NY98031

Optimum Work Methods in the Nursery Potting Process

W Radajewski, D Brown and T Franklin
Queensland Horticulture Institute

Know-how for Horticulture™

NY98031

This report is published by the Horticulture Australia Ltd to pass on information concerning horticultural research and development undertaken for the nursery industry.

The research contained in this report was funded by Horticulture Australia Ltd with the financial support of the nursery industry.

Cover price: $22.00 (GST Inclusive)
ISBN 0 7341 0226 7

Published and distributed by:
Horticultural Australia Ltd
Level 1
50 Carrington Street
Sydney NSW 2000
Telephone: (02) 8295 2300
Fax: (02) 8295 2399
E-Mail: horticulture@horticulture.com.au

Final Report
Project NY98031

(April 2001)

Optimum Work Methods in the Nursery Potting Process

W. Radajewski, D. Brown, T. Franklin

Department of Primary Industries
Queensland Horticulture Institute
Centre for Amenity and Environmental Horticulture

Project NY98031

Dr W. Radajewski
Queensland Horticulture Institute
P.O. Box 327 Cleveland 4163
Phone (07) 32861488

The purpose of this report is to provide information to the Australian nursery industry on the present state of potting production efficiency and potting labour costs and show potential methods of improving potting production performance.

Horticulture Australia Limited

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

Nursery Industry Association of Australia

APRIL 2001

Media summary

The investigation of potting labour costs has been carried out by a team of researchers from the Queensland Department of Primary Industries in collaboration with the Queensland, New South Wales and Victorian Nursery Industry Associations. All of the investigative work has been carried out on representative nurseries in these states.

The aim of the project has been to identify and recommend methods for improving nursery labour efficiencies in the area of potting up. The project has progressed through stages that resulted in the following major outcomes:

- Labour cost components of the potting operation have been identified
- Potting production inefficiencies have been identified and solutions proposed
- Benchmarks for the potting operation have been developed
- A potted plant handling system has been developed and commercialised
- Training resource material has been developed

Though research has confirmed that the vast majority of Australian nurseries operate with excessive production labour costs, nurseries display a notable lack of motivation and success in attempting to improve their production efficiency. This is because nurseries have no access to information on how they compare with other nurseries in terms of production efficiency. As a result of this:

- some nurseries choose to believe they are doing much better than everyone else and do not attempt to improve their production efficiency
- some nurseries accept they are inefficient but don't know exactly how inefficient they are or how they can improve
- some attempt to improve efficiency but have no idea of their current level of efficiency or the level they should be aiming for, typically basing their improvements on untested, non objective information and therefore fail to achieve any significant improvement or achieve a negative result (ie. production costs increase)
- the last and smallest group (estimated at not more than 1% of all production nurseries), despite being unaware of their current level of efficiency or the level they should be aiming for, try and do achieve some improvement in their production efficiency although not always in terms of an acceptable cost benefit result.

In order to maximise the benefit of research, the engineering section at DPI is proposing to establish a permanent, full time centre for nursery production research. Nursery industry members and allied manufacturers will be encouraged to use the centre's research data and information for their mutual gain and researchers will be able to continually monitor, investigate and report on all aspects affecting nursery production.

Technical Summary

The reasons for high labour costs in potting production have been studied at small, medium and large nurseries in pot sizes ranging chiefly from 100mm to 200mm. Both hand potting and machine aided potting were investigated in the 52 Australian and 10 overseas potting systems commercially operating in the nurseries collaborating with the project. Ten distinct potting systems were studied in the project: standard bench, modified bench, mobile bench, Javo, Comet, Mayer, C-Mac, rotary table, KW Engineering and the prototypes of the WHTI potting machine.

The labour cost of overall potting production was divided into three potting stages: preparation, potting, and after potting. The labour cost of potting was investigated on the basis of nine potting processes: handling planting stock, pot handling, fertiliser handling, media handling, handling pot with media, handling the potted plant, handling other associated materials, maintaining the potting area and preparing the growing area.

The lowest amount recorded for total potting of 3.1 cents per pot represents potting easy to pot plants into small sized pots and the highest amount for total potting of 35.43 cents represents potting difficult to pot plants into large sized pots. Benchmarks for the labour cost of potting production have been developed that include adjustments for the differences in potting difficulty between various plant species. The benchmark figures are suitable for nurseries to use to establish their level of potting production efficiency and determine their potential for labour cost savings.

A device has been developed and a prototype built to minimise the cost of potted plant handling which is commonly the most costly element in the potting operation. The concept of this device has been patented and a commercial company is presently involved in the development of a commercial version of the device.

In general, the investigation concluded that nursery operators' lack of objective information on various aspects of production efficiency is the major reason for existing high levels of labour cost. It also concluded that the specific reasons for excessive potting labour costs paid by nurseries is most often due to:

- inefficient organisation of potting procedures often combined with the use of an inappropriate potting system and equipment as well as poor materials handling methods are responsible for approximately 65-85% of excessive potting labour costs
- staff with inadequate job training and accompanying levels of skill and motivation is responsible for approximately 10-20% of excessive potting labour costs
- high potting difficulty of plants is responsible for approximately 5-15% of excessive potting labour costs.

The general recommendation is to increase the average daily number of plants to be potted that have similar requirements with regard to treatments, potting procedures, pot sizes, pot colours and/or to keep the daily work load as constant as possible. This strategy will immediately lower potting labour costs without any expenditure.

1 Introduction

The issue of labour efficiencies is a significant concern to the nursery industry and has led to much discussion over past years in terms of what can be done to increase nursery production efficiencies and minimise labour costs. This is a very broad issue and to comprehensively address all areas of labour efficiencies in production nurseries is well beyond the current resources of the nursery industry.

To identify the research priorities in work efficiencies in order to determine the direction and nature of this project, the Nursery R&D Committee encouraged the Queensland DPI engineering group at the Centre for Amenity Horticulture, Redlands Research Station to conduct a mail survey. Based on results from this survey it was identified that research priorities in work efficiencies were, in declining order; growing on, propagation, dispatch and administration. The split of priorities under the heading 'growing on' were; potting, placement, plant maintenance, organising production and area maintenance.

In June 1998 a workshop was held involving members of the Nursery R&D Committee, nursery industry representatives, research providers, nursery IDOs and HRDC (now Horticulture Australia Limited) to discuss the development of the project specifically in the areas of the propagation process and the potting process and to define where these processes began and finished. It was concluded that there were far more potential gains to be made in researching the potting process first.

A unanimous decision was made to concentrate the workshop and subsequent project on potting up. Potting up was defined as the process starting with the placement of a propagation container containing the plant stock to be transplanted in the potting work station, and finishing with placing the first saleable sized container containing the new transplant onto nursery internal transport. It was felt that at least some of the results of the work to improve potting processes would be applicable to propagation.

The aim of the project was to identify and recommend methods for improvements in nursery labour efficiencies in the area of potting up, from propagation container to first saleable sized container and to reduce production labour costs in nursery operations of all sizes. In order to achieve the above aim the following project objectives were defined and addressed:

- Identify labour costs involved in different tasks in the potting process
- Identify current areas and reasons for inefficiency in these areas
- Identify and develop industry best practices for potting operations
- Transfer technology into industry during and at the completion of the project by means of written materials, consultative workshops, field days and most importantly, providing information for a subsequent industry run, national training course.

The major concern of research providers was that the potting process as defined above omits a number of practical potting procedures and, therefore, only allows for a partial pattern of potting labour costs to be established (see Table 1). Table 1 shows the estimated percentage of potting labour cost investigated within the initial scope of the original project. When additional relevant tasks were investigated, it was found that approximately 52 percent of costs occur in

areas not included within the original scope of the project and therefore a revision of the scope of the project was obviously required.

Limiting the scope of the project as far as percentage of total potting labour cost involved reduces the value of the investigation and does not allow for conclusive recommendations and practical solutions to be produced as not all labour aspects of potting would be investigated. In order to avoid this problem research providers took the precaution of collecting some information related to those aspects of potting not included in the original project framework. However, the additional information collected covered only some general procedures and is based mostly on information provided by nursery operators and therefore could be considered subjective.

On the basis of the overall data collected in the first stage of the project, it has become obvious that a great portion of the total potting labour cost is related to aspects of potting other than those originally to be investigated. It was also concluded that potted plant handling is commonly the most costly element in the potting operation. Therefore improvements to the handling of potted plants should be investigated as a first priority as this offers the greatest potential savings for nurseries especially for the production of larger pot sizes (i.e. 140mm and above).

Table 1. Estimated percentage of potting labour cost as investigated within the scope of the original project

	% of labour cost (revised scope of project)	**% of labour cost (initial scope of project)**
Handling of potted plants	38	10
Plant stock handling	29	20
Media handling	10	6
Handling pot with media (before inserting plant)	7	7
Empty pot handling	4	2
Fertiliser handling	4	3
Preparing growing area	4	0
Handling other materials used during potting	3	0
Maintaining potting area	1	0
Total	**100%**	**48%**

On the basis of the conclusions above a six month extension was granted with the specific objective being the development of strategies for potted plant handling including construction of a prototype device.

A number of researchers ((*Gaydon & Radajewski 1993, Corlett 1995, Radajewski et al 1997, Hendrix 2000)*, have investigated methods for reducing labour costs in nursery production. However, only some of this research is related to potting production and in many cases hi-tech

automation was investigated and reported as the solution to high labour costs. *Corlett* 1995 concluded that the way a system is initially organised and the manner in which it is operated ultimately determines a system's level of production efficiency. This has been confirmed by *Radajewski et al 1997.*

2 Materials and Methods

2.1 Nurseries and systems investigated

The general terms of reference of the project were to investigate potting labour costs in small (1-5 staff), medium (6-15 staff) and large (over 15 staff)[1] wholesale nurseries chiefly producing pots in the range from 100mm to 200mm. The break up of nurseries collaborating with the project is shown in Table 2.

Table 2. The break up of project nurseries based on state and nursery size

	Number of nurseries per state			
	Small	Medium	Large	Total
QLD	5	4	8	17
NSW	8	8	7	23
VIC	4	4	4	12
Total	17	16	19	52

In total, the potting of approximately 145 000 pots of various pot sizes on various potting systems has been investigated (providing a total of 74 combinations of system and pot size - see Table 3 and Table 4).

Table 3. Approximate number of pots investigated in each pot size

Pot size	100mm	125mm	130mm	140mm	150mm	175mm	200mm
Number of pots	15 680	11 750	1 960	56 820	7 830	9 800	41 150

Potting systems have been subdivided as follows:

Hand potting - (all systems in which tasks in the potting stage are carried out manually)

- *Standard potting bench.* A standard potting bench is any work station in an area specifically designated for potting at which potters can pot plants. A table loaded with a quantity of potting media would be considered a standard potting bench.

[1] Defined by HRDC Technical Committee

- *Modified potting bench.* A modified potting bench is a standard potting bench, which has been modified by the addition of a hopper to feed media to the bench and/or conveyors to bring stock to the bench and/or to take potted plants away from the bench, etc.
- *Mobile potting bench.* A mobile bench is a standard or a modified potting bench on wheels. Potting commences when the mobile bench has been transported to that part of the nursery where plants are to be put down. A mobile bench might be a trailer towed behind a tractor, the rear tray of a utility or truck, or a truck mounted hopper.

Machine assisted potting - (insertion of potting media to the pot is semi-mechanised)

- *Comet potting machine.* Andersen's Engineering in Maryborough QLD produce the Comet potting machine. It delivers a continuous flow of media from two chutes. Potters stand in front of these chutes and fill empty pots with media.
- *Rotary potting tables* (no longer being manufactured)
- *Pot/bag filling machine* by C-Mac Industries and Johnson

Machine potting - (insertion of media to the pot, drilling of the hole for insertion of plant stock and in some cases, removal of the potted plant from the machine, are all mechanised)

- *Javo potting machine.* The Javo potting machine is a Dutch product. Moving pots in one direction, the machine fills empty pots with media and drills a hole in the media for the insertion of plant stock. There is the option for adding automatic pot dispensers, fertiliser dispensers, and conveyors for the removal of potted plants from the machine.
- *Mayer potting machine.* The Mayer potting machine is a German product. It works on the same principle as the Javo with similar options available for automating certain tasks.
- *WHTI potting machine.* The prototype of a new Australian designed potting machine manufactured by Williames Hi-Tech International in Victoria.
- *KW Engineering potting machine.* A new Australian designed potting machine manufactured by KW Engineering in Queensland.

Table 4. Break up of all investigated combinations of potting systems and pot sizes on basis of state

	Potting system							
	Standard bench	Modified bench	Mobile bench	Javo	Comet	Mayer	Other (WHTI, KWE, CMAC Rotary Johnson)	Total
QLD	10	6	2	3	7	0	1	29
NSW	3	1	2	5	12	2	6	31
VIC	5	1	1	3	1	1	2	14
Total	18	8	5	11	20	3	9	74

2.2 Data collection methods

The following methods of data collection have been used in the investigation of potting labour costs:

- *Generic data*
  The collection of information on nursery production profiles, plant stock and potting container size preferences, plant type, staff, machinery and current systems used for the potting process. This information has been used to categorise the various types and sizes of operations and to define how they can be compared on a common basis.

- *Detailed data collection (video recording)*
  Video records have allowed project staff to evaluate overall work practices in different nurseries. The information gained has been used firstly to benchmark all tasks involved in the potting process for each different nursery environment and, secondly, to define the labour cost of specific tasks.

- *Potting events data logging*
  An electronic data logger has been used for collecting data for the whole range of potting events. This device is designed so that recording of events takes a minimum of time and further data processing is greatly simplified.

- *Statistical data collected by nursery operators* (see sample of forms in Appendix 1):
  Nursery potting records have been requested from collaborating nurseries. This information has helped establish long term performance capabilities, including the extent and reasons for unproductive and down time. This form of data is useful for comparing different production environments.

- *Observation of potting events*
  Potting events have been observed by project staff in order to define existing work practices. Based on these observations and further discussion with nursery operators, potting production flow charts have been created and analysed.

The number and sequence of tasks performed during potting production differs from nursery to nursery and largely depends on the potting system used and type of plants produced. The following potting production information was recorded (see sample of forms in Appendix 1):

- Time required to complete any task related to potting
- Number of pots processed during this time
- Type and size of propagation and potting container used
- Number of staff involved in tasks
- Plant potting difficulty
- Name of plant
- Method and type of potting system used
- Distances between different potting production areas in the nursery
- Capacity of pot handling equipment

The labour tasks of potting were subdivided into nine separate processes (for details of the subdivision see *Attachment 1, pages 11-15*):

- Plant stock handling (any action carried out on plant stock during the potting process from the time it is picked up from the hardening off area until the plant stock is placed into the pot with media).
- Pot handling (any actions related to handling empty pots prior to filling the pot with media).
- Fertiliser handling (any actions related to handling fertiliser during the overall potting event).
- Media handling (any actions carried out on potting media until the time media is placed into the pot).
- Handling pot with media (any actions carried out with the media filled pot before plant stock is inserted).
- Handling potted plant (any action carried out on the potted plant immediately after plant stock has been inserted in the pot to the time the pot is placed in the growing area).
- Handling other materials (any action associated with trays, trolleys, trailers, stakes, labels, etc. used in the potting event).
- Maintaining potting area (any cleaning of the area or setting up machinery used for potting)
- Preparing growing area (any action carried out to prepare the growing area for newly potted plants).

Data from different potting events has been collected from each potting system a number of times (from 3 to 9 times). A data file of potting production information has been made for each collaborating nursery. The master file has been used to process results from each potting system and for each pot size. In this way an output file has been created for each pot size processed on a specific potting system in each nursery. For example, a nursery that used two different potting systems (eg. standard bench and Javo and potted three pot sizes on standard bench and two pot sizes on Javo) would have 5 different output files. The information from these files has been used to provide detailed confidential reports on production performance to specific collaborating nurseries. The summary of the results from nursery output files has been combined and processed in files based on potting system used, pot sizes used, state from which data originated, and nursery size as already defined.

3 Results

The results are based on the data collected by researchers during potting production in collaborating nurseries as well as on data provided by nursery operators. The average values shown in the following figures represent all systems, pot sizes and plant potting difficulty levels investigated during the course of the project. 140mm pots are the most commonly used in nursery production. For this reason, in the following sections, results are often corrected to 140mm pot size so results may be compared on a common basis.

It is recognised that certain plants are easier to pot than others. Therefore, plant potting difficulty has been divided into three degree of difficulty categories related to the following tasks (factors):

- Removing stock from container (C_{sr})
- Inserting plant into pot (C_{si})
- Handling stock container (C_{sc})

Where: $1 <= C_{si} <= 3$ and $1 <= C_{sr} <= 3$

The value of C_{si} and C_{sr} is arbitrary, defined on the basis of the number of sub-tasks required to complete these tasks (eg. if the number of sub tasks is two the category is also two).

Three levels of degree of difficulty have been created (easy, average, hard) for the first two of the above factors. Degree of difficulty of handling the stock container was defined as shown in Table 5.

Table 5. Sample of stock containers and category of difficulty (C_{sc})

	Bought, pre-popped stock	Container type							
		Tray 288 cells	Tray 196 cells	Tray 64 cells	Tray 42 cells	50 mm tube	75mm tube	100mm pot	125mm pot
category	1	2	3	4	5	6	7	8	9

Using the above factors, the category of stock difficulty (C_{sd}) for the specific pot size was defined by an empirical equation 1.

$$C_{sd} = (2 * C_{sr} + 2 * C_{si} + C_{sc} - 3)/2 \quad (1)$$

When plants with different category of stock difficulty were potted to the same pot size on the same potting system the average category of plants was defined as

$$C_{sd\,(average)} = \Sigma\,(pots_{(n)} * C_{sd(n)})/\,pots_t \quad (1a)$$

The *equation 1a* is solved for $n = C_{sd(min)}$ to $n = C_{sd(max)}$ where; $pots_n$ is a number of pots in '*n*' category and $pots_t$ is the total number of pots in a specific pot size potted on a specific potting system during the period of collecting data.

The overall time of potting was then corrected according to an empirical formula (see equation 2) generated from the collected data.

$$Time_{pc} = Time_{pr} + Time_{tr} * \sinh(5 - C_{sd\,(average)})/100 \quad (s/pot) \quad (2)$$

Where $Time_{pc}$ is corrected time of potting; $Time_{tr}$ is the recorded total time of tasks involved in handling stock plant at the potting station up to the time when inserted into pot; and $Time_{pr}$ is recorded time of potting.

In some cases the time of potting was corrected according to pot size. Only tasks in which handling of potted plants was affected by the pot size were corrected using correction factors as reported by *Radajewski et al 1997* (see Table 6).

Table 6. Pot size correction factor

Pot size	100mm	125mm	130-150mm	175mm	200mm
Correction factor	0.5	0.75	1	1.5	2.5

3.1 Nursery potting production data

Nursery production general data was collected in order to establish the most practical methods of reducing labour cost during potting production taking into account the required rate of production. The potted plant handling data was required for the development of the concept and the design of handling devices that could streamline the operation of transporting potted plants from the potting area to the growing area and putting them down in growing bays.

Figure 1 shows the average annual potting production per nursery for different pot sizes. Figure 2 shows a range of the minimum average and maximum hourly potting production rates for different pot sizes. There is approximately 400% difference between maximum and minimum hourly production rates for the most common pot size (140mm). This difference in production rates has to be taken into consideration when a system is set up and operated.

Figure 3 shows the average percentage of pots that are spaced (other than pot to pot) during the putting down process in the growing area directly after potting. As this figure shows, approximately 60% of all pot sizes are spaced immediately after potting so as to avoid additional plant handling at later stages when plants are reaching full maturity. Figure 4 shows a range of spacing distances (centre of pot to centre of pot) used by different nurseries for different pot sizes during putting down pots in the growing area. Different spacing is used for different types of plants and also when a specific plant size and shape is required. It is expected that other spacing patterns than those recorded are also used in some nurseries.

The wide range of spacing makes the process of task mechanisation more difficult than it otherwise would be if a few standard spacing dimensions were common to all nurseries. On the other hand, if a cost effective system for spacing were available, nurseries would perhaps be more willing to adjust their production methods in order to take advantage of the reduced cost of potting production.

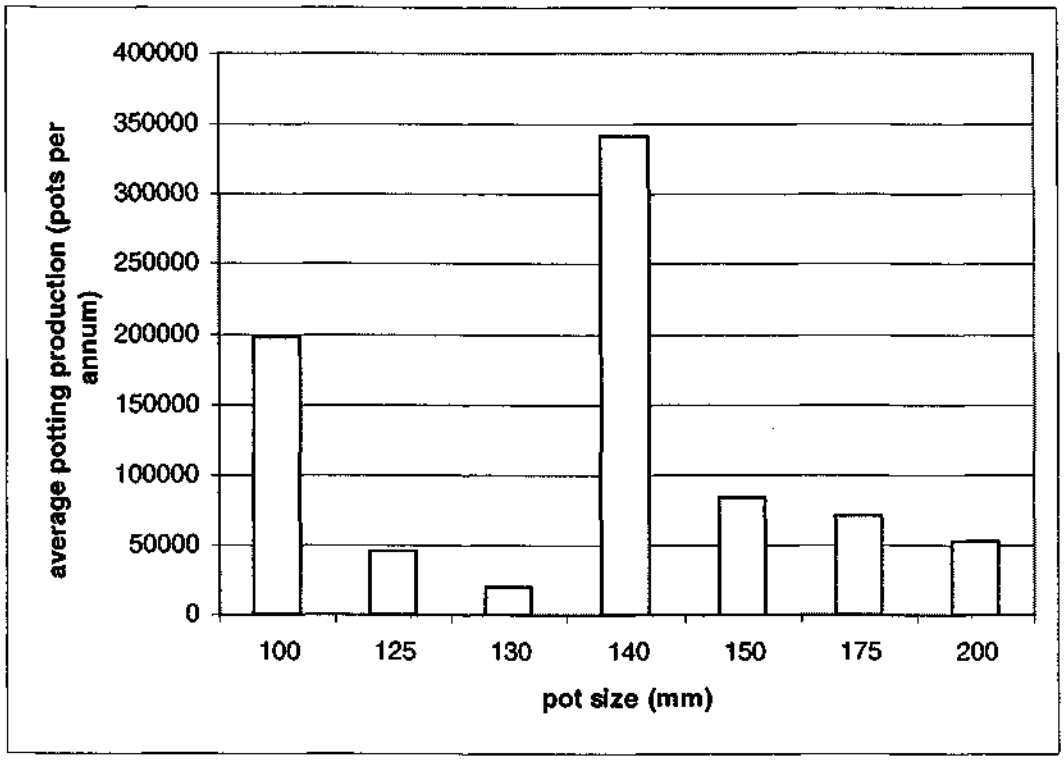


Figure 1. Average annual potting production for different pot sizes[1].

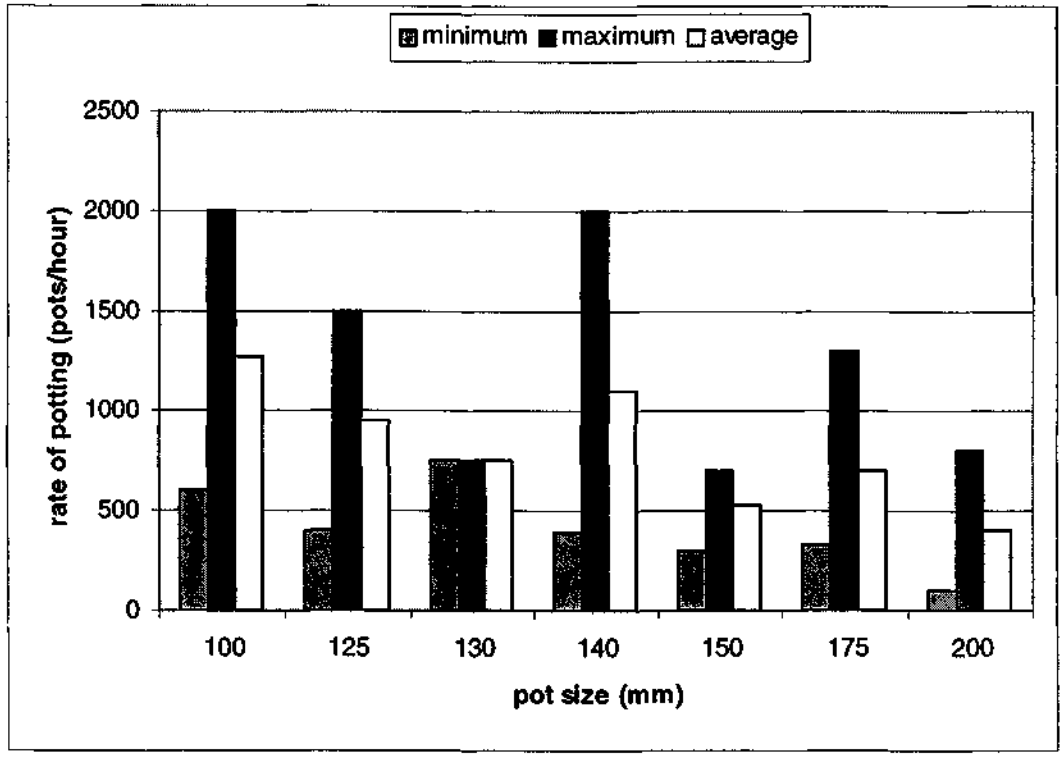


Figure 2. Range of hourly potting production rates for different pot sizes[1].

[1] Based on survey October 2000 – see Appendix 4

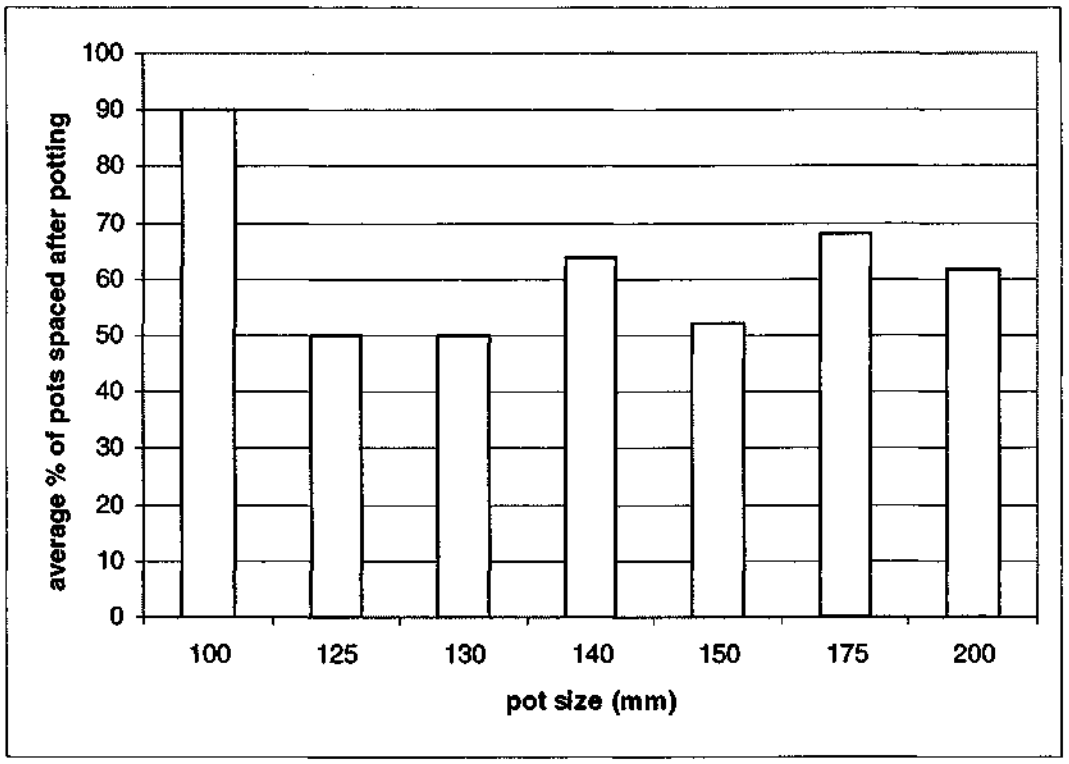


Figure 3. Average percentage of pots spaced (other than pot to pot) directly after potting[1].

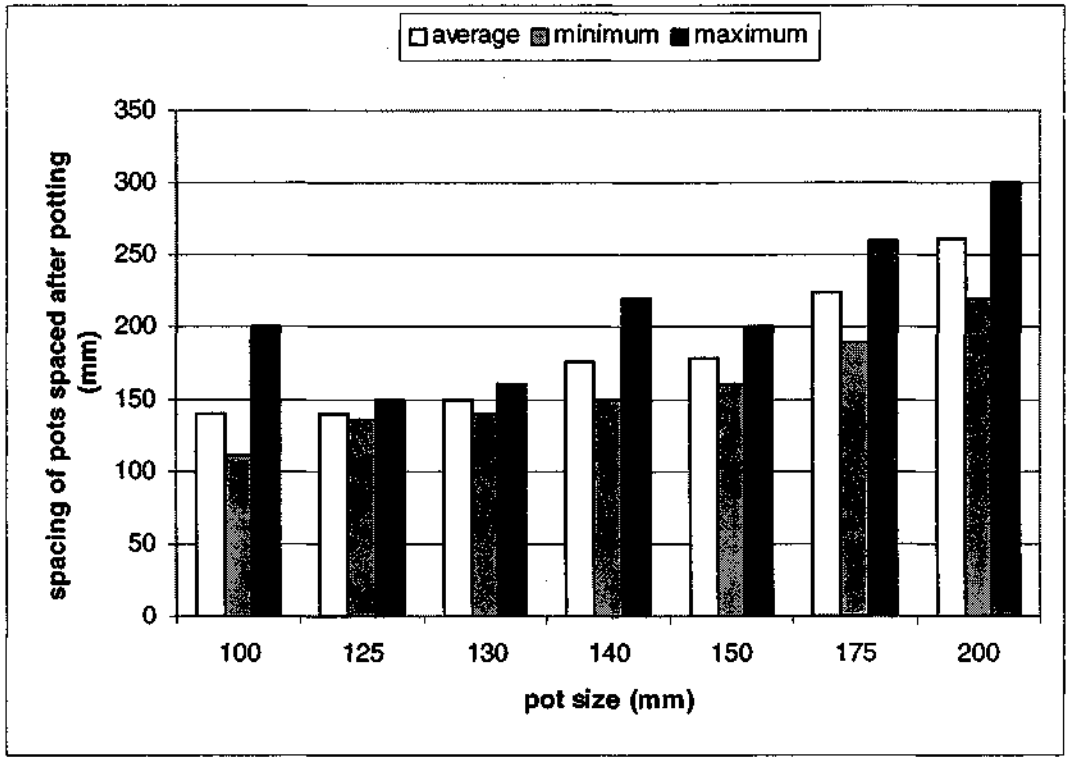


Figure 4. Range of distances (pot centre to centre) used by nurseries for different pot sizes.

[1] Based on survey October 2000 – see Appendix 4

3.2 Potting performance

In this report, potting performance and labour cost data has been recorded so that:

- different nurseries can be compared
- nurseries using similar systems (eg. Javo potting machine) can be grouped and the systems compared
- comparisons can be made between nurseries form different states
- comparisons can be made between size of nurseries
- comparisons can be made between different pot sizes

comparisons are made between all or numbers of nurseries involved in the project. Each nursery has therefore been allocated a confidential number so it may know where its labour performance (cost) figures lie in relation to other participating nurseries. The confidential number was only provided to management at the relevant nursery.

Figure 5 shows the average duration of potting tasks (seconds per pot) for the most common tasks conducted during potting production (all pot sizes used in systems during the period of data collection were used in the calculation). In some cases the description of tasks on graphs may not seem to match the tasks as they are known in some nurseries. Faced with the great variety of potting tasks (often referred to differently by different nurseries), researchers decided to use common task names and trust in the ability of nurseries to relate tasks to their own operations. For example, if a task is shown as 'loading potted plant to trailer' and a specific nursery loads potted plants to conveyors rather than trailers then in this nursery's case the time shown will refer to loading potted plants to conveyor. A description of potting tasks is provided in *Attachment 1 – pages 11-15.*

Figure 6 shows the break up of total potting time (% of total potting time) according to the potting processes for all potting systems used in this study. The tasks related to potted plant handling, plant stock handling and media handling represent 76% of the total time involved in the potting process for all potting systems used in this study.

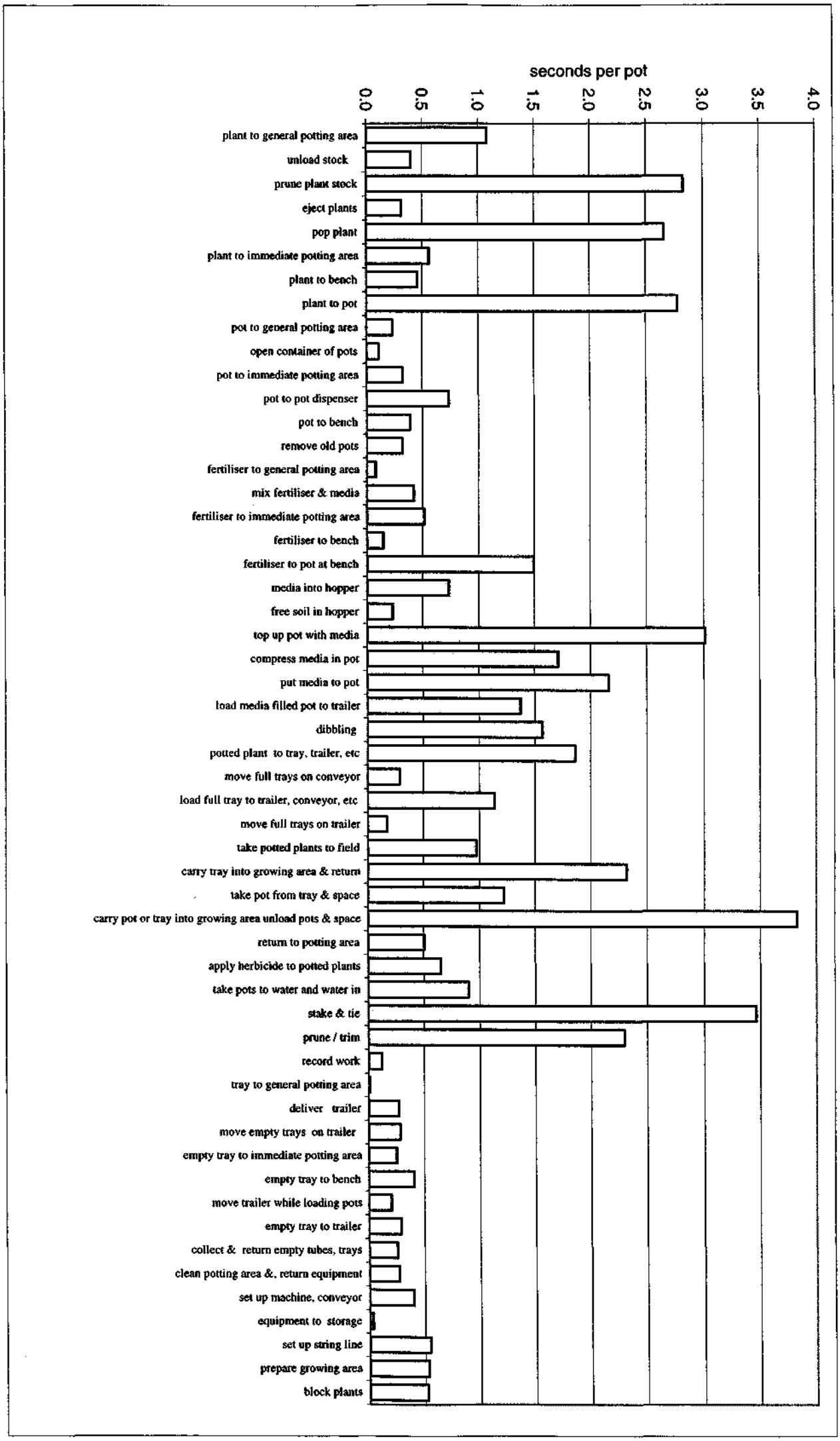


Figure 5. Average duration of potting tasks.

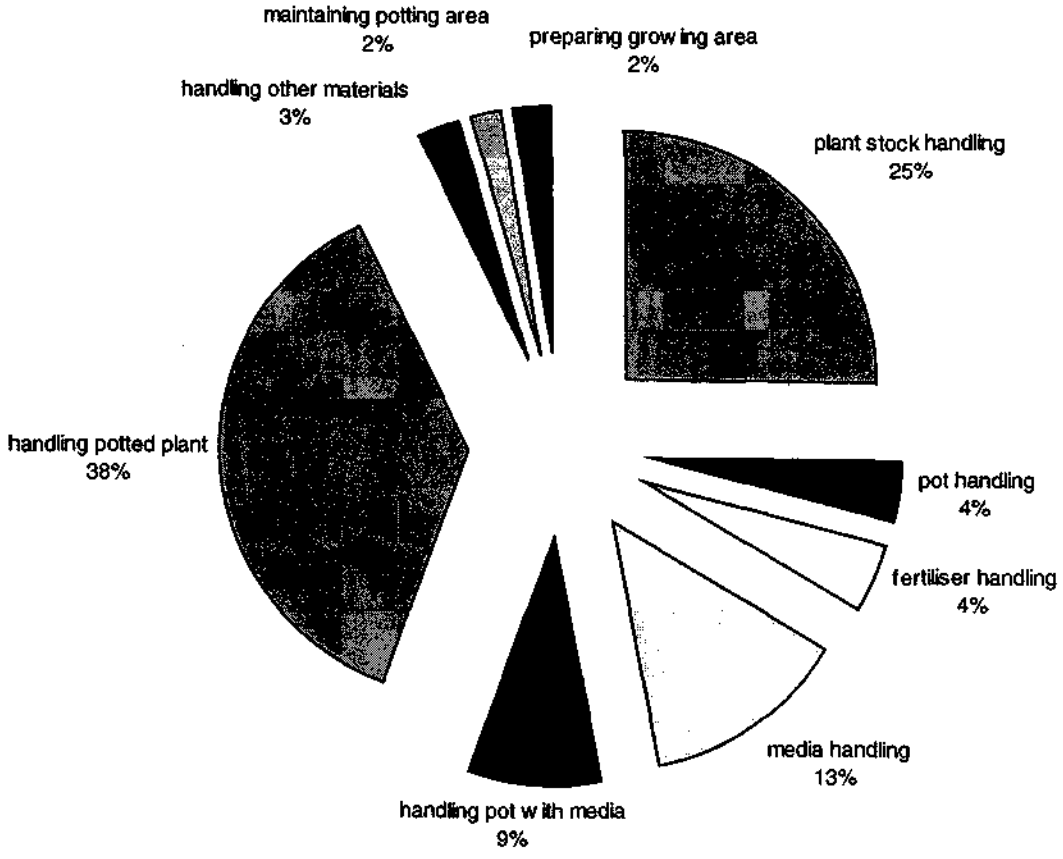


Figure 6. Break up of total potting time.

3.3 Potting cost

The *recorded* potting labour cost ($Cost_{(\$15)}$) was defined on the basis of the labour time involved in potting production and on an hourly labour rate of $15 which included all on cost charges (leave loading, superannuation ,etc.). This approach was necessary in order to compare results from all nurseries. The actual nursery labour cost rate ($Rate_{(real)}$) varies from nursery to nursery and therefore the real cost ($Cost_{(real)}$) in a specific nursery can be obtained by

$$Cost_{(real)} = Cost_{(\$15)} * Rate_{(real)} / 15 \quad (\$/pot) \qquad (3)$$

Figure 7 shows the *recorded* and *adjusted* average potting labour cost in the areas of: preparation for potting, potting, after potting and total potting, for all potting systems and pot sizes investigated during the course of the project. The adjusted average cost on this figure is higher than recorded cost because the major production records are from *large* nurseries where the category of plant potting difficulty is below the established average.

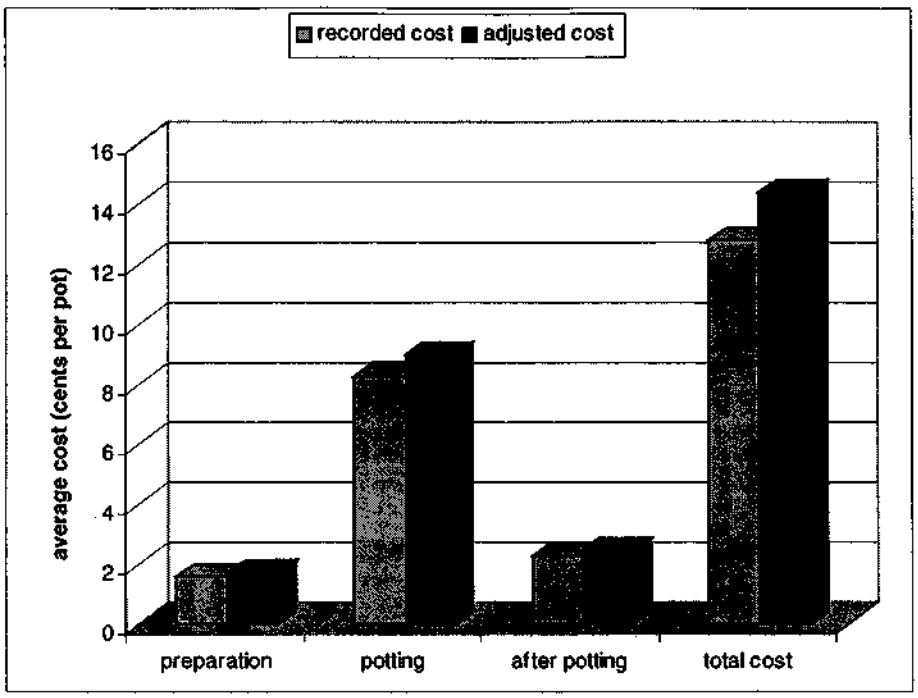


Figure 7. Average cost of potting.

Figure 8 compares the average potting cost in cents per pot for all pot sizes and all potting systems investigated during the project. Note that no adjustment has been made to account for the different levels of potting difficulty of different species of plants potted. Under each bar appears the pot size and nursery number. From this figure it is evident that some nurseries are paying over 20 cents per pot more in potting labour cost than others.

3.3.1 Potting systems

Figure 9 shows the average total cost of potting (as recorded) for different potting systems broken up into the three major potting operations: preparation, potting and after potting. It can be seen that there is an approximate 15 cents difference in the cost of labour between the '*best and the worst performing potting systems*'. However, once the cost of labour is adjusted to the same potting difficulty and pot size the difference between various systems is reduced to approximately 8 cents per pot (see Figure 10). Figure 10 shows the average total cost of potting adjusted to 140mm pot size and difficulty category five. In real terms the cost shown in Figure 10 has only academic value as the real cost to nurseries is based on values shown in Figure 9.

The details recorded for the labour cost of potting for individual nurseries are shown in Figure 11. As shown in Table 4 the number of potting operations investigated during the course of the project under each potting system is different. Therefore an average generated as shown in Figure 9 may not accurately represent a specific system. In Figure 11 the labour costs of the best performing nurseries in each potting system are much closer to each other than the average labour costs for each potting system shown in Figure 9.

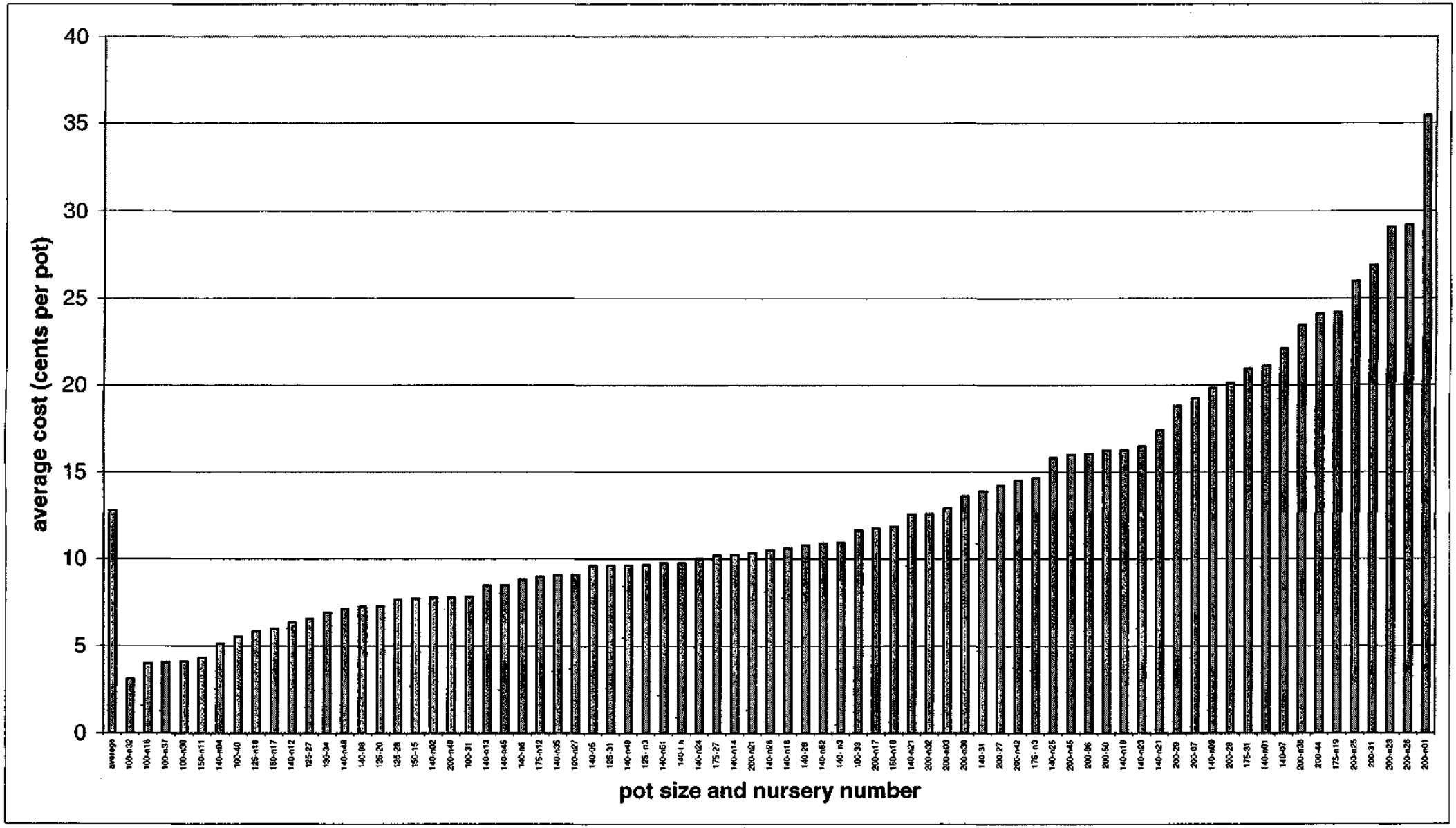


Figure 8. The average cost of potting for different nurseries.

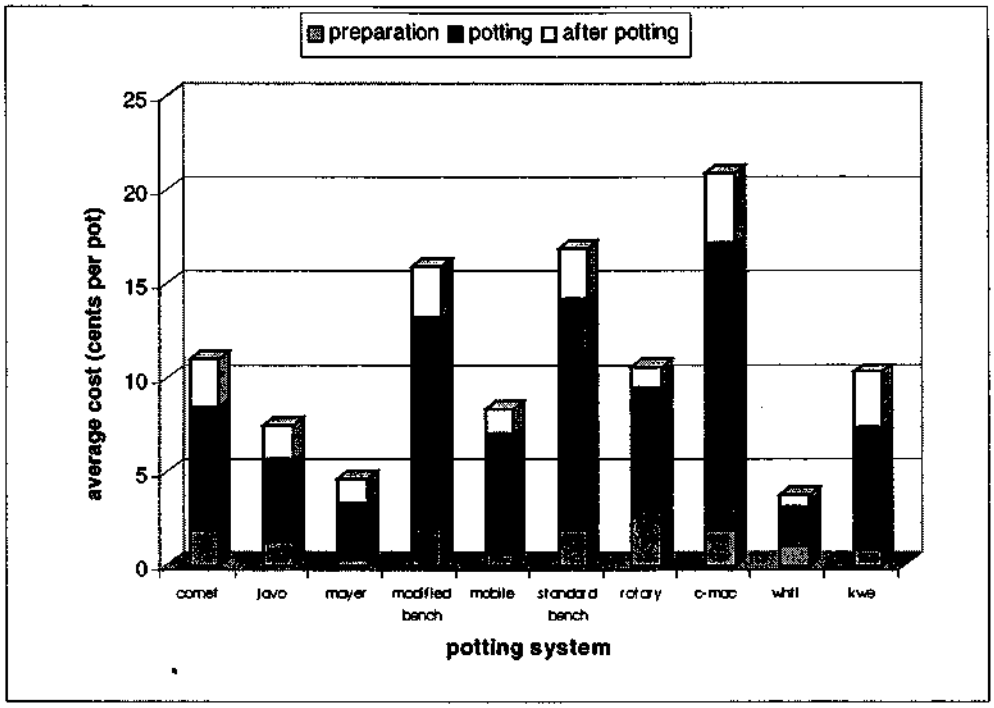


Figure 9. Average total potting cost for different potting systems.

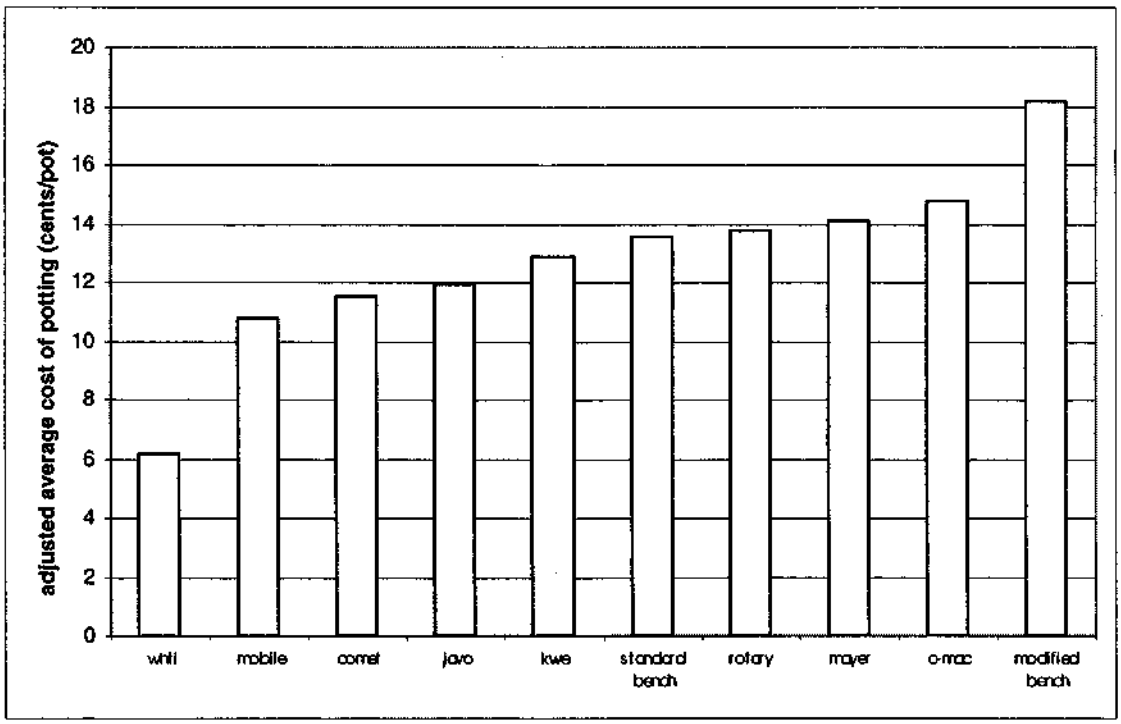


Figure 10. Adjusted average total cost of potting for different potting systems.

