fall. Assuming that the pickers can do their relatively straightforward task(s) effectively and quickly enough, the challenge to nursery managers would seem to be to maximise productivity and quality on the lowering and twisting tasks and, in the case of the UK, the directly associated tasks of trimming and pruning. Having identified this key issue, it would be appropriate to investigate the views of UK nursery managers on this topic further and establish whether the sequence of carrying out the twisting, dropping, trimming and pruning tasks may be significant. The crucial task of twisting does not seem to be closely controlled: different people develop different techniques and it would not be possible to specify, at present, one particular technique to recommend. The key requirement is not to damage the plant and, closely associated with this, is the need to complete the task quickly (see section 4.4).

De-leafing is usually the responsibility of the crop worker, who is informed how many leaves to remove by the nursery management, to attain optimal plant performance at that time. The recommended way to remove leaves is to snap them off with a twisting action: this produces least scarring on the stem and so reduces the plant's vulnerability to Botrytis. Pulling at and tearing the leaves away from the plant can create quite a large wound on the stem, inviting disease, as does cutting off with a knife and leaving a stump. Different varieties are more or less brittle so may require more or less time. This is usually taken into account when piece-work rates apply. De-leafing is one of the few opportunities that crop workers have for monitoring the lower parts of the crop and so it is felt that only in exceptional circumstances should this operation be done by pickers.

The picking tasks can be affected by both de-leafing and lowering. This is due, respectively, to ease of access to the fruits through both working around un-removed leaves and the locations of the fruits within the pickers' reach envelopes. Furthermore, some pickers use one of their hands to hold the leaf canopy aside which results in only one hand being available for picking.

4.2 Tools and equipment

As indicated in Table 2, very few hand tools and very little ancillary equipment are used in typical UK tomato production. Having said, that the following sections highlight the important areas relating to the use of specific items of equipment.

4.2.1 Platforms and trolleys

Although not listed in Table 2 (but described in sections 2.2.1 and 2.2.2) trolleys and mobile platforms that are provided for moving material and accessing the top of the crop are probably the most important equipment items.

On UK nurseries these are usually of very basic design and, as previously highlighted, the variable height working platforms are not readily adjustable. This contrasts considerably with the situation observed in Denmark and Holland where, on the facilities visited, the easily adjustable scissor-lift platforms were in common use. The most striking advantage of the use of this equipment was that workers were readily making slight height alterations to improve access to the top of the crop and their postures. As these factors interact the advantages were considered to be significant when considering both worker performance and health & safety issues.

The use of platforms without the scissor-lift mechanism (although they may be manually adjustable from ground level) demands that the crop worker uses a ladder to get on and off the raised platform. As a result it is obvious that this acts as a deterrent to dealing with a diseased or damaged plant as soon as it is found. When installed on the fixed platform, the crop worker exhibits the habit of continuing to work at the top of the crop, thereby delaying the operation of dealing with the plant/s that need attention until the row is finished. This increases the risk that dealing with the plant would be overlooked (through forgetfulness or preoccupation with another matter) and also increases the amount of time that it takes.

4.2.2 Secateurs

The secateurs used for pruning or truss trimming during picking are of poor ergonomic design. Wrist posture is an important consideration for work performance and health and safety, the latter especially since recognition of repetitive strain injuries (RSI). The principles of good hand tool design involve various considerations¹, some of which may require a compromise. However when considering the use of secateurs in tomato production (an operation that does not require excessive force for each action) wrist posture would seem to be of paramount importance. Examples of ergonomic cutters and pruning devices are shown in Annex 6. This is copied from the first page of a handtools manufacturer website².

4.2.3 Knives

The use of knives is not encouraged in the UK as knife cuts are generally regarded to put the plant at greater risk of disease. As a result the design of knives is not addressed in this report.

4.2.4 Hangers & bobbins

The exact nature of the lowering/layering task [1] depends on the design of the bobbin hanger. British growers tend to favour the conventional bobbin hanger with the support string wrapped around the main part of the body (see Fig. 2).



Fig 2: Traditional Hanger

¹ e.g. see: <http://ergo.human.cornell.edu/studentdownloads/DEA325pdfs/Hand%20Tools.pdf>
www.agrabilityproject.org/assistivetech/tips/handtools.cfm

² www.oescoinc.com/webcat/download/Hand_tools_2-5.pdf

Newer equipment, such as the Tomahawk (see figure A3.1) is yet to become popular in the UK. This is mainly due to a lack of information about the advantages of such designs and the fact that, on the surface, the cost seems prohibitive. For example, the standard bobbin hook costs €0.12 each whereas Tomahawk costs €0.36 each. Lack of experience with, or confidence in, this newer technology is also a major contributing factor.

However, the manufacturers of Tomahawk (Priva Hortivation B.V.) claim to be able to provide evidence that the use of this hanger increases production efficiency when the crop workers have been adequately trained in its' use. An examination of the use of Tomahawk revealed the importance of using the correct gauge (thickness) of supporting string, thereby further complicating its continued use and potentially further increasing the cost.

Similar designs to the Tomahawk are also marketed by the Israeli company Paskal (<http://www.paskal.biz/tomato.html>).

Also, other alternative designs of hanger bobbin are available that claim to improve labour efficiency. Another example is the Reelenz system that was designed by a New Zealand grower (see Fig. 3).

What is clear about all of the alternative hanger/bobbin designs is that no independent information is available to allow growers to fully assess the benefits of different designs or be confident of their cost / benefit characteristics. Whilst it is clear from some users (and the manufacturers) that there are benefits from adopting the technology, the messages are not clear enough that a grower can be confident in the capabilities of the equipment. On that basis there is clearly a need for more detailed independent information about the various alternatives.



Fig.3: The Reelenz Hanger

4.2.5 Crop training systems

As previously highlighted, twisting [2] is crucial to the success of the business. This is because, whether it is done in conjunction with other tasks or not, it is an operation that carries a relatively high risk of causing plant damage.