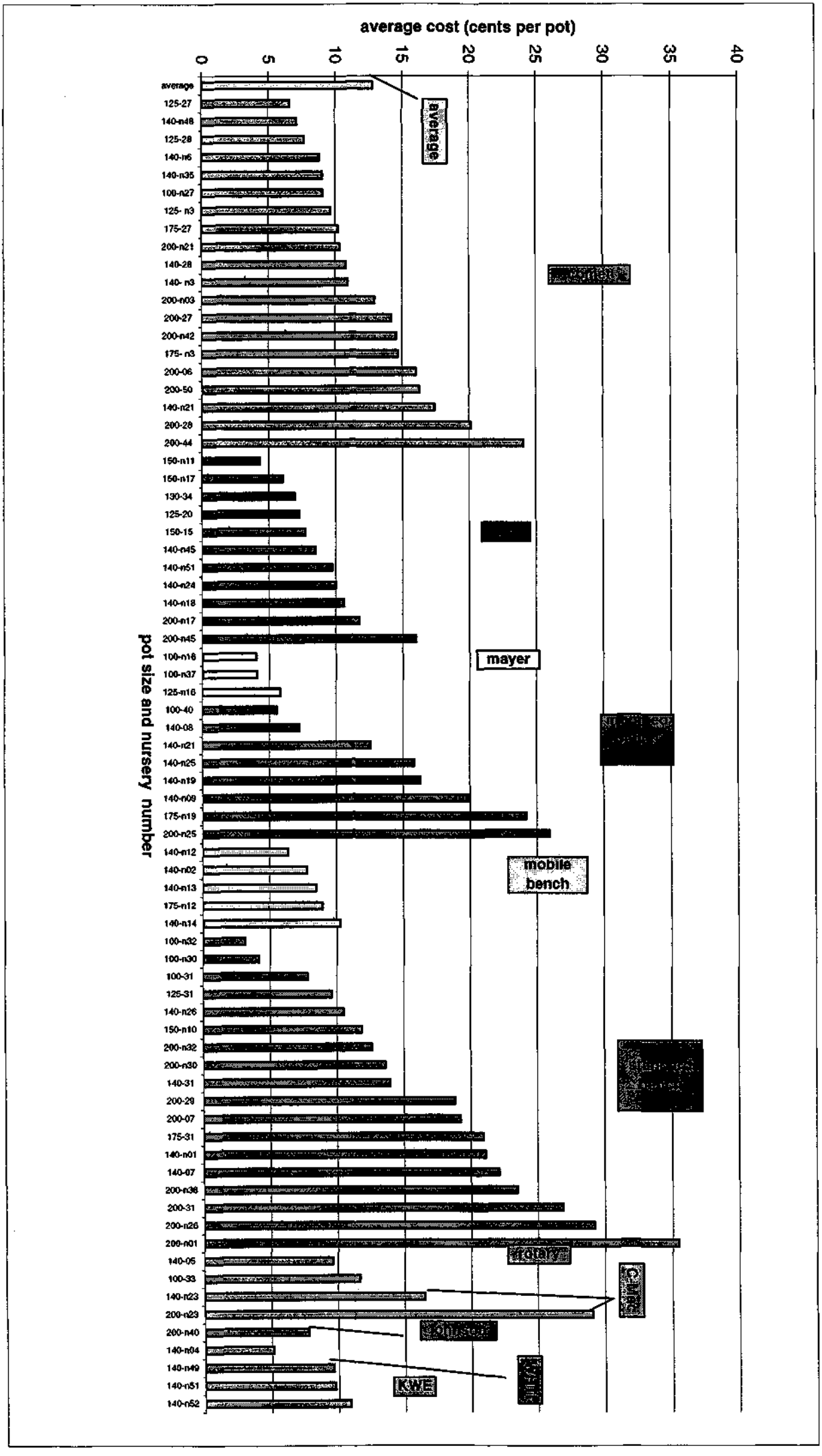


Figure 11. Total potting cost based on potting system used.

3.3.2. Mechanisation level

The level of mechanisation is defined on the basis of the degree to which manual potting tasks are replaced or eliminated by mechanical means. The following four major groups have been created:

- Manual potting (standard bench and modified bench)
- Mobile system (mobile bench)
- Semi-mechanised (Comet, C-Mac, Johnson, rotary table)
- Mechanised (Javo, Mayer, WHTI, KWE)

Figure 12 shows the total recorded cost of potting based on mechanisation level and broken up into preparation, potting and after potting. Figure 12 clearly shows that improvement in the level of mechanisation reduces potting labour cost even though some nurseries from the manual potting group out-performed nurseries from the semi-mechanised group (see Figure 11).

Figure 13 shows the break up of total average potting cost into major potting processes based on the materials handling areas of potting production. This figure shows that the major percentage of cost is in the handling of stock and potted plants. This is the case because these areas of potting production are the least mechanised in nearly all existing Australian potting systems. This is particularly true for mechanised groups where the cost of other potting production procedures is normally low due to mechanisation of potting tasks.

Figure 14 shows the total average cost as recorded and the total average cost as adjusted to 140mm pot size and average category of plant difficulty. After these corrections, the cost difference between mechanisation levels is not as great. This is due to the fact that mechanised nurseries in general are potting less difficult plants than those being potted in hand potting operations.

3.3.3 Pot size

As shown in Figure 15, pot size has a considerable effect on potting labour cost. The average labour cost involved in potting a 100mm pot is approximately one third the cost of potting a 200 mm pot.

Figure 16 shows the break up of labour cost into the major materials handling areas based on pot size. A clear pattern can be observed where the cost of potted plant handling increases with pot size. This is due to the fact that fewer plants can be handled per event when large pot sizes are involved.

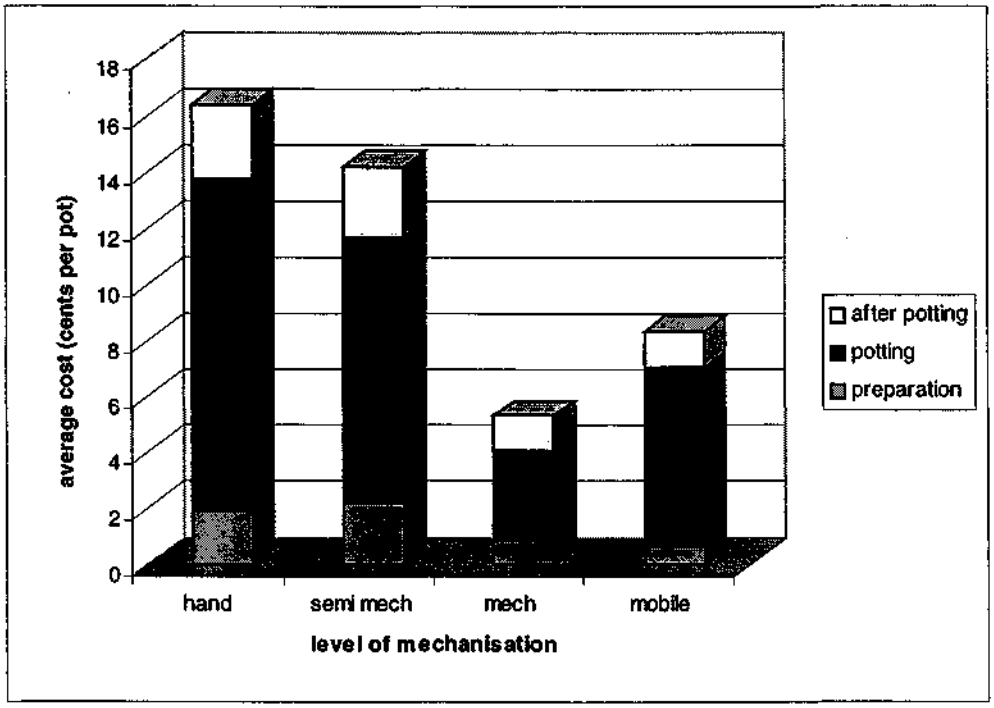


Figure 12. Total average recorded cost of potting for different mechanisation level systems.

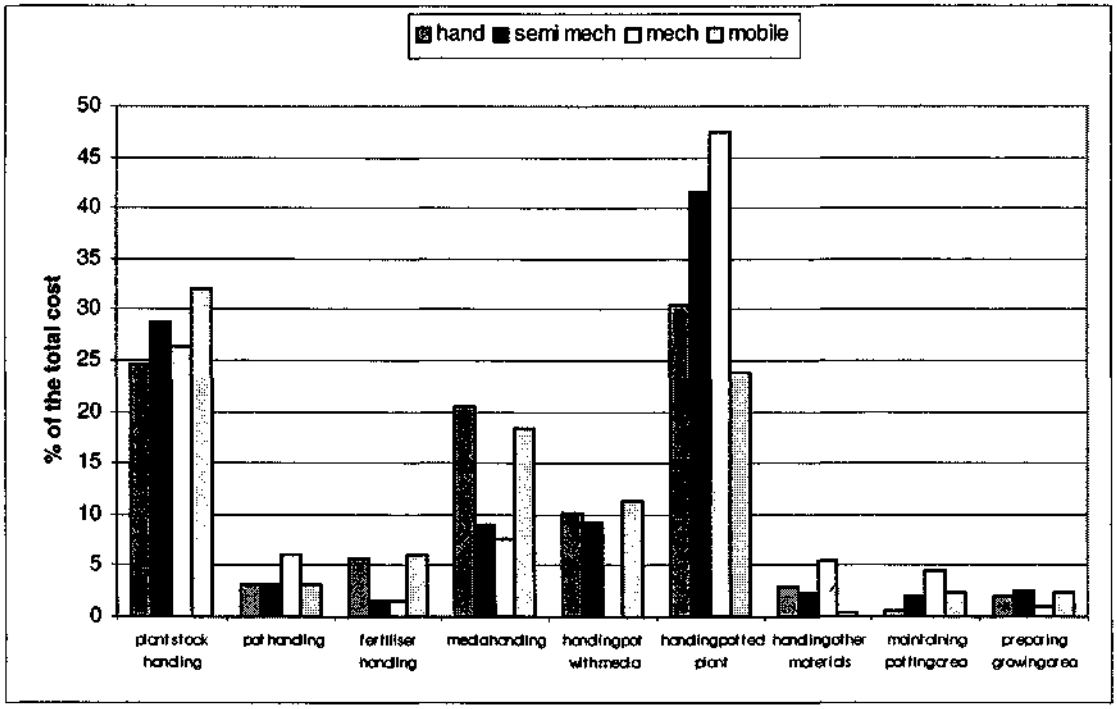


Figure 13. Break up of the average total potting cost.

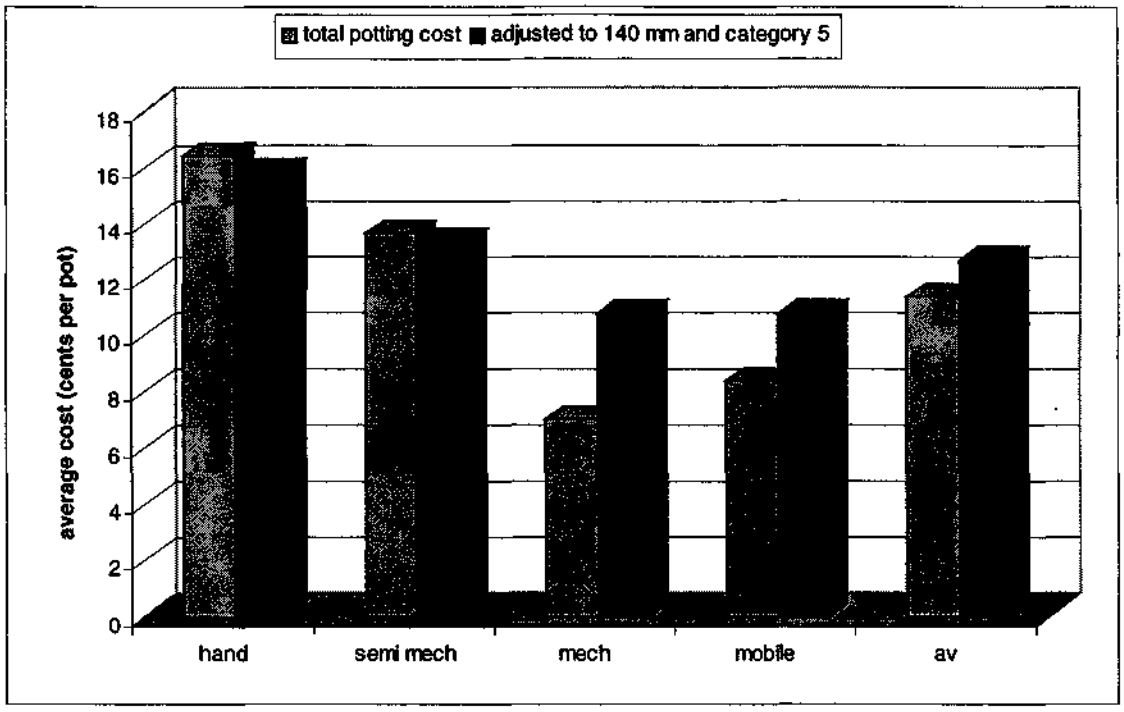


Figure 14. The total average cost of potting based on mechanisation level.

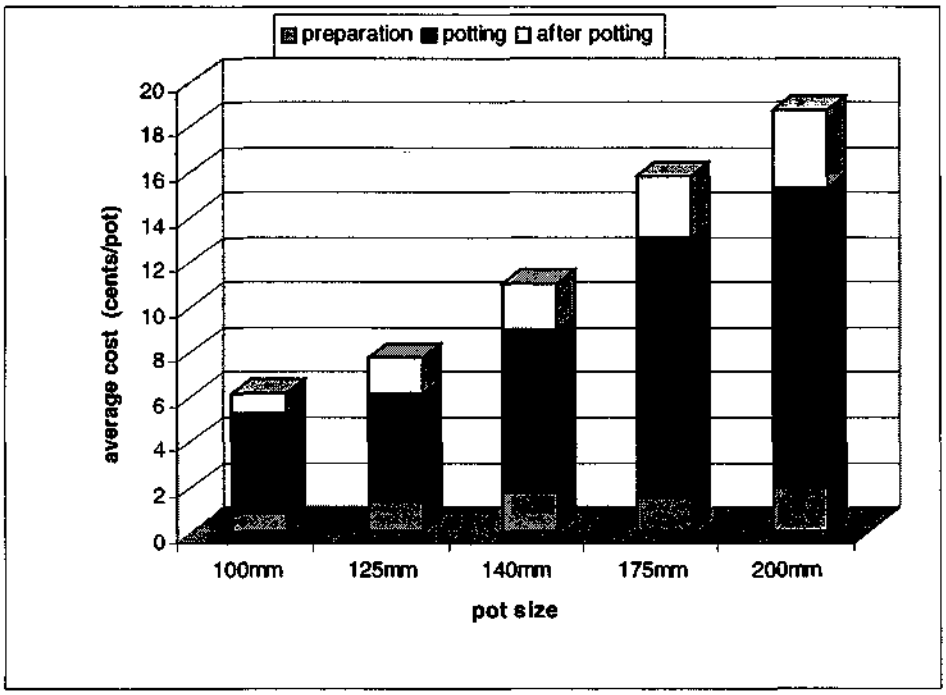


Figure 15. Break up of the average total potting cost for different pot sizes.

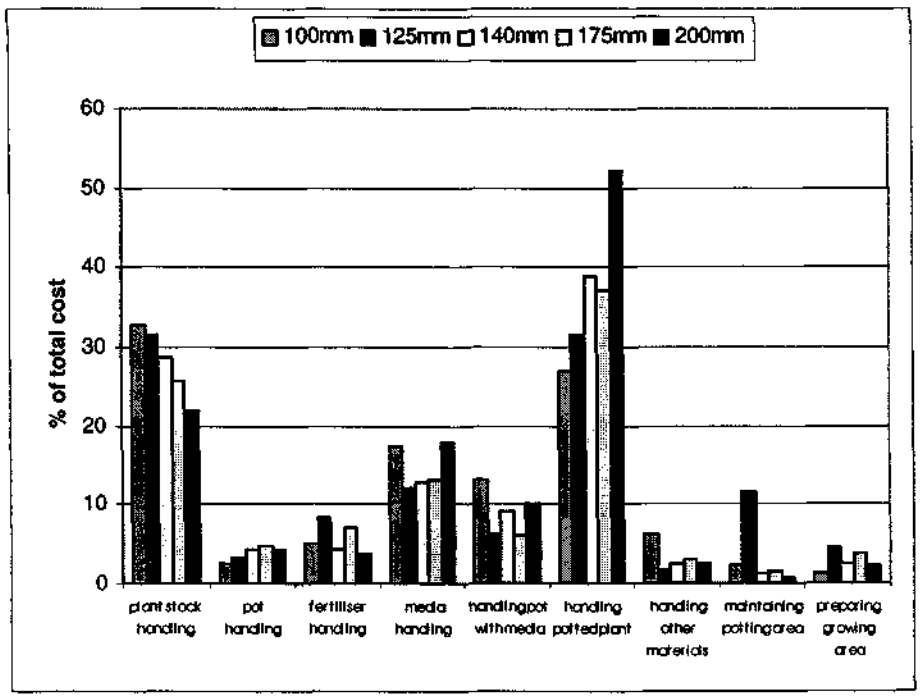


Figure 16. Break up of the average total potting cost based on pot size.

Figure 17 shows the average total potting cost for all investigated systems based on pot size. It can be seen that there is a large difference in the labour cost involved in potting the same pot size at different nurseries (eg. 200mm pot minimum 7.5 cents/pot and maximum 36 cents/pot). The difference in the cost is mostly due to differences in production efficiency in various nurseries.

Figure 18 shows labour cost (average and maximum) involved in potting as a percentage of sales price for different pot sizes. In general terms, the percentage is lower for larger pot sizes as the sales price of large pots is proportionally higher than the amount of labour used to pot them. This is valid only if the saleable pot specified in Figure 18 is produced from a single potting event.

Figure 19 shows the total average cost recorded and adjusted to potting difficulty 5. The pattern of cost remains as in Figure 18 but the difference in cost between pot sizes is reduced.

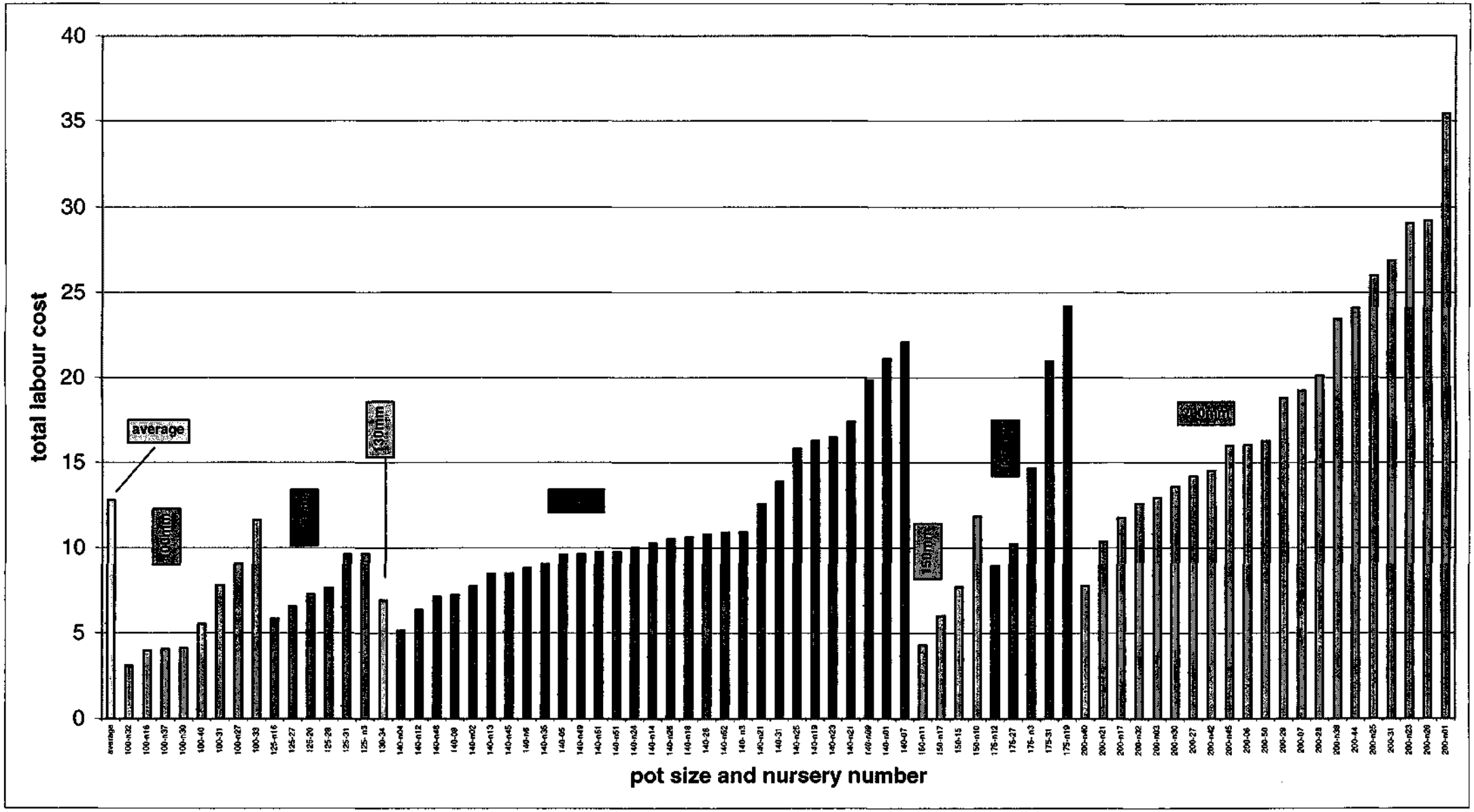


Figure 17. Total potting labor cost as recorded based on pot size.

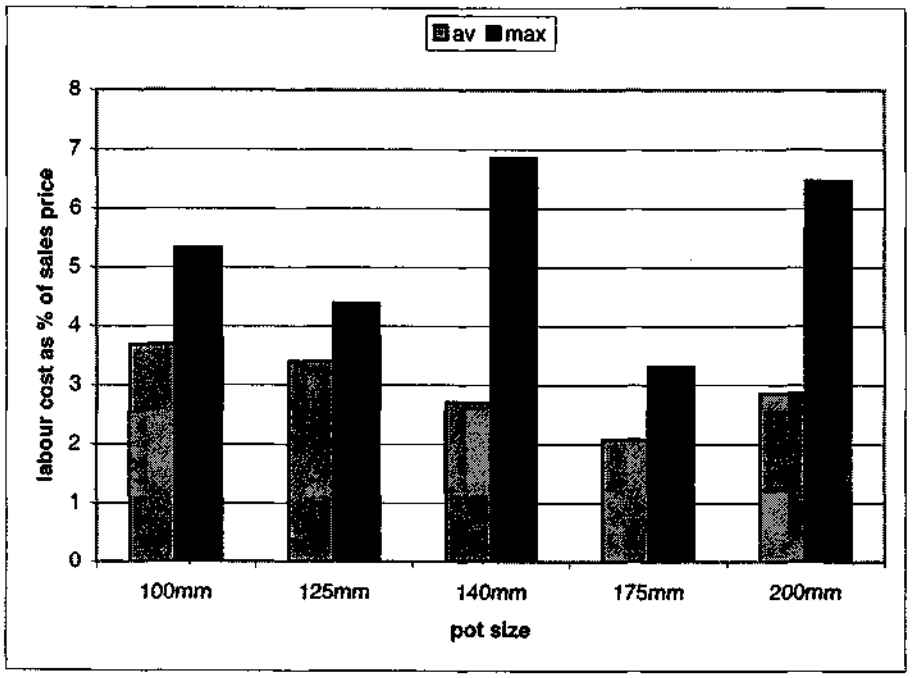


Figure 18. Labour cost as percentage of sales price.

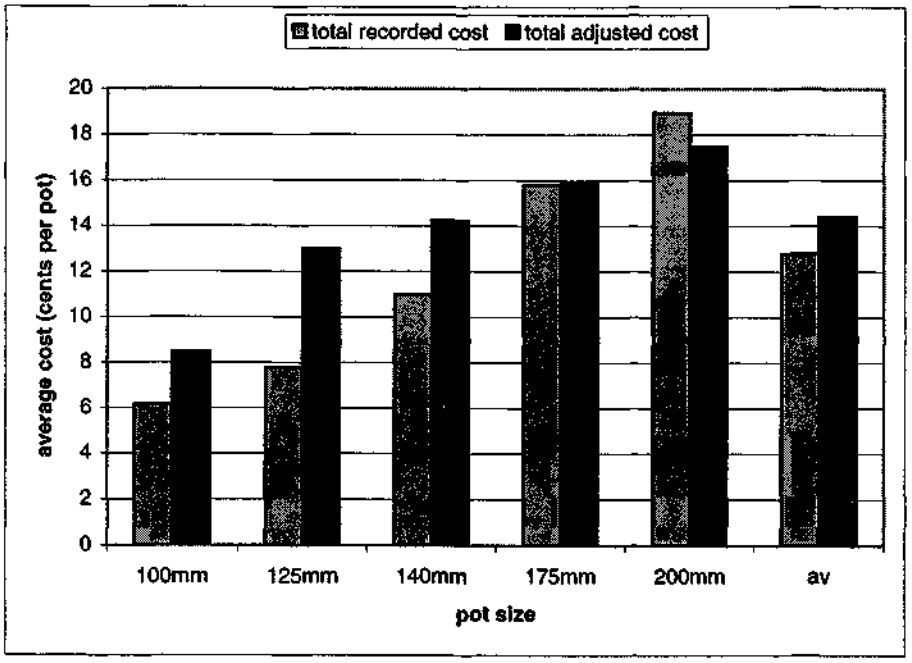


Figure 19. Total average recorded and adjusted potting cost.

3.3.4 Nursery size

The HRDC technical committee defined nursery size on the basis of the number of nursery employees - small nursery (1-5 staff), medium nursery (6-15 staff) and large nursery (over 15 staff). Figure 20 shows the break up of average total potting cost based on preparation, potting and after potting for different nursery sizes. From this graph it is clear that potting cost reduces with the size of nursery. This is due to the fact that small nurseries are normally less mechanised than medium nurseries and much less mechanised than large nurseries.

Figure 21 shows the average total recorded and adjusted potting labour cost for different nursery sizes. The pattern of the adjusted cost in this figure reflects the level of difficulty of plants potted in small and large nurseries. The adjusted cost in large nurseries is now higher than that in small nurseries. This is mostly due to the fact that, in general, large nurseries use mechanised potting systems where plants of low potting difficulty are potted to relatively small pot sizes (100mm to 150 mm).

Figure 22 shows the total average cost of potting based on nursery size in all potting systems investigated during the course of the project. There is a difference of approximately 20 cents per pot between the cost of potting within each nursery size group. This difference is the result of:

- various production inefficiencies within nurseries
- different pot sizes
- different categories of potting difficulty, and
- different equipment used by nurseries within the same size category.

Figure 23 shows the break up of the total average labour cost of potting into nine major handling areas during potting production. The percentage of the total cost is the highest for handling of potted plants, mostly due to the fact that most other operations are mechanised to some degree.

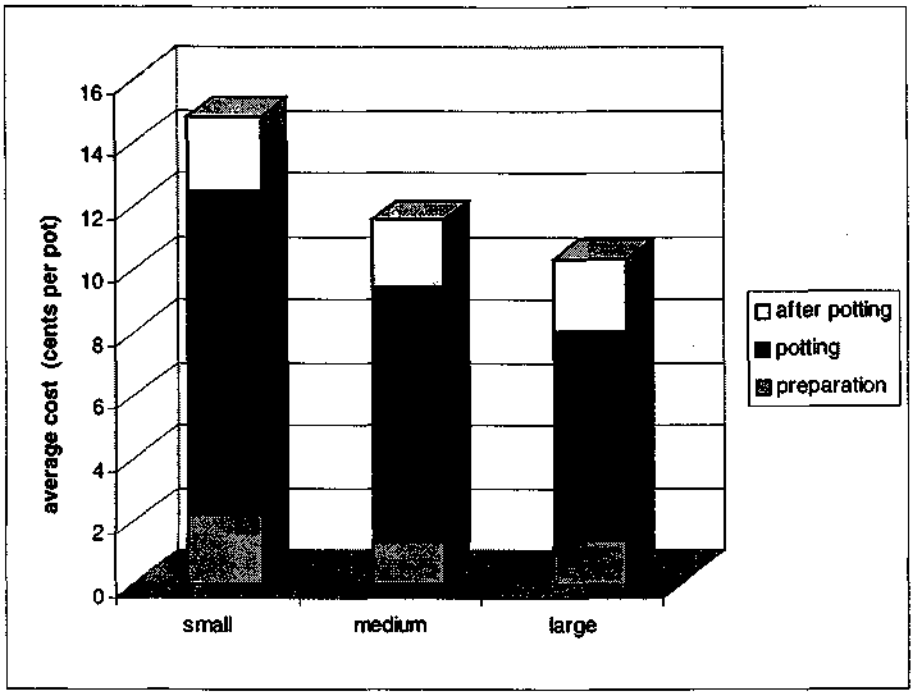


Figure 20. The average total cost of potting for different nursery sizes.

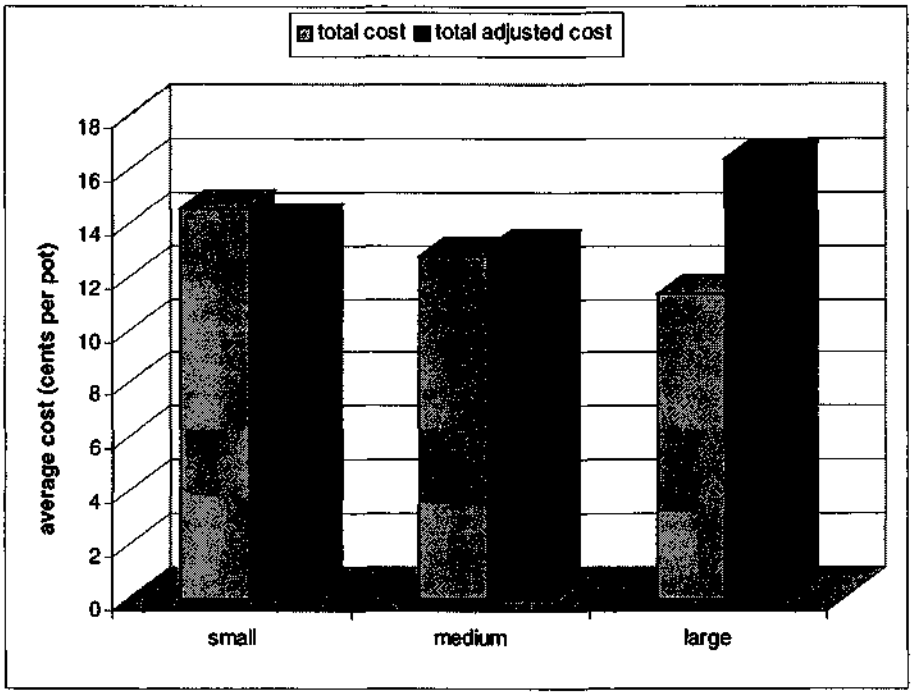


Figure 21. Total average potting labour cost for different nursery sizes.

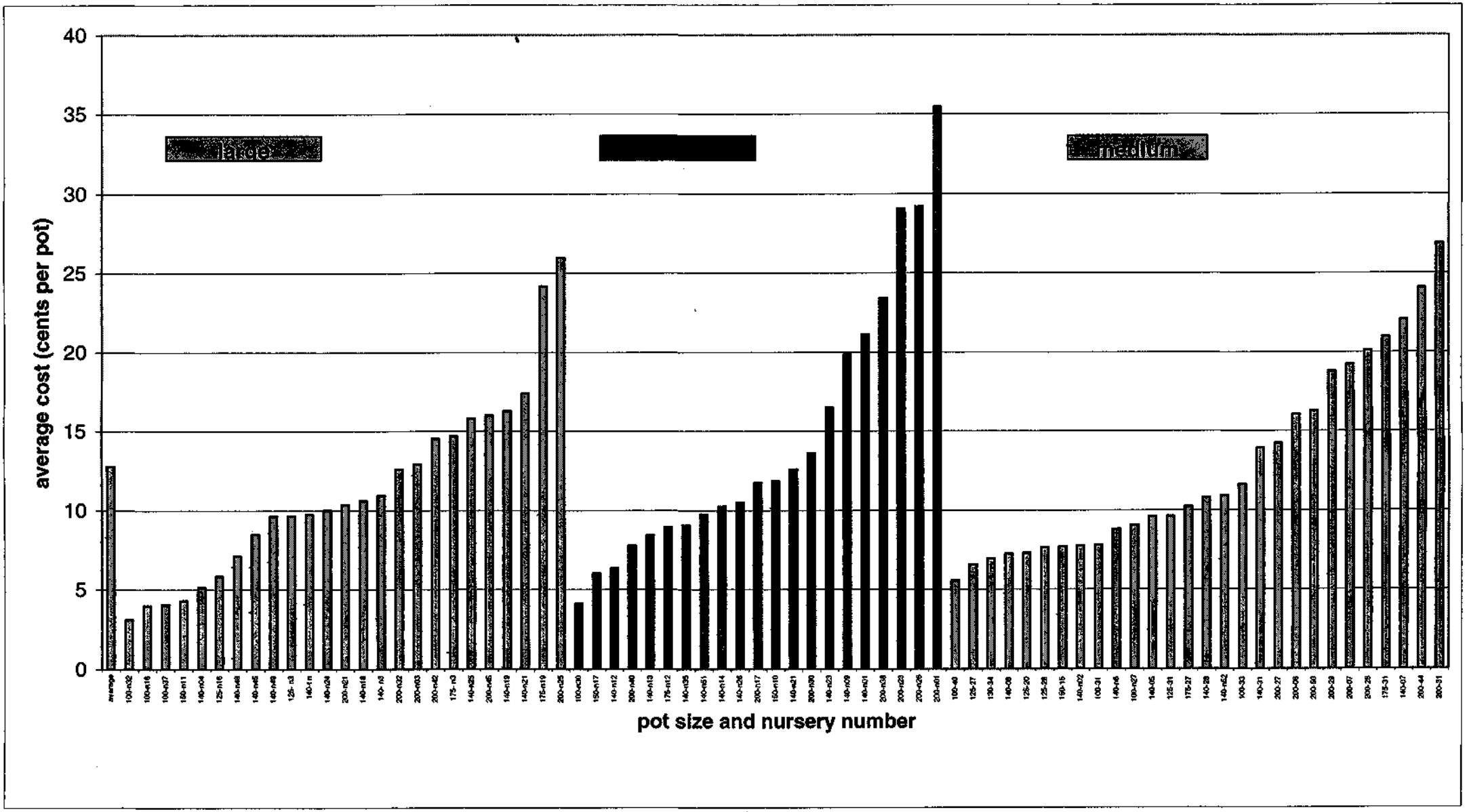


Figure 22. Average total potting cost as recorded based on nursery size.

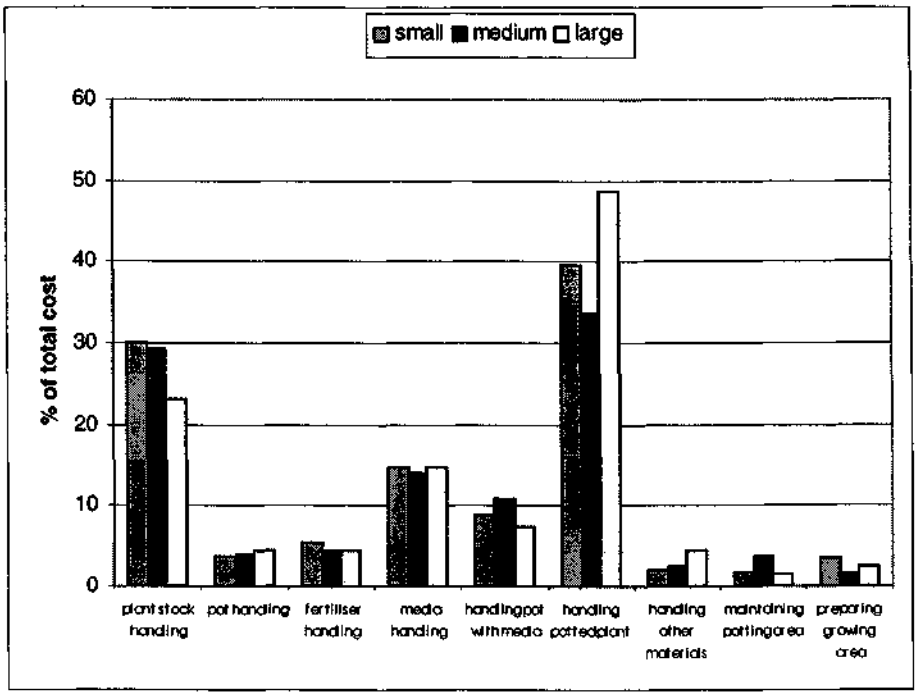


Figure 23. Break up of total potting cost based on nursery size.

3.3.5 State

The cost of potting has been investigated in three states only (Victoria, New South Wales and Queensland) as requested by the HRDC technical committee. Figure 24 shows the break up of average total potting cost into preparation, potting and after potting based on location (ie state) of nurseries. In general, nurseries in Victoria and NSW pay less in potting labour costs than nurseries in Queensland. This is only true when the cost of potting is based on the same hourly labour rate. In reality, the average hourly labour rate is higher in Victoria and NSW than in Queensland. Moreover, nurseries in Victoria are normally involved in production of less difficult plants in smaller pots than nurseries in Queensland (see Figure 25 for adjusted costs). In spite of this there is clear evidence of lower potting labour costs in Victoria. In general, this is due to the better levels of mechanisation and organisation of potting production in this state.

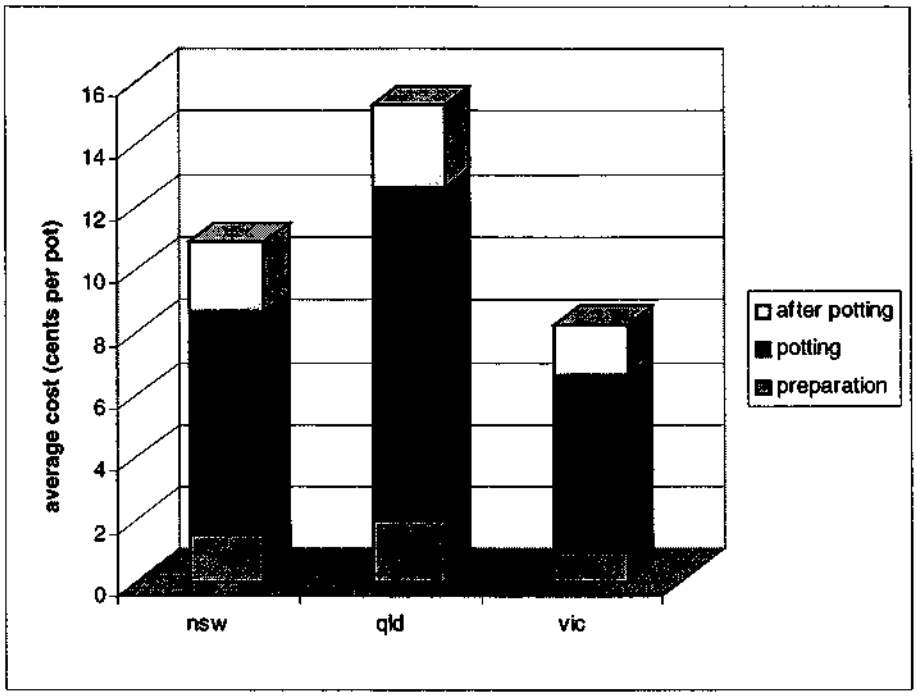


Figure 24. Break up of average total potting labour cost.

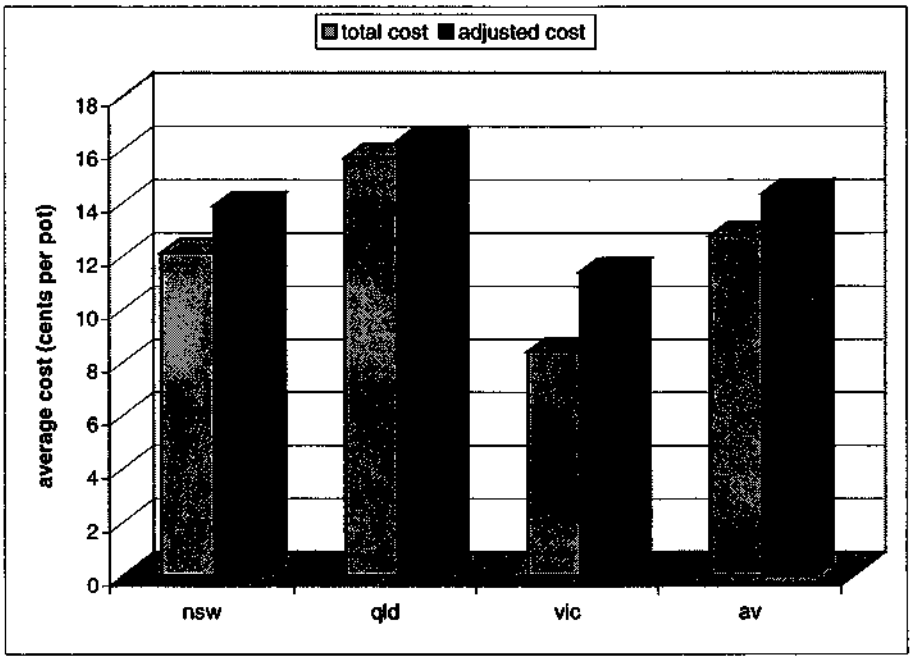


Figure 25. The average total recorded and adjusted cost of potting in the three states.

Figure 26 shows the average total potting labour cost for individual potting systems based on nursery location (ie state). Nurseries in Victoria are clearly operating at higher levels of potting production efficiency than nurseries in NSW and QLD.

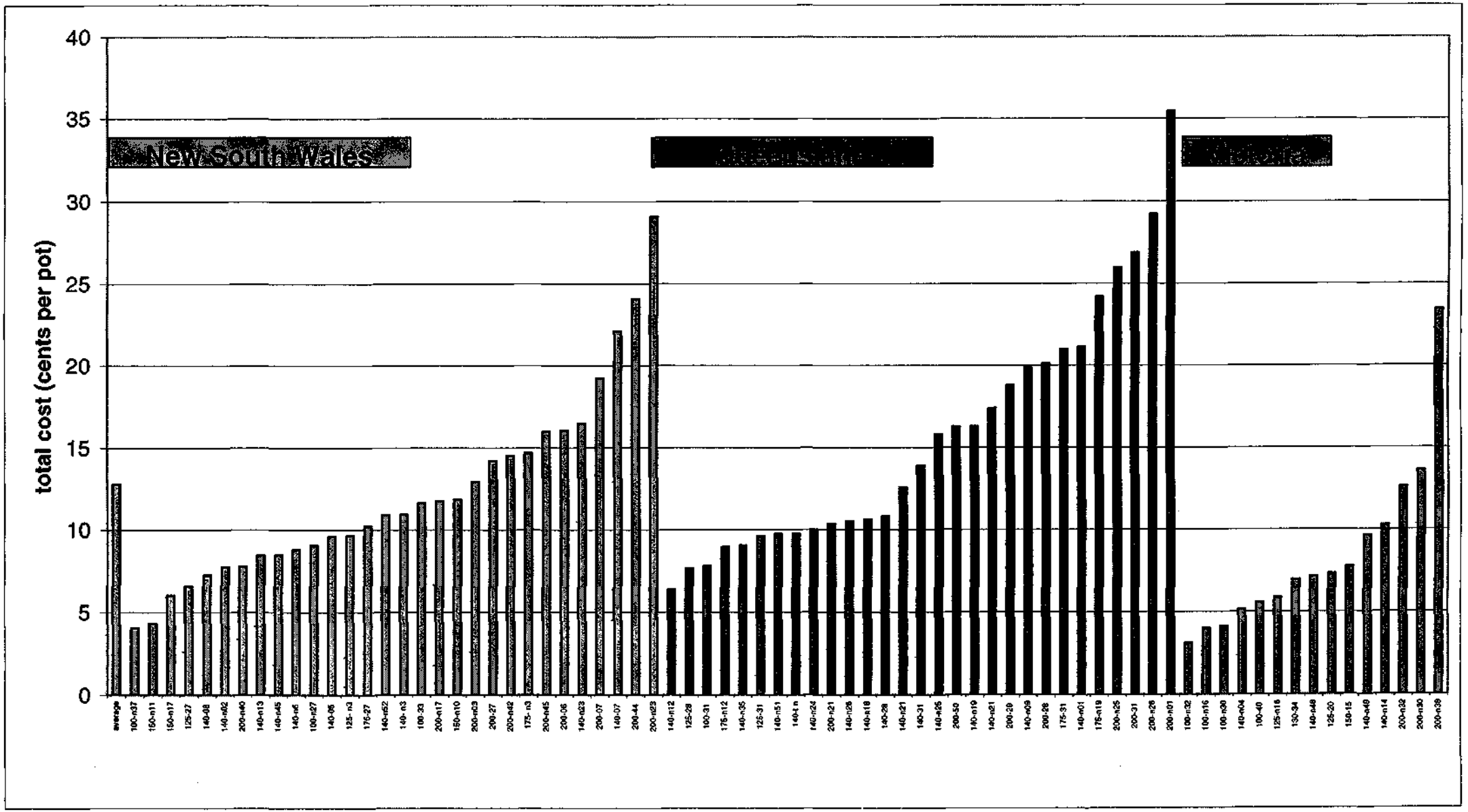


Figure 26. Average total potting cost based on state.

3.4 Handling of potted plants

As shown in Figures 6, 13, 16, and 23, potted plant handling is commonly the most costly element in the potting operation. Therefore, improvement to the handling of potted plants was investigated as a first priority as this offers the greatest potential savings to nurseries especially for those producing larger pot sizes (140mm and above).

Figure 27 shows the average total cost of handling potted plants during potting production for all collaborating nurseries. The cost of handling varies from 1 cent per pot to 17 cents per pot - the difference mostly due to the diversity of organisation and methods of plant handling.

Various ways of reducing labour cost were tested in real production situations involving the handling of potted plants in the growing area (where the majority of handling cost occurs). As a result of these tests a certain pattern of potted plant handling was established and alternative methods of moving plants proposed. Figure 28 shows some results of this investigation which involved shifting potted plants (35 trays per trailer, each tray holding 12 x 140mm pots) from a trailer into the growing bay; spacing plants; and returning all empty trays to the trailer. The results shown refer to a specific situation where the distance from the trailers to the centre of the growing bay was approximately 11m. The overall average time of putting down plants in the growing bay is subdivided into different tasks involved in the process.

The investigated procedure was as follows. Pots from the potting area were delivered to the growing area on trailers. The trailers were parked on the road adjacent to the growing bay and plants were shifted from the trailer to the growing area. Prior to and during the investigation, staff shifted pots from the trailer to the growing bay without reference to any work efficiency guidelines. Staff involved in the process worked entirely according to their own judgment. Three methods of potted plant handling were used and each of the workers involved believed their particular method to be the most efficient.

In each case, including the method proposed by researchers after conducting the investigation, the time of shifting of plants changes with the change in distance from the trailer to the specific point of the growing bay where pots are put down and spaced. Therefore, the overall time of shifting pots from the trailer to the growing bay can be reduced if the method of potted plant handling changes as the distance required to carry the potted plants also changes.

On the basis of this investigation (see summary in Figure 29) various alternative processes of putting down potted plants were simulated, the results of which are shown in Figure 30. From this figure it is obvious that the method of plant handling (optimum quantity of pots shifted per trip) depends on the distance pots have to be shifted. For short distances (up to approximately 4m) carrying individual pots by hand is the best solution (minimum number of tasks involved). However, as the walking distance increases more pots per trip' have to be shifted in order to compensate for the increased walking time. This compensation is also necessary in order to maintain a constant production rate throughout the entire potting process as well as a constant number of persons involved in production. Even though additional tasks are introduced (eg. loading and unloading a hand trolley with pots in trays) the overall time of potted plant handling per pot is reduced. This is because the time used for additional tasks is more than compensated for by the time gained through the reduction of walking time per pot between the trailer and growing bays afforded by the greater carrying capacity of the hand trolley.

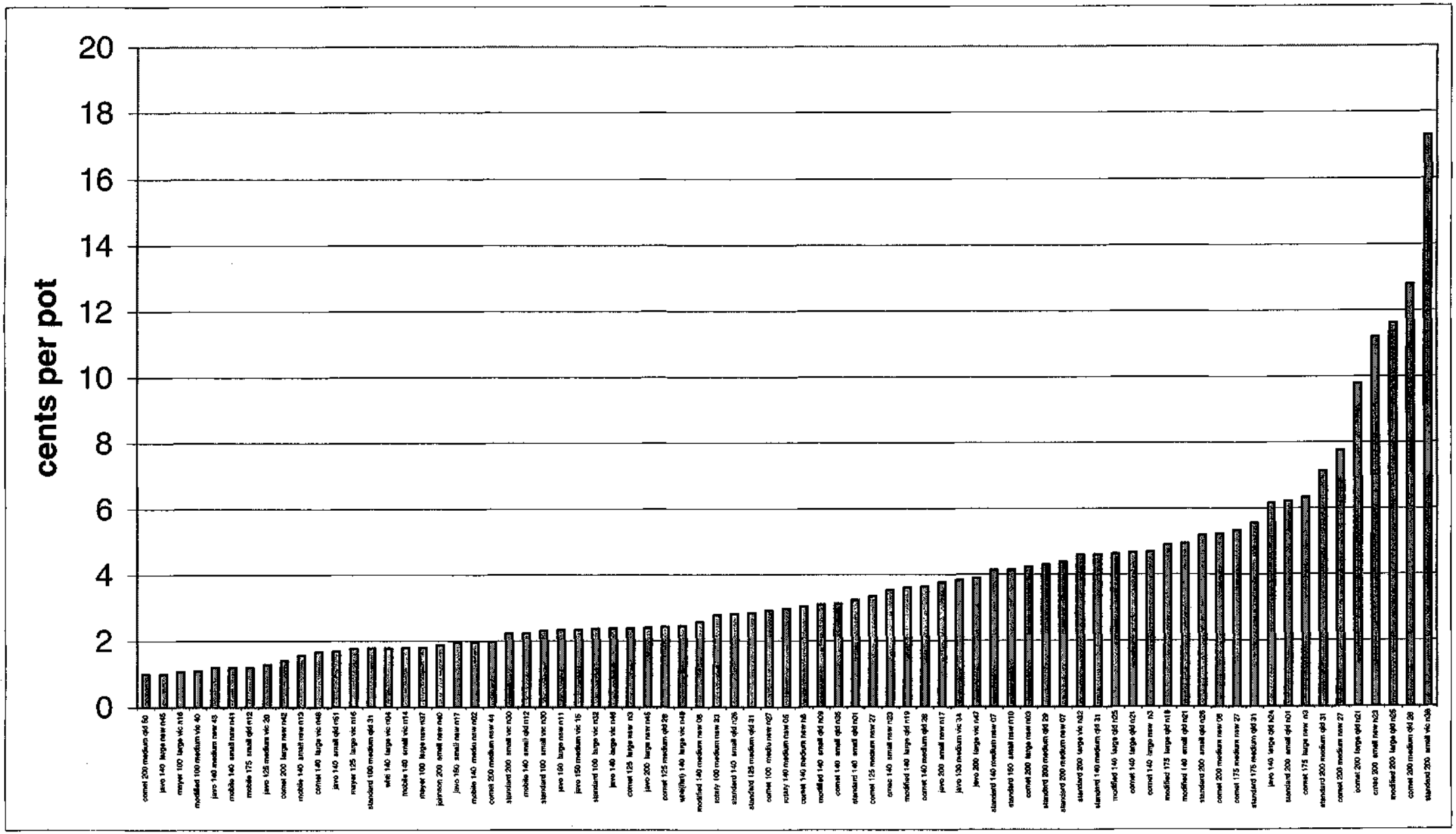


Figure 27. Cost of potted plant handling in different nurseries.

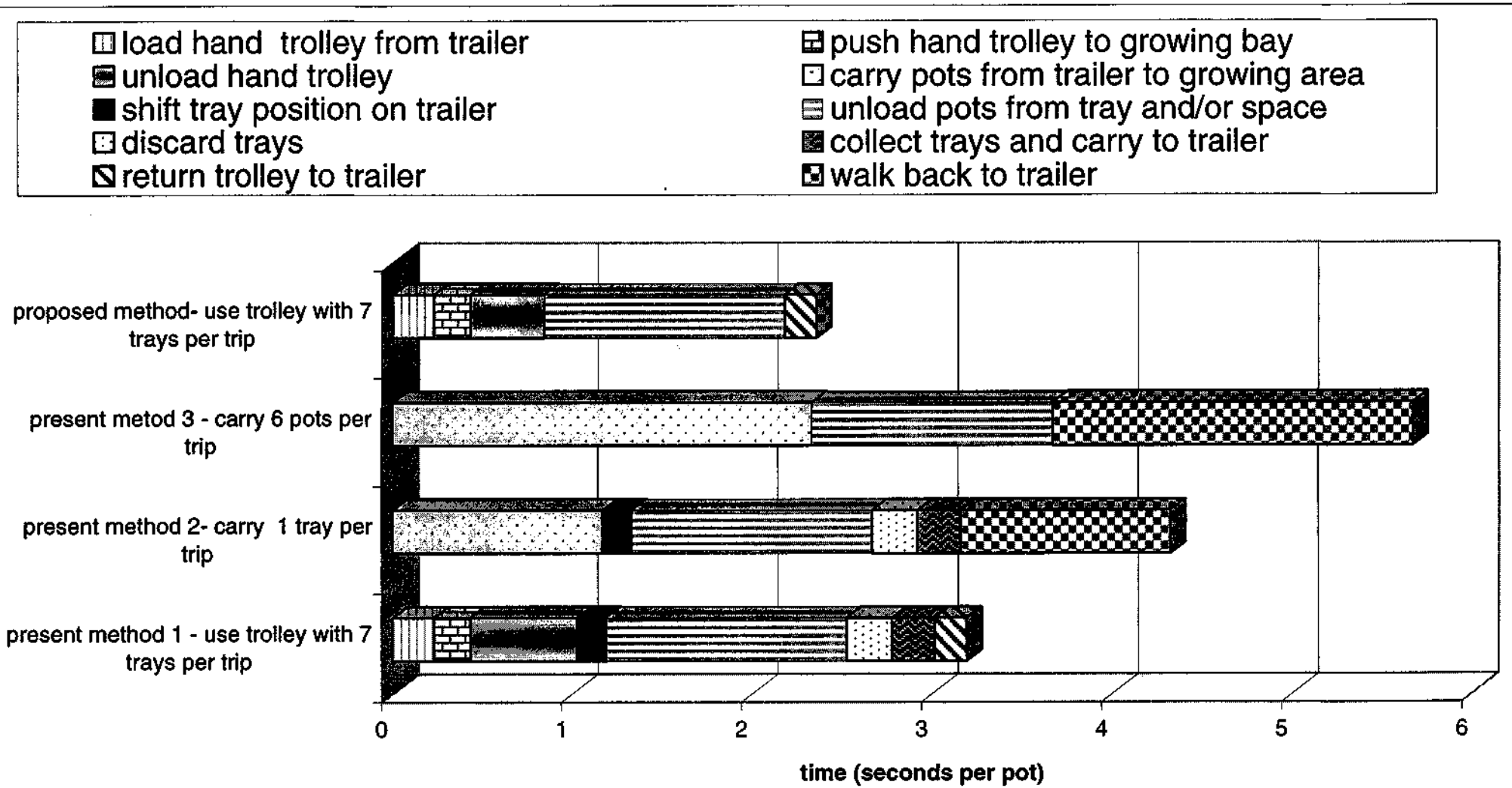


Figure 28. Time for different methods of potted plant handling.

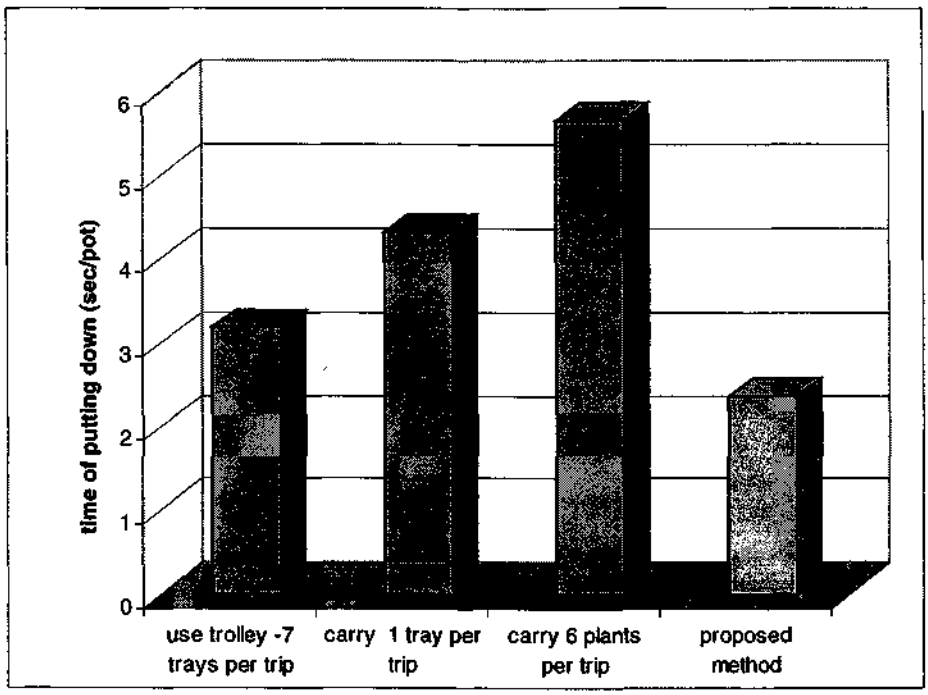


Figure 29. Summary of time used for different methods of potted plant handling.

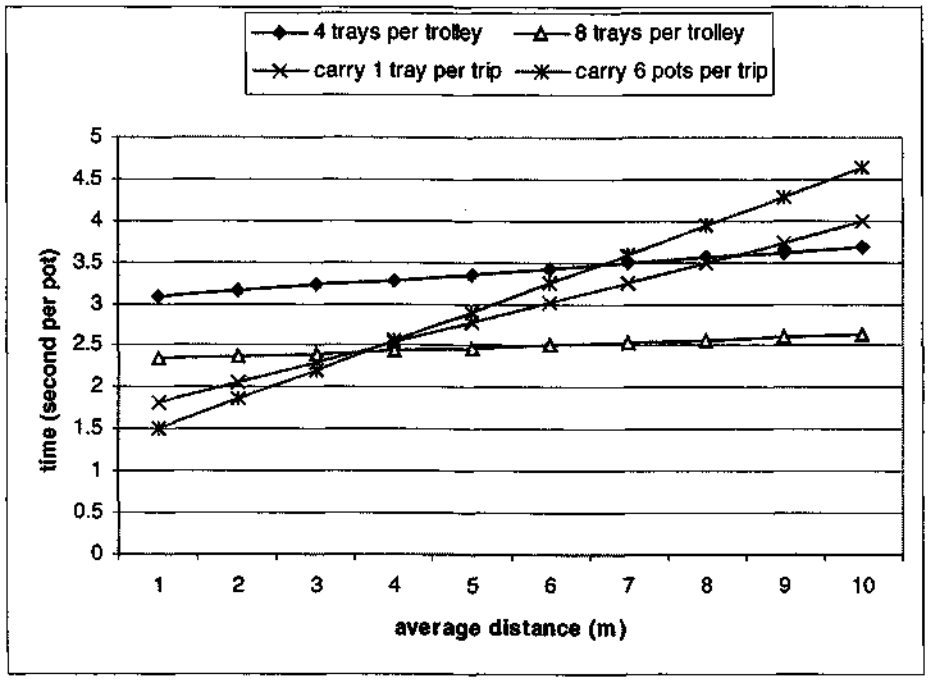


Figure 30. Simulated time for different methods of potted plant handling in growing area.

4 Discussion

Though research has confirmed that the vast majority of Australian nurseries operate with excessive production labour costs, nurseries display a notable lack of motivation and success in attempting to improve their production efficiency. This is because nurseries have no access to information on how they compare with other nurseries in terms of production efficiency. As a result of this

- some nurseries choose to believe they are doing much better than everyone else and do not attempt to improve their production efficiency
- some nurseries accept they are inefficient but don't know exactly how inefficient they are or how they can improve
- some attempt to improve efficiency but have no idea of their current level of efficiency or the level they should be aiming for, typically basing their improvements on untested, not objective information and therefore fail to achieve any significant improvement or achieve a negative result (ie. production costs increase)
- the last and smallest group (estimated at not more than 1% of all production nurseries), despite being unaware of their current level of efficiency or the level they should be aiming for, try and do achieve some improvement in their production efficiency although not always in terms of an acceptable cost benefit result.

4.1 Tasks and labour cost involved

As shown in Figure 8 some nurseries pay much more in labour costs than other nurseries to produce potted plants – the question is why? There are various factors in potting production that can influence the amount of total potting labour cost.

Some of the factors affecting potting labour costs are inherent in the type of potting production carried out. The effects these factors have on potting labour costs are recognised but are usually features of a nursery's particular targeted market area and not aspects that can be easily changed in order to reduce potting labour costs. For example, certain types of plants are more time consuming to pot than others as they require more care during removal from the propagation container, inserting to the pot, extra attention to root trimming or pruning, etc.

Potting into large sized pots is generally more time consuming than potting into smaller sized pots. As the difference between the size of the propagation container and the size of the pot being potted into decreases potting also becomes more time consuming. For example, when potting up from a 140mm pot to a 175mm pot the space between pot edge and plant stock edge is narrow and inserting media to this space is difficult. Potting into large sized pots will also increase the time needed to handle the potted plant and increase the frequency with which potting materials (eg. potting media, fertiliser, pots, etc.) need to be replenished.

Plant stock grown in tubes can take longer to remove from the tube and insert to the pot than plant stock grown in cell trays. When potting from tubes there is the additional task of disposing of each tube. Yet, even allowing for the fact that plant types, propagation containers and pot size do affect potting time, it does not adequately explain why potting labour costs vary so greatly

between nurseries. Clearly, there are other factors operating which serve to increase a nursery's potting labour costs.

Certain factors affecting potting labour costs are not inherent in the type of production carried out by a nursery but rather are the result of the manner in which the nursery organises and operates its potting system. The following issues will influence a nursery's level of potting production efficiency:

- the location of the potting area relative to the growing area
- the appropriateness of the potting system to the type and number of plants being produced
- the work technique of potters
- the operating speed of the potting machine in relation to the number of staff involved in potting production
- the allocation of tasks to potting staff
- non productive time in potting production
- levels of worker health and safety, comfort, skill and motivation
- the quality and timeliness of information issued by management to potting staff
- the method of handling potting inputs and potting outputs.

4.2 Factors affecting potting production efficiency

The following section contains observations on potting production efficiency in relation to the following factors:

- Work organisation and potting work environment
- Worker related issues
- Potted plant related factors

When nurseries fail to correctly address these factors the result is excessive production labour costs.

It has been estimated that :

- inefficient organisation of potting procedures often combined with the use of an inappropriate potting system and equipment as well as poor materials handling methods are responsible for approximately 65-85% of excessive potting labour costs
- staff with inadequate job training and accompanying levels of skill and motivation is responsible for approximately 10-20% of excessive potting labour costs
- high potting difficulty of plants is responsible for approximately 5-15% of excessive potting labour costs.

The manner in which the above factors affect the efficiency of all areas of nursery production is discussed in more detail in *Attachment 1.*

4.2.1 Work organisation

Work organisation in potting production refers to:

- management of the potting system
- management of labour
- selection of equipment and methods of materials handling
- communication

4.2.2 Potting work environment

The potting work environment refers to

- Organisation of the work station
- Potting techniques
- Operating knowledge
- Break downs and malfunctions
- Automation of tasks
- Speed of operation

4.2.3 Worker related issues

Worker related issues refer to worker safety, worker comfort, worker motivation and worker skill levels. Poor safety standards can lower staff motivation, make tasks difficult to perform and increase the incidence of work place injury. Low worker comfort levels can hamper the worker's ability to carry out tasks, can contribute to injuries, and have a negative impact on worker motivation. Well-motivated workers who understood how to carry out their tasks were a feature at all nurseries with low potting labour costs.

4.3 General industry issues

There are a number of general issues within the nursery industry that have a considerable effect on overall nursery production performance including potting production. These issues are reflections of the attitudes of nursery representatives to the following topics:

- Market size
- Production and market competition
- Information sharing
- Demonstration of equipment and systems
- Training
- Investment

An objective and open discussion of these issues is presented in *Attachment 2.*

In addition to these issues high levels of staff turn-over in nurseries also needs attention from nursery operators. Training workers is an expensive process, even when it is informal, on the job training. Yet the time and money spent on training is never wasted. The most important part of any production system is the worker and the investment made in training will be quickly repaid through improved productivity.

Workers only achieve full productivity after accumulating a reasonable amount of on the job experience. An experienced worker therefore represents a very valuable asset to the nursery. Despite the widespread recognition by nursery operators of the value of experienced workers, the nursery industry seems to be plagued by high levels of staff turnover. What is the reason for high staff turnover? Is it because the nursery award is too low? Do nursery operators fail to fully appreciate the value of experienced workers? Are insufficient steps being taken to hold on to good workers? Does management simply lack training in dealing with worker issues?

Whatever the underlying factors, there is no denying that high staff turnover affects production efficiency and represents a significant loss of investment to nurseries. Nurseries should place a much greater emphasis on training and retaining their staff.

Another pivotal issue within the industry is that the results of research funded by QDPI, HAL and NIAA into the various production areas so far undertaken (mechanisation, dispatch and potting production) are only relevant to the period when the research was carried out. The circumstances affecting production systems are continually changing (the introduction of new technologies and equipment, changes to environmental laws, increases in labour cost rates, etc.). To be of continual benefit to nursery operators, research into production labour cost issues must be an ongoing process.

In order to maximise the benefit of research, the engineering section at DPI is proposing to establish a permanent, full time centre for nursery production research. Nursery industry members and allied manufacturers will be encouraged to use research data and information for their mutual gain and researchers will be able to continually monitor, investigate and report on all aspects affecting nursery production.

4.4 Specific problems related to potting production

During visits to 52 nurseries during the project, researchers identified many problems which affect production efficiency and contribute to high potting production labour costs. Some common problems are listed bellow as corollaries to the topics of:

- design of potting systems
- organisation of potting systems and
- production methods

Common potting production problems:

- large investment in production equipment is not reflected in the labour cost saving per pot achieved
- poor access resulting from the layout of the potting area is a barrier to the implementation of improvements

- insufficient trailers available during potting results in frequent production stoppages
- haphazard disposal of empty cell trays, tubes, pots, etc., during potting production creates extra work to collect them afterwards
- investment (eg. in a new bob-cat for media loading) considered before investigating low cost solutions (eg. of using a more efficient and low cost method of media handling such as an automated media loading system)
- staff unsure how to accurately adjust potting machine to cope with pot jamming, conveyor problems, media flow, etc.
- potting inputs delivered to the potting station in small quantities
- certain potting tasks which could be easily mechanised are carried out manually
- rotation of tasks within potting crew occurs too frequently with the result that production stoppage time becomes significant

See *Attachment 1* for a detailed list of specific problems and potential solutions.

4.5 Best practice for potting production

4.5.1 Potting Optimisation Factors

There are a number of factors related to potting production which should be taken into consideration when an optimum potting system is designed, developed and operated. The optimum system will be created when -

<u>The worker has</u>

- a safe and comfortable working environment
- sound work motivation
- good work skills

<u>Plant stock is used so that</u>

- the development of roots and foliage is in the prime stage for potting
- the quantity of plants to be potted per day throughout the potting period is kept approximately the same
- the quantity of plants to be potted per potting event is maximised
- the number of species to be potted per event is minimised

<u>Containers are used so that</u>

- the number of types of propagation container used is minimised
- the number of stock plants per container (tray) is maximised
- the number of sizes, types and colours of potting containers used is minimised
- the ratio of propagation container size to potting container size is approximately not less than 0.5 (eg. 50mm tube to 100mm pot)
- containers (trays) are designed so that a mechanised system can be used for ejecting stock from containers

<u>Potting procedures and treatments occur so that</u>

- manual placement of fertiliser into the pot is minimised
- quantity of plants watered in one event is maximised
- quantity of plants pruned in one event is maximised
- quantity of plants receiving application of herbicide is maximised

Potting system operates so that

- work station design reflects the nursery's average potting production requirements
- potting area location is central to the growing area
- distances between the potting area and potting input storage areas are minimised
- coordination of potting tasks within potting system is self governing
- quantities of potting inputs and outputs handled at one time (eg. empty pots, potted plants) are maximised

Machine operating speed is adjusted so that

- the ratio of operating speed to the number of staff involved minimises non-productive time

Communication follows a

- clear and rapid system providing all necessary production information to potters

Potting technique

- based on the techniques of workers with the best production rates is applied in production

Most of the above optimisation factors are known and can be applied immediately to potting systems, however some factors, eg. ratio of potting machine operating speed to number of staff, coordination of potting tasks, etc., can only be defined through experimentation in individual potting systems.

4.5.2 Benchmarks

The benchmark costs in Table 7 are based on the lowest potting labour costs recorded from potting production systems in 52 cooperating nurseries in QLD, NSW and VIC. In the semi-automated and automated potting systems the benchmarks are based entirely on production data recorded from 10 nurseries in Europe. All benchmarks were calculated using an hourly wage rate of $15 Australian.

Table 7. Potting labour cost benchmarks (cents/pot) for different pot sizes based on low and high plant potting difficulty.

	pot size				
	100mm	125mm	140mm	175mm	200mm
hand potting	6.26 - 6.73	6.69 - 7.19	12.27 - 13.19	17 - 18.27	23.87 - 25.66
semi-mechanised	6.09 - 6.54	6.29 - 6.76	11.17 - 12	14.45 - 15.53	19.1 - 20.53
mechanised	4.99 - 5.36	5.03 - 5.41	8.71 - 9.36	10.84 - 11.65	13.37 - 14.37
semi-automated	1.07 - 1.15	1.16 - 1.25	1.26 - 1.35	1.36 - 1.46	1.45 - 1.56
automated	0.29 - 0.32	0.34 - 0.37	0.37 - 0.4	0.39 - 0.42	0.44 - 0.47

In the pot size columns the low values represent benchmark costs for potting plants with low potting difficulty and the high values represent benchmarks for potting plants with high potting difficulty.

Benchmark labour costs refer to the total potting production process, that is:

- collecting and preparing all input materials including plant stock for potting
- preparing the potting area and equipment
- potting the plants
- loading potted plants to nursery transport
- watering plants in
- delivering potted plants to the growing area
- unloading potted plants and putting down in the growing area

Only the work time of people who were visibly present and physically involved in the potting process was included in the calculation of benchmarks. For example, if a potting supervisor took an active role in potting production their time was included, but if the potting supervisor was absent during potting their time was not included.

The benchmark figures shown in Table 7 represent potting labour costs that could be achieved by all nurseries. The benchmarks in Table 7 are quite suitable for a nursery to use to establish their level of potting production efficiency and determine the amount of labour cost savings they can expect to achieve through improving their potting production systems to benchmark levels.

4. 5.3 Economic evaluation

The cost of production labour can be greatly reduced by investing in mechanised production equipment. The average amount of capital invested in mechanised nursery production equipment is much greater in overseas nurseries than it currently is in Australia. In Australia levels of investment are lower largely because nursery operators lack access to detailed objective information on the latest equipment options and because equipment manufacturers (especially of imported equipment) often provide poor levels of ongoing service.

The Australian nursery industry would undoubtedly benefit from a production research facility that could provide demonstrations and training in the selection, installation and operation of advanced production equipment and provide a forum where manufacturers could respond to the needs of customers. By utilising such a facility nursery management could make informed decisions on the best production system for their needs and optimise the organisation and operation of such systems to ensure production benchmarks were achieved.

It is quite certain that any nursery, irrespective of how low its current potting labour costs are, could reduce its costs further by improving some element of production. However, whenever a change in production methods is considered, a decision must be made as to whether the expected benefit from the improvement in productivity will be greater than the cost of implementation.

In order to be sure that any investment into nursery production is cost effective a basic economic evaluation must be carried out. The effectiveness of the investment is to a large degree

determined by the length of the pay back period. Figure 31 shows a sample of the relationship between annual production and maximum investment to achieve the specified pay back period.

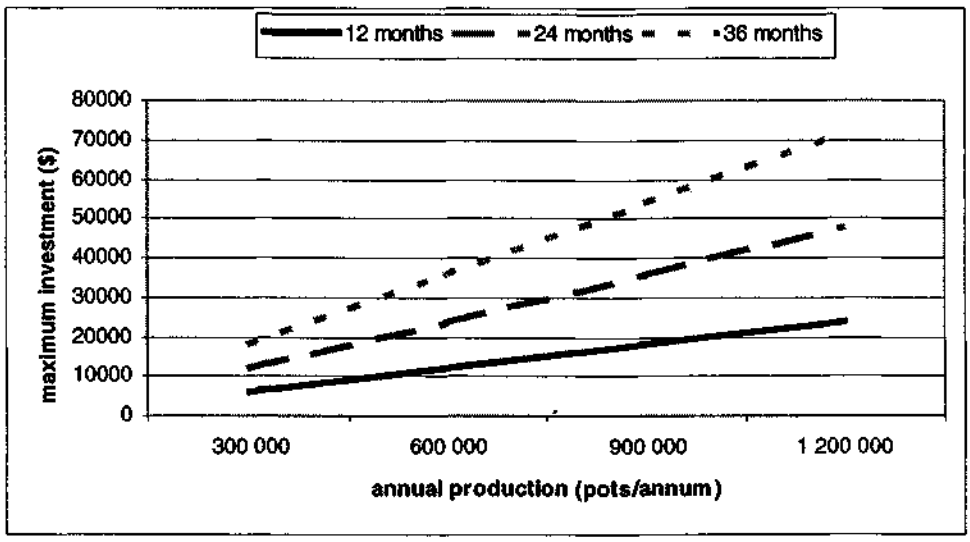


Figure 31. Relationship between annual production and the maximum investment required to achieve specified pay back period.

Information on methods nurseries can use to evaluate potting systems is provided in Appendix 2 and in Appendixes A, B, and C of *Attachment 1*.

4.5.4 Basic principles of improving production efficiency

The way a nursery operates is shaped by many factors such as market demand for product, budget limits, geographical factors, work habits, staff numbers, staff training, the experience and beliefs of nursery management, etc. Whenever a change in production methods is proposed it is important that all these factors are taken into consideration.

At present many procedures carried out during potting are based on 'commonly held beliefs' or personal experience and have not been rigorously tested. Examples of procedures which vary from nursery to nursery and have not been tested include: selecting potting media, pot size used, placement of fertiliser in the potted plant, method of watering in the potted plant and spacing the plant in the growing area.

In order to achieve minimum potting labour costs, nurseries need to research literature on potting procedures (eg. fertiliser placement, watering in requirements, etc.) or carry out their own experiments to find out whether the potting procedures they follow are relevant to their plant quality expectations and whether in fact different production procedures could be used to reduce labour costs while still achieving plant quality levels.

Nursery management will benefit by seeking input from potting staff when considering changes to production. Staff have a working knowledge of current procedures, often have a strong sense of ownership of existing production methods and are, after all, the ones who will be working in the modified production system. When a significant change to production is introduced it is

important to give staff adequate training in the new system and time to get used to new arrangements before carrying out any new evaluation of labour costs.

When seeking to improve production efficiency, most of the factors relating to the organisation of potting production need to be addressed. The methodology of improving potting production efficiency is through the elimination of specific operational problems.

A simple, logical sequence of steps can be used to solve problems associated with any production system including the problem of excessive labour costs in nurseries. When a nursery engages in the process of evaluating production efficiency and devising appropriate solutions, significant savings can result. However, when carried out properly, the process will demand time and can be complicated. Nurseries unable to commit the time or are unsure of their ability to improve production efficiency should not give up and lose the opportunity to make significant savings but should instead seek help from a recognised production system consultant.

In attempting to solve production problems the following steps are essential and must be followed:

- Define problems
- Cost problems
- Understand problems
- Find solutions
- Select solutions
- Introduce solutions
- Test solutions

This 7 step approach to solving production inefficiencies is briefly explained in Appendix 2.

5 Technology Transfer

Technology transfer activities were undertaken throughout the life of the project in the form of extension publications, reports, conferences papers, field days, demonstrations, commercial partnership activities and surveys of nursery industry operators and allied nursery industry members. As a result of technology transfer, 63% of surveyed collaborating nurseries improved their production system during the project. After project completion, technology transfer will continue to be carried out by the researchers and training staff through the International Centre for Nursery Excellence now being established by the Queensland Horticulture Institute at Redlands Research Station.

5.1 Reports and publications

- Individual, detailed, confidential potting production efficiency reports were produced for those nurseries (39) cooperating on a long-term basis with the project. Individual reports contained graphs showing high labour cost areas in potting production and how nurseries compared with the performance of other project nurseries. Reports also provided practical,

low investment strategies to reduce production labour costs. All project nurseries undertaking improvements to potting production systems based on the report received free advice from researchers on introducing improvements.

- Brief production efficiency reports were also produced for a further 12 nurseries (2 QLD, 6 NSW, and 4 VIC) which joined the project in later stages.

- Extension articles presented updated accounts of project findings. Many included offers to readers to cooperate with the project and receive free advice on production issues. (See Appendix 3 for details.)

- Project booklet - *Stage 1 Useful ideas for reducing Potting Labour Costs in your nursery* (Available from **http://www.niaa.org.au/np/index.html** as MS Word6 file or PDF file). This booklet contains graphs and details of production data collected during the project as well as specific advice on reducing potting production labour costs and general advice on achieving production efficiency in other nursery production areas. The booklet includes the benchmark standards established for different pot sizes and production systems plus self evaluation forms to help nurseries evaluate their production efficiency and compare their performance with benchmarks and other nurseries.

- Three papers for state nursery association conferences were prepared and presented providing information on project results and methods of achieving an optimum potting production system.

5.2 Project field days

Ten field days (See Appendix 3) organised during the life of the project demonstrated how nurseries could use efficiency evaluation forms to compare their performance with benchmark standards. Field days also introduced some innovative labour reducing products and encouraged group debate on practical methods of reducing excessive production labour costs. These debates highlighted the diversity of opinion on production issues and yielded a consensus of opinion that there was a definite need for a source of objective information which nursery operators could access to assist them in designing and managing optimal production systems. All field day participants received access to free follow up advice from project researchers on improving production efficiency in their specific nurseries.

5.3 Product demonstration

A prototype potted plant handling device developed during project NY 98031 by researchers is being developed for commercial release by the manufacturer C-MAC industries. This device has the potential to drastically reduce labour costs in potted plant handling. The task of potted plant handling was identified through research as the largest cost component area of potting production.

As part of the design and developmental process the potted plant handling equipment was demonstrated on four occasions to nursery industry members, HAL members and members of allied nursery industries. In addition to on-site demonstrations, general information on the device along with a request for feedback were sent out to nurseries cooperating with the project. Selection of a suitable nursery to cooperate in the development of the equipment was undertaken by researchers with input from the NSW IDO and from C-MAC Industries. This in turn led to a meeting between a Sydney nursery, project researchers, C-MAC Industries and the NSW IDO to define the concept and confirm cooperation in equipment trials.

5.4 Surveys

Three different surveys were conducted during the life of the project in order to receive feedback from growers and allied nursery industry manufacturers and to assess technology transfer rates and needs:

- potted plant handling survey
- potting production survey
- development of a demonstration and information centre survey

(See survey forms in Appendix 4.)

5.5 Training material

Information suitable for use as potting production training material within the nursery industry's competency based training program has been provided to NIAA's National Training Manager. The information represents the total findings of the project based on production data gathered as well as recommendations for reducing production labour costs. See *Attachment 3*.

5.6 Commercialisation

A concept for an improved nursery potted plant handling system has been developed that will facilitate:

(a) the semi-automatic transfer of individual potted plants from a commercial potting machine (or hand potting bench) onto the deck of a trailer
(b) the semi-automatic positioning of potted plants in discrete rows on the deck of a trailer enabling it to be fully loaded
(c) the semi-automatic unloading of a full trailer deck of potted plants onto the ground for "growing on" purposes.

To prove the practicality of the concept a specialised nursery trailer and potted plant loading device have been designed, constructed and tested. The trailer and loading device can be used in conjunction with a number of other devices arranged in several different configurations. The primary aim of introducing this equipment is to reduce labour costs currently associated with the handling of potted plants in nurseries. Both the loading and unloading operations are presently performed manually in most Australian nurseries.

There are 3 versions of the specialised trailer:

Version 1 will allow semi-automatic loading of the potted plants. Unloading will be done manually. This version has application when there is no direct access for the trailer to the growing area. A typical situation would be when potted plants are unloaded onto benches or tables.

Version 2 is similar to Version 1 except that additional attachments will allow the potted plants to be unloaded onto the ground in the growing area in a semi-automatic operation. In this situation the pots will be touching (no spacing between pots).

Version 3 is similar to Version 2 except that an additional mechanism will allow the spacing of potted plants that are unloaded onto the ground. There will be two spacing options available: (a) the long rows will be spaced apart and the pots within these rows will also be spaced apart (b) as for (a) except that all pots in each alternate short row will be offset sideways to give a staggered pattern.

Various combinations of the specialised trailer, the potted plant loading device, the potting bench or potting machine and the unloading system are described in the following examples.
It is important to note that the specialised trailer and the potted plant handling device can be used to advantage to reduce labour costs as demonstrated by, but not restricted to, the following examples. Examples of various applications for the developed potted plant handling concept are shown in Appendix 5.

One of the aims of the *potted plant handling device* survey was to establish the potential market for commercial manufacture. Figure 32 shows optimistic and pessimistic market predictions for the number of trailers and loading devices that could be sold when the equipment is fully developed by the commercial partner.

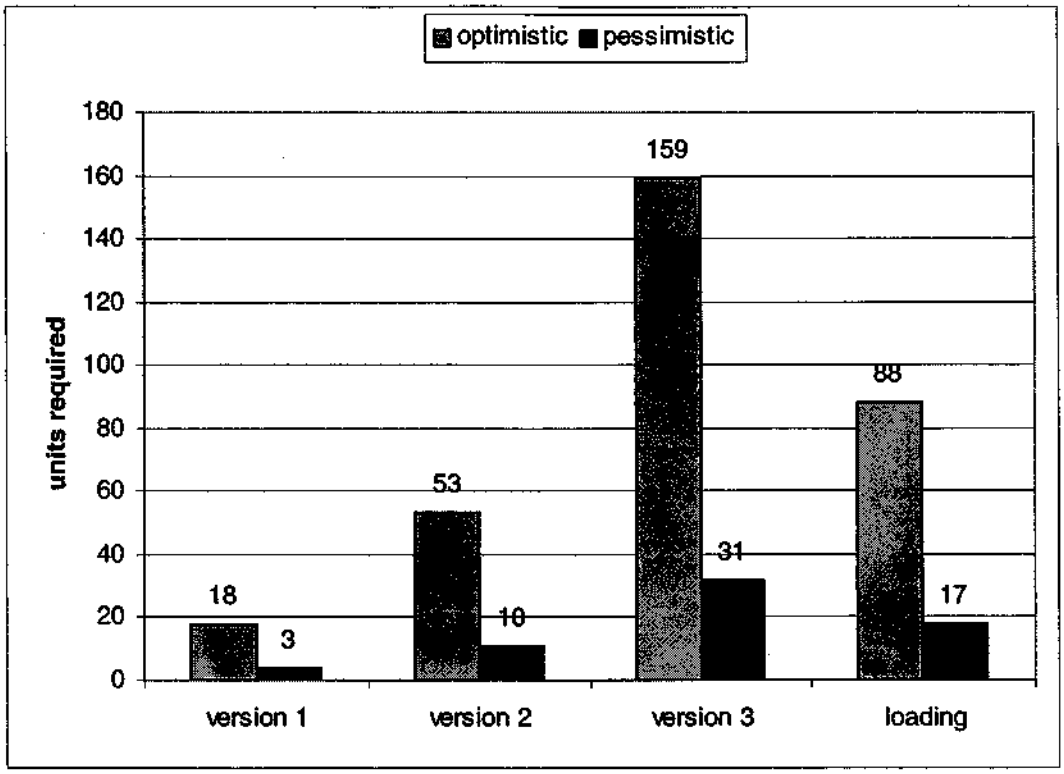


Figure 32. Potential number of potted plant handling devices required per 100 nurseries.

6 Conclusions and recommendations

From the investigation and analysis of potting data results from all participating nurseries, the general conclusion is that potting costs could be reduced immediately in most nurseries when basic production issues are addressed.

The following specific conclusions are as follows:

- Most Australian nurseries (estimated at over 95%) pay excessive potting labour costs due to:
  - inefficient organisation of potting procedures often combined with the use of an inappropriate potting system and equipment as well as poor materials handling methods are responsible for approximately 65-85% of excessive potting labour costs
  - staff with inadequate job training and accompanying levels of skill and motivation is responsible for approximately 10-20% of excessive potting labour costs
  - high difficulty of potted plants is responsible for approximately 5-15% of excessive potting labour costs.

- High cost of potting production can be directly related to the following issues
  - use of an inappropriate potting method
  - the inefficient organisation of potting procedures.

- ♦ over staffing potting production rather than attempting to streamline potting procedures to eliminate non-productive time through such strategies as the better distribution of tasks between potting staff and better organisation of potting inputs and outputs
- ♦ potting small batches made up of a number of plants with different potting requirements
- ♦ use of numerous pot colours, pot shapes, etc. during production
- ♦ use of low skilled, poorly trained and poorly motivated staff working in conditions of low OH&S.

From the investigation and analysis of potting data results from the 52 participating nurseries, the following general recommendations for improving potting production efficiency can be made:

Worker issues

- Maintain high levels of worker health and safety, worker comfort, worker motivation and worker skill
- Ensure all staff are competent to (a) operate the potting machine and (b) make any adjustments to the machine necessary to cope with situations that may arise during production
- Follow safety guidelines when potting - always wear gloves and face masks when handling or working around potting media (Steele 1996) and always follow safe handling guidelines for herbicides used during the potting process
- Allocate tasks to staff after taking into consideration their ability to perform different potting tasks

Organisation of potting system and potting procedures

- Hand potting should be used when the average daily quantities of plants to be potted (during the potting season) is below approximately 2000 plants and/or when the nursery is potting a larger number of different species requiring different treatments in various pot sizes, pot colours, and the average batch size requiring different treatments is below approximately 300 plants
- Improvements to the handling of potted plants should be investigated as a first priority as this area offers the greatest potential savings
- Ensure workers have all the information necessary to carry out potting production before production commences
- Analyse the allocation of tasks within the potting process to improve the distribution of productive tasks between workers and thereby reduce non-productive time
- Analyse the sequence and coordination of the delivery of inputs and the removal of outputs to reduce non-productive time

Improvements to the potting system

- Establish the existing amount of total potting labour costs in cents per pot
- Identify problems related to potting systems, procedures and worker issues
- Establish the cost/benefits of potential improvements
- Introduce the most beneficial changes
- Re-evaluate the potting system.

The general recommendation is to increase the average daily number of plants to be potted which have similar requirements with regard to treatments, potting procedures, pot sizes, pot colours, etc. This strategy will immediately lower potting labour costs without any expenditure.

Acknowledgments

This research project was sponsored by the Horticultural Research and Development Corporation (now Horticulture Australia Limited) and the Queensland Department of Primary Industries and was made possible by pot levy funding and the involvement of NIAA and the cooperation of nurseries from QLD, NSW and VIC. The authors would also like to thank state nursery industry development officers John McDonald, Richard Stephens and Greg King as well as Jeremy Badgery-Parker from NSW Agriculture for their valuable assistance in selecting suitable nurseries for the project and helping collect research data and organise field days.

Bibliography

Corlett, E.N., Clark, T.S. (1995). The Ergonomics of Workspaces and Machines. London: Taylor and Francis.

Gaydon , D., Radajewski, W. Trolleys the secret of increased efficiency. Australian Horticulture March 1993 pp 44-47.

Hendrix, T. (2000). Growing pot plants is moving pots. Ohio Florists' Association Bulletin No 847 pp6-8

Radajewski, W., Brown, D., Bodman, K., and Hoeks, P. (1997) Nursery Dispatch Systems. Queensland Department of Primary Industries Manual.

Steele, T. (1996). Control of legionella spp. particularly legionella longbeachae in potting mixes. HRDC Final Report NY234

Appendix 1. Data collection forms

♦ Nursery potting production forms.

List all tasks involved in carrying out the potting process at your nursery. If more than one potting method is used give a list of the tasks used in each method or for the method you would like project researchers to investigate. Use the form below to list tasks. If there is insufficient space use a separate piece of paper. Some examples of potting tasks are given.

Form 1

	TASKS	STEPS IN TASK
Planning and organising	Eg. Prepare potting schedule	Check advance orders, input details to computer
	Eg. Order pots	Consult potting schedule, count available pots
	•	
	•	
	•	
	•	
	•	
	•	
	•	
Preparing for potting	Eg. Cleaning pots	
	Eg. Prepare potting media	
	•	
	•	
	•	
	•	
	•	
	•	
Potting	Eg. Grading	
	Eg. Fertilising	
	•	
	•	
	•	
	•	
	•	
	•	
Taking pots to growing area	Unloading pots	
	Spacing pots	
	•	
	•	
	•	
	•	

Form 2

Date	Potting method 1-5 (see below)	Initial container (see below)	To next container size (mm)	Number potted	Potting difficulty 1,2 or 3	Total man hours	% in final sale pot

Date: date potting event took place - dd/mm/yy **Potting Method:** number corresponding to method used - **1.**Standard bench **2.**Modified bench **3.**Javo **4.**Comet **5.**Flat filler **Initial Container:** dimensions of plant stock container – eg. Tube 20mm, tray 200 cells, etc.

To next container size..: size of pot plant potted to – eg. 140mm, 300mm **Number potted:** total plants potted **Potting dificulty: - 1.easy 2.average 3.hard** (different plants have different potting requirements. The potting speed rating is based on the length of time needed to pot a particular plant species) **Total man hours:** add total number of hours staff take to complete potting event **% in final sale pot:** give the % of plants potted that will be not be repotted before sale.

Form 3 (used by researchers)

NURSERY NAME..... DATE / / SHEET No...
PLANT NAME..... DIFF..... START TIME..... END TIME.....
POT IN ..... POT OUT ..... POTS/TRAY.....
TRAY/TRAILER.....POTS/TRAILER.....
NO. POTTERS..... NO.EXTRAS..... TOTAL POTS..... SALE PRICE.....

		time		pots	Staff	time		pots	Staff	time		pots	Staf
1000	***STOPS***												
1010	***machine malfunction***												
1020	***lack of materials***												
1030	***lack of information***												
1040	***change plant species***												
1050	***other***												
2000	***PREPARATION***												
2100	**plant handling**												
2110	deliver plants to general potting area												
2120	unload stock from trailer & put on bench/trolley/ground												
2130	prune												
2140	grade												
2150	removal of old stakes & ties												
2150	other												
2200	**pot handling**												
2210	deliver pots to general potting area												
2220	open box/plastic bag etc.												
2230	other												
2300	**fertiliser handling**												
2310	deliver fertiliser to general potting area												
2320	mix fertiliser with media												
2330	other												
2400	**media handling**												
2410	***load hopper/bench***												
2420	other												
2700	**other materials**												
2710	deliver trays to general potting area												
2720	***deliver staks etc***												
2730	deliver trolleys/trailers												
2740	other												
2800	**potting area & machinery/equipment**												
2810	clean potting area												
2820	set up machines/conveyers												
2830	other												
2900	**growing area**												
2910	set up string line												
2920	prepare/clean growing area												
2930	block plants												
2940	other												
3000	***STANDARD POTTING***												
3100	***Deliver Plant(s) To Potting Bench***												
3110	***eject plants from tray***												
3120	***popping out plants from tubes/ trays***												
3130	***deliver plants to immidiate area***												
3140	***deliver plants to potting bench***												
3150	***other***												
3200	***Deliver Pot(s) To Potting Bench/Machine***												
3210	***deliver stacks of pots to immediate potting area***												
3220	***load pots to pot dispenser/machine***												

3230	*split stack of pots &/or put on potting bench*												
3240	*other*												
3300	*Deliver Fertiliser To Potting Bench*												
3310	*deliver fertiliser to immediate potting area*												
3320	*deliver fertiliser to potting bench*												
3330	*other*												
3400	*Media Handling*												
3410	*shift media on bench*												
3420	*shake hopper etc*												
3430	*other*												

		time		pots	Staff	time		pots	Staff	time		pots	Staff
3500	*Pot + Media (planting)*												
3510	*load media to pot*												
3520	*pot with media to trailer/other bench*												
3530	*drive to planting shed*												
3540	*unload pots/trays*												
3550	*dibbling*												
3560	*fertiliser to pot (filled with media)*												
3570	*plant to pot (filled with media)*												
3580	*top up media*												
3590	*compressing media*												
3595	*other*												
3600	*Potted Plant*												
3610	*put pot to tray/trailer/trolley/conveyer*												
	pot to tray												
	pot to trailer												
	pot to trolley												
	pot to conveyor												
	other												
3630	*load full trays to trolley/trailer/conveyer*												
	full tray to trailer												
	full tray to trolley												
	full tray to conveyor												
	other												
3640	*shift full trays on trailer/trolley*												
	shift tray on trailer												
	shift tray on trolley												
3620	*shift full trays on conveyer*												
3650	*other*												
3700	*Other Materials*												
3710	*empty trays shift on trailer(trolley)*												
	shift empty tray on trailer												
	shift empty tray on trolley												
	shift empty tray on conveyor												
3720	*empty tray deliver to immediate potting area*												
3730	*empty trays deliver to potting bench*												
3750	*trailer/trolley shifted for loading plants*												
	shift trailer for loading plants												
	shift trolley for loadfng plants												

	shift conveyor for loading plants												
3770	*other*												
4000	**TOTAL TIME OF POTTING POT (s2s)**												
5000	**TOTAL TIME OF POTTING TRAY (s2s)**												
6000	**TOTAL TIME OF POTTING TRAILER/TROLLEY (s2s)**												
7000	**ALL POTTING (all plants potted in the same category)**												
8000	**FULL EVENT (preparation+potting +after potting)**												
8500	**FULL TRIP TO UNLOAD PLANTS**												
9000	**AFTER POTTING**												
9100	**plant handling**												
9110	disposal of reject plants												
9120	other												
9200	**pot handling**												
9210	diposal/transport to storage of old pots												
9220	other												
9300	**fertiliser handling**												
9310	apply fertiliser to pots in growing area												
9500	**potted plants transport to growing area and return**												
9510	drive the tractor/push trolley with plants 2 growing area												
	tractor to growing area												
	push trolley to growing area												
9520	carry tray 2 growing area&put on ground/bench&return												
9530	unload plants from trays & space												
9540	carry pots/trays 2 growing area, put on ground&space												
	select pot from trailer/trolley/conveyor												
	carry pot to growing area												
	space pots in growing area												
	select tray from trailer/trolley/conveyor												
	carry tray to growing area												
	unload pots from tray												
9550	return to potting area												
9560	other												
9600	***treatments of potted plants***												
9610	***herbicide***												
9620	***watering (including driving to waterstation)***												
9630	***staking***												
9640	***staking & tying***												
9650	***pruning / trimming***												
9660	***recording***												
9670	***other***												
9700	**other materials**												
9710	pick up empty trays & and load to trailer												
9720	collect &/or return empty /tubes/trays												
9730	other												
9800	**potting area/ machinery**												
9820	return equipment to storage place (conveyers/tractors)												
9840	other												

Appendix 2. Methodology of solving inefficiency in potting production

Potting production is used here as an example to show how a nursery can progress from low production efficiency status to high production efficiency status and achieve a reduction in potting production labour costs. The same principles used to identify and solve potting production inefficiencies can be applied to other areas of nursery production.

Define problems

Be aware of the existence of specific production problems. It is not enough to assume that production labour costs are too high in your nursery (even though this is a safe assumption for the majority of Australian nurseries). In order to reduce labour costs you will need to target specific problems. It will help to write down a production problem as you see it.

Example: A nursery with an annual production of 300,000 potted plants (potting during October/November -140mm pots) uses a total of 6 people to operate its Javo potting system and has a daily production rate of 7,200 potted plants which includes transport of plants to the growing area and putting down plants in the growing area.

Potting labour costs are too high and daily production rates too low because of:
Frequent stoppages to potting production
Potting production is over staffed

Cost problems

Once problems have been defined the next step is to find the total potential cost of problems. Don't rely on intuition or rough estimates. You will need to know the exact cost in cents per pot to be able to determine if problems are serious and, if so, the level of resources to allocate in solving them. Base your assessment on sound existing production data or record new data. Make sure the data you use represents an average period of potting production. Once you have your data compare it to available benchmarks to find the potential cost of the problem in cents per pot.

If recorded production data shows your potting labour costs are close to or better than benchmark costs there may be no appreciable gain in improving the potting system, especially if improvement would require capital investment.

Over the last 3 weeks data records show that the nursery has used 6 people operating its Javo machine potting system to produce 7200 pots (140mm) per day. Each person works 7.5 hours per day (excluding lunch breaks) at an average hourly wage rate of $15.

Total daily labour cost = 7.5 x 6 x $15 = $675

Labour cost cents/pot = (675 x 100) ÷ 7200 = 9.375 cents/pot

Benchmark cost/pot = 4 cents/pot (see Table 1)

Production inefficiency cost/pot = 9.375 – 4 = 5.375 cents/pot

Annual production inefficiency cost = (300,000 x 5.375) ÷100 = $16,125

Comparison with production benchmark costs shows that production inefficiencies in the current potting system cost the nursery 5.357 cents/pot or $16,125 over the annual production of 300,000 pots.

Understand problems

Once production problems have been defined and costed the next step is to understand the problems in the context of the whole production system. You will need to observe every event in the production system and develop an understanding of the relationships between all events. During this observation phase you should:

- Locate where production problems occur and write down their underlying causes
- Visualise how benchmark costs can be achieved in current production system
- Collect production data to find the average time for completion of tasks and establish basic production values
- Analyse the time and dollar cost of specific problems

Don't be tempted to rush this step or go ahead with introducing improvements without carrying out steps 4, 5, 6 and 7. Basing solutions on the rapid analysis of production problems could result in a system with even higher production labour costs or in the unnecessary investment in production equipment. Each problem needs to be thoroughly analysed, and, depending on its complexity, a reasonable amount of time devoted to the process of improving its effect on production efficiency.

If nursery managers feel they have insufficient time to investigate and solve production problems they should consider employing a production system consultant. Having already calculated the total potential cost of problems in step 2 it should be a simple matter to decide whether or not it pays to hire a consultant for the job.

- *Locate where production problems occur and write down their underlying causes*

The defined problems (regular stoppages to potting production and potting production is over staffed) can in most cases be subdivided into specific problems and their underlying causes.

Problems and underlying causes contributing to regular production stoppages

Trailer is not returning from the growing area to the potting area on time

- slow manual watering process during transport of plants to the growing area
- slow unloading of trailer due to long walking distances in growing area and /or not carrying enough pots during each walk
- slow travelling between potting shed and growing area

Bridging of media hopper

- Potting media hopper not designed correctly
- Potting mix too wet because it is exposed to rain or wetted too much before loading to media hopper

Stock not delivered to potting area on time

- frequent changes in the type of plant species being potted
- potting plant stock being stored too far from potting machine

Loading potting media to hopper halts potting production due to

- access to media hopper blocked by staff operating Javo potting machine
- hopper capacity being too small

Problems and their underlying causes contributing to over staffing of potting production system

Manual loading of pots to Javo involves one person full time

- lack of automatic pot dispenser on Javo

Manual loading of fertiliser to pots involves one person full time

- lack of automatic fertiliser dispenser on Javo

- *Visualise how benchmark costs can be achieved in the current production system*

To appreciate the level of improvement required in an existing production system it is a useful exercise to see how current production output and work hours would need to alter to achieve the benchmark cost.