To reduce the risk of damage due to twisting, two different approaches/products are available.

The first is a simple plastic clip which clamps on to the supporting string and then supports the plant (see figure A5a.1) within a ring part of the clip. Thus, twisting is avoided and the plant needs less handling. This thereby reduces the risk of damage. However, purchase of these clips introduces extra expense and may raise costs even further as they may have to be removed before the waste plant material goes for composting. The alternative is to use clips that are manufactured from a biodegradable material. Whilst biodegradable clips are available, such clips are considerably more expensive (biodegradable clips cost €30/1000 whereas ordinary plastic clips cost €3.40/1000). Again there has not been the opportunity to date to measure comparative work rates (and hence assess comparative labour costs) with clips, but it is felt that the approach offers significant advantages that can result in improved work-rate and quality.

The second alternative is the Ringmaster® (manufactured by Priva Mechatronics B.V.). This approach uses a copper coated steel ring dispensed by the Ringmaster machine to hold the plant stem close to the supporting string (see figures A5a.2 and A5a.3). The shortcoming of this method is that the copper ring only keeps the stem adjacent to the supporting string but does not actually carry the weight of the plant (the system was originally developed for sweet peppers where stem strength is not an issue). This issue is being addressed by the manufacturers who are introducing a “ladder” type string. With this approach the ring is held by an “eye” in the supporting string, preventing it from sliding up or down. The alternative is that the Ringmaster has to be used in conjunction with clips.

Again, so far in this project no work study or costing data on the effectiveness of the Ringmaster system has been collected. Such information is available from the manufacturer but again it has not been independently verified.

What is clear, is that the use of techniques such as clipping and/or Ringmaster give a worker the ability to quickly reach acceptable standards of work / work rates with significantly reduced training requirements (when compared to conventional twisting). This feature alone could make such methods cost effective for growers in the UK.

4.3 Labour organisation

This is probably the most significant, yet only recently appreciated, difference between the UK tomato industry and that in Denmark and Holland.

4.3.1 Task allocation

As previously described, the labour is categorised into two groups – the crop workers and the pickers. Having made this division, management is confronted with the objective of enabling these two groups to work as a team, collectively, for the benefit of the business.

It is widely acknowledged that crop workers have to exercise more skills than pickers whilst both play significant roles in the success of the business. UK growers depend more on foreign/casual labour than their Danish and Dutch counterparts but all tend to prefer indigenous labour for the crop worker tasks. Within these categorisations, the UK growers generally require the crop workers to carry out all their crop training (tasks 1 to 4 in Table 2) virtually simultaneously whilst the Danish and Dutch growers prefer to regard each task as a separate activity and are likely to instruct their crop workers to attend to each task separately. This is because they have observed that the quality with which each task is completed more than compensates extra ‘down time’ taken by the crop workers making multiple visits to the top of the crop to complete all the tasks. This represents a substantially different management approach and one which this project has not yet had the time to assess or compare scientifically or objectively.

Subjective observations suggest that each task is completed more effectively but there is potential for the total of the tasks not to be completed as quickly. To balance that, watching one crop worker in Holland progressing along a row using both hands to lower the plants two at a time (with conventional hangers), does raise the question of exactly how much time (or quality in the broader perspective) is lost by this approach, especially when the crop workers are on scissor-lift platforms (see 2.2 and 4.2 above) when they can easily work at the ideal level. This therefore suggests that the method is worthy of significant further study.

One grower in Holland feared being “held to ransom” by his best crop workers, especially for the crop lowering and twisting tasks. He argued that if the twisting was done badly then he ran the risk of losing his business. To him this was a strong justification for using the Ringmaster® (see 4.2.5 above) to “de-skill” the twisting task.

The allocation of tasks between crop workers and pickers should not be too rigidly defined. De-leafing provides the best example of this. Strictly speaking, in the UK, de-leafing is the responsibility of the crop worker but at times when the crop may be growing vigorously but there is less to pick (maybe on a Friday), it makes good sense to allocate de-leafing to the pickers rather than to the crop workers. This has, in fact, been observed at a UK grower and such flexibility should be encouraged at all UK growers.

4.3.2 Remuneration and pay

The system of remunerating (basic rates of pay – which may be crop dependent – plus bonuses) crop workers and pickers is very complex and each UK business seems to have evolved its own procedures, criteria and formulae. This is further complicated by the UK fiscal and benefits systems (for both indigenous and foreign employees) and, as a consequence, is beyond the scope of this project to date. Nevertheless, they remain very important issues and their full understanding may be fundamental to the resolution of labour issues in the UK tomato industry. Equally, it is important to understand these issues elsewhere in Europe if the project is to proceed to compare the competitiveness of the UK tomato industry to that of mainland Europe.

4.3.3 Quality control

Another huge variable between growers, both in the UK and Denmark and Holland, is the level of quality control demanded of the pickers. In some nurseries the pickers simply have to pick the fruits, exercise minimal judgement (usually based on size and colour) between accept and reject and deposit the fruits in containers accordingly. In other nurseries the pickers may have to pick (and trim trusses) if the fruits are to be packaged “on the vine” and in some nurseries the pickers have to work under both regimes depending in which crop/variety, or for which customer, they are working. To date, the project has not been able to investigate all these alternatives. It has not, therefore, been possible to determine the impact of all these scenarios on labour productivity.

4.3.4 Staff training

The training of staff, both crop workers and pickers, is a major factor in labour organisation. The training demands are heavily influenced by the rate of labour turnover and the capabilities and attributes of the staff. These, in turn, depend on local labour markets, employment regulations, perceptions of the job and remuneration and other incentives. There are some variations in these factors around the UK (mainly perceptions and remunerations) and, of course, much greater variations between countries in the EU.