For the nursery using the Javo system with 6 potting staff the benchmark labour cost of 4 cents per pot can be achieved in either of two ways. The nursery can:

- increase the current daily production rate of 7,200 potted plants while maintaining the current daily potting labour cost of $675.

By maintaining the current daily potting labour cost of $675 and achieving the benchmark of 4 cents per pot the daily production quota would need to be
(675 x 100) ÷ 4 = 16,875 pots/day

- maintain the current daily production rate while decreasing the current daily potting labour cost.

By maintaining the current daily production rate of 7,200 pots to achieve the benchmark of 4 cents/pot the daily labour cost would need to be
(7200 x 4) ÷ 100 = $288 /day (which at $15 / hour and 7.5 hours per working day equals a potting staff of 2.56 people per day - ie. 2 full time and one at 56 % of time)

This means that to reach the benchmark of 4 cents/pot and achieve savings of $16,125 per year the nursery will either have to produce 16,875 pots per day at current labour costs or produce 7,200 pots/day and reduce daily labour costs from $675 to $288 by cutting potting staff from 6 people to 2.56 people.

In real life a combined approach targeting both production rates and staff numbers will have to be made to achieve the best possible result.

- *Collect production data to find the average time for completion of tasks and establish basic production values*

Step 1 in the collection of data is to list the potting staff and their main tasks. Some potting staff may not be engaged full time in the potting system. In a full potting day they may carry out tasks in other production areas while not loading media or delivering plant stock, etc. Only include the time staff spend engaged in potting production. If someone is considered to be on the potting staff (eg. a potting supervisor) but does not play an active, hands on role in potting, do not include their time in the production data.

Potting staff

- potter 1 – empty pots to machine
- potter 2 – fertiliser to pot
- potter 3 – plant stock to pot
- potter 4 – potted plants to trailer, load media to hopper, deliver plant stock & plastic pots to potting area
- potter 5 – drive trailer to growing area, unload potted plants in growing area, return trailer to potting area
- potter 6 - unload potted plants and space potted plants in growing area

Step 2 is to find the average times for the completion of potting tasks associated with the production problems defined. The more data recorded the more accurate the averages will be. It is common for staff to work at a faster rate when they know they are being timed so allow them some time to get used to the recording process and revert to their normal work rates. It is important to involve staff from the very beginning of the process of improving production efficiency so they do not feel threatened or react negatively to the data recording process.

Collected data (average times for completion of potting tasks)

- 14.5 minutes to unload trailer which includes driving to and from growing area and watering in plants (one person + driver)
- 3 minutes to water in each trailer load (200 pots per trailer).
- 2 minutes to drive trailer to growing area (one way)
- 2 minutes to drive trailer to potting area (one way)
- 6 seconds to carry 6 pots from trailer into growing area
- 6 seconds to walk back to trailer
- unloading and spacing potted plants 2 people (one person + driver)
- 8 minutes of production stoppage during media loading to hopper (4 times a day, 3 persons on potting machine affected by stop)
- 35 minutes per day spent clearing bridged hopper (3 persons on potting machine affected by stop)
- 30.15 minutes of production stoppage per day from plant stock change and or delivery (4 persons on potting machine affected by stop)
- 2 minutes of production stoppage for each change of trailer (3 persons on potting machine affected by stop)

Use recorded data to establish basic production values.

Basic production values

- Number of trailers of potted plants produced per day 7200 ÷200 = 36 trailers
- Total time spent potting 7.5 x 60 = 450 minutes per day (note this is clock time not total man hours)
- Total time to produce a trailer load of potted plants (includes unproductive time) 450 ÷ 36 = 12.5 minutes
- Time for watering & travel to and from growing area 3 + 2 + 2 = 7 minutes
- Time for putting down plants in growing area 14.5 - 7 = 7.5 minutes
- Number of walks during unloading 200 ÷ 6 = 34 walks per trailer
- Time spent walking (2 people) during unloading each trailer (6 x 2 x 34) ÷2÷60 = 3.4 minutes

- *Analyse the time and dollar cost of specific problems*

The cost of unproductive time in minutes and cents per pot (unproductive time refers to the total minutes Javo system is not being used for potting)

Trailer change
Unproductive time resulting from the late arrival of trailer during changing trailers for the loading of potted plants is 2 x 36 = 72 minutes per day.
Total man-hour stoppage is 2 x 3 x 36 = 216 minutes per day.
The total labour cost of changing trailers is (216 x 15) ÷ 60 = $54 per day.
The cost per pot of unproductive time is (54 x 100) ÷ 7200 = 0.75 cents per pot.

Hopper bridging
Hopper not designed correctly
Potting mix too wet (exposure to rain or over wetted before loading)
Unproductive time 35 minutes per day. Man-hour stoppage is 35 x 3 = 105 minutes per day.
The total labour cost of clearing bridged hopper is (105 x 15) ÷ 60 = $26.25 per day.
Cost per pot of unproductive time is (26.25 x 100) ÷ 7200 = 0.36 cents per pot.

Potting plant stock not delivered on time
frequent change of potted species
storage of stock too far from potting machine
Unproductive time 30.15 minutes per day. Man-hour stoppage is 30.15 x 4 = 120.6 minutes per day.
The total labour cost due to undelivered stock (120.6 x 15) ÷ 60 = $30.15 per day.
Cost per pot of unproductive time is (30.15 x 100) ÷ 7200 = 0.42 cents per pot.

Loading of potting mix to hopper
staff working at Javo block access to hopper
hopper capacity too small requiring frequent loading
Unproductive time is 8 x 4 = 32 minutes per day. Man hour stoppage 8 x 3 x 4 = 96 minutes per day
The total labour cost due to media loading is (96 x 15) ÷ 60 = $24 per day
Cost per pot of unproductive time is (24 x 100) ÷ 7200 = 0.33 cents per pot

Total daily unproductive time (2 x 36) +35 + 30.15 + (8 x 4) = 169.15 minutes
Total cost of unproductive time 0.75 + 0.36 + 0.42 + 0.33 = 1.87 cents per pot

As the selection of potential improvements to production efficiency will be based on the calculated production times and values it is of the utmost importance that all results are checked and rechecked for accuracy and are set out in an easy to understand format. The time and dollar cost of unproductive time for the example nursery calculated above is set out in Table 1.

Table 1. Unproductive time and cost resulting from production stoppages.

	Stoppage time (min)	People involved	Events per day	Man hour stoppage time (min)	Total cost (cents/pot)	Unproductive time (min)
Lack of cover over potting mix & hopper bridging (min)	35	3	1	105	0.36	35
Production stoppage for media loading (min)	8	3	4	96	0.33	32
Potted plant stock not delivered to potting area	30.15	4	1	120.6	0.42	30.15
Change of trailer	2	3	36	216	0.75	72
Total unproductive time				537.6	1.86	169.15

If unproductive time could be converted to productive time an extra 169.15 minutes would be available for production. This would increase daily production by 169.15 x 7200 ÷ (450-169.15) = 4336 pots per day

The real potting time will be decreased from
(7.5 x 3600) ÷ 7200 = 3.75 sec/pot, to
(7.5 x 3600) ÷ (7200+4336) = 2.34 sec/ pot

With this rate of potting production one trailer (200 pots x 140mm) will be produced by the Javo potting machine every (200 x 2.34) ÷ 60 = 7.8 minutes.

Potential solutions

After the potential causes of problems and the cost of problems have been defined, solutions need to be devised that will reduce production labour costs to benchmark levels. It is important that all the direct and indirect effects that potential solutions will have on production, as well as the likely return of any investment required to introduce these solutions, are carefully considered.

When calculating the return on investments the initial cost of the equipment, ongoing maintenance costs, and the life of equipment should all be taken into account.

Potential solutions to the problems of –
Production stoppages & over staffed potting production

Trailer is not returning to Javo on time from the growing area

- slow manual watering process during the transport of plants to growing area

Install a watering tunnel to reduce watering time from 3 to 0.5 minutes per trailer (watering plants in the growing area not deemed acceptable because potting media spills out onto gravel)

- slow unloading of trailer due to long walking distance and/or only carrying 6 pots per person per trip

Install a conveyor in growing area to reduce walking time from 3.4 to1.1 minutes
Use trays to carry 12 pots per time to reduce walking time from 3.4 to 1.6 minutes

- long travelling time to growing area

Use converted utility to reduce travel time from 4 to 1 minutes and increase carrying capacity from 200 to 380 pots per trip.

- not enough trailers available for potting

Buy new trailers and pull three each trip to growing area to reduce travel time from 4 to 1.3 minutes per trailer.

Bridging of media hopper

- Hopper not designed correctly
- Potting mix too wet because exposed to rain or wetted too much before loading to hopper

Improve hopper design & install cover over potting media storage area to eliminate unproductive time

Plant potting stock not delivered to Javo potting machine on time

- frequent change of potted species
- storage of stock too far from potting machine

Use multi shelf trolleys adjacent to machine to eliminate unproductive time.

Loading of potting media to hopper

- staff working at Javo block access to hopper

- hopper capacity too small

Install larger hopper able to cope with daily production to eliminate unproductive time
Install media conveyer for continuous media loading to hopper

Manual loading of pots

- lack of pot dispenser

Install automatic pot dispenser on Javo

Manual loading of fertiliser to pots

- lack of fertiliser dispenser

Install automatic fertiliser dispenser
Use potting media with pre-mixed fertiliser (nursery deems not acceptable due to quality issues)

Staff in improved system

- supervisor - loading media, delivering stock & pots (20% of time)
- potter 1 - stock to pot
- potter 2 - potted plants to trailer
- potter 3 - tractor driver + unloading potted plants in growing area
- potter 4 - unloading and spacing potted plants in growing area

The total number of staff used in the new system would be 4.2

The new cost of potting would be [(15 x 7.5 x 4.2) x 100] ÷ (7200+4336) = 4.1 cents per pot. In order to achieve 4 cents per pot the production time would have to be decreased from 2.34 sec/pot to (2.34 x 4) ÷ 4.1 = 2.28 sec/pot which would mean daily production would be (7.5 x 3600) ÷ 2.28 = 11,842 pots per day.

With this potting rate the number of potting days could be reduced
from 300,000 ÷ 7200 = 42 days per annum (the present potting production period)
to 300,000 ÷ 11,842 = 26 days per annum.

In this case the annual labour cost would be 26 x 7.5 x 4.2 x 15 = $12,285 per annum (against the cost of the old system 42 x 7.5 x 6 x 15 = $28,350 per annum).

If a reduction in the potting period was not practical other possibilities are:

- Instead of working every day of the week potting production can be carried out (7200 x 5) ÷ 11,842 = 3 days per week
- Instead of a 7.5 hour working day potting could be carried out in a shorter working day of (7.5 x 7200) ÷ 11,842 = 4 hours and 33minutes.

Whichever method is adopted it will be necessary to speed up the movement of plants from the potting area to the growing area and/or reduce the time of trailer unloading. The present time of unloading trailer is 14.5 minutes. To match the new production rate unloading time needs to be reduced to (200 x 2.28) ÷ 60 = 7.6 minutes and therefore 14.5 - 7.6 = 6.9 minutes has to be saved during the transport, watering and unloading of potted plants to the growing area.

If a number of different pot sizes are produced by the nursery make sure that potential solutions take into account the effect changes will have on overall nursery production and are not only related to one pot size.

Select solutions

Once solutions to the initial problem have been proposed and considered the next step is to select which solutions should be introduced. Remember the aim is to improve production efficiency and reduce production labour costs. Solutions and/or combinations of solutions should evaluated on their ability to reduce labour costs. The anticipated labour cost saving of each solution and/or combination of solutions as well as the expected period of return on any capital investment should be calculated and referred to during the selection process to ensure that the solution chosen is the best for the nursery.

Table 2 presents some potential solutions to production inefficiencies along with the anticipated production times and associated investment costs. Solutions are based on combinations of equipment including trailers, trays, watering tunnel, pot unloading conveyer and utility for plant transport. Note that only the last 2 combinations of options give a total unloading time less than the 2.28 seconds per pot required to reach the benchmark labour cost of 4 cents per pot. Our nursery will select one of these options.

Table 2. Potential solutions for reducing time associated with trailer travel and unloading potted plants in growing area.

	Existing system	Water tunnel	Water tunnel + 3 trailers	3 trailers + water tunnel + trays	2 trailers + water tunnel + conveyor	water tunnel + utility with 380 pots capacity
Number of trailers used	1	1	3	3	2	1
Number of people unloading pots	2	2	2	2	2	2
Walk pots into growing area –seconds	6	6	6	6	1	6
Number of pots carried during unloading	6	6	6	12	6	6
Number of walks per trailer	34	34	100	50	67	64
Total time of walking – minutes	3.4	3.4	10	5	1.1	6.3
Total pot spacing time – minutes	4.1	4.1	12.6	12.6	8.4	5.32
Watering time – minutes	3	0.5	1.5	1.5	1	1.2
Total driving time both ways – minutes	4	4	4	4	4	1
Shift conveyor or trays – min/trailer	0	0	0	0.3	0.5	0
Total unloading trip time – minutes	14.50	12.00	9.37	7.80	7.50	13.82
Total unloading trip time – seconds/pot	4.35	3.60	2.81	2.34	2.25	2.18
Approx. cost of equipment - $	0	1800	4800	5300	11000	8300
Estimated life of equipment – years		10	10	2	10	5
Estimated maintenance cost -$/annum		180	480	530	1100	830

Table 3 shows the cost of various items of equipment, which could improve production efficiency. Equipment is categorised under column headings of Media & stock handling, Plant transport and Manual work. A nursery would base its decision on which particular improvements to select on issues such as, available budget, level of labour cost savings sought, anticipated increases or decreases in production output, etc. For our example we will select the combination of improvements shown in the last column of Table 3b headed Selected options.

Table 3. Cost of equipment for potential solutions

	Media & stock handling			Plant transport		Manual work	Selected options	
	Cover media, fix hopper, Media conveyor, plant stock trolleys	Cover media, new hopper, trolleys	New system for delivery of media, trolleys	Conveyor, 2 trailers, water tunnel	3 utilities, water tunnel	pot & fertiliser dispenser	Option 1	Option 2
cover potting media	1500	1500	0	0	0	0	1500	0
Fix hopper	1800	0	0	0	0	0	1800	0
Media conveyor	3000	18000	20000	0	0	0	3000	20000
Plant stock trolley	900	900	900	0	0	0	900	900
Change of trailer	0	0	0	11000	7800	0	7800	11000
pot dispenser	0	0	0	0	0	5500	5500	5500
fertiliser dispenser	0	0	0	0	0	3000	3000	3000
Total cost	7200	20400	20900	11000	7800	8500	23500	40400

Figure 1 shows the pattern of the cost of capital investment, labour cost and total annual cost for the existing system and for each of the selected options. Capital investment refers to money spent to buy equipment. There is no capital investment amount for the existing system as it is assumed that all existing equipment has been paid off. Labour cost refers to the potting labour cost (calculated on annual production of 300,000 pots). Total annual cost represents the sum of all potting production costs resulting from:

- depreciation
- interest paid on capital investment
- labour cost
- maintenance cost and
- other running costs (electricity, fuel, etc.)

Note that materials for potting such as plastic pots, media, stakes, etc. are not included in total annual cost and the salvage value of equipment that has reached the end of its working life is assumed to be zero. In the first year the cost of the introduction of changes, including the installation of any equipment (eg. labour to install, any fittings required, etc.) and any specific training should be included.

Figure 1 shows that option 1 has similar total annual costs to option 2 and requires a much lower initial capital investment. Figure 2 shows that the production system based on option 1 will repay all investments after the production of approx. 520,000 pots (around 21 months). Option 2 will repay itself after the production of 900,000 pots (36 months)

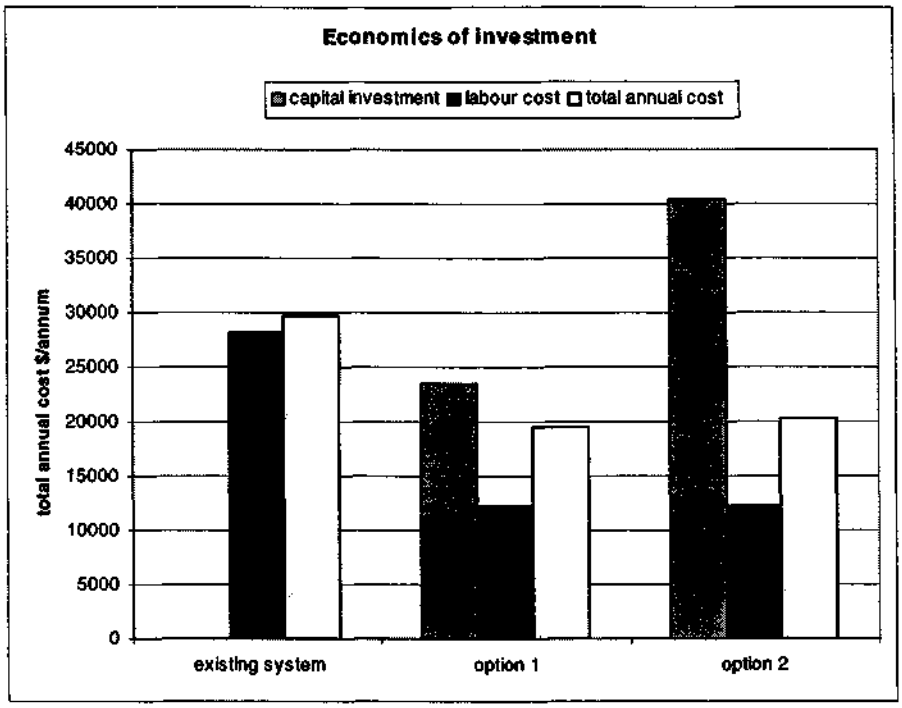


Figure 1. Cost of capital investment, potting labour cost and total annual cost for the existing system and for selected options for improving production efficiency.

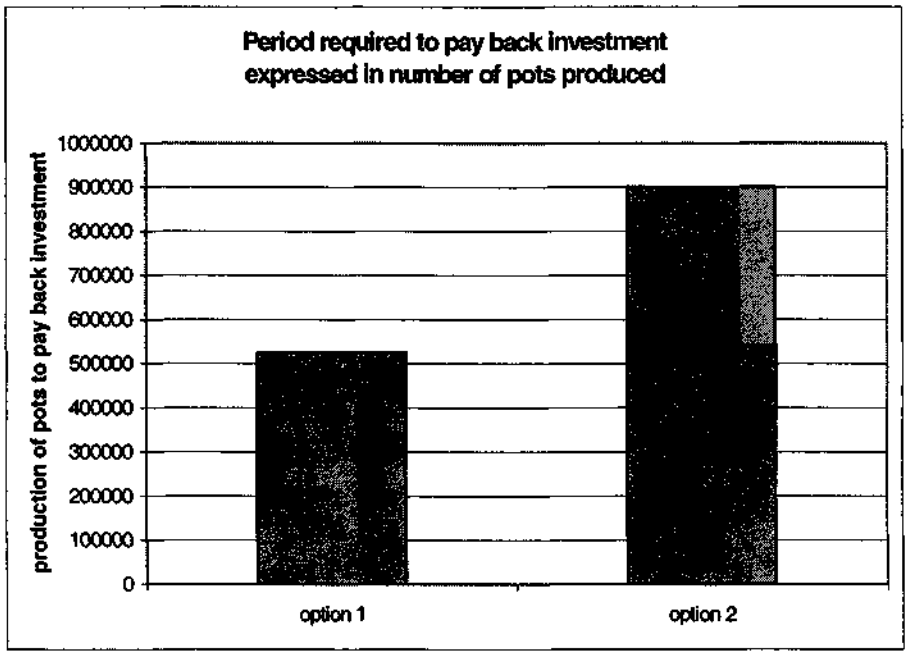


Figure 2. Pay back period for option1 and option 2.

The example nursery has compared the likely savings of various potential solutions and the pay back period on investments and decided to introduce the improvements contained in option 1 to achieve benchmark labour costs of 4 cents per pot.

Introduce solutions

If the solutions to be introduced affect the way in which potting staff carry out tasks nursery management will need to consult with staff and provide them with training in the operation of the new system. If staff are actively involved in the process of improving production efficiency from the outset they are more likely to understand the reason for changes and develop a sense of ownership in the new system. Before attempting any improvements in production efficiency discuss with staff the nursery's need to meet industry benchmarks to remain competitive and make them aware of the actual benchmark cost your nursery is aiming to achieve.

Attempts to reduce labour costs can be interpreted by potting staff as a threat to their job security or as criticism of their work rate. Consultation with staff before, during and after introducing changes to the production system will help ensure they react positively to the changes and work productively in the new system. Make sure adequate training is provided to staff and sufficient time is allowed for them to become familiar with working in the new system. During the familiarisation period seek feedback from staff to ensure they are physically and emotionally comfortable with the changes.

Depending on the extent of changes to the original system it can take some time for staff to become familiar with the new system. To avoid falling short of production quotas changes should not be introduced during the nursery's peak production periods. Introductions can be carried out in stages or in one go depending on the complexity of changes.

Test solutions

After potting staff have been trained in using the new production system, have had sufficient time to become familiar with it and have made any personal adjustments necessary the efficiency of the new production system will need to be tested. This involves recording new production data and comparing against data from the original system. Make sure new data represents an average period of production and matches the production circumstances of the original data (eg. same level of plant potting difficulty, same pot size, same potting tasks, similar level of experience in potting staff, etc.).

If the first 6 steps towards improving production efficiency are carefully and thoroughly carried out, there is a very high degree of likelihood that the potting labour cost savings predicted for the new system will be reflected in the new production data.

If the results are worse than expected you will need to carry out some or all of the following:

- check production data for mistakes
- review the circumstances of production during the recording of the data
- check the accuracy of the original calculations for the predicted labour cost savings of solutions
- record production data for the new system once again
- retest the data against the original production data
- review the causes identified as contributing to the initially defined problems.

Appendix 3. List of Technology Transfer Activities

Extension articles list

Brown, D. (1999). Potting labour costs reduced by QDPI research. Ornamentals Update July p 3-5.

Brown, D. (1999). Report on potting field days. Ornamentals Update November p 1-3.

Brown, D., Franklin, T., Radajewski, W. (2000). Nursery labour cost- you can become more efficient. Ornamentals Update November p 8-9.

Radajewski, W., Brown, D., Franklin, T. (2001). Reducing nursery production costs – how can it be done?. Ornamentals Update February p 9-11.

Radajewski, W., Brown, D. Reducing the labour costs of potting. Nursery Papers April 2000.

Field days list

20/7/99 Redlands Nursery Brisbane (40 participants)
10/8/99 Karinga Nursery Melbourne (25 participants)
10/8/99 Scotsburn Nursery Melbourne (25 participants)
12/8/99 Boulter's Nursery Monbulk (21 participants)
21/10/99 Bau Farm Nursery Alstonville (18 participants)
2/12/99 Colourwise Nursery Sydney (45 participants)
21/11/00 Proteaflora nursery (12 participants)
23/11/00 Bails nursery (28 participants)
28/11/00 Harts nursery (42 participants)
1/9/00 Sunrise Nursery (18 participants)

Demonstration events list

11/5/00 device demonstrated at Redlands Research Station (9 participants)
19/9/00 device demonstrated at Redlands Research Station (12 participants)
16/10/00 device demonstrated at Redlands Research Station (6 participants)
23/11/00 device discussed in Sydney (6 participants)

Conference papers list

Radajewski, W., Brown, D., Bodman, K., Claessens, R. Potting up – Are you efficient? 9/4/99 NIAN State Conference Ballina

Radajewski, W., Brown, D., Bodman, K., Franklin, T. Principles of efficient potting 21/11/99 QNIA State Conference Noosa

Radajewski, W., Brown, D., Franklin, T. Practical procedures for reducing potting labour costs. 8/11/00 QNIA State Conference Noosa

Appendix 4. Survey forms & results

Potted plant handling device letter & survey form

To the nursery operator

The current potting efficiency project has established that the highest labour cost component of potting production occurs in handling the potted plant.

To help the nursery industry go about reducing this cost project researchers have designed a prototype potted plant handling device which takes the majority of manual work out of loading, unloading and setting out potted plants on the ground in the growing area (the device is not suitable for unloading plants to benches). The device is best described as an innovative nursery trailer suitable for both hand potting and machine potting systems.

It is envisaged that 3 versions of the device will be produced giving nurseries the opportunity to choose a version best suited to their production system:

- Version 1 - eliminates the manual task of loading a trailer with potted plants (estimated sale price approx. $5,000 and approx. savings of 1.86 cents per average pot size 100mm to 200mm)

- Version 2 - eliminates the manual task of loading a trailer and reduces by approx. up to 80% the time needed to unload potted plants in the growing area and set them out pot to pot on the ground (estimated sale price approx. $6,500 and approx. savings of 4.16 cents per average pot size 100mm to 200mm)

- Version 3 - eliminates the manual task of loading the trailer and reduces by approx. up to 80% the time required to unload and space plants on the ground in the growing area (estimated sale price approx. $10,000 and approx. savings of 5.67 cents per average pot size 100 to 200mm)

For example: If you are potting 100,000 plants (100mm to 200mm pot size) per annum and spacing them out in the growing area, by using version 3 of the device you could expect potential labour cost savings of $5,670.

Before further development work can begin, however, researchers need to get an idea of the potential market for each version of the device. To assist us in this process please complete the following questions and fax to (07) 3286 3094. If you have any questions regarding this letter please contact Denis Brown by phone on (07) 3286 1488.

Return to Engineering Redlands Research Station - fax (07) 3286 3094

Nursery name: _____

Contact: _____

Phone: _____ Fax: _____

Address: _____ Postcode: _____

1. What is your average annual potting production (pots 100mm to 200mm)?

Pot size	Annual number of plants potted	% of potted plants placed pot against pot in growing area	% of potted plants spaced apart in growing area	Maximum spacing mm
100mm				
125mm				
130mm				
140mm				
150mm				
175mm				
200mm				
Total				

2. The device will have a capacity of approx. 200 x 140mm pots and will take approx. 2 minutes to unload and space plants in the growing area. On the basis of the sales price of the device and the labour cost savings shown on the first page, which version of the device and how many units of the device would you need to operate your potting system?

Device version number	Number of units needed

Thank you for completing the questionnaire

Please fax the form back to us at – fax (07) 3286 3094

W Radajewski
EXECUTIVE ENGINEER

NURSERY PRODUCTION INFORMATION, DEMONSTRATION & TRAINING CENTRE

Your name:.....
Nursery name:.....
Telephone:.....

Nursery labour cost projects have shown that the major reason for excessive production labour costs is the lack of objective information, demonstration and training facilities to help nursery management select, design and operate efficient production systems.

1. Do you believe an information centre for production efficiency would be a useful resource for the nursery industry?

Such a centre would be accessible to nurseries through on site demonstration of equipment and production systems as well as through newsletters and Internet pages. Demonstrations of equipment and systems would also be carried out in all other states.

2. Would your nursery make use of such a resource?

The project also established that there is very limited information available for Australian nursery operators on the selection of equipment and the organisation of production systems

3. What are your present sources of information on equipment and production efficiency issues?

Past surveys have shown that the most popular method of accessing information is through field days. However, nurseries chosen for field days do not always represent the most efficient production systems. Participants at field days can draw incorrect conclusions about the appropriate selection and operation of production equipment and systems.

4. In order to present information, demonstration and training in an optimal setting, in the most objective way and still be accessible to nurseries around Australia, production information would need to be made available in a variety of forms. List in order of preference the forms of information your nursery would make use of.

- E-mail
- Videos
- Written information (eg. posted newsletters, leaflets)
- Web based information and presentations (video streaming, chat rooms, web pages, etc)
- Personal participation activities in locations specifically chosen for their appropriateness (seminars, equipment demonstrations, training events)

POTTED PLANT HANDLING DEVICE

1. How are potted plants currently loaded to trailers at your nursery during the potting process?

2. Describe how plants currently unloaded into the growing area at your nursery?

3. What percentage of potted plants are spaced in the growing area immediately after potting? and what percentage goes down pot to pot?

4. During potting production how many people are involved in the loading and unloading of potted plants?

5. What type of surface do you have in your growing area (eg, gravel, weed mat, concrete)

6. There are 3 versions of the device under research:

Version 1 loads potted plants to a trailer (unloading is manual)
Version 2 loads potted plants and unloads them to the ground pot to pot
Version 3 loads potted plants and unloads them to the ground spaced apart

Which version would most suit production at your nursery?

7. Would your nursery be interested in participating in trials of the prototype device? (trials would be carried out during your potting production)

Appendix 5. Potted plant handling systems

Characteristics of the specialised trailer

- a special moveable deck that can be tilted at an angle to the ground
- a locking device to maintain the deck in the tilted position
- ability to move the deck from one end of the trailer main frame to the other end to facilitate the tilting operation. The geometry is such that, for the unloading operation, the rear edge of the deck can be positioned so that it almost touches the ground
- the deck itself is constructed using narrow bars or slats or wire mesh such that the material used reduces friction to a minimum. The bars or slats are spaced apart to allow any surplus potting media to fall through so that the deck is kept clean
- parallel guide bars/rails are arranged above the deck so that the potted plants can be loaded on the deck surface in straight rows
- the angle of the deck when tilted is such as to cause each individual pot to slide freely to the low end of the deck.

Characteristics of the potted plant loading device:

- a standard belt conveyor typically driven by an electric motor/gearbox with support legs arranged at each end spaced apart to allow the specialised trailer to pass under the return side of the belt and between the support legs
- a carriage with a pot deflector bar attached is fitted to the frame of the belt conveyor. The carriage is made to index along the conveyor at intervals corresponding to the distance between adjacent sets of guide bars on the specialised trailer. The function of the deflector bar attached to the indexing carriage is to deflect the individual pots sideways off the conveyor belt and onto the deck of the specialised trailer. The angle that the deflector bar is set at with respect to the direction of travel of the conveyor belt is adjustable so that the optimum position can be selected to ensure a smooth transition of the potted plant from the belt conveyor to the deck of the specialised trailer
- a fixed bar is attached along one side of the belt conveyor frame such that when the deck of the specialised trailer is tilted and its top edge allowed to rest on this bar, a smooth transfer of the potted plant from the belt conveyor onto the deck surface occurs. This smooth transfer is also assisted by arranging the deflector bar on the carriage to be at the correct angle relative to the direction of travel of the belt as explained above.

The following figures show some potential applications of the potted plant handling device.

Figure 1
This system consists of a potting machine that transfers potted plants onto the potted plant loading device. The deflector bar directs the pots onto the deck of the specialised nursery trailer with the deck in the tilted position as shown. When one full row of pots is loaded onto the deck, the carriage and deflector bar indexes along the belt conveyor automatically. The carriage comes to rest in the correct position and the next row of pots is loaded. This procedure is repeated until the deck is fully loaded. At this stage the deck of pots is lowered into the horizontal position and the loaded trailer towed forward by means of a small tractor. Any number of specialised trailers (up to say four for example) can be attached as shown and as one trailer is fully loaded and is moved forward the next empty trailer is positioned for loading. When all the trailers are loaded they are towed to the growing area where the pots are placed either onto benches or onto the ground.

For details of unloading onto the ground refer to Figure 3 (Version 2 of the specialised trailer) for unspaced pots and to Figure 4 (Version 3 of the specialised trailer) for spaced pots.

Figure 1

Loading of specialized nursery trailer (version 1 or 2 or 3) using potted plant loading device .

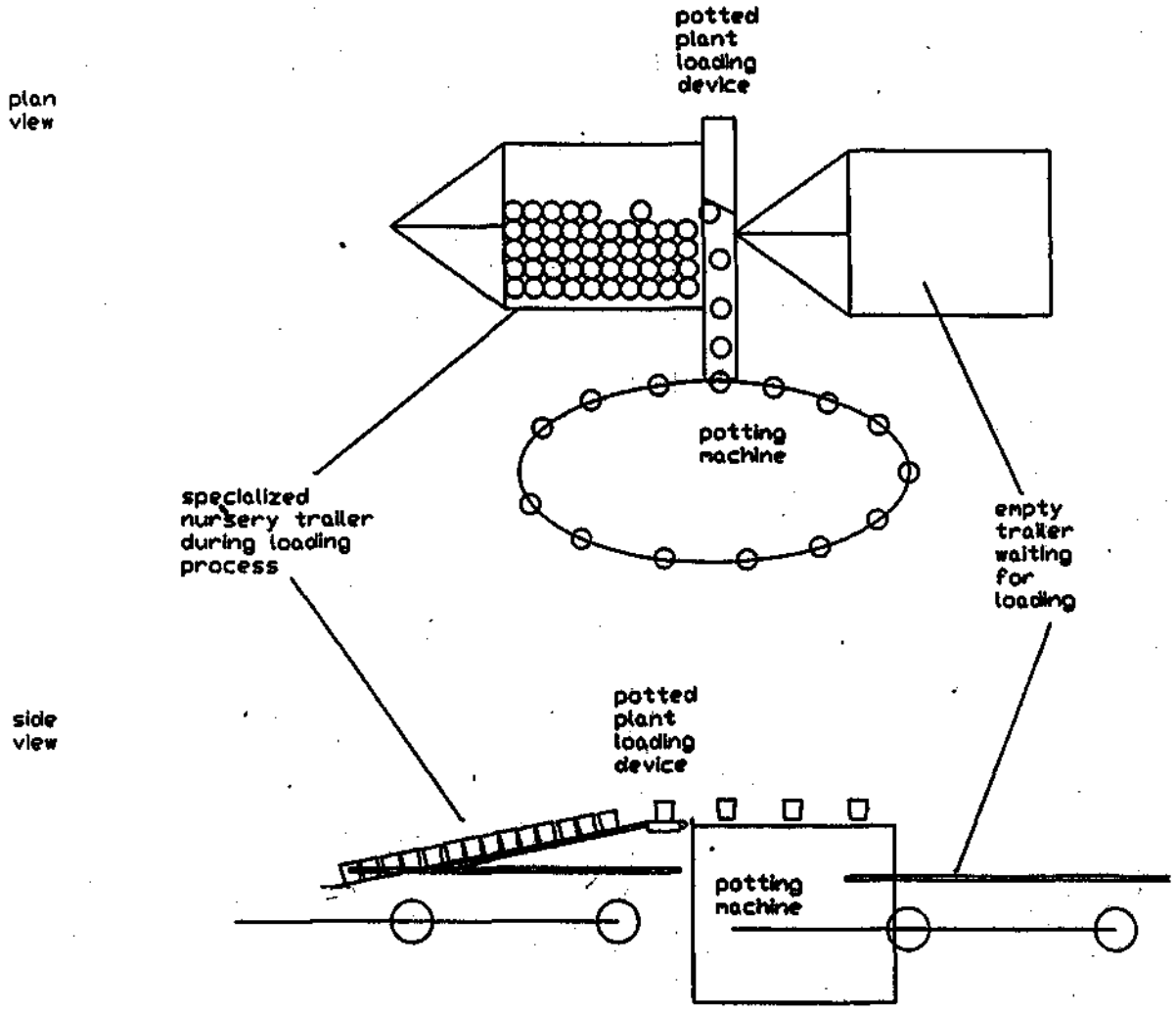


Figure 2
This system consists of a hand potting bench. The specialised trailer is positioned as shown with the deck in the tilted position. One worker is positioned on each side of the trailer as shown and as the potting operation is completed each pot is placed on the tilted deck of the trailer between the guide rails. It is preferable to work from the centre of the trailer and move progressively towards the sides in rows when placing the pots.
When a trailer is fully loaded it is towed forward by means of a small tractor and the following attached trailer is moved into position for loading. The construction of the hand potting bench is such that it allows passage of the specialised trailers underneath the top of the bench. When all the attached trailers are loaded they are towed to the growing area where they are unloaded.

For details of unloading onto the ground refer to Figure 3 (Version 2 of the specialised trailer) for unspaced pots and Figure 4 (Version 3 of the specialised trailer) for spaced pots.

Figure 2

Loading of specialized nursery trailer (version 1 or 2 or 3) during hand potting operation

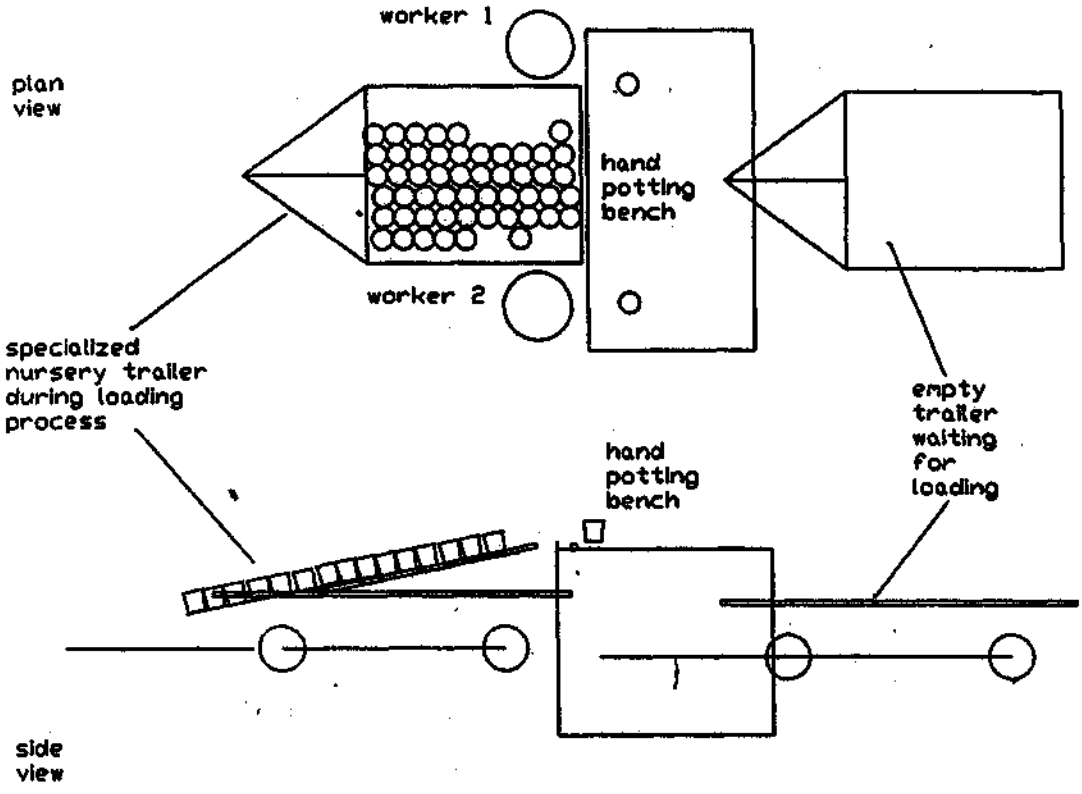


Figure 3
Each individual loaded trailer is reversed into position in the growing area and the deck tilted downwards as shown. The tractor is then driven forward and the potted plants unloaded in a semi-automatic fashion such that they are deposited on the ground unspaced as shown.

Figure 3

Unloading potted plants in growing area using specialized trailer version 2

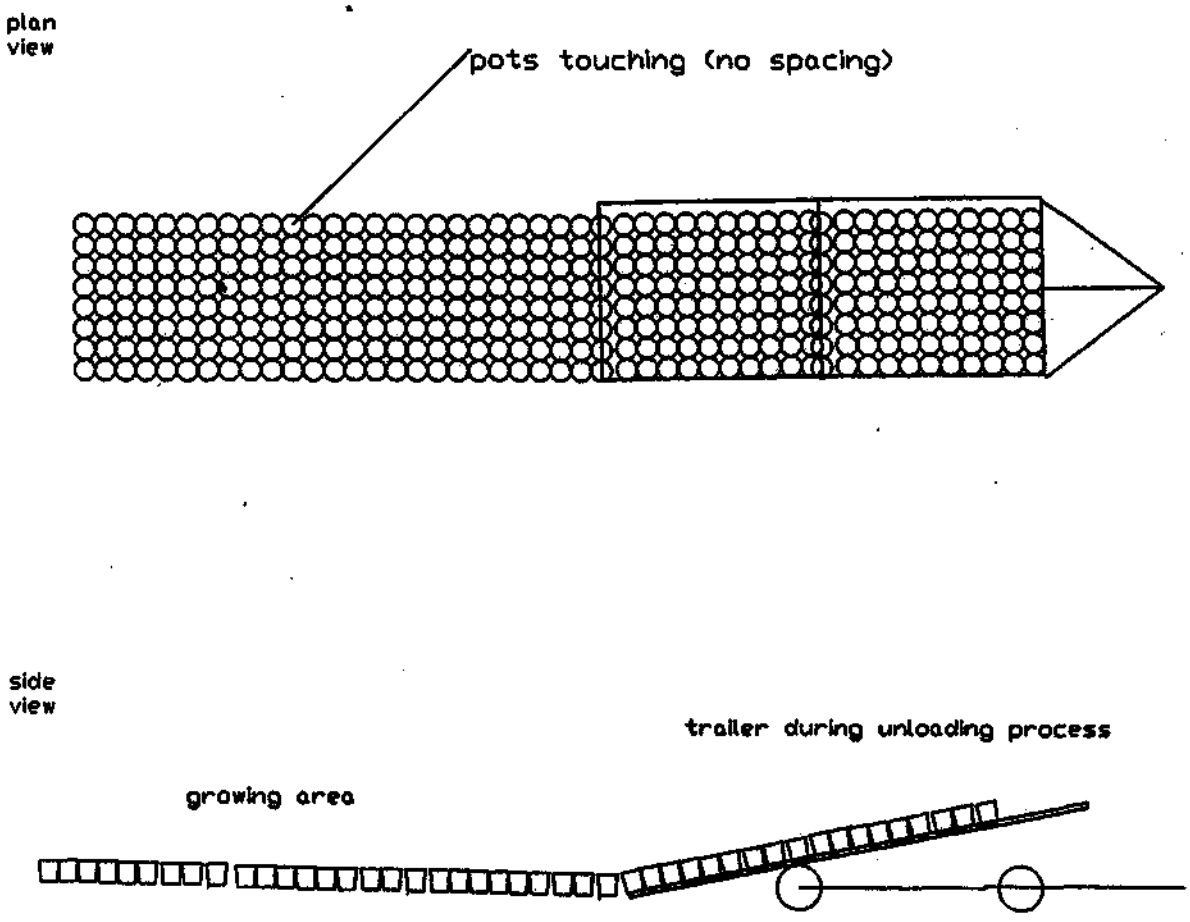


Figure 4
As for Figure 3 except that the potted plants are deposited on the ground spaced as shown. Pots can also be placed so that each alternate short row can be displaced (offset) sideways to form a staggered pattern if required

Figure 4

Unloading potted plants and spacing in growing area using specialized trailer version 3. Any combination of spacing can be achieved. Any spacing and pot centre offset can be achieved.

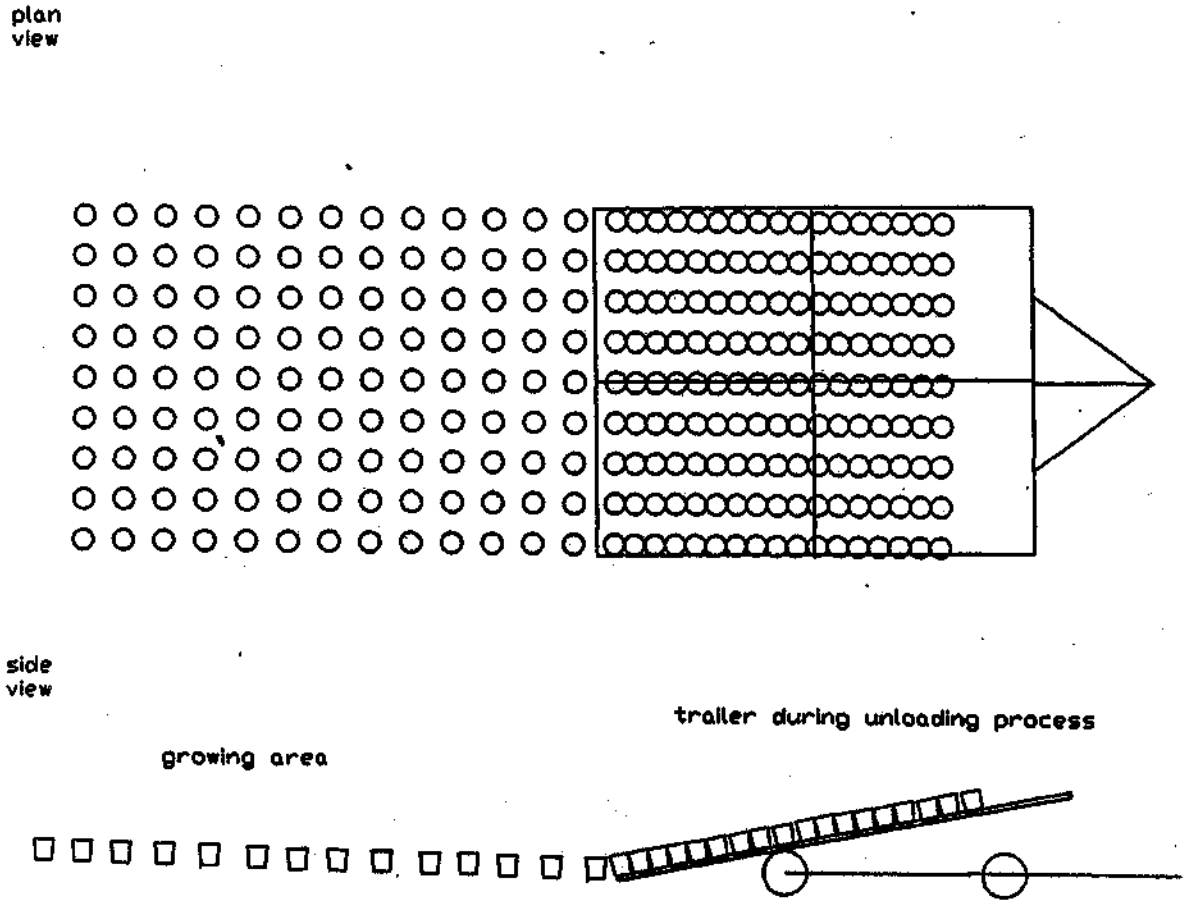


Figure 5
A mobile potting machine is positioned adjacent to the growing area as shown. In this application a belt conveyor extends from the potting machine to almost the full length of the growing area bays as shown. A special potted plant **unloading** device is arranged at 90^0 to the belt conveyor as shown.

This device is similar to the potted plant loading device described previously with the addition of a narrow, light-weight, sloping deck section attached to the indexing carriage and deflector bar assembly. Individual potted plants travel along the belt conveyor from the potting machine and are deflected sideways onto the conveyor section of the unloading device and then deflected onto the narrow sloping deck section. The pot is deposited onto the ground and the combined deck section, indexing carriage and deflector bar assembly moves the appropriate distance along the short belt conveyor so that the next pot is placed on the ground in the correct position.
When one complete short row is filled the unloading device assembly indexes along towards the potting machine so that the next row of plants is placed on the ground in the correct position. This system is capable of placing the pots unspaced, spaced or staggered.

Figure 5

Mobile potting system using potted plant loading device in combination with potted plant unloading device in growing area (spacing at any combination or pot to pot unloading possible)

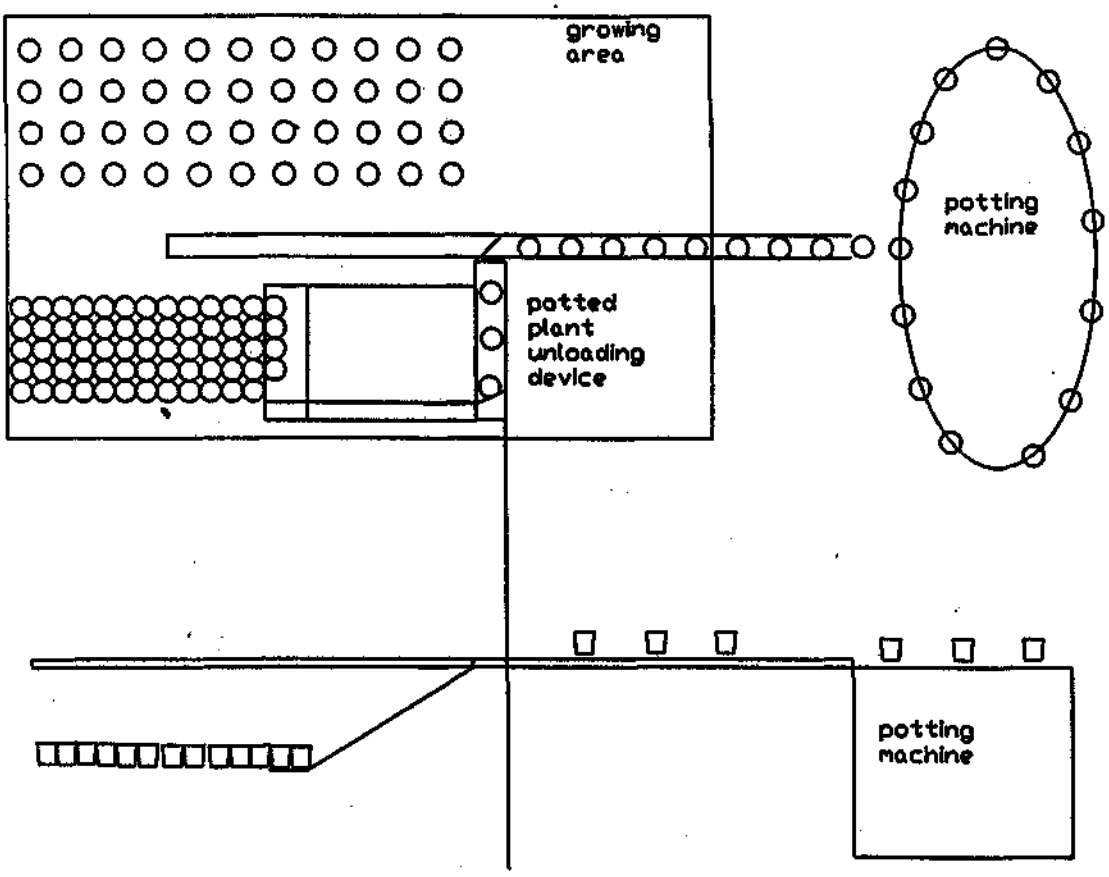
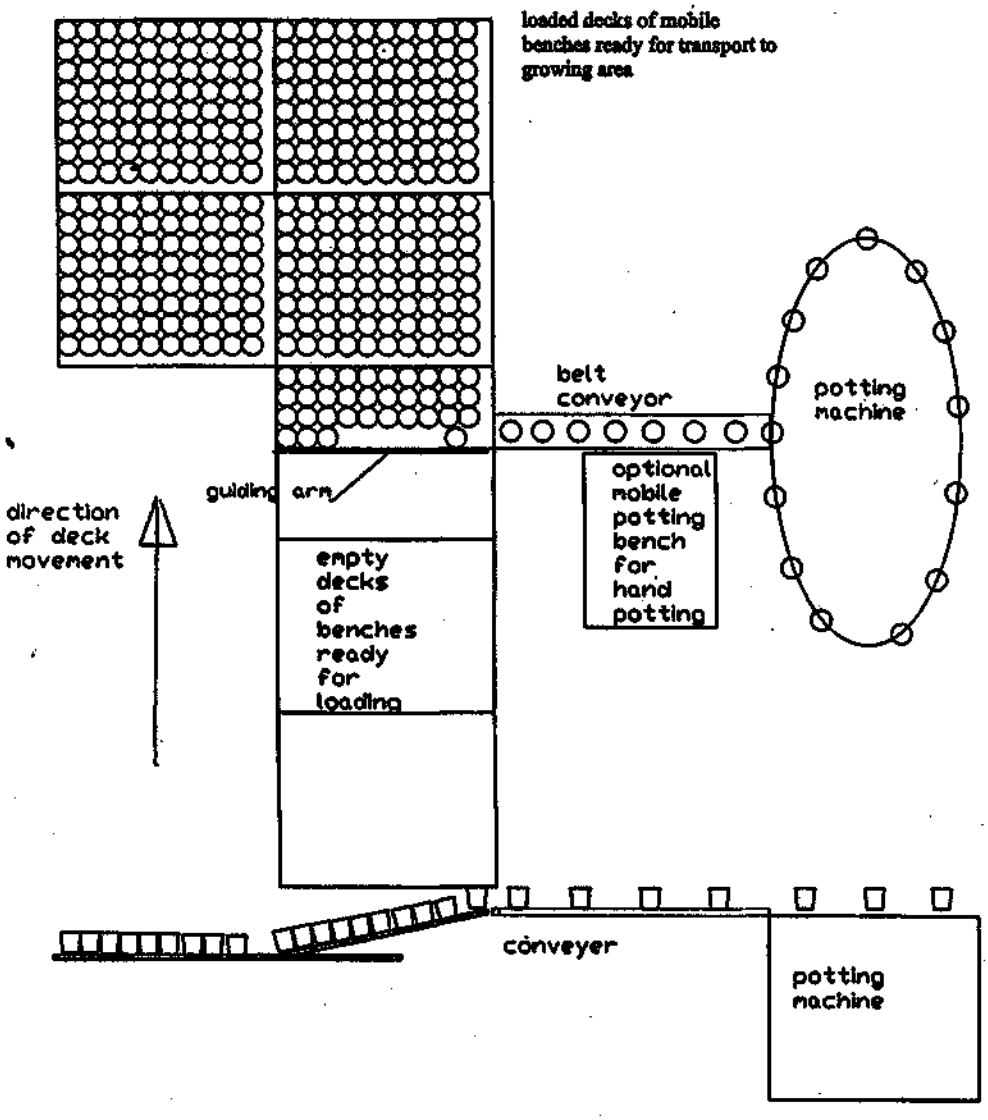


Figure 6
Alternative potted plant handling device. This method applies to a mobile bench system.

Empty decks of a mobile bench system are positioned as shown on parallel guide rails such that the surface of the decks slope at an angle sufficiently great to allow potted plants to slide down the slope for loading purposes. Potted plants from the potting machine (or optional mobile potting bench) are directed onto the belt conveyor as shown. On reaching the end of the belt conveyor the pots proceed to slide down the sloping deck. The pots are guided in a straight line by a guide bar on one side as shown and on the other side by the existing previous row of pots. (Initially the surround of the deck acts as a guide.) When one complete row is loaded the deck is indexed along to enable the next row of pots to be loaded. When each deck is fully loaded it is moved into the growing area. This can be achieved using a mono-rail system or similar.

Figure 6

Loading decks of growing benches using alternative potted plant handling device.



Appendix 6. List of Attachments

Attachment 1
Optimum Work Methods in the Nursery Potting Process - Stage 1. Useful ideas for reducing potting labour costs in your nursery. July 1999

Attachment 2
Optimum Work Methods in the Nursery Potting Process. Report from project tour to Belgium, Denmark, Germany, Netherlands and Poland. August 2000

Attachment 3
Optimum Work Methods in the Nursery Potting Process. Training material. April 2001

ATTACHMENT 1

Optimum Work Methods in the Nursery Potting Process

Stage 1
Useful ideas for reducing
Potting Labour Costs
in your nursery

W. Radajewski, D. Brown, K. Bodman, T. Franklin
Queensland Horticulture Institute – Centre for Amenity and Environmental Horticulture

July 1999

HORTICULTURAL RESEARCH & DEVELOPMENT CORPORATION
The Research Arm of the Australian Horticultural Industries

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

Nursery Industry Association of Australia

TABLE OF CONTENTS

FOREWORD

This booklet is not a final report on the project. It is an interim publication providing information about the aims and scope of the project Optimum Work Methods in the Nursery Potting Process and discusses general issues relating to potting productivity. The appendixes contain forms and instructions to help you evaluate potting production efficiency and potting labour costs at your nursery. To better understand project findings and how they relate to your nursery it is recommended that you read the main body of the booklet before using the forms to carry out any evaluations at your nursery.

The Centre for Amenity and Environmental Horticulture in Brisbane provides a consultancy service for nurseries interested in improving the efficiency of their plant dispatch and/or plant potting systems. For a free quote on the evaluation of an existing production system or the design of a new production system contact Dr. S. Underhill on telephone (07) 3286 1488 or facsimile (07) 32863094.

ACKNOWLEDGMENTS

This research project was sponsored by the Horticultural Research and Development Corporation and was made possible by pot levy funding and the involvement of NIAA and the cooperation of nurseries from QLD, NSW and VIC. The authors would also like to thank state nursery industry development officers John McDonald, Richard Stephens and Greg King as well as Jeremy Badgery-Parker from NSW Agriculture for their valuable assistance in selecting suitable nurseries for the project and helping collect research data and organise field days.

SUMMARY

The project Optimum Work Methods in the Nursery Potting Process is being undertaken in collaboration with 35 nurseries: Queensland (11), New South Wales (14) and Victoria (10). Potting production is being studied at small, medium and large nurseries in pot sizes ranging chiefly from 100mm to 200mm.

Both hand potting and machine aided potting are being investigated in the 40 potting systems commercially operating in the collaborating nurseries. Nine distinct potting systems are being studied in the project: standard bench, modified bench, mobile bench, Javo, Comet, Mayer, Bag filler, rotary table and the prototype of the WHTI potting machine.

The labour cost of overall potting production was divided into three potting stages: preparation, potting, and after potting. The labour cost of potting was investigated on the basis of nine potting processes: handling planting stock, pot handling, fertiliser handling, media handling, handling pot with media, handling the potted plant, handling other associated materials, maintaining the potting area and preparing the growing area.

Research has revealed that for all potting systems investigated the average labour cost of preparation for potting is 1.86 cents per pot, the average cost of potting is 8.50 cents per pot, the average cost after potting is 2.48 cents per pot and the average cost of total potting (combined times of preparation for potting, potting and after potting) is 12.85 cents per pot. This average was produced from all of the data collected from nurseries involved in the project and as such represents potting production carried out using various pot sizes, various plant species and various potting systems.

The lowest amount recorded for total potting of 3.1 cents per pot represents potting easy to pot plants into small sized pots and the highest amount for total potting of 35.43 cents represents potting difficult to pot plants into large sized pots. Even with a proviso about the potting difficulty factor of plants and its affect on potting labour cost figures at individual nurseries, the range of total potting costs (from 3.1 cents per pot to 35.43 cents per pot) does indicate that a very significant opportunity exists for many nurseries to reduce their current potting labour costs.

The initial parts of the investigation concluded that:

- a great difference exists in potting efficiency between nurseries mostly due to inefficient organisation of potting procedures often combined with the use of an inappropriate potting system and equipment;
- major potting labour costs lie in the areas of handling planting stock and handling the potted plant;
- overall potting production performance can be easily improved by combining plants for potting that have the same requirements and potting difficulties;
- many nurseries could instantly reduce their potting labour costs by reviewing handling methods and ensuring that all actions carried out on potting inputs and outputs were performed on quantities that represented a significant period of potting production.

From the investigation and analysis of potting data results from the 35 participating nurseries the following general recommendations for improving potting production efficiency can be made:

Worker issues

- Maintain high levels of worker health and safety, worker comfort, worker motivation and worker skill
- Ensure all staff are competent to (a) operate the potting machine and (b) make any adjustments to the machine necessary to cope with situations that may arise during production
- Follow safety guidelines when potting - always wear gloves and face masks when handling or working around potting media (Steele 1996) and always follow safe handling guidelines for herbicides used during the potting process
- Allocate tasks to staff taking into consideration their ability in performing different potting tasks

Organisation and potting procedures

- Hand potting should be used when the average daily quantities of plants to be potted (during the potting season) is approximately 1000 plants or less and/or when the nursery is potting a larger number of different species requiring different treatments in various pot sizes, pot colours, and the average batch size of these plants requiring different treatments is approx. 300 or below
- Improvements to the handling of potted plants should be investigated as a first priority as this are offers the greatest potential savings
- Ensure workers have all the information necessary to carry out potting production before production commences
- Analyse the allocation of tasks within the potting process to improve the distribution of productive tasks between workers and thereby reduce non-productive time
- Analyse the sequence and coordination of the delivery of inputs and the removal of outputs to reduce non-productive time

Improvements to the potting system

- Establish existing cost of potting
- Identify problems related to potting systems, procedures and worker issues
- Establish cost/benefits of potential improvements
- Introduce most beneficial changes
- Re-evaluate potting system.

General recommendation is to increase the average daily number of plants to be potted that have similar requirements with regard to treatments, potting procedures, pot sizes, pot colours. This strategy will immediately lower potting labour costs without any expenditure.

1. Introduction

The investigation of potting labour costs is being carried out by a team of researchers from the Queensland Department of Primary Industries in collaboration with the Queensland, New South Wales and Victorian Nursery Industry Associations, their Industry Development Officer and with NSW agriculture. All of the investigative work has been carried out on representative nurseries in these states.

'*Optimum Work Methods in the Nursery Potting Process*' is an HRDC sponsored project. The aim of the project is to identify and recommend methods for improving nursery labour efficiencies in the area of potting up. In order to achieve the project aim the following objectives were defined and addressed:

- Identify labour costs involved in different tasks in the potting process
- Identify current areas and reasons for inefficiency in these areas
- Identify and develop industry best practices for potting operations
- Technology transfer into industry during and at the completion of the project by means of written materials, consultative workshops, field days and most importantly, developing an information package and tools for a subsequent industry run, national training course.

The project will progress through the following stages:
(i) development of data collection methods,
(ii) collection of data,
(iii) evaluation of data
(iv) development and introduction (including testing and evaluation) of optimum potting methods. At the time of preparing this booklet the first three project stages have been completed.

The general terms of reference of the project are to investigate potting labour costs in small (1-5 staff), medium (5-10 staff) and large (15+ staff) wholesale nurseries chiefly producing pots in the range from 100mm to 200mm. The break up of nurseries collaborating with the project is shown in Table 1.

Table 1: The break up of project nurseries based on state and nursery size

	Number of nurseries per state			
	Small	Medium	Large	**Total**
QLD	5	4	2	**11**
NSW	6	5	3	**14**
VIC	3	4	3	**10**
Total	**14**	**13**	**8**	**35**

2. Data collection

2.1 Methodology

The following methods of data collection have been used in the investigation of potting labour costs:

- *Generic data:*
  The collection of information on nursery production profiles, container size preferences, plant type, staff, machinery and current systems used for the potting process. This information has been used to categorise the various types and sizes of operations and to define how they can be compared on a common basis.

- *Detailed data collection (video recording):*
  Video records have allowed project staff to evaluate overall work practices in different nurseries. The information gained has been used firstly to benchmark all tasks involved in the potting process for each different nursery environment and, secondly, to define the labour cost of specific tasks.

- *Potting events data logging*
  An electronic data logger has been used for collecting data for the whole range of potting events. This device is designed so that recording of events takes a minimum of time and further data processing is greatly simplified.

- *Statistical data (collected by nursery operators).*
  Nursery potting records have been requested from collaborating nurseries. This information has helped to established long term performance capabilities, including the extent and reasons for unproductive and down time. This form of data is useful for comparing different production environments.

- *Observation of potting events*
  Potting events have been observed by project staff in order to define existing work practices. Based on these observations and further discussion with nursery operators, potting production flow charts have been created and analysed.

2.2 Potting tasks for data collection purposes

The number and sequence of tasks performed during potting production is different in different nurseries and largely depends on the potting system used and type of plants produced. The following potting production information was recorded:

- Time required to complete any task related to potting
- Number of pots processed during this time
- Type and size of input and output container used
- Number of staff involved in task
- Plant potting difficulty
- Name of plant
- Method and potting system used

- Distances between different potting areas
- Capacity of pot handling equipment

For the purposes of data collection two criteria were used to categorise tasks in the potting process:

- which stage (area) of potting tasks occurred in, and
- which particular potting process tasks occurred in

2.2.1 Stage of potting

The tasks performed during overall potting can be related to the three major stages of production:

- preparation for potting
- potting
- after potting

Table 2 shows how potting tasks were categorised for the purpose of data collection and for the purpose of establishing where labour costs lay.

Table 2. Tasks as they relate to the main potting stages.

Preparation for potting	Potting	After potting
Plant to general potting area	Eject plants	Remove old pots
Unload stock	Pop plants	Fertiliser to pot in field
Prune	Plant to immediate area	Dispose of reject plants
Grade	Plant to bench	Potted plants transport to growing area and return
Remove old stakes & ties	Plant to pot	Take potted plants to field
Pots to general potting area	Pot to immediate potting area	Carry tray into growing area & return
Open container of pots	Pot to pot dispenser	Take pot from tray & space
	Pot to bench	
Fertiliser to general potting area	Fertiliser to immediate potting area	Carry pot or tray into growing area unload pots & space
Mix fertiliser & media	Fertiliser to bench	Return to potting area
Media into hopper	Shift media on bench	Apply herbicide to potted plants
Trays to general potting area	Free soil in hopper	Take pots to water & water in
Deliver stakes etc.	Put media to pot	Staking
Deliver trailer	Load media filled pot to trailer	Stake & tie
Maintaining potting area	Trailer with media filled pots to planting area	Prune / trim
Set up machines, conveyor	Unload media filled pots	Record work
Set up string line	Dibbling	empty tray to trailer
Preparing growing area	Fertiliser to pot at bench	Collect & return empty tubes, trays
Block up plants	Plant to pot	Equipment to storage
	Top up pot with media	
	Compress media in pot	
	Potted plant to tray, trailer, etc.	
	Move full trays on conveyer	
	Load full trays to trailer, conveyer, etc.	
	Move full trays on trailer	
	Move empty trays on trailer	
	Empty tray to immediate potting area	
	Empty tray to bench	
	Move trailer while loading pots	

2.2.2 Process of potting

The labour tasks (costs) of potting were also divided into 9 separate processes:

- Plant stock handling – (Plant stock handling refers to any action carried out on plant stock during the potting process from the time it is picked up from the hardening off area until the plant is placed into the pot with media)
- Pot handling (any actions related to handling empty pots prior to filling the pot with media)
- Fertiliser handling (any actions related to handling fertiliser during the overall potting event)
- Media handling –(all actions carried out on potting media from the time media is loaded to the hopper, etc. to the time media is placed into the pot)
- Handling pot with media (any actions carried out with pot and media before stock is inserted)
- Handling potted plant –(any action carried out on the potted plant immediately after the stock plant has been placed in the pot to the time the pot is placed in the growing area)
- Handling other materials (any action associated with trays, trolleys, trailers, stakes, labels, etc. used in the potting event)
- Maintaining potting area (any cleaning action or setting up machinery used for potting)
- Preparing growing area (any action carried out to prepare growing area for newly potted plants)

A brief description of tasks and how they are categorised under the nine potting processes is shown in Table 3.

Table 3. Potting processes and the tasks which occur in them

Potting process	Definition of task
Plant stock handling	
Plant to general potting area	Deliver plant stock to the potting area
Unload stock	Unload plant stock from internal transport
Prune	Prune top or trim roots of plant stock
Grade	Grade plant stock suitability for potting
Remove stake	Remove the stake from plant stock containers
Eject plants	Dislodge stock from cell trays
Pop plants	Remove stock from tubes
Plant to immediate potting area	Deliver plant stock to a position near the potting bench
Plant to bench	Deliver plant stock onto the potting bench
Plant to pot	Insert plant stock to the pot
Dispose of reject plants	Dispose of inferior plant stock
Pot handling	
Pot to general potting area	Deliver empty pots to the potting area
Open container of pots	Open the packaging pots are delivered in
Pot to immediate potting area	Deliver pots to a position near the potting bench
Pot to dispenser	Place pots into a potting machine's automatic pot dispenser
Pot to bench	Place pots onto the potting bench or into a machine without an automatic pot dispenser
Remove old pots	Dispose of pots plant stock grew in
Fertiliser handling	
Fertiliser to general potting area	Deliver fertiliser to the potting area
Mix fertiliser & media	Add fertiliser to potting media and mix using tractor bucket, concrete mixer, shovel, etc.
Fertiliser to immediate potting area	Deliver fertiliser to a position near the potting bench
Fertiliser to bench	Place fertiliser onto the potting bench
Fertiliser to pot at bench	Place fertiliser into the pot
Fertiliser to pot in field	Apply fertiliser to the surface of newly potted plants in the growing area
Media handling	
Media into hopper	Load potting media into a hopper or onto a potting bench
Shift media on bench	Use hand, shovel, rake, etc. to move media closer to the potter on a potting bench
Free soil in hopper	Free the obstructed flow of media in a hopper by hitting the sides or digging into the media with a shovel, etc.

Potting process	Definition of task
Top up pot with media	After inserting the plant stock add potting media up to the rim of the pot
Compress media in pot	Applying pressure to the soil around the plant stock to fix it upright
Handling pot with media	
Put media to pot	Filling an empty pot with potting media
Load media filled pot to trailer	Loading pots filled with potting media only (no stock planted) to a trailer
Trailer with media filled pots to planting area	Driving a trailer of media filled pots to an area where planting of stock will take place
Unload media filled pots	Unload pots filled with media to the ground or a bench for planting of stock to occur
Dibbling	Making a hole in the potting media for the insertion of plant stock or fertiliser
Handling potted plant	
Potted plant to tray, trailer, etc.	Loading a potted plant to internal transport
Move full trays on conveyor	Push trays of potted plants on conveyor to the trailer
Load full tray to trailer, conveyor, etc.	Place full tray of plants onto a conveyor
Move full trays on trailer	Pushing full trays of potted plants across the trailer during trailer loading
Take potted plant to field	Transport potted plants to the growing area
Carry tray into growing area & return	Carry a full tray of plants into the growing area, place the tray on the ground and return to the trailer without unloading the tray
Take pot from tray & space	Take pots from a tray and space them out in the growing area
Carry pot/tray into growing area unload pots & space	Carry loose pots or full trays into the growing area and space pots on the ground
Return to potting area	Drive empty trailer back to the potting area
Apply herbicide to potted plants	After potting apply pre-emergence herbicide to plants
Take pots to water and water in	After potting drive to the watering area and water plants
Staking	Fix stakes into media of potted plant
Stake & tie	Fix and tie stakes to potted plant
Prune/ trim	Prune potted plant
Record work	Make a record of the type and quantity of plants potted
Handling other materials	
Tray to general potting area	Deliver empty trays (to be used to hold potted plants) to the potting area
Deliver stakes, etc.	Deliver stakes to the potting area
Deliver trailer	Deliver trailer (or other means of transporting potted plants) to potting area

Potting process	Definition of task
Move empty trays on trailer	Arrange empty trays on trailer for the loading of individual pots
Empty tray to immediate potting area	Deliver empty trays to a position near the potting bench
Empty tray to bench	Move empty tray onto potting bench
Move trailer while loading pots	Move (push or drive) trailer during potting to reduce walking distance between potting bench and trailer
Empty tray to trailer	Place empty tray onto trailer
Collect and return empty tubes, trays	Gather empty trays or tubes from the potting area and return to storage
Maintaining potting area	
Clean potting area	At the end of potting event clean up media, plant refuse etc.
Set up machine, conveyor	Carry out any tasks needed to ready machine for operation. Attach conveyor to machine or move and assemble conveyor in the growing area.
Equipment to storage	Return to storage any equipment used during potting
Preparing growing area	
Set up string line	Use string, straight edge, etc. to define where potted plants will stand in growing area
Prepare growing area	Sweep leaves, rake gravel in the growing area
Block plants	Make room to place down newly potted plants by moving pots already standing in the growing area closer together

3. Potting production methods and systems

The number of different potting production methods and systems in use in the nursery industry is a reflection of the differences in the size of nurseries, differences in the types of plants produced, differences in the amount of capital available and other nursery influenced factors.

Potting production based on degree of mechanisation:

- Hand potting (all tasks performed without any mechanised equipment)
- Machine aided potting (eg. use of conveyor for loading pots & media, Comet for filling pots with media)
- Partially automated system (eg. automated loading of media to pot, fertiliser to pot, drilling in media filled pot)
- Fully automated system (all major tasks are mechanised)

Potting production based on production flow at the potting station:

- Batch potting (eg. potting is carried out by repeating the same task to a number of pots until all steps in the potting event are completed and the batch of pots is finished)
- Continuous potting (pots are produced singly from start to finish)

Potting production based on continuity of work at the potting station:

- Interrupted potting (each potting stage is carried out by the same workers and therefore work at the potting station stops, for example when workers take plants to the growing area)
- Non-interrupted potting (all potting stages are carried out at the same time by different workers)

Potting production based on potting system used:

- standard potting bench - A standard potting bench is any work station in an area specifically designated for potting at which potters can pot plants. A table with a quantity of media on it is a standard potting bench.
- modified potting bench - A modified potting bench is a standard potting bench, which has been modified by the addition of a hopper which feeds media to the bench, conveyors to bring stock to the bench and plants away from the bench, etc.
- mobile potting bench - A mobile bench is a standard or a modified potting bench on wheels. Potting commences when the mobile bench has been driven or towed to that part of the nursery where plants are to be put down. A mobile bench might be a trailer towed behind a tractor, the rear tray of a ute or truck, or a truck mounted hopper.
- Javo potting machine - The Javo potting machine is a Dutch product. Moving pots in one direction the machine fills empty pots with media and drills a hole in the media for the insertion of plant stock. There is the option for adding automatic pot dispensers, fertiliser dispensers, and conveyors for the unloading of pots from the machine.
- Comet potting machine - The Comet potting machine is produced by Andersen's Engineering in Maryborough QLD. It delivers a continuous flow of media from two chutes. Potters stand in front of these chutes and fill empty pots with media.
- Mayer potting machine - The Mayer potting machine is a German product. It works on the same principle as the Javo with similar available options for automating tasks.
- 'Other' potting systems investigated - Other potting systems include 2 rotary potting tables no longer being manufactured, the prototype of a new Australian designed potting machine from Williams Hi-Tech International and a bagging machine by C-Mac Industries.
- Other potting systems in use in Australian nurseries that were not made available to the project and for which no data is available.

In total, 40 potting set ups are being investigated in 35 nurseries (see Table 4).

Table 4. The break up of nurseries on the basis of state & potting system used

	Potting method							
	Standard bench	Modified bench	Mobile bench	Javo	Comet	Mayer	Other	**Total**
QLD	3	4	2	3	3	0	0	**15**
NSW	2	1	2	2	3	1	4	**15**
VIC	3	1	1	3	0	1	1	**10**
Total	**8**	**6**	**5**	**8**	**6**	**2**	**5**	**40**

4. Factors affecting potting production efficiency

The following section contains observations on potting production efficiency in the areas of:

- Work organisation
- Potting work environment
- Worker related issues
- Potted plant related factors

4.1 Work organisation

The manner in which nursery work is organised and managed has a profound affect on the efficiency of all areas of nursery production (Radajewski *et al* 1997).

Work organisation in potting production refers to:

- management of the potting system
- management of labour
- selection of equipment and methods of material handling
- communication

4.1.1 Management of the potting system

Managing the potting systems includes such things as the initial selection of the potting system used by the nursery, organising the layout of the potting area, deciding where watering in plants will take place, how plants are to be spaced in the growing area, how fertiliser is applied to plants, whether potting production will be carried out using non-interrupted potting (potting production continues while plants are being put down in the field), interrupted potting (potting production stops while plants are put down in the field) or a combination of both, etc.

The management of the potting system may not always be a carefully considered response to production factors. The type of potting system used by a nursery could be the result of chance events such as picking up a particular potting machine at a bargain price, or inheriting a potting system from a previous owner or era. Like the potting system used, the layout of the potting area can also be determined by random circumstances or habit. Potters may be walking relatively long distances to pick up small quantities of potting materials (such as empty pots, plant stock or fertiliser), and equally long walks to remove potting outputs (such as empty tubes and trays and potted plants) just because the location of inputs and destination of outputs has never been evaluated from the point of view of production efficiency.

Potting data processed to date shows that the figures for minimum potting labour costs in cents per pot are very similar across all potting systems. This indicates that all potting systems can be equally efficient if they are properly managed, ie. suitable for the type of plant production at the nursery and with the potting area laid out to allow for the efficient delivery of inputs and outputs. High maximum figures on the other hand represent inefficient potting production and show us that many nurseries are using potting systems which are unsuitable for their type of production and/or that they have poorly designed potting areas.

4.1.2 Management of labour

Management of labour includes the allocation of tasks to potting staff, preparing task rotation schedules, establishing production quotas, training staff, etc. The most profitable situation for a nursery is to use the minimum number of staff to reach production targets. However, it was observed during the project that medium and large-sized nurseries generally tend to over-staff their potting operations. It was also observed in many nurseries that certain potting staff are not consistently and productively employed. For example, if a person's task is to drive plants to the field, put them down and return to the potting area for the next load, that person will not carry out any productive work (they may carry out some cosmetic duties) if the next trailer has not been completed by the potters.

The problem of staff waiting around to begin their primary tasks stems from a lack of synchronisation between the completion of one task (eg. the potters' task to pot up a trailer load of plants) and the beginning of another (eg. the driver's task to take the trailer load to the field, put plants down and return to the potting area). The reluctance of the waiting staff to help out with tasks which they consider to be outside their job

description contributes to the problem. The solution to the problem is to review the overall potting system and locate where synchronisation of tasks can be improved by either allocating real and productive tasks to waiting staff and/or by improving the production efficiency within the various stages of the potting process to decrease the waiting time gap between dependent tasks.

On the other hand, if, in the example given above, the driver's time for putting down plants in the growing area was longer than the time it took potters to pot up a trailer load then even more non-productive time would result through an increased number of people (ie. all the potters) waiting on the empty trailer to return.

Obviously it is difficult to get the synchronisation of dependent tasks just right as timing can be thrown out as potting or putting down time increases or decreases due to potting different species of plants, using different pot sizes, putting plants down in different areas of the nursery, etc. To avoid the situation where lack of synchronisation creates non-productive time production buffers should be used.

Production buffers could take the form of extra trailers for potters to continue potting (instead of waiting for an empty trailer to return from the growing area), sending one of the potters into the growing area to help with plant unloading or changing from non-interrupted potting production to interrupted potting production - eg. 2 people pot a trailer load of plants and then both go to unload the plants before returning to the potting area and potting another trailer load of plants.

Some nurseries in the project used 'potting supervisors' to manage potting production. In some of these nurseries this person was a full-time hands on working member of the potting crew while at other nurseries the potting supervisor only visited the potting area periodically to check on production progress and deliver instructions to potting staff. The project did not study the input of supervisors who were not working full time in potting, however, there seems good potential in those nurseries where the supervisor's input was limited to have one or several of the full time potters assume the role of potting supervisor. For this to occur, all necessary information required for potting would need to be available for the potter/supervisor. If the information currently being communicated from potting management to potting supervisor to potting staff could be directly communicated from potting management to potting staff then the position of non-potting potting supervisor could be made redundant.

4.1.3 Material handling and equipment

Material handling and equipment refers to the method and the equipment used for moving the materials (inputs and outputs) used in potting. A great variety of methods for material handling were observed at the nurseries investigated. Empty pots were delivered to the potting bench by hand, trolley or trailer, media was brought to the bench by the shovel load or using a front end loader, potted plants were carried to the trailer by hand or placed in trays and loaded by conveyor, plant stock was brought considerable distances by hand one tray at a time or delivered in large quantities by automatic conveyor to the potting bench.

Many nurseries could instantly reduce their potting labour costs by reviewing handling methods used for potting inputs and outputs and taking steps to ensure that

whenever material was delivered to the potting area or removed from the potting area, it was done quickly and in quantities that represent a significant period of potting production. For this to occur the location of inputs and outputs would need to be reviewed, the quantities in which inputs and outputs were delivered would need to be reviewed and thorough production information would need to be available to potters to enable them to bring materials in significant quantities.

4.1.4 Communication of information

A lot of information needs to be processed before potting can begin:

- What stock is to be potted?
- How much of the stock is to be potted?
- Where is the stock located?
- What size, type and colour pots are to be used?
- How many people will be potting?
- Who will be doing which tasks?
- If equipment is necessary, is it available and serviceable.
- Availability of suitable growing medium.
- Which fertiliser will be used, is there sufficient, how will it be applied?
- Which planting stock should be rejected?
- Where are the potted plants going?
- Do they receive a herbicide application?
- Does the growing area need to be prepared?
- How much water should they get prior to being put down?

When any information is unavailable to potting staff, production time can be wasted while they seek instruction from potting supervisors or nursery management. When potting staff have all the information necessary for potting then work can begin promptly and continue without interruption. In smaller nurseries where managers often participate in the potting process decisions on potting production can be communicated instantly to potting staff. In medium and large nurseries, however, information needs to travel from nursery production manager to potting supervisor, from potting supervisor to potting staff and from potting staff to potting staff.

To reduce the potential for communication failure disrupting potting production nursery management should set up a reporting system to monitor available quantities of potting materials (media, pots, stock, etc.), ensure potting materials are ordered ahead of time and available in the potting area and ensure that necessary information has been communicated to all relevant potting staff before potting production starts. When this is done potters can become largely self managing and production stops due to lack of information will be eliminated.

4.2 Potting work environment

The potting work environment refers to

- Organisation of the work station
- Potting techniques
- Operating knowledge
- Break downs and malfunctions
- Automation of tasks
- Speed of operation

Organisation of work station

The work station includes the actual potting work bench and the surrounding area. As the work station is the focus for the movement of inputs and outputs it is essential that room for the storage of these materials during potting exists and that access to them during potting is not impeded. A poorly organised work station will have a distinct affect on the production efficiency of machine potting systems. As potters are working to the speed of the machine they have a very small window of opportunity to select inputs and remove outputs without falling behind the machine's production speed. A nursery will not compensate for a poorly organised work station by reducing the operating speed of the machine or lowering the expectation of production rates for hand potting staff. The only solution is to improve the organisation of the work station to enable more efficient potting production.

An unavoidable fact of working on a standard, modified, or mobile potting bench is that the presence of potting media makes it hard to find flat space to stand pots, place plant stock, fertiliser etc. Operating a potting machine also involves using a work bench area for the storage of plant stock etc. and, as with hand potting, the manner in which the potting machine work bench is organised can affect potting production efficiency.

If a potting work bench is poorly organised potters can spend considerable time carrying out many small actions moving potting materials (stock, pots, fertiliser, empty tubes, trays, etc.) about on the bench as they seek access to potting media or operate the potting machine. Work space can be optimised by keeping materials for potting off the potting bench but close to potters (eg. stands or conveyors in for plant stock, bins for disposal of tubes, utilising unused space under potting bench to store other potting inputs and outputs).

4.2.2 Potting techniques

Potting can be undertaken in a variety of ways. For example, in hand potting:

- a large quantity of pots can be filled with media, loaded to a trailer or bench and then have plant stock inserted to each pot (batch production)

- a small quantity of pots can be filled with media at the work bench and stock inserted to each pot (batch production)
- or an individual pot can be filled with media at the bench and stock inserted into the pot (continuous production).

Significant differences were detected between the productivity of potters (hand potters and those operating potting machines) working in the same nursery. This variation can be put down to the better work station organisation, motivation and potting technique of the more productive potters. Over time potters often develop their own particular potting technique and method of organising the work station. However, these techniques and methods might not always be the most efficient options available. Nurseries should review the productivity of individual potters and where possible use more productive potters to train others in technique and work station organisation.

4.2.3 Worker skill

Worker skill in operating potting machines was generally observed to be good in the straight forward operation of the machines. A lack of skill was observed, however, when accurate adjustments needed to be made to the machines (eg. conveyors, pot dispensers) to cater for changes in operating circumstances such as occur when changing pot sizes or moving the machine to another location in the nursery.

The importance of staff skill levels is not limited to the operation of potting machines. Staff need high skill levels in all areas they are likely to encounter in their work. When potting staff do not know how to carry out a certain task then production is halted while they seek out assistance or even worse, plant quality is affected if they should attempt the task without advice. Potting staff should all know the potting requirements of different species (eg. water, herbicide, fertiliser, pruning, media, pot size, pot colour), how to identify suitable and different plant stock, how to grade plant stock, where potted plants are to be placed in the growing area, etc.

4.2.4 Break downs and malfunctions

Despite the age of many potting machines observed no potting machines broke down while researchers were recording potting data. This is probably more of a testimony to the solid construction of the machines rather than the result of regular maintenance. Machine malfunctions, on the other hand, were quite frequently observed. Common potting machine malfunctions included:

- empty pots jamming in the pot dispenser
- Empty pots jamming in potting machine
- Empty pots jamming in the media outlet
- Potted plants falling over as they are swept onto the conveyor
- Media filled pots jamming in the machine
- Potting media bridging in the external hopper
- Potting media sticking to the sides of the machine's internal hopper

Pot dispenser malfunctions were a common source of production stops for Mayer machines and those Javo machines with automatic pot dispensers. The causes of pot jamming included:

- using second hand pots or pots with non-standard profiles (these tend to jam together),
- staff difficulty in determining exactly why pots were jamming,
- difficulty knowing precisely how far to adjust elements of the dispenser to eliminate pot jamming.

In hand potting, equipment break down and malfunction was mainly limited to the very common problem of potting media bridging (ceasing to flow) in hoppers. In fact, this malfunction was a common occurrence in most potting systems using hoppers (ie. all except standard potting bench). When a hopper bridges, production time is affected as someone works to remove the bridging with a shovel, length of wood, rubber mallet, etc. The reasons for hopper bridging include, poorly designed hoppers, hoppers made of materials which restrict media flow, hoppers with pitted, rusted or painted interiors, and using media with a high moisture content.

The frequency with which malfunctions occur highlights how a lack of thorough operating knowledge (knowing how to both operate and adjust the machine, regulate the moisture content of media, etc.) can affect production efficiency.

4.2.5 Mechanisation and automation of tasks

Full automation in potting would involve pots being filled with media automatically, plant stock ejected and inserted to the pot automatically and potted plants taken from the machine and loaded to the trailer, conveyor, etc. automatically. Though such systems are common overseas, no such fully automated systems in Australian pot production nurseries have yet been encountered during the potting project.

In machine potting the tasks of inserting pots to the machine and inserting fertiliser to pots generally involve one person full time and the constant nature of these tasks makes it difficult for the pot inserter or fertiliser inserter to contribute to any other tasks. The initial cost of buying or building a pot dispenser or fertiliser dispenser would quickly be amortised by reducing the number of staff needed to operate the potting machine.

When hand potting, adding fertiliser to each pot adds several seconds per pot to the potting process. Nurseries that choose pre-mix or to buy potting media with fertiliser already mixed have an immediate advantage over nurseries that add during the potting process. Some nurseries expressed prior problems in using pre-mixed potting media and fertiliser while other nurseries were satisfied with the results obtained. Reluctant nurseries mentioned concerns such as premature fertiliser release in the media if potting was delayed and fertiliser not being in the optimum position in the pot to serve plant growth. Nurseries that added fertiliser by hand also differed in their opinion on the best place to insert fertiliser in the pot (ie. under the plant root ball in the pot, in the sub-surface of the soil, or on the surface of the growing medium).
Automatic fertiliser dispensers exist and these need investigation in improving accuracy and labour use in potting.

4.2.6 Optimum speed of operation

In some cases, when the potting staff is not being fully utilised, the efficiency of potting (ie. the labour cost per pot) can be greatly improved by reducing the speed at which the potting machine works. When machine speed is reduced the number of people required to operate the machine can also be reduced as staff can now manage extra tasks and the potting tasks can be spread over fewer people. The daily production of pots will obviously be slightly decreased but this will be offset by a reduction in labour costs.

In hand potting, the optimum operating (potting) speed is one that can be sustained for lengthy periods of production. Potting at a very fast rate only to fall away during the day due to tiredness will be less productive than maintaining a steady potting speed throughout the day. When establishing production quotas for hand potters and machine potters, nursery management should base its targets on sustainable operating speeds.

4.3 Worker related issues

Worker related issues refers to worker safety, worker comfort and worker motivation and worker skill levels. Poor safety standards can lower staff motivation, make tasks difficult to perform and increase the incidence of work place injury. Low worker comfort levels can hamper workers' ability to carry out tasks, contribute to injuries, and have a negative impact on worker motivation. Well motivated workers who understood how to carry out their tasks were a feature at all nurseries with low potting labour costs.

4.3.1 Worker safety

- *Safe handling of potting media*

Reports commissioned by the Nursery industry have concluded that the unprotected handling of potting media carries the potential for the transmission of infectious disease (Steele 1996). The advice from the Nursery Industry Association of Australia, however, is that all people working with or in the vicinity of potting media should wear gloves and specified face masks. Nurseries that do not ensure staff follow safety guidelines for handling potting media risk being judged negligent in fulfilling their duty of care to staff.

- *Safe herbicide application*

Many potters place granular pre-emergence herbicides onto plants after potting. Researchers noted that workers did not always wear the full complement of recommended safety protection. The application should ideally take place out of the immediate potting area where herbicide residue can come in contact with other workers. Instructions for the safe handling of products such as Rout and Ronstar are clearly displayed on product packaging, and in their Material Safety Data Sheets.

- *Safe operation of machinery*

The operation of potting machines involves staff coming into close, and sometimes direct, contact with moving machinery parts. Apart from normal operation of the machine, interaction between person and machine also occurs when adjustments are carried out on the machine, when maintenance is carried out, as machines are moved from one potting location to another and when staff attempt to fix malfunctions and breakdowns during potting. As many of the potting machines used in nurseries are quite old, commonly lack warning labels and operating instructions and can be prone to malfunctions, nursery management and staff need to be especially vigilant when using these machines.

From a safety point of view it is essential that any person using the potting machine (or any piece of mechanised equipment in the potting operation) be fully familiar with the operation of the machinery and also know the safety procedures to follow when attempting to fix malfunctions and make operating adjustments. Conspicuous warning signs should be placed on danger spots on machinery. Clearly written operating instructions displayed on potting machines can help keep staff conscious of safe operating procedures. Older potting machines may not carry any operating instructions or warnings. The nursery should clearly write the operating instructions and mark the danger areas on such machines to reduce the potential for injury.

- *Hearing protection*

Loss of hearing is one of the most common reasons for worker compensation claims in Australia and New Zealand with around 14,000 claims for noise induced hearing loss lodged each year. Loss of hearing is not only caused by sudden exposure to explosive levels of sound or by prolonged exposure to very high levels of sound. Hearing loss can be caused by prolonged exposure to sound levels of around 85 decibels. Working at a potting machine eight hours a day for a number of years could well have a detrimental affect on the hearing of potting staff if they do not wear ear protection. Very few potting staff wear ear protection despite working with or in close proximity to potting machines, tractors, front-end loaders, etc. Nursery management should be aware that prolonged exposure to relatively low level noise can result in hearing loss and investigate the noise levels produced in the potting area, seek feedback from potters on levels of discomfort and provide hearing protection where required.

- *Maintaining potting equipment in a safe state for use*

Equipment used in potting is subject to a lot of wear and tear and as the condition of things such as wire trays, potting machines, trailers, tractors, hoppers, etc., deteriorate they not only reduce the efficiency of production they also begin to pose a safety risk to potting staff. For example, when handling broken wire trays the sharp wire ends can catch at hands and clothing. If old vehicles used for internal transport have jagged body panels these can pose a risk to workers. Trailers with broken metal rails or broken wire mesh bases can cut staff loading and unloading pots.

Although the potential for injury exists in all workplaces, the likelihood of an injury occurring will increase significantly if equipment is allowed to fall into disrepair. Nurseries can limit the potential for such injuries occurring by staying alert to

possible sources of injury, regularly maintaining potting equipment and replacing any equipment that has become dangerous to use.

4.3.2 Worker comfort

Worker comfort is one of the most important, yet one of the most consistently neglected factors determining production efficiency (Corlett 1995). All work requires effort but there is nothing indulgent in creating an environment that allows the work to be carried out with a minimum of effort.

An uncomfortable work environment places unnecessary physical demands on potting staff that will limit their productivity. For example, a worker using inappropriate tools in a cramped work station with poor lighting, exposed to wind or rain will tire more rapidly, be more susceptible to work related injuries, be less motivated to perform and ultimately be less productive than a worker performing the same task in less stressful surroundings. Any improvements that a nursery makes to levels of worker comfort can be expected to have a positive influence on overall productivity.

A list of injuries indicative of low worker comfort levels is shown in Table 5.

- *Protecting staff from the elements*

There was a very high awareness among nurseries of the need to protect workers from the sun and most nurseries provided sunscreen and required workers to wear a hat when in the field. However, opportunities for increasing worker comfort through the provision of mobile shade/rain/wind structures were frequently available, especially in situations where potting took place in the open air or in open sided structures.

- *Moving media on benches*

Moving media on potting benches (standard, modified and mobile benches) was often carried out by workers using shovels while standing at ground level. Shovels are not designed for moving soil forward along a horizontal plane. Hoes or rakes are far more suitable tools for moving media in this situation.

- *Prolonged standing on hard surfaces*

Leg fatigue will be experienced after only one to two hours standing on a hard surface. Standing for long periods on hard surfaces places stress on the plantar muscle (sole), increases venous pressure in the legs, can lead to spurs growing on the heels and places stress on the lower back. All potting staff who are standing for significant periods of time should be provided with proper ergonomic matting to cushion their feet and legs (rubber door mats can be uneven and therefore unsuitable) and should be encouraged to wear cushioned sole inserts in their shoes (especially when work boots are worn). Many nurseries investigated provided rubber matting for potters standing for long periods on hard surfaces. However, a significant number were without such matting and the area of matting at other nurseries was too small, limiting the potters ability to move their position during potting.

Nurseries could also benefit by trialing the use of stools (special ergonomic 'sit stands' are available which take most of the weight of a stationary worker without them actually sitting down at the job) for workers who are engaged in prolonged standing tasks. Foot stands, which are placed in front of the worker and can be used to take the weight off one leg would be the next option if it was decided that ergonomic chairs were not suitable.

Table 5. Injuries and symptoms indicative of low worker comfort levels

Symptom	Potential solution
Leg and foot fatigue	• Improve work station design • Provide rubber matting over concrete floors • Ensure floors in work area are firm, level and dry • Provide ergonomic chairs for standing staff • Provide foot rests for standing staff • Use cushioned inserts in work boots
Hand strain/injuries	• Wear gloves when potting • Use rubber mallet, not the hand, to dislodge media from hopper sides • Use pot lifters to load and unload loose pots
Back fatigue	• Use adjustable benches • Use ramps to raise the working height at low trailers • Provide training in proper lifting techniques • Improve work station design • Use hand trolley to transport heavy inputs/outputs (eg. fertiliser bags)
Hearing loss	• Reduce machine noise • Provide ear plugs
Sunburn, heat stress	• Provide sun screen, hats, sunglasses, water • Provide sun shade for outside work stations
Repetitive stress injuries	• Increase task rotation • Review work procedures, work station design & the suitability of tools used

Symptom	Potential solution
Eye strain	• Increase natural light or install electrical lighting
Exposure to wind, rain, sun	• Provide cover from elements
Amounts of potting media dust detectable in the nose after potting	• Educate workers to the risk of inhaling and ingesting potting media • Supply masks & gloves to potters
Noticeable drop in worker productivity as day progresses due to tiredness	• Create a more stimulating and comfortable work environment Eg. feedback on progress meeting production targets, rewards for meeting or exceeding production quotas, increasing worker comfort through any of the methods given above

4.3.3 Worker motivation

When designing a potting production system, worker motivation is just as important a consideration as materials handling or organisation of the potting area. Motivated workers will help an efficient potting system perform to its potential and make a less than efficient system perform much better than it has a right to. On the other hand, unmotivated workers can counteract the benefits of an efficient system and make an inefficient system look very bad indeed. One motivated and skilled worker is a much more valuable asset than two average workers. The minimum award wage for nursery staff is one of the lowest for all industries. In terms of increased productivity it might pay to increase wages slightly as the first step in creating a better motivated workforce.

Money is the primary impulse for most of us to get up and go to work each day, but there are many other aspects that give workers the desire to work productively for an employer. A sense of belonging, achievement, importance and self respect are examples. The work place can be the source of practically any positive emotion which helps keep the worker interested and committed to performing their responsibilities in a diligent manner day in and day out.

Fully understanding a worker's motivation requires personal communication between the manager and the staff member. Not all nursery managers may have the time or inclination to discover the needs and wants of each staff member. Some nurseries have a high employee turn over which can make management wary of investing too much time to individual staff members. High employee turn over could also make management react against the concept of understanding and building the motivation of workers. Yet, high employee turn over can often be attributed to low levels of worker motivation. The motivation of workers is clearly an extremely important consideration for managers intent on developing an efficient production system. For managers interested in researching and improving worker motivation at their nurseries

various models for raising worker motivation can be found in the many management skills books now available.

Aspects of potting production that can affect worker motivation include levels of health and safety and worker comfort. Attending to these issues will enable workers to more easily carry out their tasks and will show workers that management is professional about its role and concerned for the well being of workers.

4.4 Potted plant related factors

There are a number of factors directly associated with potted plants that affect the performance of potting. These factors include:

- Plant type and state of root development
- Container used (propagation container and potting on container)
- Daily quantity of plants to be potted
- Placement of fertiliser
- Watering-in procedures
- Placing plants in the growing area (ie. spaced or unspaced)

In a well organised potting system such factors may have only a small affect on overall potting performance. However, in a poorly organised system these factors can compound other inefficiencies to create significant production problems.

4.4.1 Plant type

During the potting project it was observed that certain types of plants are more difficult to plant than others. Plant types were divided into those propagated in cell trays and those propagated in tubes. Potted colour varieties typify the types of plants propagated in cell trays while shrubs and trees typify the types of plants propagated in tubes. Very few nurseries bare-root plants into pots.

Generally plants propagated in tubes (50 - 100mm) took longer to pot than plants grown in cell trays (42-288 cells per tray). Cell trays hold large numbers of plants and plant stock is easily ejected from the tray and easily inserted to the media filled pot. Cell trays take little time to discard from the potting bench. Tubes, on the other hand, take longer to bring to the potting area, take longer to eject from the tube, take longer to insert to the media filled pot and take longer to discard.

The maturity of the plant stock was also a factor in potting labour costs. Over-mature stock slowed down the potting process by making it difficult to dislodge from the tube and cell tray and requiring the potter to sometimes trim roots or stems. Better coordination between propagation and potting would eliminate problems caused by over-mature stock, both in terms of potting times and in pre-potting preparation.

4.4.2 Containers used

The size and type of the propagation container, the size and type of the of the pot being used for potting-on and the ratio of the size of the propagation container to the

potting-on container can all influence the speed with which potting can be carried out. As discussed in the section on plant type, it was generally found that plant stock grown in cell trays is easier to pot than plant stock grown in tubes, and this can be used to opportunity in some situations where the same plants can be produced in either. The fact needs to be recognised always in planning the resources needed in individual potting operations however.

Filling large pots (eg. 175mm, 200mm, 250mm) with potting media takes longer than filling small pots (eg. 100mm, 140mm 150mm) with media. The pot filling process in potting machines with variable media flow will not be affected by the size of the pot as the media filling is automatic, however, the number of pots able to be produced in a given time will decrease as larger pots take up more room in the machine, and potting inputs (empty pots, fertiliser, media, etc.) will need to be replenished more frequently.

The ratio of the size of the propagation container to the potting-on container affects potting time in the following way. When potting from a 50mm or 70mm tube to pots of size 140mm and up the tube stock fits into the pot while still allowing plenty of space around the plant for potting media to be easily inserted. However, when inserting 70mm plant stock into a 100mm pot it becomes more difficult to insert and compress potting media into the pot to fill the narrow gap between plant stock and pot side. This problem will also occur when potting-on plants from say a 140mm pot into a 175 mm pot. The space between plant stock and pot wall becomes narrow and difficult to fill with potting media.

4.4.3 Quantities of plants potted

When the variables in potting remain constant during a potting event (ie. pot size, type of pot, colour of pot, propagation container size, plant stock type, treatments carried out on potted plant, etc.) production can proceed in an efficient manner. However, when potting variables change frequently during the potting event production efficiency falls as staff need to meet the new set of potting requirements for each new type of plant.

Frequently changing potting requirements means increased time spent seeking production information, more time spent bringing in new potting inputs, time spent rearranging the work bench, etc. Breaks in production continuity also affect the potting rhythm of potters resulting in lower production rates. Nursery operators interested in achieving greater production efficiency should attempt to pot in large batches of plants with similar potting requirements.

4.4.4 Fertiliser placement

Of all the processes carried out in potting the placement of fertiliser (granular types) has proven to be the most variable. Where is the best place to put fertiliser in the potted plant? On the surface of the potted plant, under the surface of the potted plant, under the root ball of the plant, distributed through the potting media ? From an efficiency perspective the quickest option is to either mix it into the potting media before potting begins (assuming that the mixing process is done by the media supplier or in an efficient manner by the nursery) or place it onto the surface of the potted

plant after potting (preferably using a fertiliser dispenser). The most time consuming method is to insert fertiliser into each pot during the actual potting process.

Nurseries have no doubt settled on a particular method of fertiliser placement after analysing production related to nutrition.