The training of pickers is less demanding on nursery management than the training of crop workers. After being shown the principles and undertaking a brief basic practice period, most of the time devoted to training is for on-the-job practice and getting up to the required speed of working. For pickers this may be around two weeks but some managers (e.g. in Holland) believe that crop workers take a whole season to become fully accomplished.

Clearly, if the training processes could be accelerated, labour efficiency would increase. In theory, this may be achieved by faster, or more intensive, basic training and a reduced period of practising whilst attaining the desired speed of working. The nature of the training may also affect labour efficiency as one of the most common methods is to assign a new worker to a more experienced worker (often a team or a group leader) thereby reducing the work rate of the more experienced worker. However, it is not clear at present how much the nature or style of staff training affects the overall labour efficiency of the business and, therefore what would be the benefit of any training aids.

4.3.5 Conclusions

There is a notable difference between labour organisation, including recruitment, between the UK and practices in Denmark and Holland. In the UK, most casual workers (mainly pickers but some crop workers) are usually students of Eastern European origin and, due to employment laws, are available for work for one season only. This imposes a high training load on nursery management, especially early in the season when they arrive and when there may be a considerable language barrier. However, being students they are usually very capable and motivated to work hard to earn as much as possible. On the other hand, in the EU countries visited, the casual workers (mainly pickers but some crop workers, as above), even if of foreign origin, would return to tomato nursery work from season to season. This reduces the training demand significantly, but they may not achieve such a high level of work performance towards the end of the season as the students on which the UK businesses depend so heavily. Nevertheless, the Danish and Dutch nurseries visited expected to employ more eastern European students in the future.

4.4 Rates of work

Where possible, target work rates for the main recurrent tasks from Table 2 were obtained during interviews with the growers. These are given below in Table 3 but, in fact provide only a “snapshot” for a particular crop at that time. Work rate targets are generally dependent on the variety, maturity of the plant and, sometimes, the weather conditions.

Table 3. Example target work rates at nurseries visited

Task		Site A UK, modern glasshouse (Rounds)	Site B UK, modern glasshouse (Cherries)	Site C UK, old glasshouse (Santa)	Netherlands, modern glasshouse (Aranca)
1	Lowering / layering	400 heads/ hour	370 / hour	300 / hour	>750 / hour
2	Twisting				
3	Trimming				
4	Truss pruning			Requires extra labour	
5	De-leafing	1200 plants / hour	960 / hour	720 / hour	
6	Clearing floor	4 paths / hour (but depends on path length)		1.5 min / path (c. 190 plants)	
7 & 9	Picking and packing individual fruits		60 kg / hour (c. 4000 fruits)		250 kg/ hour (average over season)
8 & 10	Picking and packing vines	325-375 kg / hour	100 kg / hour		

Work rates were not obtained during the visit to Pedersen's nursery in Denmark. This was due to the lower priority placed by the nursery on speed and higher priority attributed to quality.

The rates in Table 3 show considerable variation but, as mentioned, this may be due to the differences in variety stage of crop development. This undoubtedly affects picking but can also affect the crop training tasks ([1] to [4]). Also some varieties are more fragile than others (e.g. cherries and rounds) and plants grow at different rates.

Considering the situation at site B, tasks [1] to [4] have to be completed in approximately 10 seconds to meet the target. These four tasks can be sub-divided into six discrete activities when considering crop training as a whole. These are, together with likely timings based on measured data:

- i. Surveying the plant and deciding what needs to be done (1.0 second)
- ii. Unwinding string whilst moving bobbin laterally (1.5 seconds)
- iii. Plucking out (trimming) side shoots and discarding (2.0 seconds)
- iv. Twisting (string around plant stem, without trapping leaves) (2.5 seconds)
- v. Pruning trusses (1.0 to 3.0 seconds)
- vi. Moving on to next plant (1.0 seconds).

Except for i) and vi) which should be done first and last respectively, ii) to iv) may be done in any order although there may be some merit in identifying a preferred order of actions. This analysis allows 2.5 seconds per plant for twisting [2] but when twisting is done as a standalone activity in Holland (last column in Table 3), nearly 5 seconds is allowed. It seems that this would create less risk of damage to the plant. At the same site, although the task of lowering [1] was not timed, one worker moved along the crop without stopping lowering with both hands. This almost certainly required less than 1.5 seconds per plant. It may be helpful to UK growers if the methods of implementing tasks [1] to [4] were investigated with a view to making recommendations based on overall productivity and quality scientific assessments, rather than assuming that, just because labour is expensive, speed of completing a task is the priority criterion.

Factors affecting work rates of each of the tasks listed in Table 3 are discussed briefly below.

4.4.1 Lowering

The main factor affecting the speed of lowering the crop is the design of the bobbin. Conventional bobbins have to be lifted off the supporting wire, twisted to release a length of string, moved laterally and re-hung on the wire. Designs such as the Tomahawk avoid the need for the twisting movement but still have to be moved laterally. The Tomahawk does, however, require two-handed operation and so would preclude the option of lowering two plants simultaneously (to speed up the operation). Lowering may be done as a standalone task or in conjunction with the other tasks ([2] to [4]), usually before them, but not necessarily. For example, it may be easier to trim out the unwanted shoots before lowering if the platform height is not easily adjustable and lowering would make the shoots less accessible. The same may apply to truss pruning when it is practised.

4.4.2 Twisting

This is probably the most important individual task regarding overall productivity as this is when the plant faces its greatest risk of damage (losing a head generally means losing three trusses of fruits before a side shoot can be trained to continue normal plant growth). Therefore, any means of reducing the risk of damage should improve overall productivity. There are three main approaches to reducing this risk:

- i. increasing the skill level of the crop workers
- ii. allowing more time for twisting (possibly by making it a standalone task)
- iii. using an alternative training system such as plastic clips or Ringmaster®.

All of these have been previously discussed above but each grower would have to determine the best business option as each of these methods introduces a number of implications. If twisting is done in conjunction with the other tasks that are carried out at the top of the crop, it would seem logical (and more time efficient) not to do it before lowering [1].

Some brief observations have been made of the time requirements of using clips and the Ringmaster®. Clipping a plant takes up to 3 seconds and using the Ringmaster® takes a little less than 2 seconds. These times compare to that observed for conventional twisting which was 2.5 seconds.

The ideal method of conventional twisting seems not to be amenable to specification as individuals develop their own “best practices”. It should perhaps be regarded as an art rather than a science. It would seem unwise to specify that the stem should be held with one particular hand and the string with the other. To avoid plant damage it would seem better to primarily twist the string around the plant rather than the plant around the string. Nevertheless, observations indicate that the best techniques involve coordination of both hands, with neither hand making exaggerated movements and the hand holding the stem moving more as a rotation of the wrist and the hand holding the string making the greater excursions. On the evidence to date, it is not possible to suggest which should be done with the left or the right hand (and, indeed, whether there is a difference between left-handed and right-handed crop workers).

4.4.3 Trimming

This may be done as a standalone task or in conjunction with the other tasks ([1], [2] and [4]). No observations have been made on the time required for trimming.

4.4.4 Truss pruning

This may be done as a standalone task or in conjunction with the other tasks ([1] to [3]). No observations have been made on the time required for truss pruning. This is a task which could be carried out by suitably trained pickers (quite feasible) if the crop worker cohort is under (time) pressure.

Some time data collected from crop workers carrying out tasks [1] to [4] together in a crop of Aranca tomatoes showed that the time spent on each plant varied from 6 to 16 seconds over two adjacent rows. The frequency distributions for these two rows in time intervals of one second are shown in figure 4.

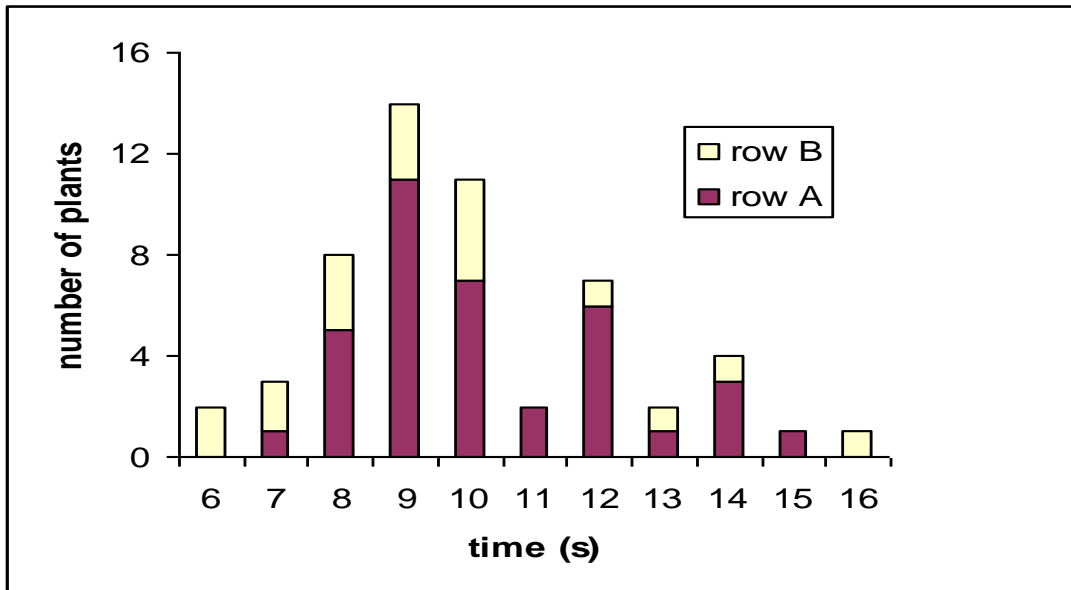


Fig. 4: Times per plant for tasks [1 to 4] in two part rows.

Although the mode (most frequent) value is 9 seconds, the average is just over 10 seconds and there is a suggestion of a bimodal distribution. This could be explained by the time taken for a normal plant to be between 9 and 10 seconds and the time taken for “problem” plants being between 12 and 14 seconds. A time of 10 seconds per plant is very close to the site B target of 370 per hour (9 seconds would give 400/hour and 10 seconds would give 360/hour). This clearly indicates that, if a worker has to deal with a large number of problem plants, the target work-rate becomes un-achievable.

4.4.5 De-leafing

No observations have been made on the time required for de-leafing but target times vary considerably (720 to 1200 plants per hour) between the UK growers visited. This is a task which could be carried out by suitably trained pickers (quite feasible) if the crop worker cohort is under (time) pressure.

4.4.6 Cleaning

The policy on cleaning between the rows varies from grower to grower and no observations have been made on the time required. At some nurseries it may be the responsibility of the crop worker whilst at others there may be specialist cleaning staff.

4.4.7 Picking (fruits or vines)

Picking always involves some degree of quality control. At the most basic level (usually for picking individual fruits) three criteria have to be considered. These are colour, size and integrity (i.e. no splitting). If fruits are being picked “on the vine” there will be extra criteria depending on the needs of the customer. As the criteria become more stringent, the rate of picking and packing is likely to decrease, as pickers have to exercise more judgement on selection or have to trim or arrange trusses before placing them in punnets.

The rate of picking has been found to be related to whether the plants have been de-leafed just prior to picking. Two pickers were observed at site B and the results are shown in Table 4.

Table 4. Row average picking times (s) per truss for two pickers

	Picker L			Picker G			
	Row 1	Row 2	Mean	Row 1	Row 2	Row 3	Mean
Not de-leafed	6.4	5.65	6.03	5.5	5.72	6.21	5.81
De-leafed	4.9		4.9	4.9	5.1		5.0

It would therefore seem appropriate for de-leafing and picking to be arranged such that the pickers do not start working in a row until after it has been de-leafed.