4.4.5 Watering

Watering-in the potted plant was another procedure that was observed to be carried out using a wide variety of methods. Methods included, automatic watering tunnels, hand watering in the potting area, hand watering in a designated watering station some distance from potting, hand watering in the growing area after plants had been put down, and watering by using the overhead irrigation system. Given the fact that plant types produced and quality obtained did not differ greatly between nurseries it seems that although the efficiency of watering methods differed, the same end result (healthy plants) was achieved by all methods.

4.4.6 Spacing plants in the growing area

Spacing out plants in the growing area followed either of two patterns; potted plants were unloaded pot to pot in the growing area leaving no space between them or pots were unloaded and spaced out in the growing area to allow for optimum growing space. Certain plant species placed pot to pot did not require to be moved in the time between potting and their collection for dispatch, however some plants spaced pot to pot needed to be subsequently moved apart during their growing cycle at the nursery. Subsequent spacing out of pots placed pot to pot is an extra step that could have been accomplished in the task of putting down potted plants in the growing area – not space economical. Sometimes it is much cheaper to originally place pot to pot and leave until ready for wider spacing than to do so immediately.

4.4.7 Pruning plant stock

Pruning plant stock was observed to be carried out before potting took place, during the potting process (ie, individual potted plants were pruned after being inserted to the pot), after potting in the potting area (ie. once loaded to a trailer, etc.) and after potting when placed down in the growing area. Pruning plants after they had been placed in the growing area is probably the least efficient of all methods as it involves the worker crouching uncomfortably and it is difficult to access plants in close proximity to each other. It is also less suitable in terms of plant growth.

5. Results of investigation

In this report, and in future general reports to the nursery industry, potting labour cost comparisons may be made between all or a number of nurseries involved in the project. Each nursery has therefore been allocated a confidential number so that it

may know where its labour cost figures lie in relation to other participating nurseries. The number was only provided to management at the relevant nursery.

In some cases the description of tasks on graphs may not seem to match the tasks as you know them at your nursery. Faced with a great variety of potting tasks (often referred to differently by different nurseries) and limited by the space available under graphs to describe these tasks researchers decided to use the most common task names and trust in the ability of nurseries to relate tasks to their own operations. For example if a task is shown as 'loading potted plant to trailer' and your nursery loads potted plants to conveyors and not trailers then in your nursery's case the time shown will refer to loading potted plants to conveyor. A description of potting tasks is provided in Tables 2 and 3.

5.1 Overall potting performance

The following sets of graphs (figures 1a-f & figures 2a-f) show the average duration of potting tasks (seconds per pot) and the break up of total potting time (% of total potting time) for the potting systems standard bench, modified bench, mobile bench, Comet, Javo and Meyer.

Figures 1a to 1f show average potting task times (in seconds per pot) for each potting system (all pot sizes used in the systems during the period of data collection were used in the calculation).

Figures 2a to 2f show the break down of the average total potting time for the various potting systems into the potting processes of plant stock handling, pot handling, fertiliser handling, media handling, handling the pot with media, handling the potted plant, handling other materials, maintaining the potting area and preparing the growing area.

It can be seen that plant stock handling and handling the potted plant take up the majority of total potting time for all systems but in mobile potting systems handling the potted plant does not take up as large a % of total potting time because of the elimination of the task of transporting potted plants to the growing area.

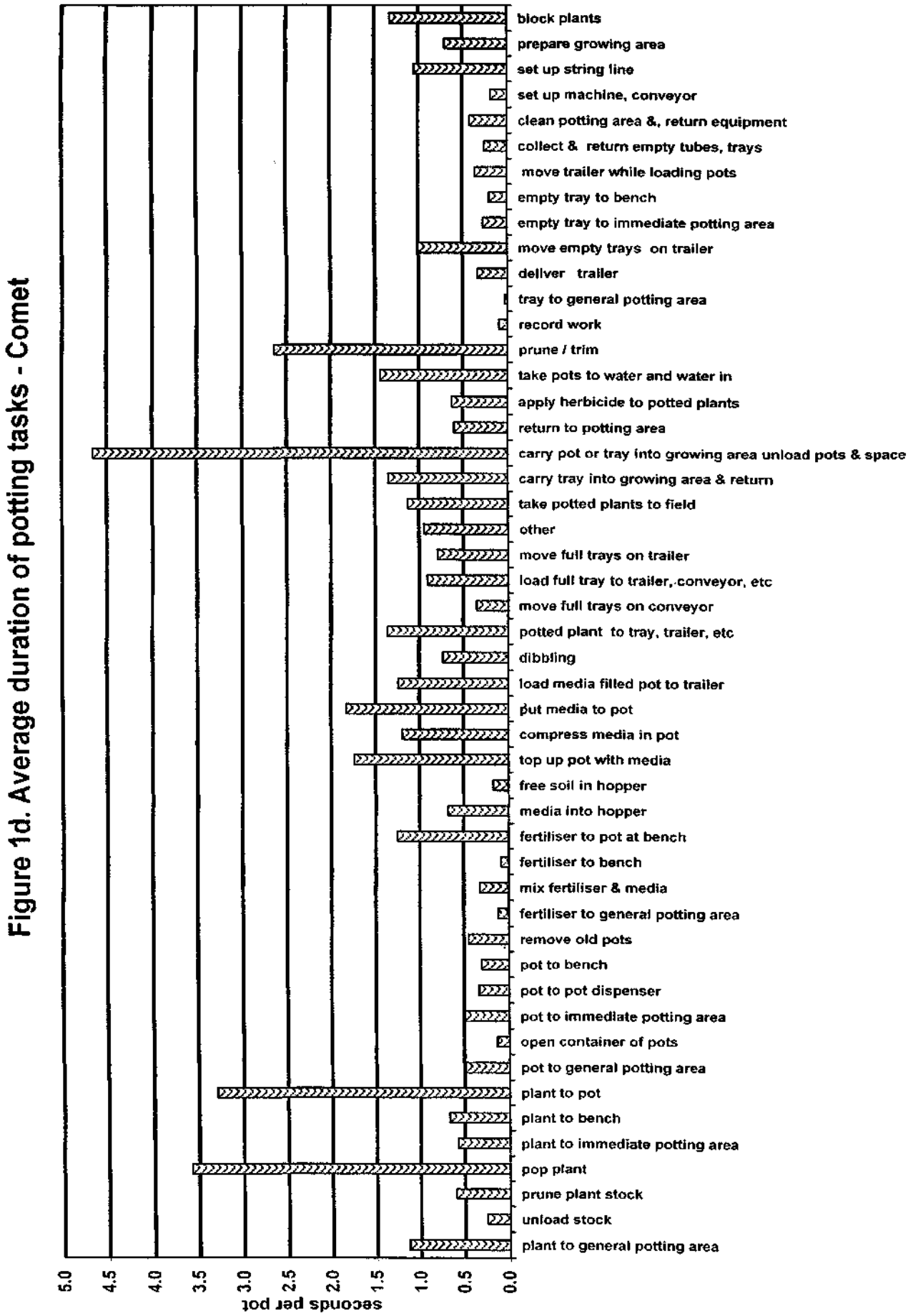


Figure 1d. Average duration of potting tasks - Comet
block plants
prepare growing area
set up string line
set up machine, conveyor
clean potting area &, return equipment
collect & return empty tubes, trays
move trailer while loading pots
empty tray to bench
empty tray to immediate potting area
move empty trays on trailer
deliver trailer
tray to general potting area
record work
prune / trim
take pots to water and water in
apply herbicide to potted plants
return to potting area
carry pot or tray into growing area unload pots & space
carry tray into growing area & return
take potted plants to field
other
move full trays on trailer
load full tray to trailer, conveyor, etc
move full trays on conveyor
potted plant to tray, trailer, etc
dibbling
load media filled pot to trailer
put media to pot
compress media in pot
top up pot with media
free soil in hopper
media into hopper
fertiliser to pot at bench
fertiliser to bench
mix fertiliser & media
fertiliser to general potting area
remove old pots
pot to bench
pot to pot dispenser
pot to immediate potting area
open container of pots
pot to general potting area
plant to pot
plant to bench
plant to immediate potting area
pop plant
prune plant stock
unload stock
plant to general potting area
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
seconds per pot

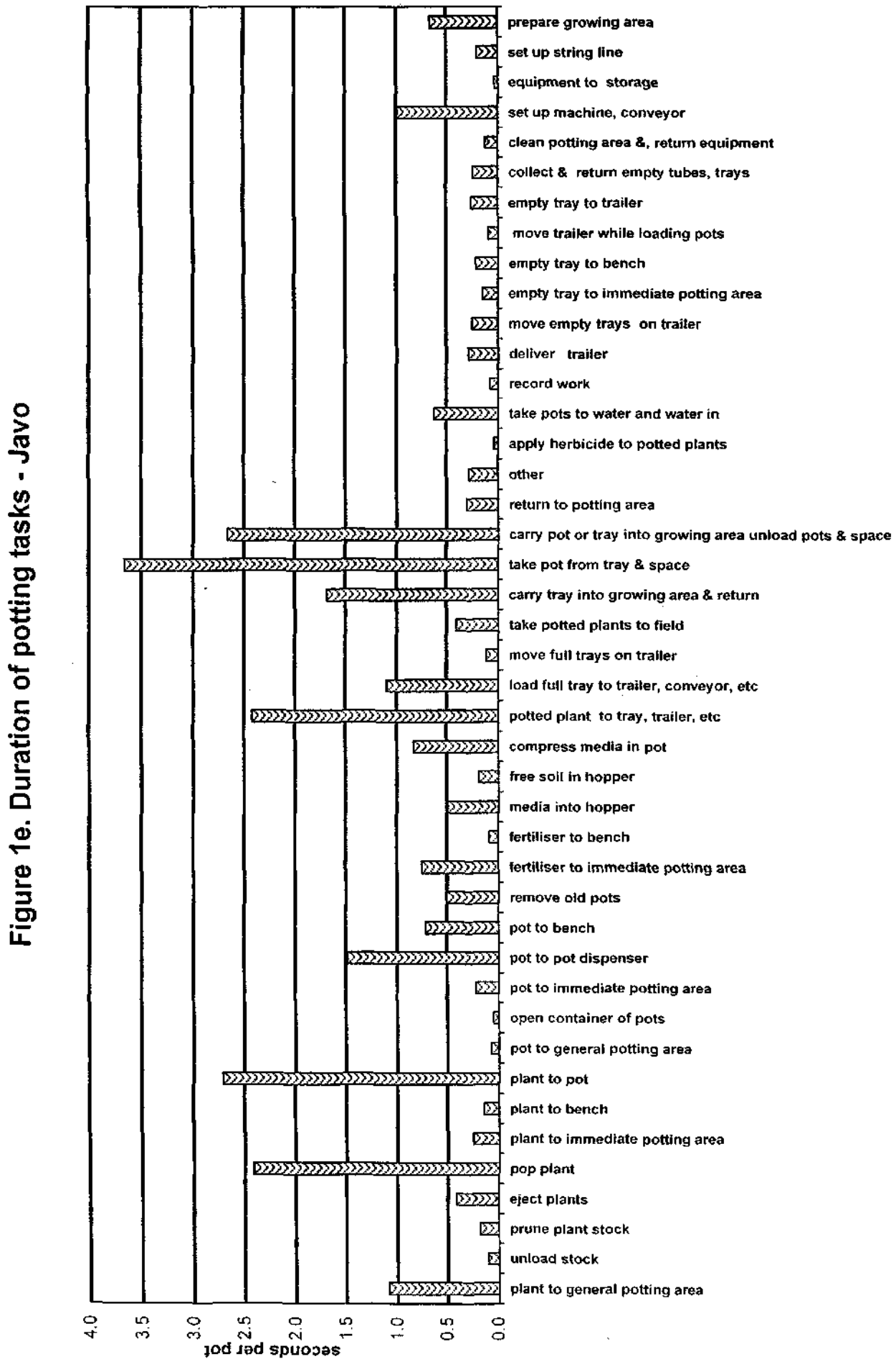


Figure 1e. Duration of potting tasks - Javo

Figure 2a. Break up of total potting time - Standard Bench

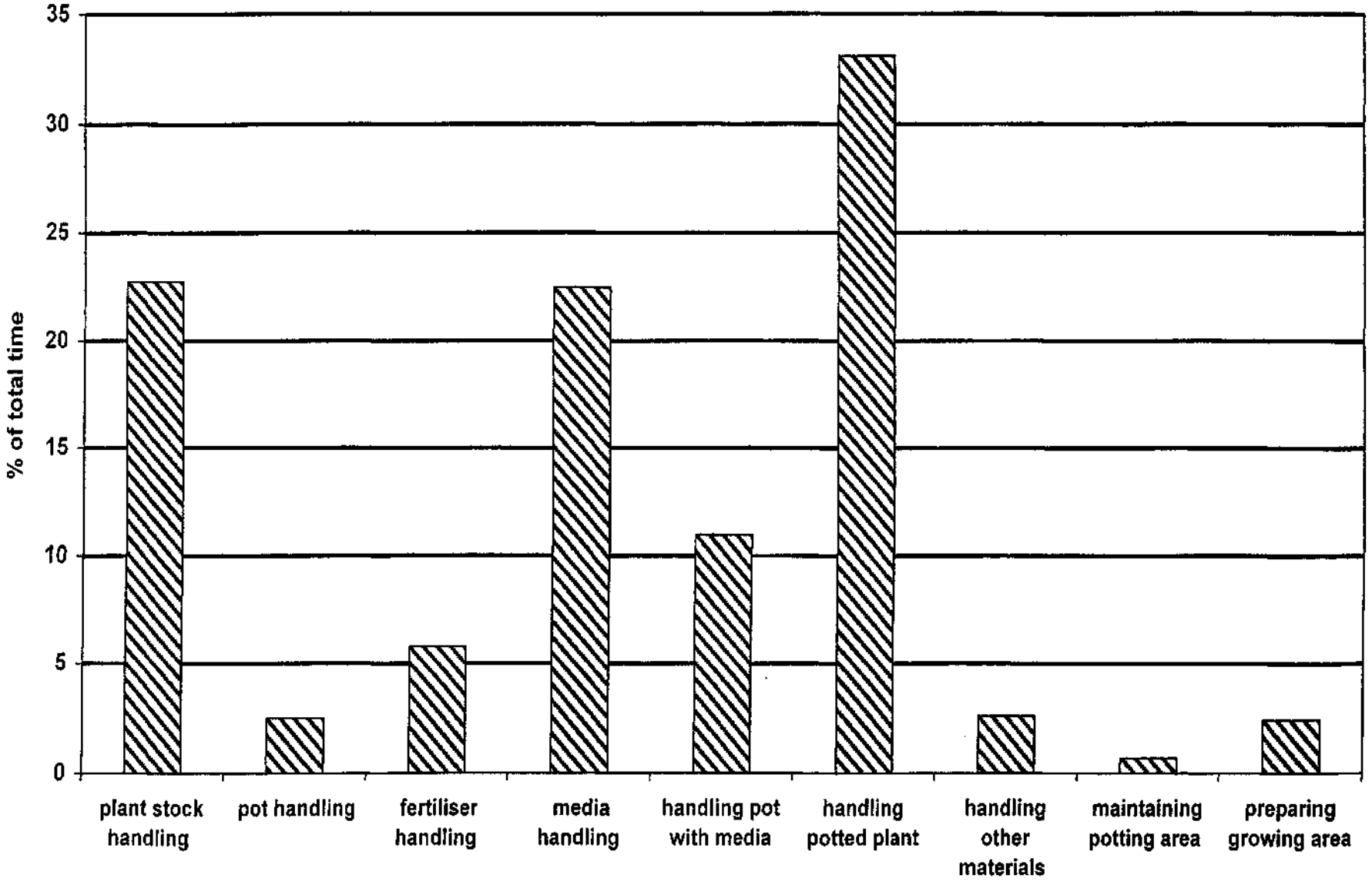


Figure 2b. Break up of total potting time - Modified Bench

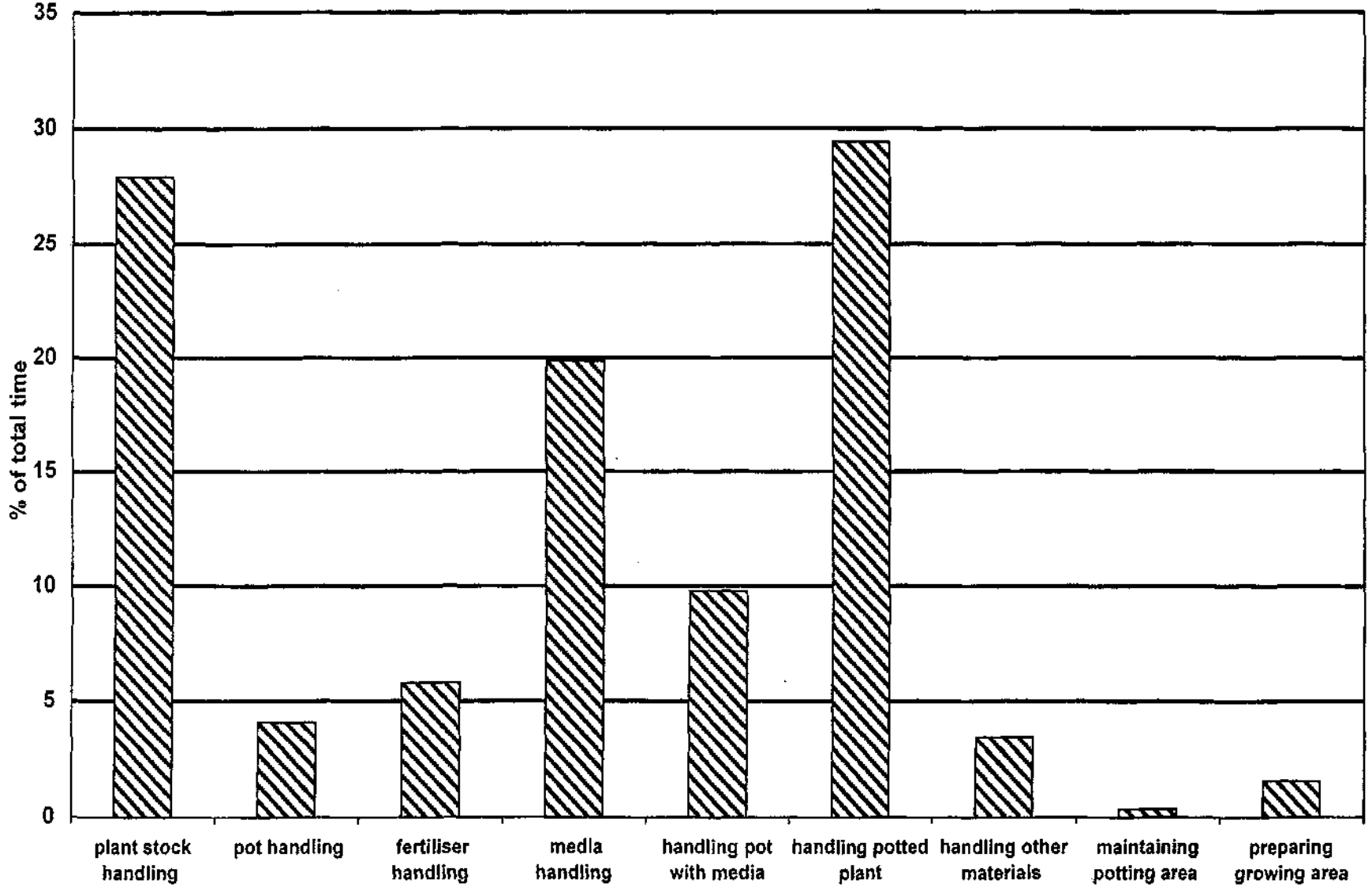


Figure 2c. Break up of total potting time - Mobile Bench

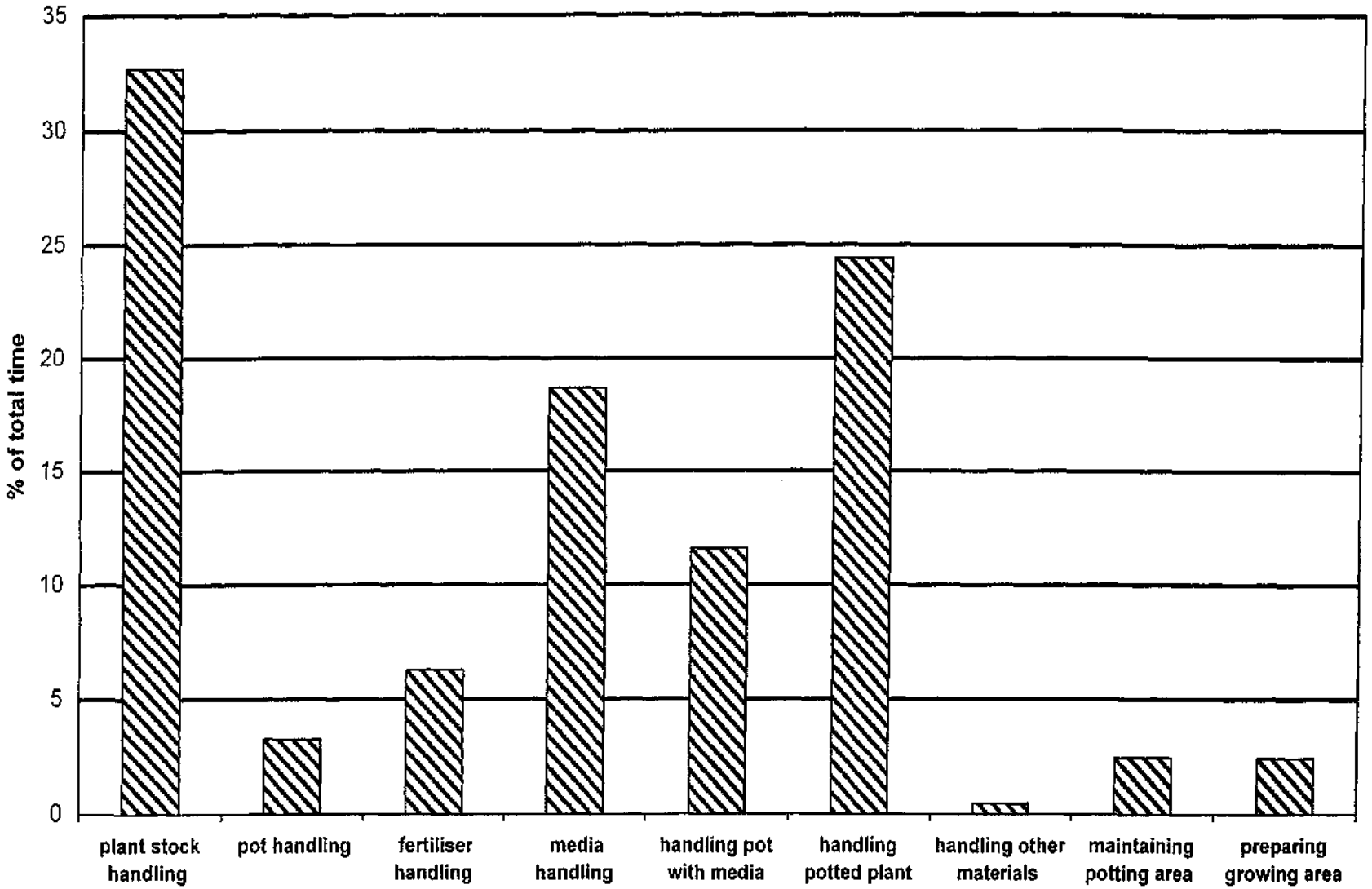


Figure 2d. Break up of total potting time - Comet

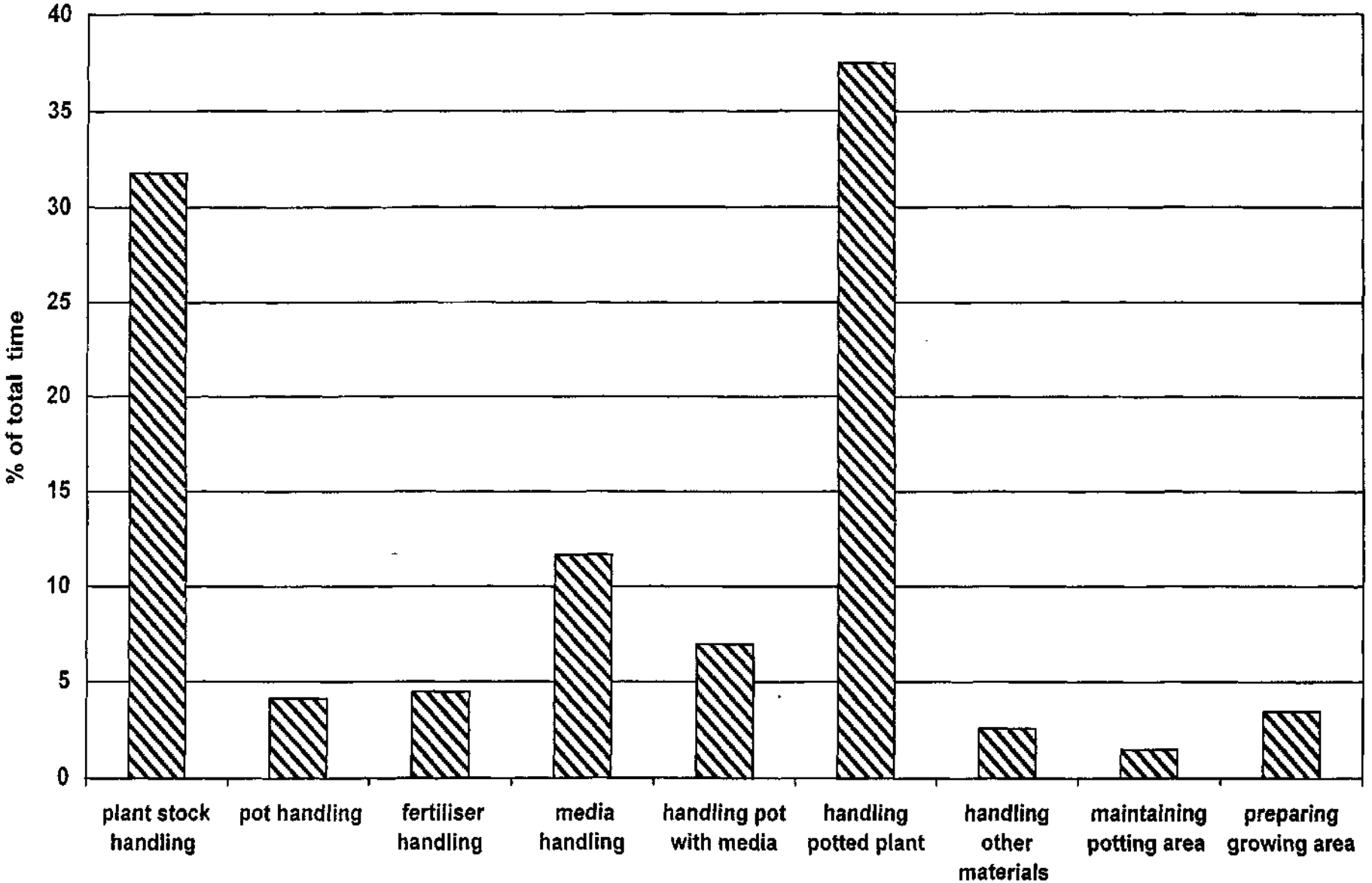


Figure 2e. Break up of total potting time - Javo

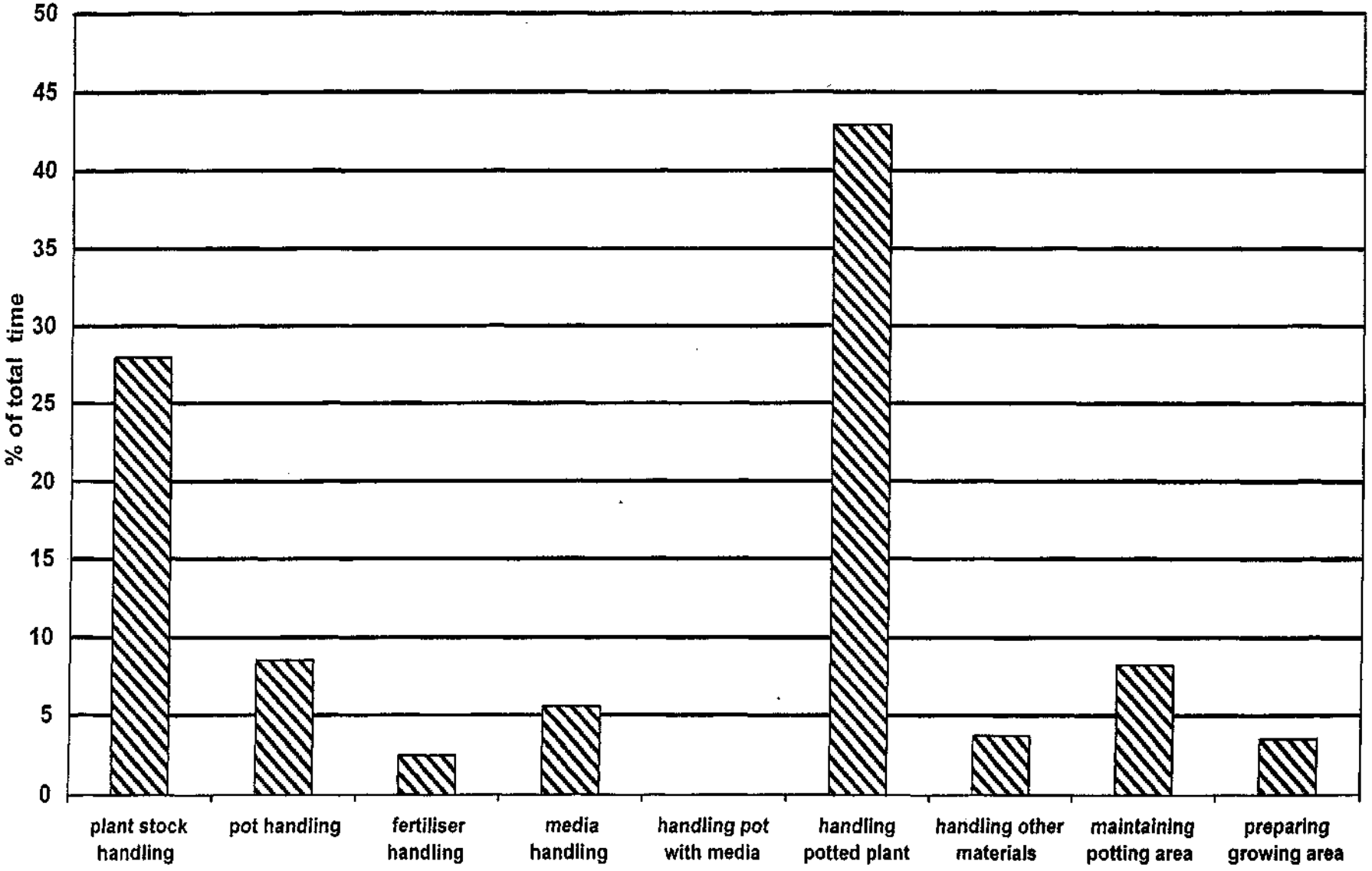
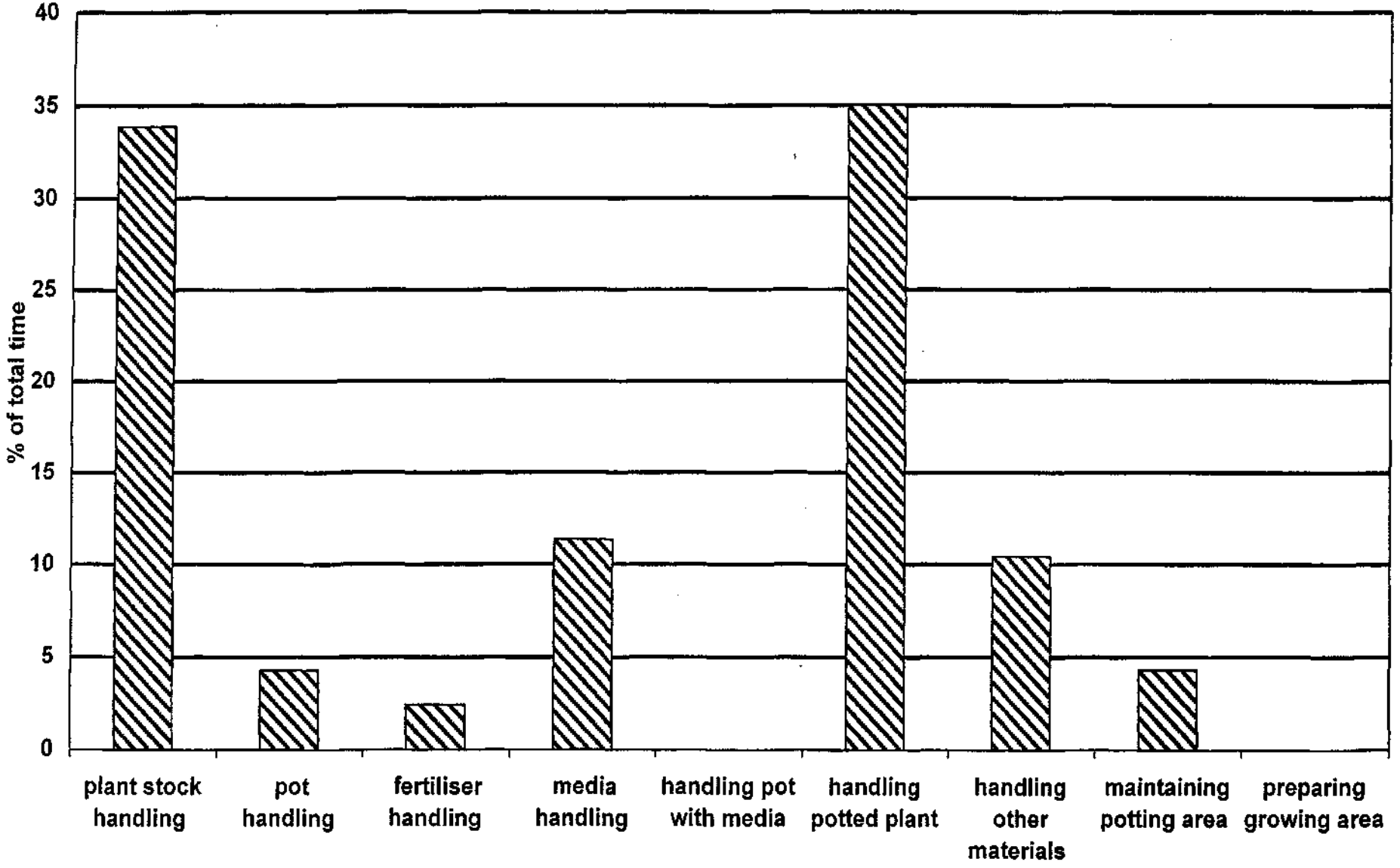


Figure 2f. Break up of total potting time - Mayer



5.2 Average Potting cost

Figures 3a to 3e show the average potting labour cost in the areas of preparation for potting, potting, after potting and total potting, for most of the potting systems investigated during the project. Each graph shows the average potting labour costs for nurseries using a particular potting system for the production of a various pot sizes.

Figures 4, 5 and 6 show the minimum, average and maximum potting costs required to produce various pot sizes using average values from all potting systems investigated during the project.

Figure 7 compares the average potting cost in cents per pot for all pot sizes and all potting systems investigated during the project. Note that no adjustment has been made to account for different levels of potting difficulty for different species of plants potted. Under each bar of the graph is a description of the potting system in 2 letters:

St = standard bench
Mo = modified bench
Mb = mobile bench
Co = Comet
jv = Javo
my = Mayer
bg = C-Mac bag filler
ro = rotary table
ht = Williams Hi Tec Engineering

Next is written the size in millimetres of the pot used (eg. 100 = 100mm), finally the code used to represent the nursery where the data was collected (the identity of each nursery is confidential). Information at **co-140-n6** therefore relates to a Comet machine potting system producing 140mm pots at nursery site n6.

Figure 8 shows the average labour costs of potting for all potting systems investigated during the project. Note that the costs are for 140mm pots except for the Mayer system which did not produce any 140mm pots during the period of data collection. Also note that costs have not been adjusted to take into consideration the potting difficulty of different types of plants produced.

Potting costs adjusted to take potting difficulty into consideration will be reported in a later stage of the project.

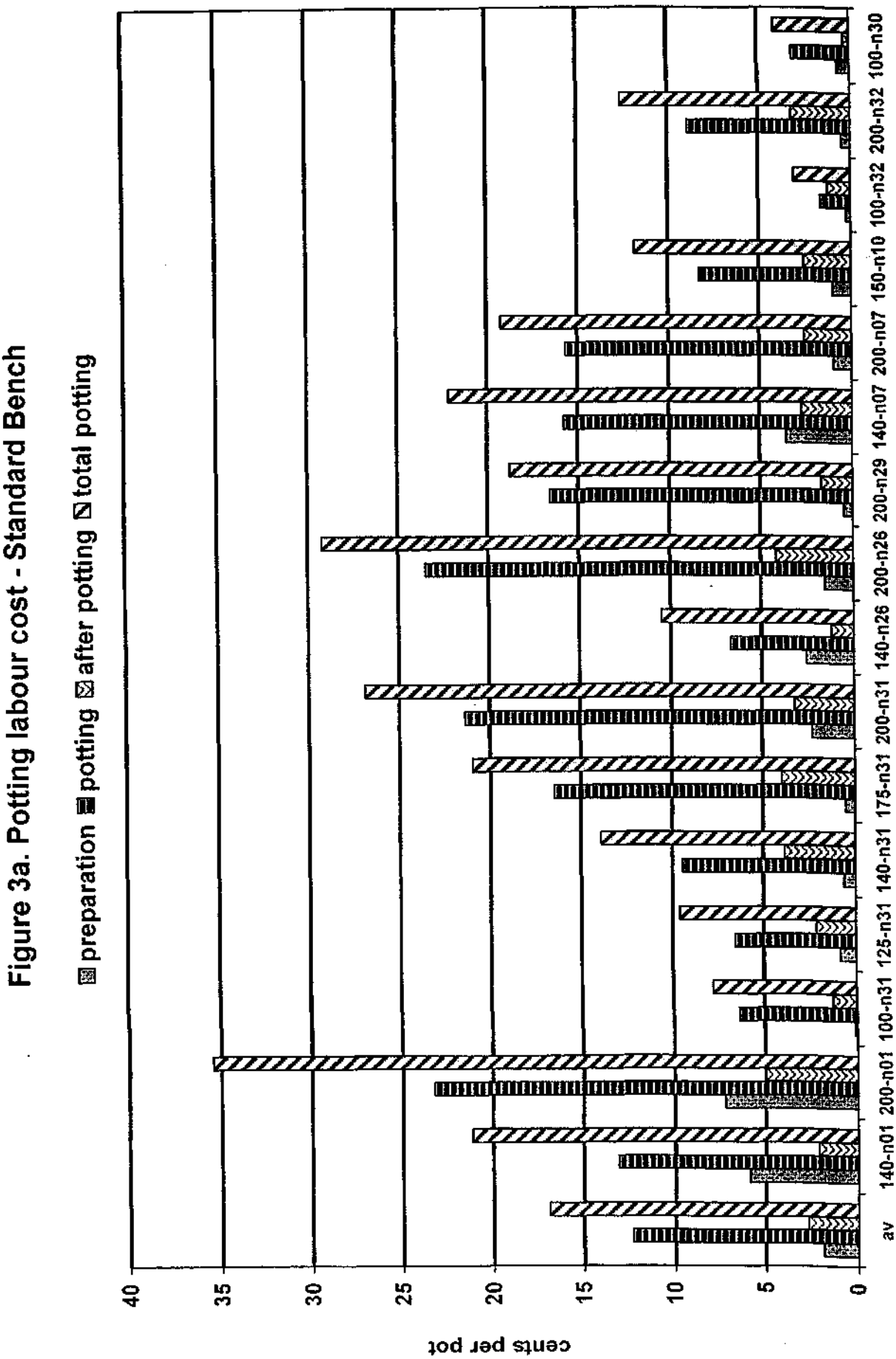


Figure 3a. Potting labour cost - Standard Bench
preparation
potting
after potting
total potting
cents per pot
0
5
10
15
20
25
30
35
40
av
140-n01
200-n01
100-n31
125-n31
140-n31
175-n31
200-n31
140-n26
200-n26
200-n29
140-n07
200-n07
150-n10
100-n32
200-n32
100-n30

Figure 3b. Potting labour cost - Modified Bench

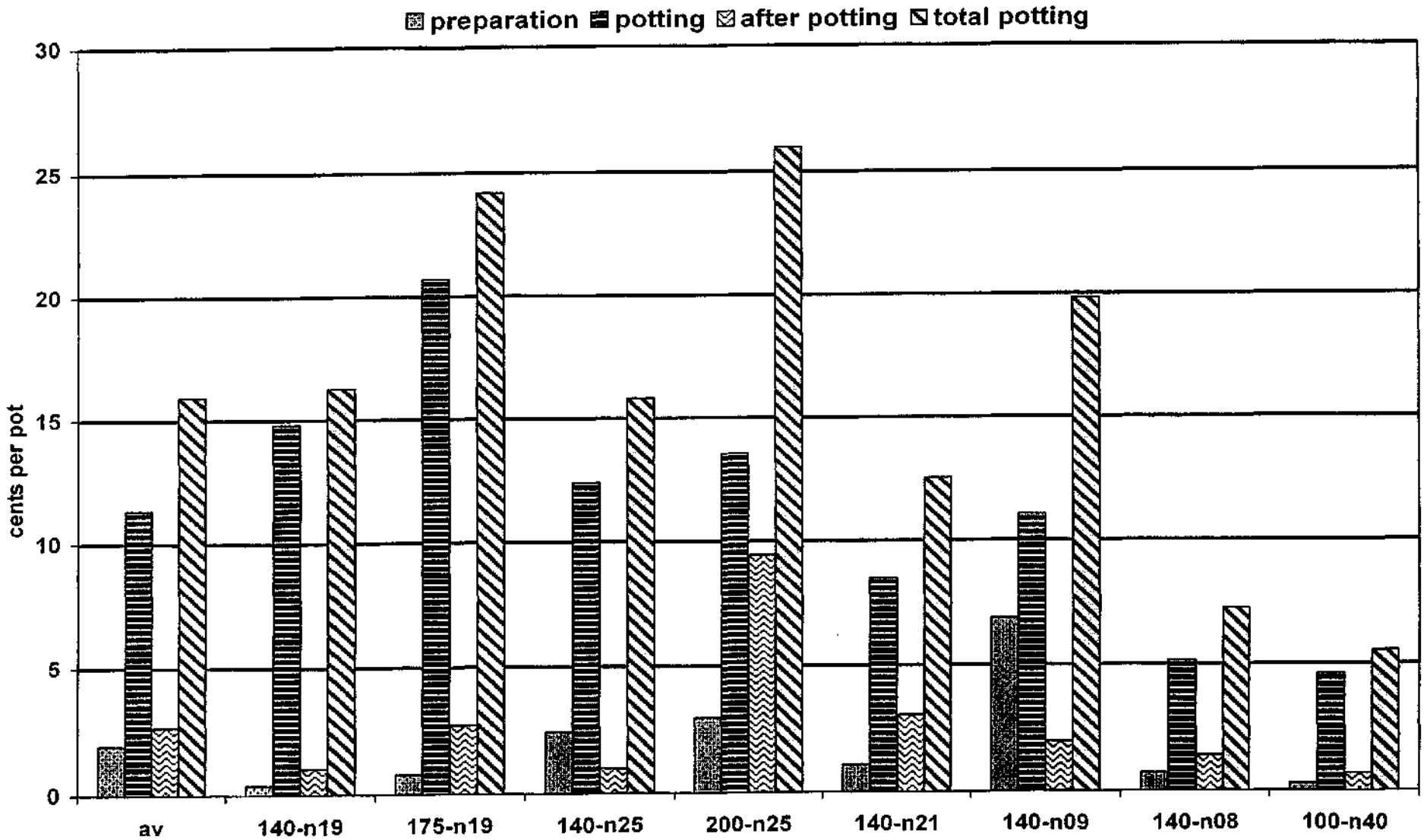
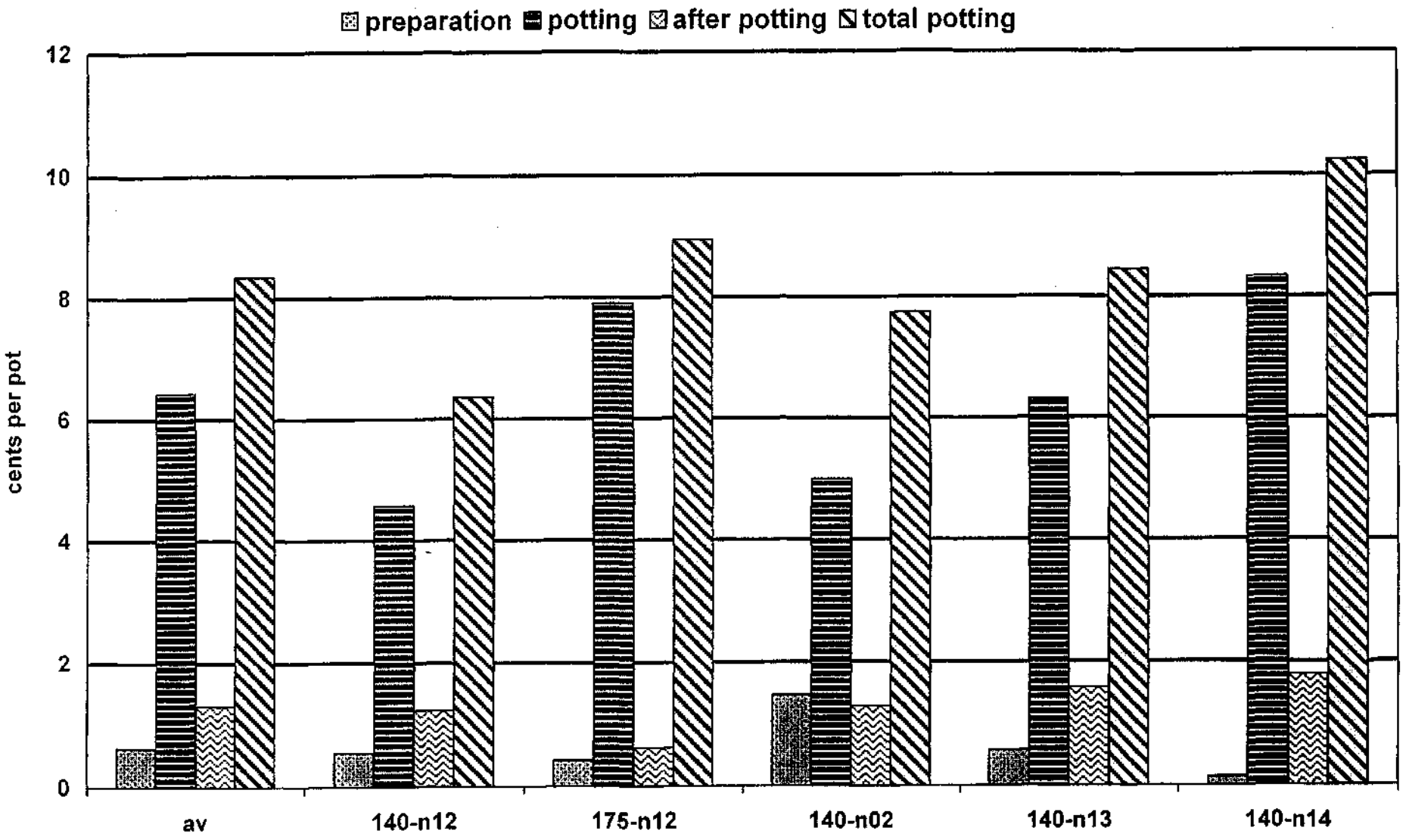


Figure 3c. Potting labour cost - Mobile Bench



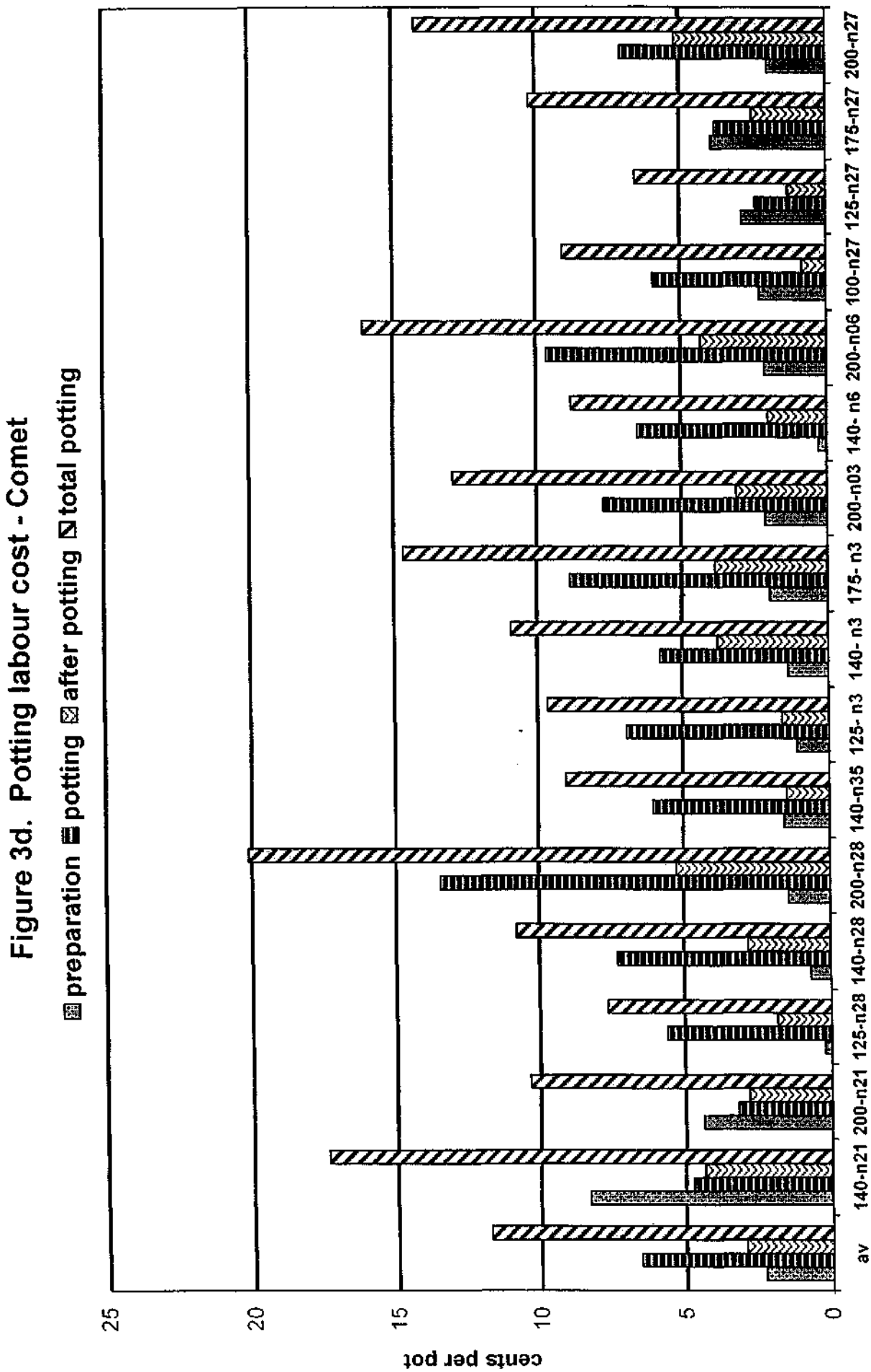


Figure 3d. Potting labour cost - Comet
preparation
potting
after potting
total potting
cents per pot
0
5
10
15
20
25
av
140-n21
200-n21
125-n28
140-n28
200-n28
140-n35
125- n3
140- n3
175- n3
200-n03
140- n6
200-n06
100-n27
125-n27
175-n27
200-n27