These results are also interesting in that the management was convinced that picker G was faster than picker L. On this very limited evidence this conviction seems to be true for rows that had not been de-leafed. The two pickers had started on the same day but one (G) had developed a picking posture facing the plants whereas L was facing 45° ahead of the plant she was picking. This may be to get a preview of the next plant and planning a picking strategy. It seemed evident from watching some pickers (including the faster ones) that they were not always looking at what they were picking. This suggests unusual hand-eye coordination skills which may be innate or may be developed on the job.

The rate of picking may also be influenced by whether the crop has been lowered, depending on the stature of the picker and ease of access to the fruits. Taller pickers may prefer the crop not to have been dropped whereas shorter pickers may prefer, and work more quickly in, a lowered crop. No data were collected on this.

Some managers believe that pickers work faster if standing rather than sitting but, again, no data were collected on this.

5 Conclusions and recommendations for year 2 investigations

5.1 Conclusions

The conclusions drawn from the work carried out to date are:

1. At the nurseries visited in Denmark and Holland, the composition of the labour pool was substantially different to that found on nurseries in the UK. The workforce on these nurseries also had greater season to season continuity than on nurseries in the UK. This reduced the burden brought about by the need to train new staff at the start of every season.
2. In the UK there is a culture of combining individual tasks in order that a crop worker can simultaneously carry out the operations during a single pass through the crop. This is particularly the case with work at the top of the crop where twisting, dropping, trimming and pruning are all carried out at the same time. Nurseries in Holland take a different approach, often breaking tasks down into their individual components. This is because they believe that this approach gives better workforce efficiency and it gives the option to more closely allocate staff according to their natural abilities.

3. The use of scissor lift working platforms (that allow the working height to be easily and regularly changed) was common on the nurseries in Denmark and Holland. Platforms of this type are judged to be better when considering both the quality and speed of work as they give the worker the opportunity to be in the correct position for carrying out the allocated task/s.
4. Where tasks are combined, the order in which they are carried out should be carefully considered. For example a top of crop worker who is carrying out lowering, twisting, trimming and pruning should not lower first as this is likely to mean that the remaining tasks have to be carried out outside the comfortable working zone.
5. Two alternatives to conventional crop twisting are available. These are clipping systems and Ringmaster®. Some measurements of the task times for these approaches indicate that labour rates that are equivalent to, or less than, conventional twisting can be achieved. In addition other advantages may result including reduced training times, less plant damage and less variability in the rates achieved by different workers. Independent data on the performance and costs associated with these techniques is not available however.
6. Whilst the target work-rates set by the UK nurseries are readily achievable, they require that workers operate close to their full speed. Measurements taken on the nurseries showed that the most common factors restricting the speed of work were unnecessary distractions and 'problem plants'.
7. From the work study data collected, there was no evidence to suggest that the workers observed on UK nurseries were slower or less proficient than those observed in Denmark or Holland.
8. Whilst there is limited use of hand tools (e.g. knives, secateurs etc.) on UK nurseries, it was identified that the ones in use were of poor quality and had little consideration of the principles of good ergonomic design. This was particularly the case with secateurs, where it was thought that advantages could be gained by moving to a design that held the operators wrist in a more neutral position.

5.2 Recommendations for year 2 investigations

The work carried out to date has successfully identified a number of areas where it is considered there is significant potential for realising improvements in labour efficiency. It is therefore proposed that the most promising of these areas should be studied in detail in the second year of the project. The specific recommendations are:

5.2.1 Work organisation

As discussed, current practice on UK nurseries is for operatives to carry out several tasks at the same time when working the crop (e.g. twist, drop and trim etc). This is in contrast to many nurseries in northern Europe where 'task breakdown' is practiced. Under this regime workers are only required to carry out one task at a time (e.g. twist only or drop only). Also, in many cases, workers are only trained to carry out one task. This is expected to reduce training times.

It is recommended that the implementation of work methods based task separation should be investigated on a UK nursery and the effect on work rate and quality measured and compared with conventional work organisation.

5.2.2 The use of improved tools / facilities

It is proposed that a nursery should be equipped with improved tools in order that the effect on work rate and quality can be studied. It is recommended that the study should include:

- Motorised picking trolleys
- Variable height work platforms
- Ergonomically superior secateurs.

5.2.3 Crop training methods

Crop twisting has been identified as one of the most critical operations on a tomato nursery. In an attempt to overcome the need for twisting and improve work-rates, two commercially available solutions should be studied in detail. These should be:

Ringmaster® – the method developed by Priva that uses a wire ring to hold the plant to the string and support the crop.

Clips – the technique that uses a plastic clip to support the crop on the string.

Both Ringmaster® and clips should be used during the 2005 cropping season and their effectiveness compared with traditional twisting. Performance of the systems should be compared in terms of:

- Work-rate
- Capital cost
- Consumables cost
- Cropping problems introduced by the system
- Crop disposal costs.

All of the above will provide invaluable information to growers that will enable them to evaluate their current systems and integrate improvements that will result in cost effective improvements.

Annex 1

Site Description	Site A – UK, modern greenhouse facilities
<i>Crops observed</i>	Rounds, Plums, Cherries
<i>Crop work and picking routines</i>	7-day cycle. Picking usually 3 times/wk (Mon-Sat), but sometimes twice. Usually 5am to 3pm.
<i>Organisation of labour</i>	Crop-workers and pickers. Crop workers have allocated rows of 12 - 14,000 heads. Pickers do not have their own area. Pickers are all students and work for the company for 6 to 7 months (the duration of their permits). De-leafing every 7 days (Mon-Fri). Crop workers are regarded as crucial for the success of the business.
<i>Composition of labour force</i>	English crop workers (salaried), most of picking labour comes from eastern Europe (students). These crop workers are paid hourly. Pickers are on piece-work.
<i>Recruitment of labour</i>	Eastern Europeans through Concordia. Very difficult to get UK staff, especially with experience. Other staff of UK origin tend to be awkward and difficult to retain.
<i>Breakdown of tasks</i>	1, 2, 3 & 4 combined. 7 & 9 combined or 8 & 9 combined, depending on variety/house. 5 done separately. 6 done separately both by crop workers. 10 done separately at grading. Crop workers are responsible for 11, 12, 13 & 14.
<i>Target work rates/task times</i>	[1] & [2] 400/hr. [5] 1200/hr. [11] & [12] 5 to 10 mins for ½ path [6] 15 mins for ½ path. [8] minimum of 250 punnets/hr (6 on vine).
<i>Performance monitoring</i>	At the fundamental level crop workers check their own quality. Manager's observations.
<i>Particular local practices</i>	As staff become more experienced, the area they control (crop workers) increases. Job rotation between packing and picking. 4.2 heads/sq m in Rounds house.
<i>Particular local concerns</i>	Good/bad crop work affects yield by up to 20%. Secondary growth (off-shoots/side shoots) on Cherries (Conchitas) when they are stressed. This creates extra demands on staff. Up to 25% of Cherry crop can be wasted by injudicious splitting of trusses (usually on colour).
<i>Other</i>	Robotic sprayer. Machine vision facility in grading area (categorises into 4 colours). Low level of bureaucracy in management.

Annex 2

Site Description	Site B, UK modern glasshouse facilities
<i>Crops observed</i>	Cherries, Vines, Classic Rounds, Plums (also visited packhouse)
<i>Picking routine</i>	Pickers work all day. Total area is divided into two – one half picked Mon, Wed & Fri, the other half on Tue, Thu & Sat. Most plants get picked twice a week.
<i>Organisation of labour</i>	Crop workers are salaried and work a minimum 39 hrs/wk Mon-Fri and longer if their tasks are not completed. Start between 06:30 and 07:00 by agreement with supervisor. They are responsible for 8 to 12,000 plants. Persistent poor performance leads to disciplinary action. Pickers paid by piece-work at rates based on the average week over the whole season. Thus their pay can vary according to the stage of the crop. They work Mon-Sat. Pickers organised into teams of up to 10 and are overseen by a picking leader. Picking leaders start between 07:30 and 08:00.
<i>Composition of labour force</i>	Locals, including some students, and mainly foreign students. Picking leaders tend to be locals but employed on a seasonal basis. Most pickers (70%) are students; the other 30% are seasonally engaged locals and these are now the most difficult to recruit.
<i>Recruitment of labour</i>	Crop workers mainly local people but recruitment becoming increasingly difficult. Most students are from eastern Europe and recruited via Concordia.
<i>Breakdown of tasks</i>	[1], [2], [3] & [4] combined. Crop worker does [5], but assisted by students (pickers) if necessary. [6] done by cleaner (not crop worker or picker) with engine-powered device. [11] & [12] done by crop workers. Pickers do [7] & [9] and [8] & [9].

<i>Target work rates / task times</i>	<p>[1], [2], [3] & [4] 370 /hour. [5] 960 /hour; supervisor to advise on how many leaves to remove (usually 3); to be completed by 14:00 to allow wounds to dry before evening (avoid botrytis). [7] picking individual Cherries 5 boxes/hour (i.e. 60kg or about 4,000 fruits). [8] picking vines (8 fruits) 100 kg/hr; (this is often exceeded at peak growth times).</p>
<i>Performance monitoring</i>	<p>For crop workers there is an objective assessment system carried out by the company management (e.g. Block Leader); results are related back to pay. The assessment involves ascribing a score each of 21 factors related to crop training (i.e. [1], [2], [3] & [4]. De-leafing [5] is scored on 8 different factors. The 29 individual scores are added together to give an overall score for the crop worker during that period. This system also helps protect the crop workers' income and bonuses from the possible effects of poor picking. Quite a complex system for calculating pickers' pay. They have a month to "get up to speed" before piece-rates apply.</p>
<i>Particular local practices</i>	<p>The company provides reasonably explicit written details on the role of crop workers, key areas for success and the tasks involved. The same type of information is available for pickers. Some relaxation of colour code (AVN) if picking on Fri and Sat. Use of Nomad recording system. It is the crop workers' responsibility to ensure that their individual areas (inc. trolleys etc) are kept tidy and safe. There are equivalent responsibilities stated in writing for pickers. No packing in greenhouses.</p>
<i>Particular local concerns</i>	<p>Broken heads: loss of income, cost of training. Considerable emphasis on the <i>speed</i> of performing tasks. Wastage due to damaged trusses.</p>
<i>Other</i>	<p>Prefer not to use knives for trimming, de-leafing because plant disease threat and operator health and safety. Risk of botrytis on damaged plants can be reduced by wrapping tape around "wound". Wide variety of packing regimes, as requested by different supermarkets; lines may change several times a day. One crop worker took me down a row after he had lowered it etc to show me how he checked 1) all debris was in aisle between rows (not lying on plants to increase disease risk), 2) all side shoots had been removed, 3) stems all within supports and 4) that no disease was developing. Do not swap attention from side to side when going down rows (on any tasks).</p>