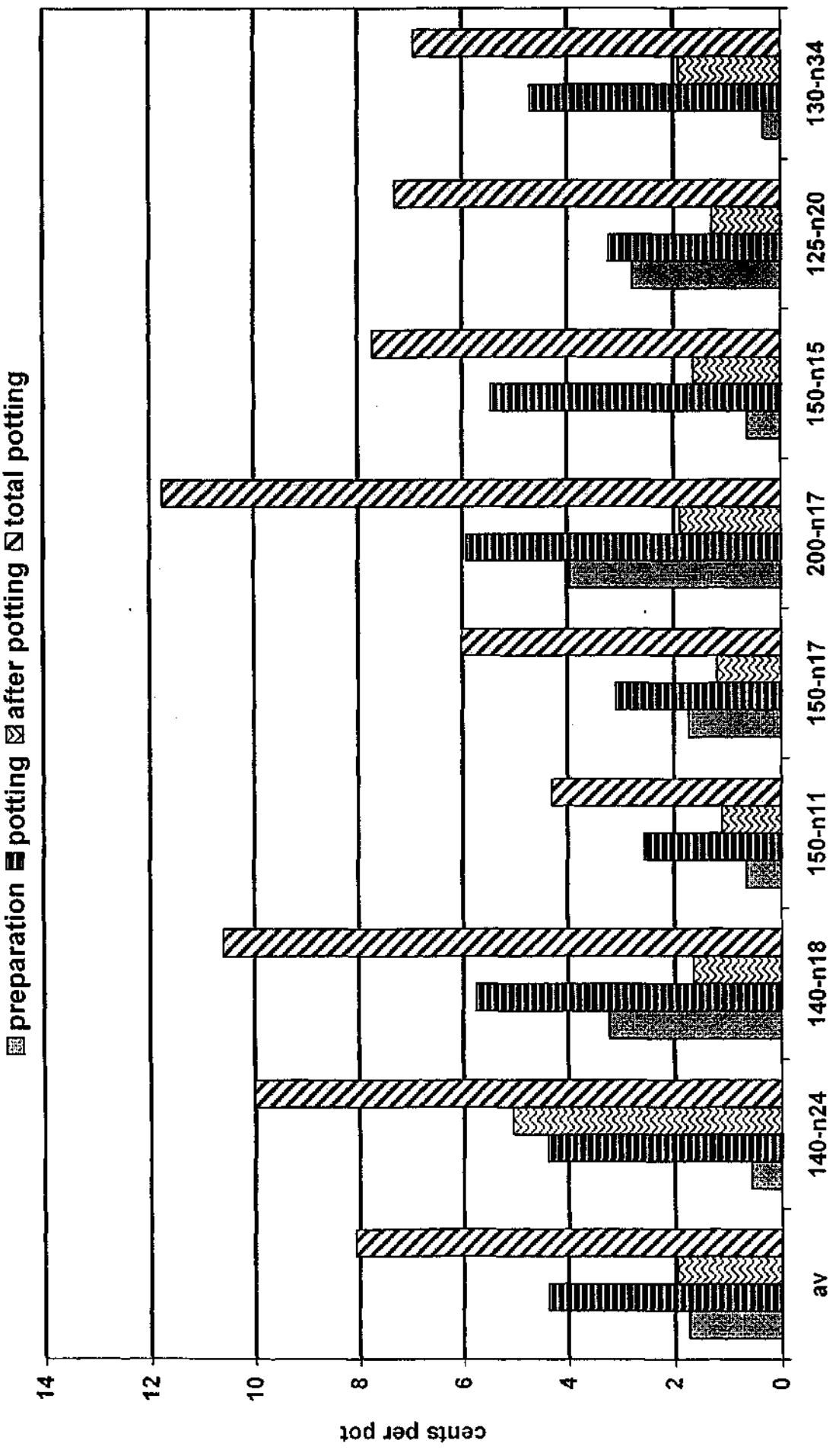


Figure 3e. Potting labour cost - Javo

Figure 4. Minimum cost in main areas of potting for all potting methods

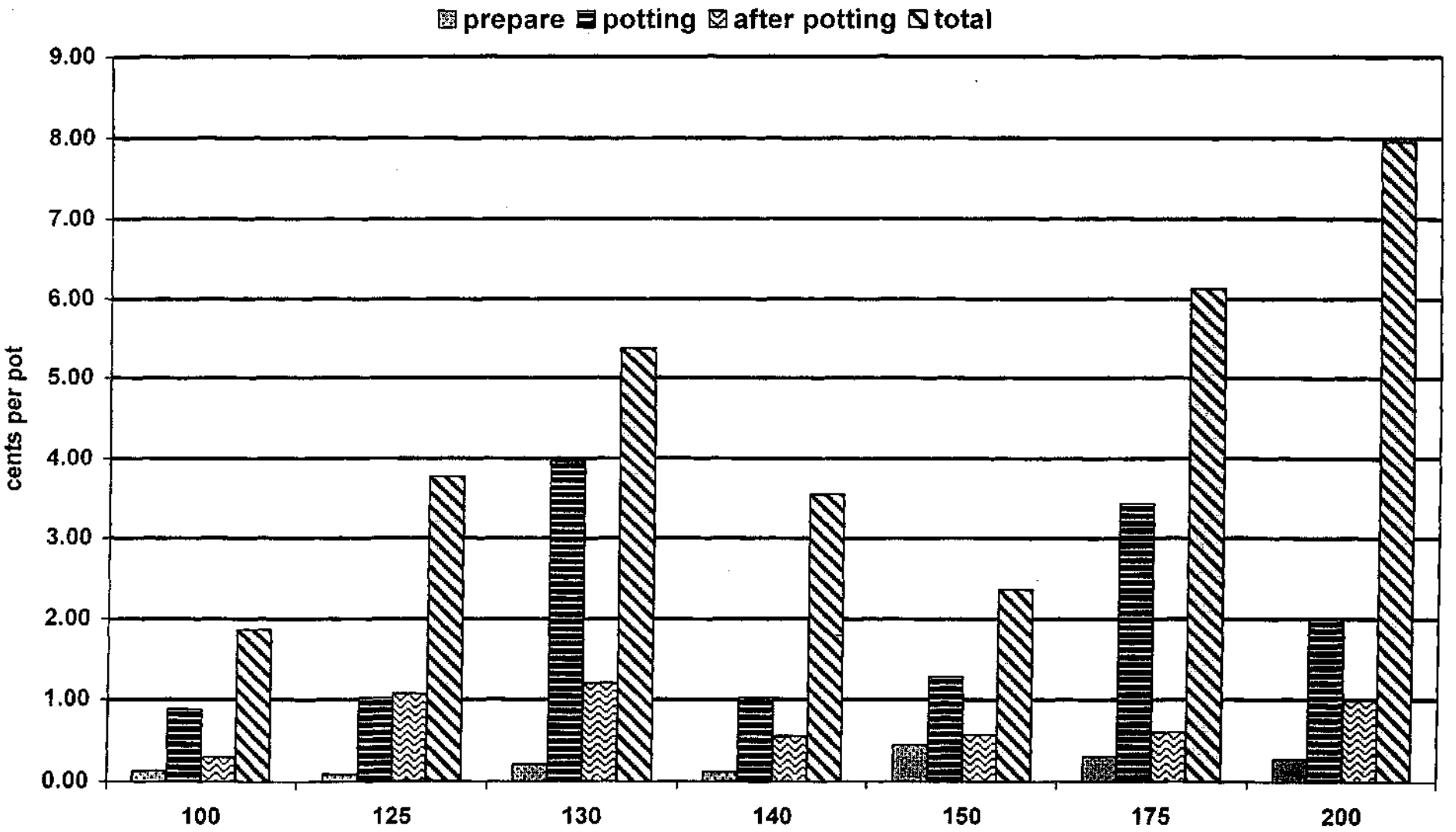
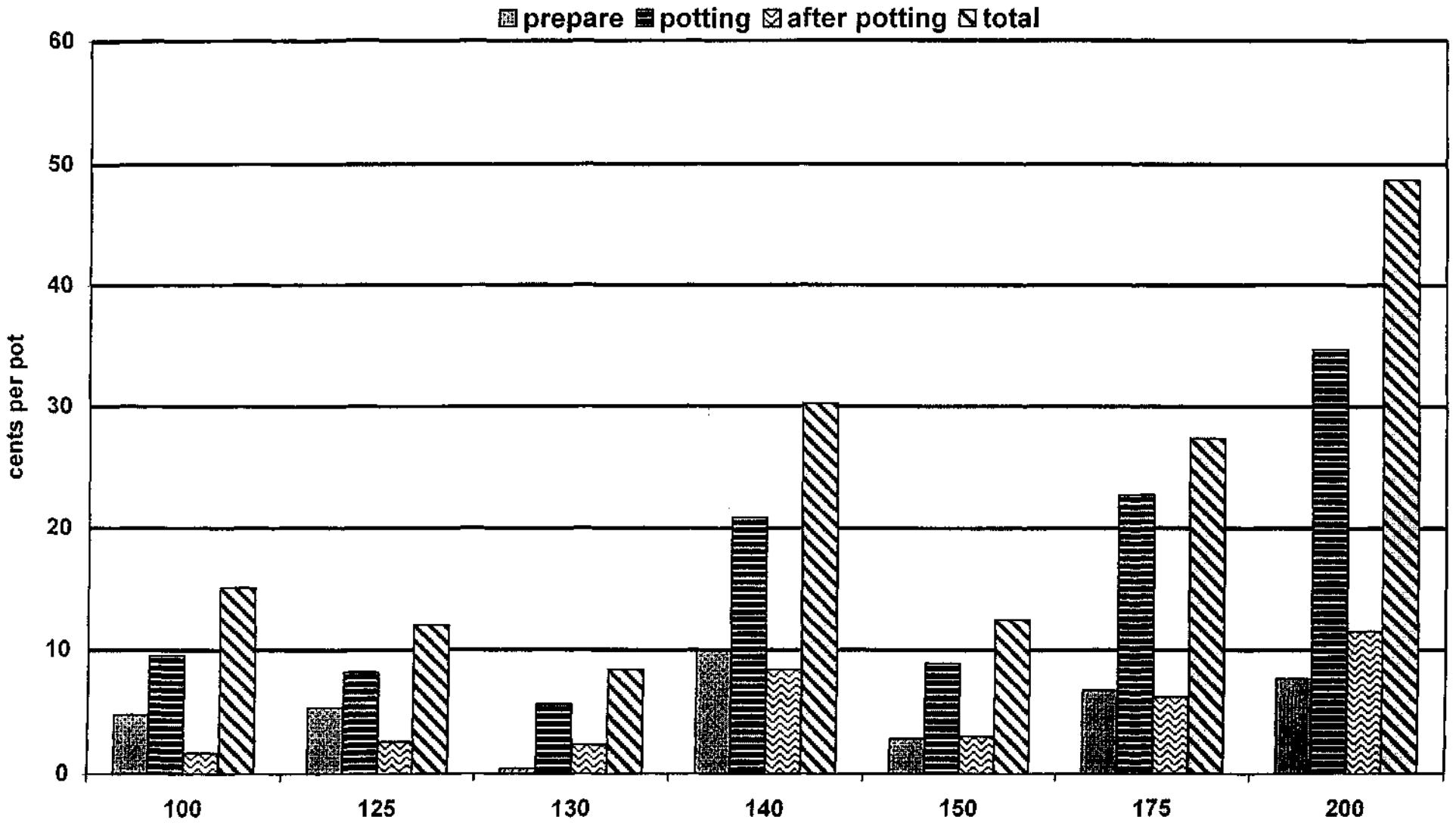


Figure 6. Maximum cost in main areas of potting for all systems



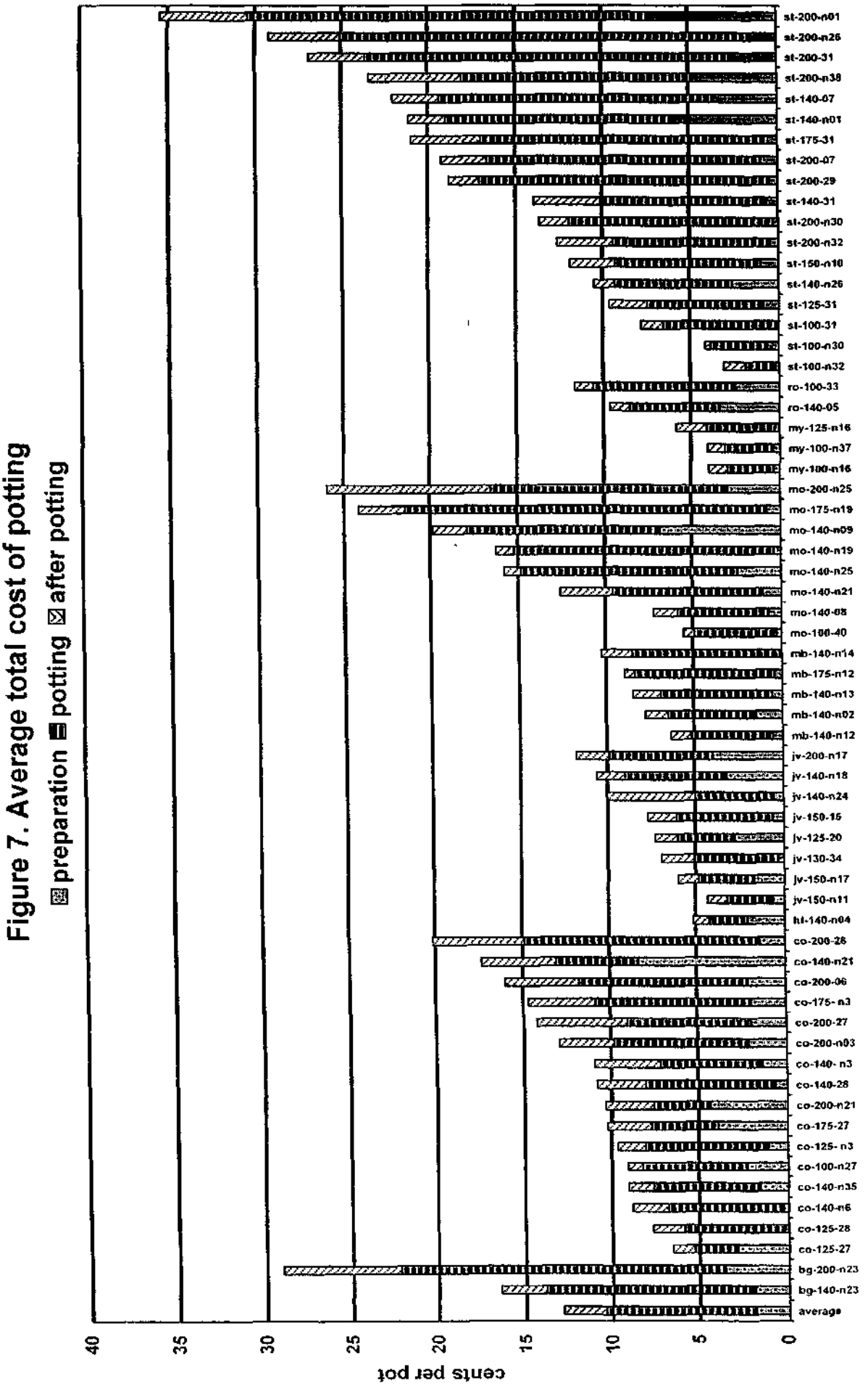
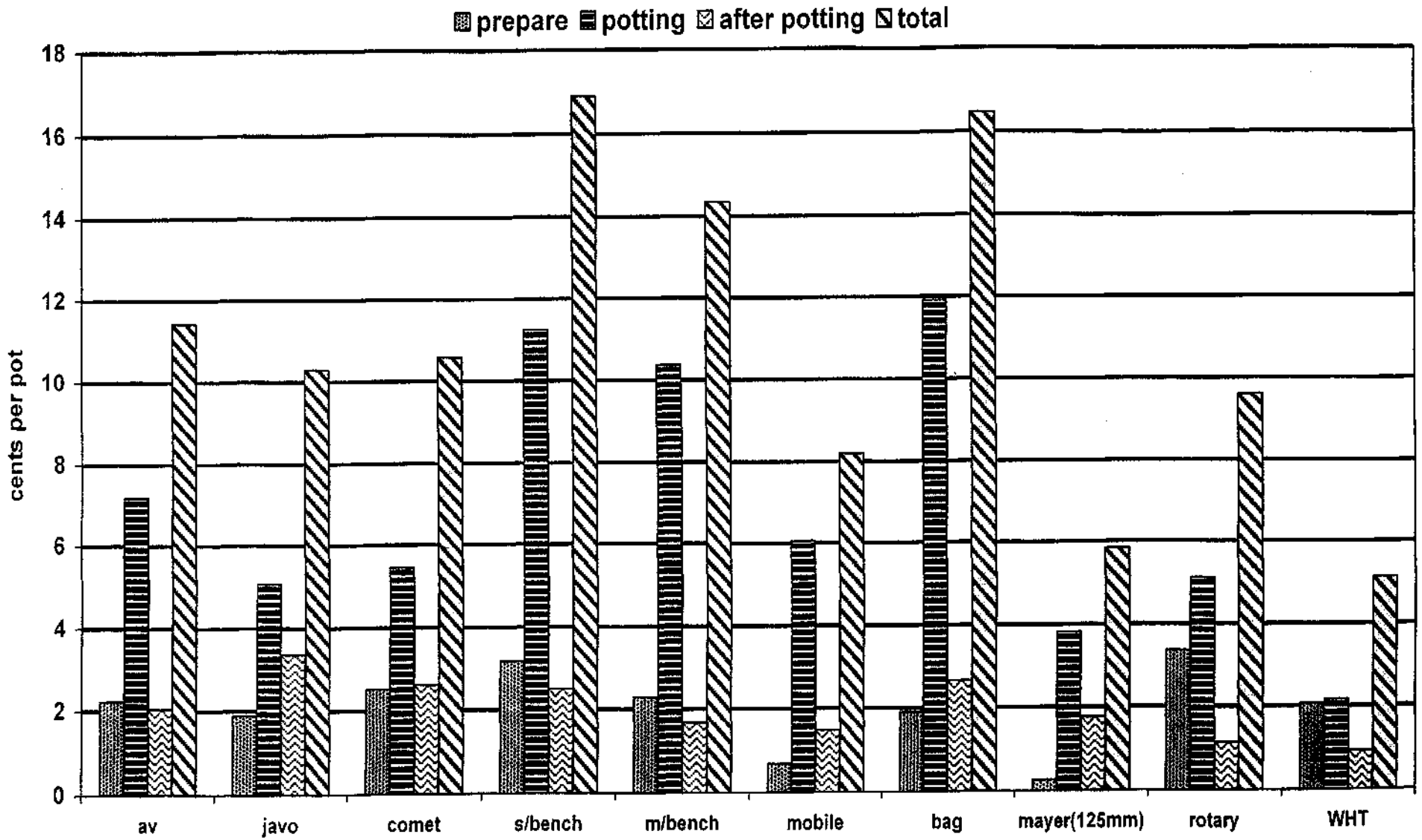


Figure 7. Average total cost of potting
preparation
potting
after potting
cents per pot
40
35
30
25
20
15
10
5
0
st-200-n01
st-200-n26
st-200-31
st-200-n38
st-140-07
st-140-n01
st-175-31
st-200-07
st-200-29
st-140-31
st-200-n30
st-200-n32
st-150-n10
st-140-n26
st-125-31
st-100-31
st-100-n30
st-100-n32
ro-100-33
ro-140-05
my-125-n16
my-100-n37
my-100-n16
mo-200-n25
mo-175-n19
mo-140-n09
mo-140-n19
mo-140-n25
mo-140-n21
mo-140-08
mo-100-40
mb-140-n14
mb-175-n12
mb-140-n13
mb-140-n02
mb-140-n12
jv-200-n17
jv-140-n18
jv-140-n24
jv-150-15
jv-125-20
jv-130-34
jv-150-n17
jv-150-n11
ht-140-n04
co-200-26
co-140-n21
co-200-06
co-175- n3
co-200-27
co-200-n03
co-140- n3
co-140-28
co-200-n21
co-175-27
co-125- n3
co-100-n27
co-140-n35
co-140-n6
co-125-28
co-125-27
bg-200-n23
bg-140-n23
average

Figure 8. Average cost of potting 140mm pots



5.3 Potting systems

The following section contains general information on the potting systems investigated in the project. Nursery industry representatives chose the potting systems to be investigated. The fact that certain potting systems were not included because they were not available for study in the project is no reflection on the efficiency of those systems. The potting systems are divided into hand potting and machine potting.

The information provided is intended as a very general guide to help nurseries determine which potting system is best suited for them. More definitive advice on which potting systems are suitable for which types of potting production will be available at a later stage of the project. Nurseries contemplating changing their production systems now should do so only after a thorough analysis of their potting production needs and discussion with the manufacturers of any potting equipment and not solely on the basis of information provided here.

Hand potting

Hand potting (ie. standard bench, modified bench, mobile bench systems) can place more physical demands on potters than potting at a machine so the production rate of hand potters tends to fall away during the day due to fatigue. The production of hand potters is also influenced by the efficiency of their potting techniques and their work ethic (motivation) unlike machine potters whose production rates are largely dictated by the speed setting on the machine.

To counter falling production during hand potting it becomes even more important to ensure worker comfort levels are high and that materials handling is as efficient as possible. Hand potting systems are often faced with problems due to potting media encroaching on workbench space. Media makes it difficult to store and stand empty pots, store trays of plant stock, store tubes, trays, etc. Potting production rates will be improved by ensuring adequate work space is available to potters. Many nurseries using hand potting methods could also improve their production rates by reviewing the potting production rates of individual potters and helping them to improve their potting techniques where necessary.

Adding fertiliser by hand during the potting process (more commonly observed in QLD nurseries) is a time consuming element of hand potting as it involves extra actions in getting the fertiliser, dibbling a hole for the fertiliser, inserting the fertiliser and covering the fertiliser with media. NSW and VIC nurseries seemed more prepared to streamline their potting process by buying in potting media which had been already mixed with fertiliser. However, it may be that dibbling etc is your best option based on plant nutritional needs and should therefore be adopted.

5.3.1 Standard Bench

Potting using a standard bench involves placing potting media onto a fixed flat surface such as a table, filling empty pots with media by hand, inserting plant stock to the pots by hand and loading the potted plants to a trailer, etc., by hand.

Production notes

The work surfaces of standard benches were observed to be constructed from of a variety of materials ranging plywood to stainless steel. Stainless steel, though more expensive than wood, has the advantage of being easy to sterilise. Galvanised steel is not a suitable material for a standard bench as it reacts to fertiliser in the potting media.

5.3.2 Modified bench

Potting on a modified bench involves potting by hand on a flat raised surface to which potting media is fed by a hopper (flow from the hopper being gravity or mechanically assisted). Some modified benches also have conveyors (gravity or electric) to bring plant stock into the potting bench and/or to take the potted plants to a trailer, etc.

Production notes

As soon as you incorporate a hopper into a potting system moisture control of the potting media becomes very important. The design of many potting media hoppers makes them prone to bridging. This bridging becomes more frequent when the potting media is too moist. Hoppers with motorised conveyor system under the hopper to deliver media to the potter are not generally troubled by hopper bridging. Such arrangements will also leave more room on the potting bench as the hopper can be situated some distance away from the bench. Nurseries with gravity flow hoppers can counter bridging by installing vibrating mechanisms to the hopper. The simplest and cheapest solution to hopper bridging is a well designed hopper and adequate control of potting media moisture content.

Many modified benches with gravity flow hoppers (ie. the hopper is situated above the potting bench) were observed to suffer from a serious lack of adequate work space at the bench. This results in cramped conditions for the potter and time lost arranging inputs and outputs in the limited work space available.

When designing or buying a modified bench make sure that:

- bench height is suitable for all staff (adjustable bench height or adjustable standing platform will improve worker comfort)
- the front panel of the hopper does not come too close to the potters head (potters will be cramped for work space)
- there is sufficient flat bench space at the front of the modified bench for actual potting to comfortably take place and still allow for the storage of empty pots, plant stock, etc.
- hopper design does not cause constant bridging of potting media.

5.3.3 Mobile Bench

Potting using a mobile bench involves placing media onto a mobile flat surface or into a hopper and transporting the mobile bench to the growing area where potted plants are to be put down. Once in the growing area potting takes place at the mobile bench and the potted plants are directly unloaded into the growing area. A mobile bench

could be a trailer towed by tractor, the rear tray of a truck or ute, a hopper mounted onto a trailer or truck, etc.

Production notes

Mobile benches are used to reduce potting labour costs by cutting down the time taken to transport potted plants to the field. Project research has confirmed that handling the potted plant does make up a considerable part of total potting costs. As mobile potting takes place in the field, away from main stores of potting materials (potting media, empty pots, herbicides, fertiliser, potting tools, plant stock, water, etc.) there is an increased likelihood that the inefficient handling of other materials will occur. To eliminate this risk mobile benches should be able to store all potting materials required for a significant period of potting.

Mobile bench potting requires less potting staff to carry out total potting as travel to the growing area is reduced to a minimum. Mobile bench potting, when combined with a conveyor to take plants from the potting bench into the growing area, can be a highly efficient means of getting the potted plant into the growing area. This efficiency will be lost however if the conveyor is not situated to allow potters at the mobile potting bench to easily load potted plants to the conveyor.

As mobile bench potting takes place in the field, it can place the potting production schedule at the mercy of the weather. Some form of easily moveable shelter from the sun, rain and wind will raise worker comfort levels and help maintain production rates in all conditions.

Machine potting

Various models of the Comet, Javo and Mayer potting machines were investigated during the project. Information provided here refers to the general features of these potting machines. If you need details about the production performance of specific models you should contact the manufacturers.

For machine potting to be an efficient option for potting production, staff need a thorough knowledge of all aspects of using the machine (including fixing malfunctions) and the machine has to be operated according to manufacturer's guidelines. For example, malfunctions such as pot jamming in machines can be virtually eliminated if nurseries follow the manufacturer's advice to use new, standard shaped pots rather than second hand or non-standard pots.

5.3.4 Comet potting machine

The Comet potting machine is an Australian product. It provides a continuos flow of media to empty pots held under the soil flow. Potters stand facing either of 2 media flow outlets and insert plant stock to the media filled pots. Some nurseries have fitted their Comet potting systems with gravity conveyors to bring plant stock in to the potters and take potted plants out to the waiting trailer.

Production notes

Comets have a limited internal hopper capacity which nurseries can increase by adding an external hopper. Comets can be fitted with wheels to allow mobile potting to take place. Comets were observed in small, medium and large nurseries. The absence of a pot dispenser (potters hold pots under the media outlet) means that a great range of different sized pots can be filled with media at the potter with only minimal adjustment (ie. the rate of soil flow) required.

5.3.5 Javo potting machine

The Javo potting machine is produced in the Netherlands. The Javo machine fills empty pots with media, drills a hole for insertion of plant stock and moves the media filled pots to a point where plant stock can be manually inserted. There are options for attaching an automatic fertiliser dispenser, an automatic pot dispenser and a conveyor to deliver potted plants to trailer.

Production notes

The Javo potting machine allows the option of automatic fertiliser dispensing and automatic pot dispensing. Nurseries using a Javo machine and carrying out these tasks by hand should investigate the possibility of mechanising to reduce the total number of staff required. The automatic pot dispenser on Javos was periodically observed to malfunction when required to dispense second hand or non-standard pots. This problem was resolved by using new, standard pots.

The number of people required to operate a Javo (including putting down potted plants) varied greatly from one nursery to another. Of the 8 Javo systems studied the fewest number of people observed successfully operating a Javo was 3 (1 inserting plant stock to pots, 1 unloading potted plants to trailer and inserting empty pots to the Javo, 1 driving potted plants to the growing area and putting down). The greatest number of people operating a Javo system was 8 (3 ejecting plant stock from tubes, 1 inserting empty pots to the Javo, 1 inserting plant stock to pots, 1 unloading potted plants to trailer, 2 driving trailers to the growing area and putting down plants).

If ejecting stock was performed at the Javo by the potter the overall number of people involved could be reduced. A nursery's decision to eject plant stock before potting is usually based on the impression that the potter does not have sufficient time to eject each plant from its propagation container and pot it. However, by slowing down the machine, and streamlining the stock ejecting technique many nurseries could successfully incorporate stock ejection and potting in one operation at the Javo.

The internal hopper of the Javo is quite small and most nurseries add an external hopper to feed the Javo. If the external hopper used is prone to bridging it will reduce the potting production rate as someone will be required to manually free the obstruction. As discussed in the section on modified benches, the design of the hopper and control of the moisture content of potting media become important when using hoppers in a potting system.

5.3.6 Mayer potting machine

The Mayer potting machine is a German product. There are various models available with differing pot holder ranges, production capabilities, hopper capacities, etc. Empty pots are released from an automatic pot dispenser into a carousel which carries pots under a continuous soil flow. Holes for insertion of plant stock are drilled into the media filled pots which then continue on to where the potter manually inserts plant stock. Potted plants are then automatically transferred onto a mechanical conveyor and delivered to the trailer or directly into the growing area. Insertion of plant stock can take place after media filled pots have been automatically transferred onto the mechanical conveyor.

Production notes

The models of Mayer potting machines investigated during the project had relatively small capacity internal hoppers (1 cubic metre) and consequently had to be re-filled regularly during the course of the day. The media loading process meant stopping potting production and the frequency with which media needed to be loaded increased with an increase in pot size. The narrow width and height of the internal hopper made using a wide bucket to load the media impractical. Mayer's were filled using cubic metre bags or boxes of media which were lifted above the hopper using a fork lift and then released or up ended.

Problems with pot jamming in the automatic pot dispenser were observed in Mayer potting machines. Mayer operators were observed to have difficulty adjusting the dispenser to eliminate the problem. It was not clear whether inability to solve the pot jamming problem was a reflection on operator knowledge or a lack of refinement in the dispenser adjustment mechanism.

5.3.7 Williams Hi Tec International potting machine

This potting machine is an Australian product. The machine observed during the potting project was the first commercial prototype. The machine is an automatic potting machine with speed control, automatic pot dispenser, automatic drilling and mechanical conveyor out. Customers will have the option of buying the complete machine or separate working elements of the machine (starting with hopper and automatic soil flow) according to their current budget and production needs. As a nursery grows or more capital becomes available to it, other elements can be purchased until the complete fully automatic machine is assembled.

Empty pots are released from an automatic pot dispenser in a series of 1,2 or 3 pots onto a carousel which carries pots under a continuous soil flow. Holes for insertion of plant stock are drilled into the media filled pots which then continue on to where the potter manually inserts plant stock. Potted plants are then automatically transferred onto a mechanical conveyor and delivered to the trailer or directly into the growing area. Insertion of plant stock can take place after media filled pots have been automatically transferred onto the mechanical conveyor.

Production notes

The WHTI potting machine can handle virtually any pot size the nursery wishes, by buying the appropriate pot dispenser template. The machine can be operated with 1 potter and 1 plant loader (putting down plants in the field may take extra staff depending on the nursery's organisation of potting tasks). The machine's unique pot dispensing system is able to cope with new pots, reused pots and pots with non standard shapes. No pot jams were observed while the WHTI was in operation.

6. Problems and solutions

The following tables show the problems and potential solutions recorded for nurseries participating in the project. Tables are arranged on the following basis:

- Plant stock
- Pots
- Media
- Fertiliser
- Potted plants
- Equipment
- Workers
- General issues

Note that the effectiveness of potential solutions for reducing potting labour costs will not be known until the project completes the implementation and evaluation of improvements stage.

Plant stock

Problems	Potential solutions
Inefficient materials handling – 3 – 4 potters working with one tray of stock on the bench results in constant walking to and fro for small quantities of stock	• Before potting begins split stock in trays into equal amounts for each potter • Each potter works from own full stock tray
Inefficient materials handling – Plant stock delivery into truck and out of truck to potting bench involves a lot of double handling, walking and low capacity carrying. (stock carried by hand into truck & from truck to general potting area, from general area to table in potting area and from there to pots on bench)	• Load stock to truck using industry standard trolleys (half pallet sized trolleys with adjustable shelves) • Unload stock from truck in trolleys which can be pushed directly to the potting bench
Potters repeatedly take from to 1-6 tubes of stock by hand from the stock on the trailer to the bench when potting	• Take whole tray of stock to bench • increase bench size or provide table to hold stock in trays between potters
Species difficult to remove from tray	• Assess quality of stock before potting begins and water if this will assist popping • Better coordination between propagation and potting (to ensure stock is not root bound)
Palms in 140mm pots were root bound and needed to be bashed on ground, against hard edge or stamped on to break and remove pot	• Review potting production schedule (pot palms earlier) • have special tool for cracking off pot
Rubbish from palms (broken pots, pruned plant material) are thrown to ground for later picking up	• Put rubbish straight to bin at potting station

Problems	Potential solutions
Time consuming manner of removing weeds from surface of plant stock	• Remove weeds in one action - wearing gloves would facilitate this technique
Quality of stock (too old) meant time spent trimming and pulling from tubes	• Better synchronisation of potting with propagation to avoid over mature stock
Plant stock brought on hand barrow (10 x 42 tubes/tray)	• Bring tube stock on ute to increase carrying capacity (convert roof & front hood into stock carrying area for example) • Provide potters with daily production information so they may select and bring stock in larger quantities
Cell trays brought from shade house by hand in very small quantities	• Bring tube stock in larger quantities from shade house (use multi-shelved trolley etc.)
Location of stock holding/growing area is some distance from Javo and involves walking through dispatch work area to access and return	• Relocate position of stock growing area to one nearer and more easily accessible to potting area
Plant stock delivered over a considerable distance in small quantities	• Locate stock growing area closer to potting area • Use large capacity equipment to deliver stock directly to Javo (eg. Multi shelved trolley) • Ensure person whose task it is to deliver stock has information on daily potting production to enable them to bring stock in large quantities
Tube stock is held on central bench which only holds 2 trays (20 x 75mm tubes per tray – trailer holds 55 x 200mm plants). Low capacity of stock bench means excessive walking for stock during potting.	• Increase capacity of stock holding bench (trial multi-shelved trolley for stock delivery and holding).
Javo only holds 200 tubes in central bench (Javo stops when potter goes for more stock)	• Use trolley to hold stock next to Javo • Increase capacity of Javo central bench • Use gravity conveyor to bring stock to Javo bench • Allocate task of delivering stock to Javo to trailer driver
Popping out stock needs to take place before production can begin and involves most of crew with 2 people continuing to be engaged full time once Javo starts.	• Pop all stock at Javo. Existing person at Javo pops as well as inserting. One of existing people popping out moves to Javo and inserts as well. Saving of 1 person.
Method of getting stock off trailer, popped and to Javo central bench very inefficient	• Streamline stock from trailer to Javo (gravity conveyor and work stations leading to Javo)
Plant stock moved from truck to potting area by hand	• Use high capacity trolley (multi- shelved) to carry stock in bulk when unloading truck delivering stock and when delivering stock to potting area
Popping stock before potting begins is time consuming and involves all potters	• Trial popping stock at Javo (ie. stock is ejected and inserted to pots as they travel on Javo)

Problems	Potential solutions
Plant stock was pruned before potting and then again after potting had finished	• Prune stock on one occasion either before or after potting has taken place
Plant stock delivered to potting area is placed on racks behind the potter and also onto the floor behind these racks. Stock placed on the floor takes up a large surface area in the potting shed and requires the potter to walk further to access it.	• Load all plant stock to racks behind the potter. If capacity of these racks is inadequate use multi shelved trolleys which can be wheeled to the trailer for stock loading and then returned to a position directly behind the potter.
Bench for holding stock is stationary and requires potter to walk distance for stock	• Put wheels on bench so stock can be positioned closer to Javo • Use gravity conveyor to feed stock into Javo

Pots

Problems	Potential solutions
Failure to mechanise potting task – Task of pot insertion to machine requires one full time person (with some extra help when second hand pots used)	• Make one person responsible for inserting pots and loading pots to trailer • Buy or make a pot dispenser
Stacking tubes on Comet made difficult due to lack of space (keep falling over)	• Dispose of tubes to bins at potters side without stacking
Inserting empty plant stock tubes to horizontal plastic bag difficult. Stacking tubes on bench before inserting to bag also time consuming.	• Review need to stack tubes • Provide each potter with tube bin/bag which could be filled with discarded loose tubes and emptied to main storage when full
Pots left in stacks approx 2 metres from hand potters and returned to in cycles of 5 pots (each tray of plants potted involved relatively long trip for new pots and stacking of old pots)	• Get pots in immediate potting area closer to potting bench using dispenser or under bench storage space
Very little room for pots (empty or full) on modified bench work area	• Redesign modified bench to increase width of bench available to work on
Frequent change of pot colours & sizes	• Pot in large batches of required pot size or colour • Know before pots are brought to potting bench/machine how many pots of each colour/size are needed
Old pots jammed and were difficult to prise apart	• Make pot stackers aware of difficulty, design tool for separating pots
Tube bulk bin full and potters needed to store empty tubes in other place	• Review delivery of tube & pots to storage and the emptying schedule of storage bins (provide equipment for storing and moving larger numbers of these materials)
Potters constantly taking pots from the point where they are stored on tractor	• Place pot holders along sides of trailer to reduce walking distance for empty pots

Problems	Potential solutions
Person loading pot dispenser unaware of how many pots of certain colour to stack up (on many occasions pots of certain colour were taken down from conveyor and returned to box because they were no longer needed)	• provide information to potters on how many pots of certain type are to be potted
Double handling in delivering empty pots to potting bench. Pots go from general storage area to immediate potting area to holding carousel to rotary table.	• Deliver box directly from storage to potting bench dispense to table directly from box. A frame could be designed to hold flaps of cardboard box open during dispensing or contents could be tipped out into holder.
Reused pots in stacks are brought from storage some distance away	• Locate pots closer to Comet and with access unhindered by dispatch production
Reused pots are jammed together and very difficult to separate because pot cleaners bang pots together	• Review current pot handling during cleaning and identify any practices that compress stacked pots (eg. storing stacks of pots vertically) • Train pot cleaners to handle stacks carefully to avoid jamming pots

Media

Problems	Potential solutions
Wet potting media clogs Javo and slows potting	• Improve control of moisture content of potting media • Build roof over media pile
Mixing own media may not be as economical as appears (increased down time in potting, mixing time, lack of concentration during media mixing affects resulting media mix)	• Time the media mixing process and non productive time during the process (time wasted by staff as they wait for potting to recommence) to calculate overall cost in wages of media mixing and compare this against the additional cost of buying media with fertiliser pre-mixed
Media full of large solid lumps of soil	• Review mixing procedure or buy pre-mixed potting media
Media mixing is time consuming as it involves dropping bucket of media into mini hopper mounted on conveyor feeding concrete mixer truck, person required to push media through hopper and up conveyor by hand.	• Buy pre-mixed media with fertiliser • Trial use of fertiliser tablets inserted to pot during potting or when plants in field • Apply fertiliser to (surface of) potted plants in growing area using fertiliser dispenser • Design mixing station with hopper above truck height that can still be accessed by tractor • use larger ground hopper with conveyor into mixer to deliver media and fertiliser

Problems	Potential solutions
Present method of mixing fertiliser and media may be adequate for small pot sizes (eg. 140mm) where the large number of pots produced from a mixing batch of media is high, but when potting to larger pots (eg. 200mm) the same mixing process produces many fewer pots (up to one third the amount of 140mm pots).	• When potting to larger pot sizes apply fertiliser to pots by hand at the potting bench rather than mixing media and fertiliser using the tractor and concrete mixer
Media sticks in hopper slowing soil flow	• Reduce moisture content of potting media (protect media from rain) • Improve hopper design • Have suitable tools on hand to free obstructed flow
Loading media to potting bench involved 2 people (1 drove & 1 guided driver and used hands to pat down media in bucket), a time consuming and potentially dangerous practice	• Use one person to load media (allocate productive task to second person) • Train staff to competently & individually load media to bench
Shovel used to move media forward on bench. Preferred tool (rake) was sometimes used but the head was too small for the media quantities involved and length of the rake handle caused difficulties	• Provide short-handled large-headed hoe for this task
Potting media is open to the weather and media with high moisture content could clog the hopper and machine reducing potting productivity	• Control moisture content of potting media • Build roof for outside media storage area • Build (retractable) roof for hopper which is partially exposed to the sky
Media pile considerable distance from potting bench. Media loading to bench is made difficult by the confines of the potting area. Fumes from the bob cat loader hang in the confines of the potting area after media loading	• Locate media closer to potting bench • Locate potting bench closer to outside wall of potting shed (will involve structural modifications) where loading can take place without need for machinery to enter potters work area
Media pile dumped in doorway of potting shed means potting has to occur in the sun (need to clear media for doors to shut)	• Always dump media in such a way to allow potting to take place out of the weather
When potting 140mm pots, media shovelled from pile dropped by media producers to potting bench (this was beyond the strength capability of female potter)	• Design hopper which can be loaded straight from media truck • Get ergonomic shovels • Get bucket on tractor for media loading
Media on floor spreads over potting shed during potting requiring periodic cleaning and making standing at potting bench uncomfortable	• Confine media to hopper, box frame etc. • Provide raised platform with rubber matting for potters to stand on while working at potting bench
Loading of media to mobile bench made difficult by absence of side walls on trailer. Media continually spills off during loading.	• Fit (hinged) side to trailer to speed media loading

Fertiliser

Problems	Potential solutions
Hand placing of fertiliser to pot surface (not often done in potting – usually top-dress is partway through growing cycle) appears wasteful with considerable fertiliser spilling out of pot onto ground	• Buy pre-mixed media or dibble on fertiliser if this is a viable option to save labour time dispensing and save money on spillage of fertiliser. Can avoid using fertiliser in some instances (fertigation).
Potter left side of Comet has to reach across his body for fertiliser and pots while potter on right side of Comet can get fertiliser and pots with right hand	• Move left side person's fertiliser and pots to centre of comet grate • Ensure left handed potters go to left side of Comet • Attach shelf on Comet face to hold fertiliser and pots for right handed potter standing on left hand side of Comet

Potted plants

Problems	Potential solutions
Unloading pots to field takes 2 people. Travel time to and from growing area is non productive for second person	• Provide enough stock, trailers, etc. to enable 1 person to keep potting when putting down occurs
Potter pays excessive attention to arranging pots on the trailer	• Reduce time loading trailer by instructing potters to be less concerned with maximising pot capacity of trailer by fiddling with pots
Writing on each pot by hand to define species is time consuming	• Use indelible coloured marker etc. to quickly mark pot for differentiating between plant types
Writing species name (type) on pots when they are already loaded on the trailer is time consuming	• Write names when potted plants on bench • Write on empty pots before media filling • Use indelible coloured marker to speed process of plant marking
After potting, 1 potter waters in plants and other potter is largely unoccupied	• Allocate productive task to person not watering (eg. filling pots, preparing growing area) • Trial system where one person keeps potting while other puts down plants in growing area
When loading potted plants, potters each walk some distance from potting bench ute to load several plants	• Position ute and bench closer together to reduce walking distance during loading
When conveyors out are full (ie. trailer not back from putting down plants), potters have nowhere to put full trays of potted plants	• Improve coordination between tasks • Provide an extra trailer in the potting area so that potted plants can be loaded when other trailer(s) still in the field
Potted plants in trays on out conveyor are loaded length ways but this is space consuming and trays need to be turned side on by potters to increase available space when waiting for the trailer to arrive and take plants	• This is a design oversight caused by too narrow width between hoppers. Make an extra trailer available in the potting area to allow loading of plants when other trailer(s) still in the field

Problems	Potential solutions
Potters wait several seconds to load to conveyor to ensure person unloading has an interval to put down pots before next 4 pots arrive	• Use pot lifter to put down pots (this will speed process of putting down and make the job less tiring) • Adopt new processing system from truck to conveyor that allows a continuous output of pots to the conveyor (not the current batches of 4 pots)
Unloading pots from conveyor requires low bending	• Use pot lifters (designed for spaced or pot to pot) to remove pots from conveyor and place on ground
The current method of processing pots means that the person putting down pots in the growing area is not fully occupied	• Streamline current potting process to increase output and thereby keep person putting down fully occupied
Loading growing bay from front to back makes walking into bay more and more difficult as pots are put down in bay	• Put potted plants to growing bay from back of bay to the front of the bay
Carrying pots into growing area was observed to take place in quantities of 4,7 & 8 x 140mm pots by 3 different potters	• Load potted plants at ute to plastic tray, carry plastic tray into field, unload pots, return to ute with empty tray • Attach gravity conveyor to ute which can be swung into growing area, pot to tray on ute, place full tray onto gravity conveyor, when conveyor full walk into growing area and unload pots from trays to the ground, collect trays and return to ute • use pot lifter to carry pots into growing area
Small capacity of carts to used to take plants to field. This increases travelling time required to and from field	• Increase capacity of carts (detachable extra tiers, trailers, etc.)
When unloading pots in field, the length of the growing bay (21m) and not driving trailer into growing bay means unloading very time consuming. Hand barrow used to transport trays from trailer into bay has low capacity.	• Increase bay width (possibly road width) to allow trailer to be driven into bay • increase capacity of hand barrow • use conveyor to carry pots in trays from trailer into field (would require person in field at all times unloading trays from conveyor, spacing pots from trays, collecting trays)
Internal road badly rutted in places slowing tractor delivering plants to field	• Improve irrigation pattern to reduce run off • Increase capacity of drains
Person putting plants down often unoccupied while waiting for trailer to be filled	• Allocate productive tasks to waiting staff • Improve the coordination of tasks to reduce non-productive time
Loading pots to trailer during potting (potter executes 180 degree turn x 2 every 4 pots 140mm)	• Move tube stock to side of each potter and use centre conveyor to load trailer

Equipment

Problems	Potential solutions
Continual problem of pots jamming in pot dispenser and sweep arm crunching or toppling pots when pushing them onto conveyor	• Analyse cause of pot jamming problems with Mayer and ensure all potting staff know how to identify and fix machine malfunctions
Crushed pots fell into hopper and jammed in media outflow resulting in uneven pot filling	• Remove pots from mouth of hopper periodically • Fix dispenser problems
Too much potting media in pots contributes to dirty pots and excess soil build up around carousel of Mayer	• Modify auger to also displace some soil from the pot • Reduce the flow of media from hopper to pots • Improve self cleaning equipment on Mayer (mounted brushes, rubber soil levellers etc.)
Undoing the knot under the full media bag to release media is difficult as the weight of the media presses against the knot	• Supply long nose pliers etc. to help with undoing knot • Adopt different fastening system (eg. side flap released by removing 2 lengths of pvc) • Have supplier deliver media in open wooden boxes
Conveyor on stands and made of 5 sections which are heavy to lift and require several people to move	• Investigate using collapsible wheel mounted conveyor for delivery of plants to growing area
Continual problem: arm designed to sweep pots from Mayer onto conveyor crunching or toppling pots. Machine operator unable to satisfactorily fix problem	• Analyse problems with Mayer and ensure all potting staff know how to diagnose and fix machine malfunctions
Low capacity of carts 11 x 18 (100mm) means travelling time from potting area to growing area is considerable	• Increase cart capacity (attachable extra tiers etc.)
No tool handy to free potting media in hopper	• Get rubber mallet, short handled hoe for media release
Machine down time due to lack of materials (media, pots, trailers, etc)	• Better synchronisation of inputs necessary to maintain potting production
Failure to mechanise certain tasks in machine potting (eg. Fertiliser dispensing, pot dispensing, unloading pots to trailer)	• Utilise mechanical solutions to carry out machine potting tasks where possible
Potting machine malfunction due to poor maintenance	• Carry out periodic machine maintenance

Problems	Potential solutions
Workers unsure how to accurately adjust machine to cope with malfunctions arising from different pot sizes, media consistencies, etc.	• Obtain instructions on adjusting machine (from manufacturer or through in house experimentation) and ensure all workers receive training in all facets of machine operation • Isolate the cause of the malfunction occurring (is it the type or condition of the pots or media used, a damaged element on the machine, etc.) and attempt to fix the root problem.
Lack of trailers for potting when dispatch production in operation	• Obtain more trailers to allow both production processes to operate at the same time • Do not use trailers to hold plant stock
Opening plastic pot bag with secateurs proved difficult. Secateurs were unable to be located on one occasion	• Have Stanley knife etc. permanently on the empty pot bench for this task
Potting bench is sagging badly and appears as if it could collapse	• Replace or repair potting bench
Chairs used to pot at lower tier of trailer broken and difficult to move along length of trailer (wheels catch on media & gravel on ground)	• Fix, replace, modify chairs to allow easier use (attach bigger wheels to travel over media on ground)
Full trailer pushed to tractor after loading rather than bringing tractor to trailer (difficulty stopping trailer's momentum when arriving at coupling point)	• Bring tractor to trailer not vice versa
Some conveyor rollers stick and hold up delivery of full trays to trailer	• Fix or replace sticking rollers
Available work space at rear of mobile hopper and on potting table is inadequate and results in slowed production as pot fillers stop when no more space available to stand media filled pots	• Redesign (enlarge) and reorientate work stations to provide more room for placement of pots
Conveyor is heavy and difficult to move and set up in igloos	• Redesign bench layout in igloos to facilitate easy delivery and assembly of conveyor in igloos • Add wheels (& adjustable legs) to conveyor
Conveyor requires someone at potting end to control on/off for person putting down (this involves potter stopping production walking up to several metres to conveyor and switching it on or off)	• Have conveyor controls accessible to person putting down and person potting at trailer (foot operated on/off switch) • Have conveyor situated as close as possible to potter working at trailer
Conveyor set up at rear of trailer and as potters use up media on the trailer, the distance potters walk to load pots to conveyor increases	• Drive trailer so that conveyor ends in the middle of the long side of trailer. Each potter stands on either side of conveyor and loads pots directly to conveyor. When media is finished on one side, drive trailer out, turn it around and bring other side of trailer next to conveyor