Annex 3

Location	Alfred Pedersen & Son ApS, Odense (Denmark) (www.tomater.dk)
<i>Crops observed</i>	Classic, Rounds, Plums , Cocktail (Cherries)
<i>Picking routine</i>	Usually twice a week but sometimes Rounds picked only once a week.
<i>Organisation of labour</i>	Crop workers start when they want to; they aim to finish their on-the-crop tasks by 11:00 when they start attending to other tasks (e.g. reporting). Crop workers work Mon to Fri. Pickers work Mon to Sat. Pickers start at 06:00. Pickers work in Groups under a Leader. Leaders train new pickers.
<i>Composition of labour force</i>	Mainly Danish – both regular/salaried staff (crop workers) and casual/seasonal students (usually pickers). Some Polish students (about 6) started this year (this apparently does not save the company money because of the employment laws). All staff, Danish or foreign, are employed under the same terms and conditions and are all members of the Union.
<i>Recruitment of labour</i>	Mainly local for regular staff and from within Denmark for students. Recently recruited a few Polish students in anticipation of supply of Danish students diminishing. Recruitment of foreign staff is through an agency and they are paid via the agency. Foreign workers are eligible for flat payment rates only and they are not entitled to bonuses. However, they can work extra hours and earn overtime. One member of staff runs a training section for crop workers and is responsible for tuition and monitoring. The company feels that this is preferable to the previous mentoring system. All new crop workers go into the same house.
<i>Breakdown of tasks</i>	Tasks [1], [2] & [3] done separately from [4]. [5] usually done by crop workers (usually 3 leaves per week). In Block 4, [1] & [2] may be done separately as they are twisted every week but lowered only every 2 weeks (Almater – more fragile – see below). [6] debris cleared every 3 weeks (using brush and basket).

<i>Performance monitoring</i>	Pickers paid mainly by weight (kg/hour) for tasks [7] & [9]. There seems to be a lot of handling of boxes, cartons and crates.
<i>Particular local practices</i>	<p>Increasing interest in “unusual” varieties.</p> <p>Employ schoolchildren to put empty punnets in boxes prior to picking (piece-work).</p> <p>Punnets sold entirely by weight (target 280 – 325 g) so no special compositions necessary.</p> <p>Use Privassist monitoring system.</p> <p>Use of tannoy system to announce when picking requirements change.</p> <p>For some varieties (e.g. Almater) tasks [1], [2] & [5] paid as piece-work.</p> <p>Ringmaster® used with capsicum crop (Block 6).</p> <p>De-leafing is synchronised with pickers’ needs as far as possible but the plant considerations are paramount.</p> <p>Fruits obscured by leaves and close to the floor take longer to pick.</p> <p>In Block 3 (Almater) plants lowered every 2 weeks, changed from previously every week (every time a plant is lowered, it is stressed and the risk of damaging these more fragile plants increases).</p> <p>In certain periods, these are picked only once a week.</p> <p>Tomatoes from Block 4 (Almater) are not handled after picking [7] & [9] as the whole grading and packing process is automated.</p> <p>Use of different coloured support strings to denote (code) plant history.</p> <p>Use Tomahawks® (for holding support strings) in Block 1 (see figure A3.1).</p>
<i>Particular local concerns</i>	<p>Paying pickers by weight alone is not appropriate as it takes as long to pick a 70g fruit as it does to pick one of 80g.</p> <p>Considerable emphasis on giving staff (esp. crop workers) flexibility to plan their own day.</p> <p>Future (rising) labour costs: previous pay rises (over last 20 years) have been largely covered by increased productivity, but there seems very little scope to do this further.</p> <p>Future development probably lies in specialist products/niche markets but these are likely to be more labour-intensive.</p>
<i>Other</i>	<p>Very calm atmosphere here.</p> <p>No-one seems to be rushing about or working against the clock.</p> <p>We saw one girl pruning trusses [4] going very carefully and methodically.</p> <p>People are needed by grading machines to remove any unwanted fruits (split, too red etc).</p>



Fig. A3.1: Tomahawk supports in use at Pederson's Nursery, Denmark

Annex 4

Location	Site C, UK, older glasshouse (<i>Most of the below relates to House 1.</i>)
<i>Crops observed</i>	Plums, Santa
<i>Picking routine</i>	Twice per week: 1/3 Mon, 1/3 Tue, 1/3 Wed, 1/2 Thu, 1/2 Fri.
<i>Organisation of labour</i>	Crop workers and pickers. Each crop worker responsible for about 7,000 to 8,000 plants (42 paths). Works 39 hours/week, typically 06:00 to 14:00 (i.e. before hottest time of day). Each half-path (i.e. one side of the central aisle) 90 to 100 heads. Bonuses at end of season for crop workers who lose least heads. Only one crop worker is a student. Most pickers are foreigners.
<i>Composition of labour force</i>	Mainly foreign (e.g. Portuguese, North African but approx 50% students from eastern Europe). 8 supervisors and technicians plus 34 other full-time staff and 46 casual staff. There are about 30 pickers.
<i>Recruitment of labour</i>	Only very small turn-over of full-time staff. Eastern Europeans recruited via Concordia.
<i>Breakdown of tasks</i>	One week crop work cycle. [1], [2] & [3] done together. [4] not necessary. Do [5] before [1] so can do it standing rather than sitting on trolley. [6] done by crop worker; leaf trusses left on floor for 2 days (to wilt) before sweeping up. Pickers [7] & [9] do not always wait for de-leafing before picking a path.
<i>Target work rates / task times</i>	[1], [2] & [3] combined 38 mins per path. [5] 15 mins per path. [6] 3½ mins per path.
<i>Performance monitoring</i>	House supervisors look after 2 or 4 acres. Those with 4 acres may have an assistant supervisor. Supervisors responsible for training (done by putting with more experienced member of staff) and assessing task [5]. Crop work assessed randomly by a manager using a score sheet.

<i>Particular local practices</i>	<p>Increase plant density by training side shoots in March (when light gets stronger).</p> <p>One crop worker who is very fast at [1], [2] & [3] does twice the normal area (i.e. 1 acre, 14,000 plants) but no [5]. In this case, some of the pickers may do [5].</p> <p>In the Melrow House truss pruning [4] is done but to keep fruit size and ripeness as consistent as possible on the truss, not because the fruits are picked on the vine. Aim to have 9 fruits per truss.</p> <p>For this variety, leaf trusses usually removed when trimming [3] to provide more light and space for the top of the plant (this house has a particularly low roof). One of the operators removes these upper leaf trusses as a separate task.</p>
<i>Particular local concerns</i>	<p>Nature of crops grown for customers may not be highly bred so often more vulnerable to disease.</p> <p>Plum and Santa plants less fragile than Rounds so easier (therefore quicker) to work with.</p> <p>Try to snap leaves off rather than tearing or even using a knife as this reduces disease threat.</p> <p>Where truss pruning carried out, extra labour required.</p> <p>Piece-work rates calculated and adjusted weekly: this is to keep weekly income as steady as possible throughout the growing season.</p> <p>The system is designed to allow the fastest pickers to earn about £7 per hour.</p>
<i>Other</i>	<p>Do not grow specifically for high production but more to meet specific markets.</p> <p>There may be benefit in making truss pruning [4] a stand-alone task in the houses, where it is done.</p> <p>One of the crop workers thinks it takes up to 3 years to become fully experienced.</p> <p>Side shoots called "wooters".</p>

Annex 5a

Location	Westland, Holland The Greenery
<i>Crops observed</i>	Cochita Cherries (at 4.2 heads per sq m)
<i>Organisation of labour</i>	Crop workers (usually Dutch) and pickers. Main labour resource is for picking. Pickers paid piece-work.
<i>Composition of labour force</i>	2 Partners, 2 full time contract workers plus about 20 casual workers. These are mainly Polish and Turkish plus a few from an agency. Mostly, the same casual workers return every year so are reasonably well experienced.
<i>Recruitment of labour</i>	Becoming harder to recruit good crop workers. Many casual workers return from season to season. New ones provided by an agency and trained by contract workers. (Some experienced Polish workers also train new Poles.) Training manual available with all tasks explained (not in Polish and no illustrations).
<i>Breakdown of tasks</i>	[1], [2], and [3]. [4] not usually required except at early in season when many fruits are forming. [5] every 10 days (and arrange for it to be just before picking when possible). [8] & [10] combined.
<i>Target work rates / task times</i>	Picking Cherries 110 kg/hour average, ranging from 70 150 kg/hour. Expect 15 fruits per truss. For larger fruits (100 – 120 g) expect 400 kg/hour. Clipping using plastic clips (replacing twisting) 0.18 to 0.2 plants per second.
<i>Performance monitoring</i>	
<i>Particular local practices</i>	Use of Ringmaster® for “clipping” instead of twisting. Green rejected tomatoes not thrown away but given to local dairy farmer for fodder. All new scissor lift trolleys. Better trolleys encourage up and down mobility and so workers are less likely to delay (and possibly forget) a task that requires them to descend briefly (e.g. attending to a disease concern).
<i>Particular local concerns</i>	Labour costs have now overtaken energy costs.
<i>Other</i>	Clipping is quicker than twisting and less likely to cause plant damage. Can do clipping manually or with Ringmaster® which applies copper rings to hold the stem near the string. (Brief observation of Ringmaster® suggests a rate of 0.5 to 0.6 plants per second)



Fig. A5a.1: Plastic clip



Fig A5a.2: Ringmaster® in use



Fig A5a.3: Ringmaster® copper ring

Annex 5b

Location	Westland, Holland Triomaas
<i>Crops observed</i>	Campari (relatively large, > 80 g each).
<i>Picking routine</i>	
<i>Organisation of labour & Composition of labour force</i>	Crop workers (Dutch staff are always crop workers) and pickers. Also have Polish and Turkish staff.
<i>Recruitment of labour</i>	
<i>Breakdown of tasks</i>	[5] usually 3 leaf trusses each time. [6] not done. [8 & 9] combined.
<i>Target work rates/task times</i>	
<i>Performance monitoring</i>	
<i>Particular local practices</i>	Use of Tomahawk® here (2.3 ha). Particularly advantageous with the heavier fruits and plants here. Crop workers have knife hanging around neck but rarely used for anything other than cutting broken stems (i.e. not for de-leafing). Highly automated packing and grading system (800 boxes per hour).
<i>Particular local concerns</i>	
<i>Other</i>	Recommended string size is 1200 m/kg. Jetti Prins (of Priva) joined us for this visit.

Annex 5c

Location	Westland, Holland (Van Kester)
<i>Crops observed</i>	Aranca (2.5 to 3.5 heads per sq m)
<i>Picking routine</i>	
<i>Organisation of labour & Composition of labour force</i>	Most of the labour (regular and casual) is Polish or Dutch students. The Poles that are employed on a seasonal basis tend to be the same people every year. Crop workers paid on an hourly basis (with bonus if appropriate). Pickers paid piece-work according to the prevailing rate (depends on stage of crop).
<i>Recruitment of labour</i>	
<i>Breakdown of tasks</i>	[1], [2] or "clipping", [3] & [4] all carried out separately. Sometimes [2] and [3] combined but manager strongly holds the opinion that less mistakes (causing loss of productivity) are made if these two tasks are kept separate from [1] especially and [4]. [4] may be combined with [2].
<i>Target work rates/task times</i>	Twisting at least 750 heads per hour. Picking averages at 250 kg/hour over the season but target for piece-work rates according to the stage of the crop.
<i>Particular local practices</i>	Use of Ringmaster®. The stem support usually comprises 2 copper rings and 1 plastic clip (see Figures in Annex 5a) in repeated sequences.
<i>Particular local concerns</i>	Good twisters could "hold the company to ransom", which is why use of the Ringmaster® is regarded so positively. All employees to ensure that high quality is maintained.
<i>Other</i>	Do not work in glasshouses when (air) temperature exceeds 32 °C.

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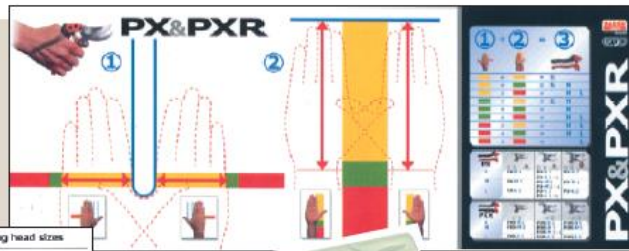


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