Problems	Potential solutions
Wire trays catch on each other and edges of trailer adding time to trailer loading and unloading	• Use plastic trays capable of holding 12 x 150mm pots
Empty trays are returned haphazardly to trailer in growing area by people putting down plants necessitating rearrangement of trays before plants can be loaded from Javo	• Instruct staff putting down plants to arrange empty trays on trailer ready to accept potted plants
Current set up of machine and hopper in the shed leads to problems when delivering pots, media, stock, etc.	• Model or trial different placement of Javo, hopper, trailer loading area, stock handling area, etc. to reduce material handling time
Trailer mesh base lifting in places and catching pots, rail of trailer broken and poses risk to plant loaders & unloaders	• Repair unsafe aspects of trailers
Shovel for hopper clearing placed against hopper after use where it fell onto potter	• Make holder for shovel at hopper
During media loading tractor bucket comes close to head of potters, dust generated by hopper loading blows across Javo	• Move potters back when media loaded, build solid board between potters and hopper to reduce dust and danger of being struck by bucket

Workers

Problems	Potential solutions
Potters do not wear gloves and face masks while potting or when in the immediate vicinity of potting media	• Educate potters to dangers of unprotected handling of potting media • Provide potters with gloves and face masks
Pre-emergent herbicide shaken onto ground immediately prior to potting means potter inhales herbicide each time he bends to place pots on ground (eg. Potter put down 507 pots which is 63 low bending and breathing-in actions over herbicide in 100 minutes)	• Apply herbicide some time after potting has finished or well before potting is scheduled to take place (ie days before) • Wear masks when potting
Potter has no matting to reduce leg fatigue	• Provide ergonomic matting for potter
Potter stands on slight incline (for drainage) on path	• Provide adjustable platform for standing potter
Potter stands in water from irrigation	• Design platform so water can flow under it
Person putting down plants is quite tall and has to bend very low to place pots on ground	• Design pot lifter for putting down plant from conveyor to ground
Potter unsure of procedures (which stock to pot, where to put down potted plants, etc.) and spent time seeking information from supervisor	• Give potter more responsibility / training / information necessary to make decisions without seeking assistance

Problems	Potential solutions
Barely enough room for 3 people to operate (2 potting 1 loading pots to trailer) in space between bench and trailer	• Relocate bench so that trailer is not behind but to the side of the bench giving potters more room to operate • Move trailer slightly further from bench (or hopper further from trailer) • Pot to trays and use gravity conveyor to take trays to trailer
Potters heads are close up against the side of hopper making it difficult to work	• Redesign modified bench to give potters more work space away from front of hopper
Failure to wear gloves & masks when applying pre-emergence herbicides	• Educate workers to the risk of unprotected handling of herbicides • Follow handling guidelines on product packaging • Provide gloves & masks • Apply herbicides well away from unprotected workers
Failure to wear ear protection when working at noisy machines	• Make ear plugs available for staff
Stringline pegs protrude from ground and are potentially hazardous to workers in growing area	• Use pipe set into ground at ground level (attach spike to string line for insertion to ground level pipe) rather than protruding pipes to anchor string lines (pipes were not observed being used to guide hose)
Working in the wind, rain or sun without adequate protection	• Provide (mobile) structures to protect workers from the weather • Encourage workers to take precautions against the sun (provide sun screen, hats, water)
Potters stand for long periods on hard, uneven or wet surfaces	• Supply rubber matting for stationary workers • Trial ergonomic furniture for certain potting tasks (eg. chairs, sit stands, foot rests) • Ensure ground in the work area is dry & level
Potting speed varies greatly between potters (faster potter can produce nearly twice the amount of the slower potter in same time)	• Review work methods of slower potter • Use faster potter to train slower potter • Discuss and introduce daily productivity targets and provide training to ensure all potters can meet targets
Trailer driver bare headed for lengthy period on an extremely hot, sunny day	• Instruct all staff to use sun protection
Ground at bench uneven, one potter stands on ground, other on platform made of wooden pallet	• Level out ground and provide rubber matting for potters
Shovel used for moving media on bench (shovel not intended to be used in horizontal plane)	• Use rake or large headed hoe for soil moving
Media dust blows into face of potters when tractor loads media to bench. Tractor bucket comes close to potters	• Media loader should instruct potters to stand aside when media loading under way

Problems	Potential solutions
Filling 200mm pots by person on knees (kneepads worn) carries potential for back injury	• Pot on a raised surface with cushioned matting to reduce leg fatigue • Fill pots on ground with shovel (some brace to hold them in place on the ground may be required) then load them to trailer for inserting plant stock
Potter has to walk in mud when pushing rolling bench to potting area and into growing area	• Seal ground around rolling benches to provide better working conditions for potter
The female staff member did the majority of heavy work when potting into 250mm (lifting 200mm from trailer to bench, popping 200mm, lifting 200mm plug to 250mm pot, filling 250mm pot with media, lifting 250mm pot and dropping to compress media, pushing 250mm pot across bench to 2nd potter (who trims and stakes and loads to trailer)	• Rotate tasks between staff members on a more frequent basis when dealing with larger pot sizes • Investigate reducing potting mix weight eg. Sandless mixes (where applicable)

General issues

Problems	Potential solutions
Assumption by management that slow potting is the price for producing high quality plants	• Observe potting in progress and notice how the problems listed by researchers are being caused by production inefficiency and not through extra attention to plant quality. If quality is affected at all in potting it would be in the relatively brief task of placing the plant in the pot whereas the handling of inputs and outputs is either efficient or inefficient and has no impact on plant quality
Watering takes place some distance from potting area. This adds to the time it takes to put plants down in the growing area and increases the likelihood of problems coordinating potting production with the arrival of an empty trailer	• Water plants in the plant loading area using a watering tunnel etc. so that when trailers were fully loaded they could be taken immediately to the growing area (drainage would have to be installed in the trailer loading area)
Potting stops when watering and putting down plants is carried out. During watering- in plants and travelling to growing area and from growing area, second person's time is completely non productive	• Trial productivity gain of using 1 person to put down while second continues to pot (this task could easily be carried out by one person)
The metal post in the area where trailers are parked for plant loading is an obstacle to the person loading plants and means trailers can not be parked as close as possible to machine	• Remove, relocate post to enable better access for plant loading
Procedure for setting up stringline over-elaborate and time consuming	• Permanently mark matting in growing areas to enable person putting down plants to place plants in straight rows by sight

Problems	Potential solutions
Work space on bench is severely restricted by potting media, difficult to position tray of stock on media pile, potted plants are placed on floor during potting and then picked up and loaded to ute which increases walking distance for pot loading	• Place pots on ground near media, shovel media into pots, load pots to ute, insert stock to media filled pots on ute • Park ute directly behind bench so that potted plants can be loaded as they are potted
Pruning takes place after potting despite difficulty holding long stems during potting	• Prune lanky stock before potting
Large difference in the productivity of individual potters - Potters develop and use different potting methods. The nursery preferred batch production method was not the quickest method observed. Most productive potter believes continuous production method provides a better working rhythm	• Review batch versus continuous potting at your nursery (see 4.2.2 Potting techniques) • Use faster potters to train others in technique and work station organisation • Establish reasonable production targets for potters
Inefficient materials handling – Potting materials run out during potting session (stock, fertiliser, pots, etc.)	• Better utilise storage space available on tractor and on underside of trailer to store potting materials required for a significant period of potting • Provide information to potters on quantities to be potted so they can load sufficient quantity of inputs required for potting before travelling to potting area.
Trailers in loading aisle need to be manhandled to move around post (conveyor support post juts too far into trailer's path)	• Move central pole protecting conveying edge out of trailer path
Pots knocked over pulling heavy hose through bays	• review hose dragging method • increase number of taps in growing area • insert pulleys at ends of paths to guide hose
Frequent down time due to change of trailer & rotation of potting crew	• Reduce crew changes. Change crew on daily or after lunch basis • Change layout to allow 2 trailers to dock at once
Access to materials in potting area hindered by posts, height of ceiling (in case of media loading to hopper), etc.	• Reposition posts, increase height of roof at hopper, etc., to allow better access to potting materials
Nursery has 5 people to operate Javo which seems excessive. Other nurseries with similar production styles use only 2, 3 or 4 to operate Javo.	• Seek to reduce staff numbers by reallocating tasks (Eg. allocate position of compressing media in pot to plant stock inserters) • Slow operating speed of Javo to enable reduced number of staff to cope with tasks (small decrease in overall productivity will be made up for in reduced overall labour cost)
Matting in growing area was flapping in wind requiring plant unloader to spend time securing before plants could be put down	• Ensure growing area prepared for pots before potting production begins

Problems	Potential solutions
Lack of space and staff for potting production when dispatch is operating	• Reorganise staffing levels (review task allocation in dispatch to ascertain if current staff numbers are justified) and reorganise the location of potting materials to allow dispatch and potting production to run at the same time
Lack of production coordination between propagation, potting, dispatch negatively affects potting productivity (old stock from propagation difficult to remove from tubes, potting production secondary to dispatch work)	• Review and improve coordination between potting production and plant stock growing. Arrange staff and equipment to enable some potting production to continue even when urgent dispatch work is being carried out
Access to potting media is via dispatch area which can cause delays in bringing media to Comet	• Review and reorganise layout in shed to allow better access to potting materials and dispatch materials when both production processes are running

7. Creating the optimum potting system for your nursery

It is impossible to design one optimum potting system which would be suitable for every nursery. Each nursery needs to define their best operating conditions on the basis of circumstances at their nursery.

7.1 Potting Optimisation Factors

Research has found that optimisation factors exist in potting which should be taken into consideration when a potting system is created. The optimum system will be created when -

The worker has

- a safe and comfortable working environment
- sound work motivation
- good work skills

Plant stock is used so that

- the development of roots and foliage is in the prime potting stage
- the quantity to be potted per event is maximised
- the number of species to be potted per event is minimised

Containers are used so that

- the number of types of propagation container used is minimised
- the number of sizes, types and colours of potting containers used is minimised
- the ratio of propagation container size to potting container size is approximately greater than 0.5 (eg. 50mm tube to 100mm pot)

Potting procedures and treatments occur so that

- manual placement of fertiliser into pot is minimised
- quantities of plants watered in one event is maximised
- quantities of plants pruned in one event is maximised
- quantities of plants receiving application of herbicide is maximised

Potting system operates so that

- work station design reflects nursery's average potting production requirements
- potting area location is central to growing area
- distances between potting area and input storage are minimised
- coordination of potting tasks within potting system is self governing
- quantities of potting inputs and outputs handled at one time (eg. empty pots, potted plants) are maximised

Machine operating speed is adjusted so that

- the ratio of operating speed to the number of staff involved minimises non-productive time

Communication follows a

- clear and rapid system providing all production information to potters

Potting technique

- based on the techniques of workers with best production rates is applied in production

Most of the above optimisation factors are known and can be applied immediately to potting systems, however some factors, eg. ratio of potting machine operating speed to number of staff, coordination of potting tasks, etc., can only be defined through experimentation in individual potting systems.

7.2 Potting Systems

At this stage the project is able to give advice on which type of potting (hand potting method or machine potting method) best suits certain production parameters.
In general terms hand potting is more suitable for nurseries when:

- average daily quantities of potted plants during the potting season is approx. 1000 or less, and/or
- average batch sizes of plants requiring different treatments, procedures, pot sizes, pot colours, or of plant types that are in clearly different categories of potting difficulty, is below approx. 300

If the average batch size of plants requiring different treatments is below approx. 300 but the daily quantity potted is much greater than 1000, then generally it will still be more efficient to increase potting staff rather than use machine potting. This is assuming that the potting machine has not been specifically designed to cope with variable potting requirements.

Assuming that the optimisation factors listed above have been taken into account, in all other cases machine potting systems should be more suitable and more efficient than hand potting.

The following descriptions of the potting systems investigated in the project included brief description of the set up at nurseries in each of the systems that returned the lowest potting labour cost per pot. By reading these descriptions and matching which nurseries are closest to your own production profile you will gain some insight into which potting systems are being used to advantage.

7.2.1 Standard bench

Standard bench potting is most commonly carried out in small nurseries. Larger nurseries generally use potting machines for the bulk of their production but also usually have an area set aside for hand potting plants into large sized pots or for potting plants that are difficult to remove from the propagation container and/or take a significant time to insert into the pot.

Standard bench potting appears to be a suitable option for small nurseries with comparatively low annual production, with limited equipment budgets and where the majority of production involves difficult to pot plants or where production is characterised by large pot sizes (175mm and up), small quantities of pots (approximately 1000 pots per day during potting season) in small pot sizes (100mm to 140mm) or small batches of plants to be potted in differing pot sizes.

Success story

The lowest average total potting cost of all nurseries investigated was for a medium sized nursery using 2 potters to produce 100mm pots in a standard bench system. The average total potting labour cost at this nursery was 3.1 cents per 100mm pot (see figure 7). The factors which helped this nursery achieve such low labour costs using a standard bench potting system were:

- Very good materials handling (high capacity trailer for delivering plants to the growing area, ample work space on bench, large media holding capacity of bench, fertiliser pre-mixed into media, anti-fatigue matting on floor at bench, close proximity of empty pots, plant stock and water)

- Potters possessed efficient potting techniques and were well motivated

7.2.2 Modified bench

Most of the production guidelines for using the standard bench apply also to the modified bench system. If the design of the modified bench is otherwise suitable (hopper flows well, adequate work space is available), the materials handling improvements such as mechanical media flow and the use of roller conveyors, should assist in improving the efficiency of materials handling over that of a standard bench system.

Success story

The lowest average total potting cost among nurseries using a modified bench was at a nursery using 3 potters to produce 100mm pots. The average total potting cost was 5.53 cents per pot (see figure 7).

The factors which helped this nursery achieve such low labour costs using a modified bench potting system were:

- thorough potting production information was available to potters at the beginning of the day allowing delivery of necessary inputs in large volumes (plant stock, media, empty pots, etc.)

- very good materials handling (large capacity hopper, large capacity plant stock racks in close proximity to potting bench, bulk bags for old tubes, bulk bags for empty pots, adequate room on potting bench for potting to take place, anti-fatigue matting, potted plants loaded to trays at bench, conveyors taking potted plants to trailer, potted plants put down in trays in growing area, plants watered-in after placed down in growing area (reduces carrying weight), use of a media hopper with foot controlled mechanical flow to counter bridging).

- Potters possessed efficient potting techniques and were well motivated

7.2.3 Mobile bench

Mobile bench systems are still based on hand potting so the production profile suggested for standard bench and modified bench potting systems applies here also. Nurseries with large travelling distances from a fixed potting area to the growing area, or nurseries which for some reason find it difficult to continually travel from a fixed potting area to the growing area (eg. lack of staff, lack of equipment, poor condition of internal roads, etc) may find a mobile bench system a good option for streamlining their potting process.

Success story

The lowest average total potting cost among nurseries using a mobile bench was at a nursery using from 1 to 3 potters to produce 140mm pots. The average total potting cost was 6.35 cents per pot (see figure 7). This nursery used an open trailer towed behind a tractor and a portable electrical conveyor to deliver potted plants from the trailer/potting bench directly into the growing area.

The factors which helped this nursery achieve such low labour costs using a mobile bench potting system were:

- Good materials handling (mobile bench could hold all potting materials required, conveyor into field reduced potted plant handling time)

- Potters possessed efficient potting techniques and were well motivated

7.2.4 Comet

As the Comet requires only minimal adjustment to cope with different pot sizes it is well suited for nurseries with a large range of pot sizes. It is doubtful whether a Comet is any quicker than the hand potting systems (ie. standard bench, modified bench, mobile bench) when it comes to filling small pots (eg. 100mm – 140mm). In real terms the Comet potting machine's contained continuous flow of media helps keeps the potting area clean and reduces potter fatigue.

Success story

The lowest average total potting cost for Comet systems was a nursery using 3 people (2 potting, 1 selecting plant stock) to produce 125mm pots. The total potting labour cost at this nursery was 6.56 cents per pot (see figure 7).

The factor which helped this nursery achieve such low labour costs using a Comet potting system was:

- Good materials handling
- Potters possessed efficient potting techniques and were well motivated

7.2.5 Javo

Most nurseries using Javos were large nurseries (ie. over 15 staff) and/or had comparatively large annual production to justify the expenditure required for a new machine. As there are numbers of older Javos available second hand, smaller nurseries (ie. without large equipment budgets) could still benefit from Javo machines. Most nurseries using Javos also tended to pot large quantities of plants into a limited range of pot sizes.

There is no reason why small nurseries cannot benefit from using Javo potting machines. One of the lowest average total potting labour costs (6 cents per 150mm pot) was found at a small nursery using 3 people (1 inserting plant stock, 1 loading potted plants to trailer, 1 transporting potted plants to growing area) to operate a Javo potting machine to produce all of their 150mm and 200mm potted plants.

Success story

The lowest average total potting cost among nurseries using a Javo was at a nursery using 6 people to produce 150mm pots. The average total potting cost was 4.3 cents per pot (see figure 7). The nursery used a super Javo machine with automatic pot dispenser and conveyor delivering potted plants to the trailer. (1person inserted stock to media filled pots at the Javo, 1 person loaded potted plants to the trailer, 1 person kept up quantities of pots and media, 1 person drove the trailer to the growing area, 2 people put down plants in the growing area). The factors which helped this nursery achieve such low labour costs using a Javo potting machine system were:

- Good materials handling (conveyor delivering potted plants to the trailer, potted plants loaded to the trailer in trays, potted plants carried into growing area in trays, large capacity pot dispenser, large capacity racks for plant stock, close proximity of most potting materials to Javo)
- Plant stock potted was easy to eject and insert to pot
- Potters possessed efficient potting techniques and were well motivated

7.2.6 Mayer

The 2 nurseries investigated which used Mayer potting machines were both large scale nurseries. The Mayers were relatively small machines (hopper capacity) and easy to move and position. This allowed for mobile potting in the growing area and reduced the time needed for potted plant handling. The limited internal hopper capacity of the Mayer would seem to make it more suitable for small sized pots unless hopper capacity was increased with an external hopper or larger machine model.

Success story

The lowest average total potting cost among nurseries using a Mayer was at a nursery using 3 people to produce 100mm pots. The average total potting cost was 3.99 cents per pot (see figure 7). The nursery used a Mayer with automatic pot dispenser and conveyor delivering potted plants into the growing area. (1person inserted stock to media filled pots at the Mayer, 1 person unloaded potted plants into the growing area, 1 person kept up quantities of pots and media). The factors which helped this nursery achieve such low labour costs using a Mayer potting machine system were:

- Potting in the growing area and using a conveyor to deliver potted plants directly to the growing area kept potted plant handling to a minimum
- Plant stock was easy to eject and insert to media filled pots
- Good materials handling (close proximity of large quantities of empty pots, plant stock, potting media)
- Potters possessed efficient potting techniques and were well motivated

7.2.7 Williams Hi Tec International potting machine

As the WHTI machine is a new potting machine there is no opportunity to purchase cheaper second hand machines as is often the case with Comets and Javos. Therefore the WHTI machine would be suitable for any nursery with comparatively high annual production and/or the necessary budget to buy new equipment. The unique modular assembly of the machine does however also make it an attractive option for nurseries interested in buying the machine in stages as their production figures and equipment budgets increase.

Success story

Only one nursery currently uses the WHTI machine. The machine was trialed using various combinations of workers. The minimum combination being 3 people (1 person inserting stock, 1 person loading potted plants to the trailer and 1 person taking potted plants to the field). The average total cost of potting was 5.13 cents per 140mm pot (see figure 7). The factors which helped this nursery achieve such low labour costs using a WHTI potting machine system were:

- Good materials handling (large capacity hopper with mechanical feed to potting machine, close proximity of potting materials to potting machine, large capacity trailers for delivering potted plants to growing area)

- Potters possessed efficient potting techniques and were well motivated

8. Changing a system to reduce labour costs

It is quite certain that any nursery, irrespective of how low its current potting labour costs are, could reduce its costs further by improving some element of production. However, whenever a change in production methods is considered a decision must be made as to whether the expected benefit from the improvement in productivity will be greater than the cost of implementation. The way a nursery operates is shaped by many factors such as market demand for product, budget limits, geographical factors, staff numbers, staff training, the experience and beliefs of nursery management, etc. Whenever a change in production methods is proposed it is important that all these factors are taken into consideration.

At present many procedures carried out during potting are based on 'commonly held beliefs' or experience and have not been scientifically tested. Examples of procedures which vary from nursery to nursery and have not been tested are selecting potting media, pot size used, placement of fertiliser in the potted plant, method of watering-in the potted plant and spacing the plant in the growing area.

In order to achieve minimum potting labour costs, nurseries need to research scientific literature on potting procedures (eg. fertiliser placement, watering-in requirements, etc.) or carry out their own experiments to find out whether the potting procedures they follow are relevant and whether different procedures can be used to reduce labour costs while still achieving plant quality levels.

Nursery management will benefit by seeking input from potting staff when considering introducing changes to production. Staff have a working knowledge of current procedures and are the ones who will be working in the modified production system. When a significant change to production is introduced it is important to give staff adequate training in the new system and time to get used to new arrangements before carrying out any new evaluation of the labour costs.

Appendixes A, B, C and D provide information on methods of evaluating potting systems which can help nurseries:

- identify problems and potential areas for improvement in their systems
- calculate their potting costs on a cents per pot basis
- calculate the cost benefit of introducing improvements to their potting systems
- re-evaluate the effectiveness and benefit of any improvements made

The Centre for Amenity and Environmental Horticulture in Cleveland, Brisbane provides a consultancy service for nurseries interested in improving their production efficiency in the areas of plant dispatch and/or plant potting systems. For a free quote on the evaluation of an existing production system or the design of a new production system contact Dr. S. Underhill on (07) 3286 1488.

9. General project conclusions

From the investigation and analysis of potting data results from the 35 participating nurseries, the following general conclusions regarding labour costs in potting can made:

- A great difference exists in potting efficiency between nurseries which is mostly caused by the use of an inappropriate potting method and/or the inefficient organisation of potting procedures

- All potting systems can be similarly efficient assuming that they are appropriate for the nursery concerned and are well organised

- Nurseries tend to over staff their potting production crews rather than attempt to streamline potting procedures to eliminate non-productive time through such strategies as the better distribution of tasks between potting staff and better organisation of potting inputs and outputs

- Potted plant handling is commonly the most costly element in the potting operation

- Potting large batches of the same plant are more efficient than potting the same quantity of plants made up of a number of plants with different potting requirements

- The cost of potting increases with an increase in pot size but the relative cost (labour cost related to the plant sales price) is lower for larger pots (based on one potting event ie. potted directly from propagation container to pot plant is sold in)

- Altering standard pot designs for marketing purposes (using various pot colours, pot shapes, etc.) can increase the cost of potting

- Worker comfort is often overlooked as a contributing factor to low production efficiency

- High worker motivation is a recurring feature at all nurseries with low total potting labour costs

- Failure to address worker safety issues in potting can lead to a reduction in long-term production efficiency

- Inadequate research into the affect of potting procedures on plant growth has lead to a variety of methods being used to pot the same types of plants

The general conclusion is that potting costs could be reduced immediately in most nurseries when basic production problems are addressed.

10. General project recommendations

From the investigation and analysis of potting data results from the 35 participating nurseries, the following general recommendations for improving potting production efficiency can be made:

Worker issues

- Maintain high levels of worker health and safety, worker comfort, worker motivation and worker skill
- Ensure all staff are competent to (a) operate the potting machine and (b) make any adjustments to the machine necessary to cope with situations that may arise during production
- Follow safety guidelines when potting - always wear gloves and face masks when handling or working around potting media (Steele 1996) and always follow safe handling guidelines for herbicides used during the potting process
- Allocate tasks to staff taking into consideration their ability in performing different potting tasks

Organisation and potting procedures

- Hand potting should be used when the average daily quantities of plants to be potted (during the potting season) is approximately 1000 plants or less and/or when the nursery is potting a larger number of different species requiring different treatments in various pot sizes, pot colours, and the average batch size of these plants requiring different treatments is approx. 300 or below
- Improvements to the handling of potted plants should be investigated as a first priority as this offers the greatest potential savings
- Ensure workers have all the information necessary to carry out potting production before production commences
- Analyse the allocation of tasks within the potting process to improve the distribution of productive tasks between workers and thereby reduce non-productive time
- Analyse the sequence and coordination of the delivery of inputs and the removal of outputs to reduce non-productive time

Improvements to the potting system

- Establish the existing amount of total potting labour costs in cents per pot
- Identify problems related to potting systems, procedures and worker issues

- Establish cost/benefits of potential improvements
- Introduce most beneficial changes
- Re-evaluate potting system.

General recommendation is to increase the average daily number of plants to be potted that have similar requirements with regard to treatments, potting procedures, pot sizes, pot colours. This strategy will immediately lower potting labour costs without any expenditure.

11. Appendixes

The appendixes contain forms which can be used to evaluate potting production efficiency and potting labour costs per pot at your nursery.

It is suggested that the following sequence be used when evaluating production efficiency at a nursery:

1. Carry out a rapid diagnosis of potting production efficiency using the form in appendix A

2. Calculate your total cost of potting in cents per pot using the potting cost form in appendix B

3. Use the evaluation form in appendix C to identify and score the efficiency of various aspects of potting production at your nursery.

4. Calculate the cost benefit of improving elements of your potting system (QDPI will calculate this for your free of charge).

5. Use the results from A,B, C and D to develop a written plan for reducing potting labour costs at the nursery.

A. Rapid diagnosis of potting production efficiency

The following checklist can be used to carry out a rapid diagnosis of any potting production system. Observe potting production in progress and place a tick in either the YES or NO box for each question.

An answer of YES indicates that:

- potting labour costs are higher than necessary
- potential exists for reducing labour costs
- the nursery should investigate the problem in more detail.

GENERAL ORGANISATION OF POTTING

Layout of the potting area

1.	Is the potting area too cramped for production to be easily carried out?	YES NO
2.	Do other production areas encroach on potting production space?	YES NO
3.	Could the potting area be better located in another part of the nursery?	YES NO
4.	Could the arrangement of elements within the potting area (potting bench, media hopper, trailers for loading potted plants, stores of materials, etc) be changed to improve potting production?	YES NO
5.	Could the distance potting materials are delivered be reduced by relocating the source of inputs and/or the destination of outputs?	YES NO
6.	Are staff constantly observed walking to and fro for limited quantities of potting materials?	YES NO

Suitability of equipment used

7.	Do production figures make other potting systems more suitable options than the one now used (ie. could hand potting be replaced by machine potting or vice versa?)	YES NO
8.	Could the frequency of trips for potting inputs and outputs be reduced if the capacity of trailers, trolleys, etc., was larger?	YES NO

9. Is the design of trailers, trolleys, etc., unsuitable for the nursery terrain and the manner in which they are used by staff in potting production? YES NO

10. Does the media hopper frequently bridge (require constant attention to dislodge obstructed flow)? YES NO

Allocation of tasks

11. Do some staff appear to be more productively employed than others? YES NO

12. Could tasks be distributed between fewer staff? (this may involve a reduction in the speed of production. eg. slowing down a potting machine to allow less staff to operate) YES NO

13. Do some staff carry out the same tasks all the time (eg. certain staff always pot and certain staff always load pots) YES NO

14. Are tasks carried out in an illogical order? (eg. watering occurs before lifting plants therefore they become much heavier to lift, surface application of fertiliser occurs before watering flushing out large quantities of fertiliser) YES NO

15. Could tasks be carried out at a different stage of potting production to involve less people or reduce some staff waiting to begin their primary task? YES NO

16. Could some tasks be mechanised? YES NO

17. Could some tasks be removed altogether by using new technology or changing the way the nursery has traditionally carried out tasks (eg. consider buying fertiliser and media ready mixed instead of adding fertiliser during potting, watering plants in the field instead of at the potting area)? YES NO

Coordination of tasks

18. Are workers non-productive while waiting for someone else to finish a task? YES NO

Potting technique used

19. Are some potters conspicuously slower than other potters? YES NO

20. Could specific training in potting technique and organisation of work station speed up the production of some potters? YES NO

HEALTH AND SAFETY

Risks posed by equipment

21. Do workers operate noisy machinery without hearing protection? YES NO

22. Do workers come into close contact with machinery? YES NO

23. Are some potting staff untrained/inexperienced in the operation of machinery? YES NO

24. Does potting equipment have high injury risk areas which area unlabelled? YES NO

Risks posed from materials in the potting environment

25. Are herbicides & potting media handled without gloves and mask? YES NO

26. Do things such as trays, pots, casual water etc. make movement through the potting area difficult? YES NO

Risks posed from work practices

27. Does the way in which tasks are carried out seem likely to pose a risk of injury to workers? (constant lifting, turning, awkward posture at the work station etc.) YES NO

WORKER COMFORT

28. Do staff complain of sore feet, backs, etc. from prolonged standing? YES NO

29. Could anti-fatigue matting be used to reduce fatigue in standing potters? YES NO

30. Could ergonomic tools be used to make potting tasks easier? (eg. pot lifters for loading and unloading pots, ergonomic stools for working at the potting bench) YES NO

31. Do tools used make the task difficult to carry out? YES NO

32. Are workers exposed to the elements? YES NO

33. Does work station design make it difficult for workers to easily carry out their tasks? YES NO

34. Is lighting in the potting area inadequate? YES NO

WORKER SKILL

35. Do staff constantly seek instruction on how to carry out tasks? YES NO

36. Is time lost due to problems experienced by staff adjusting the potting machine? YES NO

37. Does potting production fall when certain key staff are absent? YES NO

WORKER MOTIVATION

38. Would workers react favourably to an incentive scheme for meeting daily production quotas? YES NO

39. Are workers easily distracted from their tasks? YES NO

40. Do some workers appear less interested than others in working productively? YES NO

41. Do some workers complain about conditions, management decisions, work load, etc? YES NO

MATERIALS HANDLING

42. Can some steps involved in getting materials into or out of the potting process be eliminated? YES NO

43. Can the quantities in which materials are handled be increased? YES NO

44. Could production information given to potting staff be made more thorough to allow more efficient delivery of potting inputs? YES NO

The quantities in which potting materials are delivered

45. Can the quantity of materials delivered be increased to reduce the number of trips required to bring them into or out of the potting area? YES NO

The capacity of equipment used to deliver materials

46. Can the equipment used to deliver materials be changed or modified to increase carrying capacity YES NO

The distance materials are delivered

47. Can the distance materials are delivered be reduced? YES NO

B. Evaluating potting cost at your nursery

The following form can be used to carry out a simple evaluation of the cost of potting in cents per pot at your nursery. It is best to use the form when variables such as pot size, number of staff potting and the plant type being potted do not change. Results will be more accurate if potting staff record the details (start time, end time, number of staff, quantity produced) as they work.

Potting labour cost in cents per pot is calculated by multiplying the total time worked by the hourly wage rate in cents and dividing the result by the number of pots produced. For example if a nursery pays an hourly rate of $14 and 5 staff take 1 hour to produce 1000 x 140mm pots then a total of 5 man hours has been worked at a cost of $14/ hr which equals $70 or 7000 cents. 7000 cents divided by 1000 x 140mm pots equals 7 cents per 140mm pot.

Nurseries can use their own hourly wage rates when calculating the labour cost of potting. Note that project graphs included in this booklet are based on an hourly labour rate of $15 per hour. This amount was intended to reflect an average hourly wage plus leave loading, superannuation contributions, etc.

The project divided potting into 3 stages:

1. Preparation for potting (includes all work involved in getting ready for potting up until the time the first pot is ready to be produced)
2. Potting (from the time the first pot is produced to the time the potted plant is placed onto trailer, conveyor, etc.)
3. After potting (the time from when the potted plant is placed onto transport up till the time it is placed down into the growing area)

These 3 stages taken together represent total potting. If the total number of people involved in potting is constant the nursery can use the form to calculate its total potting costs by:

- recording start time and staff numbers from the beginning of preparation for potting
- recording end time and quantity of pots produced when the potted plants have been placed down in the growing area at the end of potting.

A nursery can also record time and staff numbers and quantity produced separately for each of the 3 stages and add results together to give total potting labour costs:

- record start time, end time, number of staff and quantity potted (this figure will only be known after potting has finished) for preparation for potting costs
- record start time, end time, staff numbers and quantity potted for potting costs
- record start time, end time, number of staff, quantity potted for after potting costs
- add the costs in of the 3 stages to find total potting labour costs.

This method will give a more accurate result when the number of staff involved in the 3 stages differs or when the 3 stages are not carried out consecutively. Eg. when preparation for potting involves 2 people, potting involves 4 people and after potting involves 2 people or when preparation is carried out the day prior to potting.

Potting form

Circle stage being recorded:

PREPARATION for POTTING; / POTTING / TOTAL POTTING

Date	Start time	End time	Number of staff	Total time	Pot size	Quantity potted

Potting labour cost in cents per pot = $\frac{\text{(total time worked) x (hourly rate in cents)}}{\text{Number of pots produced}}$

C. Overall evaluation of potting system

In any production system time is money and producing potted plants is no exception. The longer it takes to produce a potted plant the higher the labour cost becomes and high labour costs mean less profits when plants come to be sold. It follows then that all nurseries should place a high priority on achieving plant quality goals with minimum possible potting labour costs.

The potting process consists of:

- preparation for potting (eg. bringing plant stock to the potting area)
- actual potting (eg. transferring plant stock into pots with potting media and loading to internal transport)
- after potting (eg. transporting the potted plants to the growing area and putting down)

Project research has revealed that potting labour costs vary greatly from one nursery to another. For the 35 nurseries investigated during the project, the labour cost of total potting for 140mm pots (that is preparation for potting, actual potting and after potting) varied from a minimum of **3.15 cents** to a maximum of **37.17 cents** per 140mm pot! It is interesting to note that the sales price of plants produced at the higher labour cost was not necessarily proportionally higher than plants produced at the lower labour cost. Labour costs in the potting stage of total potting also varied from one nursery to another. Potting costs recorded for 140mm pots varied from a minimum of **1.02 cents** per 140mm pot to **28.13cents** per 140mm pot! The great difference in total potting costs existing in such a small sample of nurseries (35) indicates that in the wider nursery industry a very large number of nurseries must be paying far more than they need to for potting production.

How can one nursery pot plants for 3 cents a pot while it costs another 37 cents?

Some of the difference in total potting costs can be explained by the type of plant being potted. Some plant stock require extra care while being taken from the propagation container and placed into the growing-on pot. Plant stock grown in tubes generally takes longer to remove from the tube and insert to the pot than plant stock grown in cell trays. When potting from tubes there is the additional task of disposing of each tube. Yet, even allowing for the fact that plant types and propagation containers do affect potting time, it does not adequately explain why potting labour costs vary so greatly.

Clearly, there are other factors operating which serve to increase a nursery's potting labour costs.

Identifying the factors that increase potting labour costs.

Through the investigation of potting labour costs in over 40 potting systems at 35 nurseries project researchers have been able to pin point a number of general factors in potting production which can make production less efficient and increase potting labour costs. The good news for nursery operators is that, once you know what to look for, problems affecting potting efficiency can be quite easy to identify and solve.

The factors which can affect potting labour costs are:

- **General organisation of potting**
- **Potting production**
- **Worker related issues**
- **Methods of materials handling**

An evaluation of potting production efficiency using the evaluation form in appendix C involves assessing the degree to which these factors are influencing labour costs at a nursery. The steps in carrying out an evaluation of potting efficiency are:

- observe potting production
- isolate aspects in potting production which are related to each of the 4 factors affecting labour costs
- score the affect each of these aspects has on total potting labour costs
- list the reason for your score along with any potential improvements that could help lower potting labour costs
- calculate the average score for each of the 4 factors affecting potting labour costs

GENERAL ORGANISATION OF POTTING

The general organisation of potting refers to the way in which the nursery has designed and set out its potting system. It is the visible evidence of nursery management decisions on issues such as:

- where potting should take place
- how equipment used in production should be arranged in the potting area
- the type of equipment used to carry out potting tasks
- the type of potting system that is used by the nursery (eg. hand potting or machine potting)

What to look for when scoring the general organisation of potting.

- Systems design

- could the potting area be better located in another part of the nursery?

- is sufficient space available in the potting area for production to be easily carried out?

- do other production areas encroach on potting production space?

- could the arrangement of elements within the potting area (potting bench, media hopper, trailers for loading potted plants, stores of materials, etc) be changed to improve potting production?

- is the growing area set out to allow easy manoeuvring of trailers, etc.

- do production figures or other circumstances at the nursery make other potting systems a more suitable option than the one currently used (ie. could hand potting be replaced by machine potting or vice versa?)

- Suitability of equipment used

- do trailers, trolleys, etc., have sufficient capacity for carrying adequate quantities of potting inputs and outputs?

- is the design of trailers, trolleys, etc. suitable for nursery terrain and the manner in which they are used by staff in potting production?

- does the media hopper allow the free flow of potting media or does it require constant attention to dislodge blockages?

POTTING PRODUCTION

Potting production refers to the way in which potting staff go about performing tasks in potting production.

What to look for when scoring potting production.

- Information communication

- are staff aware of what potting production is to be carried out on the day? Do staff know how much is to be potted, where potted plants are to be put down and what treatments (pruning, herbicide application, etc.) are to be carried out on potted plants or do they need to seek this information out?

- Allocation of tasks to staff

- has non productive time been eliminated from the production cycle or are workers observed to be sometimes non productive?

- are workloads more or less equal among staff or could one or more positions be removed by reallocating tasks to less staff? (this may involve a reduction in the speed of production. eg. slowing down a potting machine to allow less staff to operate)

- is the synchronisation of tasks good or does non productive time exist because certain staff need to wait on others to finish a task before they can begin their primary task?

- Potting technique

- could all potters benefit from some assistance organising their work stations?

- is the output of potted plants in a given time roughly the same for all potters or are certain potters conspicuously slower than other potters?

- could specific training in potting technique (ejecting stock, handling media, inserting fertiliser, handling potted plant) speed up the production of some potters?

WORKER RELATED ISSUES

- Health and safety

Health and safety refers to any issues that might constitute a risk to the health or safety of potting staff. Poor health and safety levels can affect staff motivation, result in down time due to injury or sickness, and potentially cost the nursery money in compensation payments.

What to look for when scoring health and safety.

- do workers operate noisy machinery with adequate hearing protection?

- do workers come into close contact with machinery?

- do people seem competent in the operation of machinery?

- are injury risk areas on the machine clearly labelled?

- are safety guidelines being followed when herbicide, potting media, etc., is handled (ie. do potters wear masks and gloves)?

- do things such as trays, pots, water etc. lying in the potting area, pose a risk to workers?

- does the way in which tasks are carried out seem likely to pose a risk of injury to workers (constant lifting, turning, awkward posture at the work station etc.)?

- Worker comfort

Worker comfort refers to any issues that make it difficult for staff to carry out their duties with minimum effort. Potting production rates naturally tend to drop throughout the day as staff become tired and this trend is accelerated in systems with poor worker comfort levels. There is a growing international trend for worker comfort levels to be regulated and enforced in the same manner as health and safety issues.

What to look for when scoring worker comfort.

- do staff who are required to stand for prolonged periods on hard surfaces have cushioned matting for their feet?

- could staff use ergonomic tools to take make tasks easier (eg. pot lifters for loading and unloading pots, ergonomic stools for working at the potting bench)

- are the tools used the most appropriate for the task?

- are workers adequately protected from the elements?

- are work stations designed so that staff can carry out their tasks with minimum effort?

- is adequate lighting available in the potting area?

- Worker skills

Worker skills refers to the ability and knowledge workers have to carry out their allotted tasks.

What to look for when scoring worker skills.

- are potting staff able to competently operate equipment used in potting?

- do potting staff know how to carry out task in potting without constant referral to the potting supervisor?

- do staff appear in need of training in related potting tasks?

- Worker motivation

Worker motivation refers to a worker's level of enthusiasm / willingness / dedication / work ethic, call it what you will. Well motivated workers were a feature in nurseries with lowest potting labour costs. Motivated workers out produce under motivated workers and are more likely contribute to the improvement of potting production.

Levels of worker health and safety and worker comfort can have an impact on worker motivation.

What to look for when scoring worker motivation.

- do workers appear interested in working in a productive manner?
- are workers easily distracted from their tasks?

METHODS OF MATERIALS HANDLING

Methods of materials handling refers to the way in which potting inputs and outputs are transported about the nursery. Potting inputs and outputs include empty pots, plant stock, potting media, potted plants, fertiliser, trays, discarded plant material, old pots, etc.

Efficient materials handling is influenced by such things as:

- the frequency with which potting materials are handled
- the quantities in which potting materials are handled
- the capacity and condition of equipment used to deliver materials
- the distance materials are delivered.

What to look for when scoring materials handling.

- Handling of pots, stock, media, fertiliser & potted plants

- can some steps involved in getting materials into or out of the potting process be eliminated?
- can the quantities in which materials are handled be increased?
- can the quantity of materials delivered be increased to reduce the number of trips required to bring them into or out of the potting area?
- can the equipment used to deliver materials be changed or modified to increase carrying capacity?
- can the distance materials are delivered be reduced by relocating storage areas?
- could some handling tasks be removed altogether by using new technology or changing the way the nursery has traditionally carried out tasks (eg. consider buying fertiliser and media ready mixed instead of adding fertiliser during potting, watering plants in the field instead of at the potting area)?
- are materials located so that they do not interfere with potting production (eg. boxes of pots in the road of staff operating potting machine, trays on the ground making walking difficult etc.)?

There are 3 columns to be filled out on the form:

SCORE 1-9	REASONS FOR YOUR SCORE	POTENTIAL IMPROVEMENTS

Evaluation scores are entered in the column SCORE 1-9. The score you give to a particular production issue will relate to how effectively that issue contributes to minimising potting labour costs at the nursery. Scores can range from 1 through to 9. 1 is very poor, 5 is average and 9 is excellent.

For example, the first issue on the form under the heading of the GENERAL ORGANISATION OF POTTING is 'location of the potting area'. If you believe that the 'location of the potting area' is very good ie. that the potting area is located in the best spot in the nursery to minimise potting labour costs you might score it 7, 8 or even 9. If you believe that the position of the potting area is responsible for increasing potting labour costs (eg. it is not centrally located in the nursery, is a long way from potting materials, etc.) you might score it as a 4, 3, 2 or even 1, depending on the extent to which you believe the location of the potting area is contributing to increasing total potting labour costs.

The second and third columns are for writing down the reasons for your score and potential solutions for solving any problems you have identified. Ensure every person completing an evaluation form does write down the reasons for their score and wherever possible provides potential solutions to the problem. This will be of great help when nursery management and staff meet after the evaluation to discuss the results of the evaluation, problems identified and potential improvements aimed at reducing potting labour costs.

	Name: Nursery:	SCORE 1-9 1 = very poor 5 = average 9 = excellent	REASON FOR YOUR SCORE	SUGGESTED IMPROVEMENTS
System design			GENERAL ORGANISATION OF POTTING	
1	Location of the potting area	( )		
2	Layout in the potting area	( )		
3	Potting work station design	( )		
4	Layout of the growing area	( )		
5	Suitability of potting method	( )		
Suitability of equipment used				
6	For planting stock handling	( )		
7	For media handling	( )		
8	For potted plant handling	( )		
Information communication			POTTING PRODUCTION	
9	Staff knowledge of requirements	( )		
Allocation of tasks to staff				
10	Elimination of non productive time	( )		
11	Coordination of tasks	( )		
Effectiveness of Potting technique				
12	Organisation of work bench	( )		
13	Ejecting plant stock	( )		
14	Handling media on the bench	( )		
15	Inserting fertiliser to pot	( )		
16	Handling the potted plant	( )		

		SCORE 1-9	REASON FOR YOUR SCORE	SUGGESTED IMPROVEMENTS
Health & safety			WORKER RELATED ISSUES	
17	Safety levels in equipment use	( )		
18	Safety levels in material handling	( )		
19	Safety levels in work practices	( )		
Worker comfort				
20	Comfort levels in the potting area	( )		
21	… in transport to growing area	( )		
22	… in the growing area	( )		
Worker skills				
23	Level of workers' skill	( )		
Worker motivation				
24	Level of workers' motivation	( )		
Empty pot handling			METHODS OF MATERIALS HANDLING	
25	Pot to potting station	( )		
Plant stock handling				
26	Stock to potting station	( )		
Media handling				
27	Delivering to potting station	( )		
Fertiliser handling				
28	Delivering to potting station	( )		
Potted plant handling				
29	In the potting area	( )		
30	Watering/transport to growing area	( )		
31	In the growing area	( )		

D. Calculating the cost/benefit of improving your potting system

Once a nursery has found its total potting costs in cents per pot (appendix B) and carried out an evaluation of its production efficiency (appendix C) these results can be used to find out the approximate cost/benefit of introducing improvements to the potting system.

The software used to calculate the cost/benefit has been developed by the Queensland Horticulture Institute and at a later stage of the project it will be made available to nurseries interested in evaluating their potting production efficiency. For the time being however, QHI will run a cost/benefit analysis free of charge for any nursery that sends in its total potting cost in cents per pot (appendix B) and completed evaluation forms(s) (appendix C). Results of analysis will be strictly confidential.

Send your information to the: Engineering Section, QHI, PO Box 327, Cleveland Q 4163.

BIBLIOGRAPHY

Corlett, E.N., Clark, T.S. (1995). The Ergonomics of Workspaces and Machines. London: Taylor and Francis.

Millner, P.D., Olenchock, S.A., Epstein, R., Rylander, M.D.J., Haines, J., Walker, B.L., Horne, E., and Maritato, M. (1994). Bioaerosols associated with composting facilities. Compost Science & Utilisation 2 (4) pp 6-57.

Radajewski, W., Brown, D., Bodman, K., and Hoeks, P. (1997) Nursery Dispatch Systems. Queensland Department of Primary Industries Manual.

Steele, T. (1996). Control of legionella spp. particularly legionella longbeachae in potting mixes. HRDC Final Report NY234.

Steele, T. (1994). Legionella longbeachae and infections from environmental sources. National Nursery News July p 8.

ATTACHMENT 2

Optimum Methods in the Nursery Potting Process

Report from project tour to Belgium, Denmark, Germany, Netherlands and Poland

W. Radajewski,

Queensland Horticulture Institute – Centre for Amenity and Environmental Horticulture

August 2000

HRDC

Queensland Government
Department of Primary Industries

Nursery Industry Association of Australia

TABLE OF CONTENTS

ACKNOWLEDGMENTS

This project tour was partially sponsored by the Horticultural Research and Development Corporation and the Department of Primary Industries and was also privately funded. The author would like to thank all those that helped in organising and conducting this tour, specifically Mr Denis Brown (RRS, QHI), Dr Jan Willem Hofstee (Department of Agrotechnology and Food Sciences, Wageningen University) and Prof Dr Z. Majewski, (Department of Production Management and Engineering Warsaw Agricultural University).

Synopsis

During the course of HRDC projects (NY 403 and NY 98031) it has been established that the labour time required for production of potted plants in the Australian nursery industry is generally much higher (by approximately 100%) than the time required for production of the same number of potted plants in European nursery production systems. These projects have also established that the chief direct reason for low productivity in the Australian nursery industry is inadequate organisation of the production process while the chief indirect reasons are the set up and layout of nurseries, sub-optimal planning, low levels of specialisation in plant production and low levels or the inappropriate use of mechanisation equipment.

Investigation of production methods in European nurseries shows that effective information and training systems are essential tools for developing and maintaining high levels of production efficiency in the nursery industry. High levels of crop specialisation in the European nursery industry do undoubtedly play an important part in their ability to achieve highly cost-effective production. However, even European nurseries producing a relatively large number of different plant types (200-300), as is commonly the case in the Australian nursery industry, and using similar production methods to those used in the Australian nursery industry still mange to achieve very efficient production figures through the use of appropriate production organisation and mechanisation equipment (eg. as evidenced in Belgium).

Various cost-effective methods and systems of increasing nursery productivity that could be easily adopted by the Australian nursery industry were investigated during the overseas project tour. The major areas of this investigation are related to the appropriate planning and organisation of production in the existing nursery production environment, efficient use of existing equipment and the work motivation of personnel. The organisation of plant dispatch including external transportation models was also investigated.

Links with various manufacturing and research organisations have been established that may lead to close cooperation between QHI and its overseas counterparts. The potential for such cooperation with a research group in Holland (Wageningen Agricultural University and Turf Research Centre) and in Poland (Department of Production Management and Engineering Warsaw Agricultural University) is now being examined.

There are a number of overseas manufacturers that have expressed interest in introducing their technology to Australia. Since most of the equipment and technologies developed for the European nursery industry can not be directly adopted by the Australian nursery industry without some changes it is essential that evaluation and then demonstration of equipment to Australian nursery operators is carried out in order to select the most suitable designs. It is proposed that QHI should take the leading role in the provision of services to assess, develop and demonstrate high productivity nursery systems by creating a demonstration nursery facility at Redlands Research Station.

1 Introduction

Since 1991, during the course of HRDC sponsored projects (NY 128, NY 403, NY98031), many different nurseries in Australia and overseas have been visited by researchers involved in these projects. The last overseas visit was conducted in 1994, while various Australian nurseries have been visited on a regular basis up to the present time.

Previous (1991-1994) assessment of Australian and overseas (USA, Europe) leading nursery production methods, systems and efficiencies revealed a large performance difference that local industry seemed unable to bridge. During the period 1994 – 2000 a clear improvement in production performance has been recorded in the Australian nursery industry.

In order to compare Australian nursery industry achievements with overseas benchmarks, a project tour was organised and conducted (see itinerary in Appendix 1). The tour had to be conducted by a project team member with a sound knowledge of the systems, principles and methods of operation and equipment relevant to Australian nurseries. For the comparison to be meaningful the different market requirements and therefore different production needs in Australia and overseas had to be taken into consideration.

The main aim of this study was therefore to compare the effectiveness of production methods, to create new benchmarks for the nursery industry and to establish links with research organisations and overseas nursery allied industries.

The specific objectives of the project tour were:

- To improve industry competitiveness and therefore potential access to new markets by providing information on new technologies leading to enhancement of product quality and improvement in productivity

- To create links between QDPI and leading research centres as a basis for future cooperation (eg. Development of new technology for nursery industry, exchange of researchers, fostering of student work experience programs)

- To develop internationally competitive nursery production and material handling systems with improved profitability levels based on higher productivity and reduced cost of production

- To promote quality management methods for production and handling of nursery products

- To establish current and future trends and developments in nursery mechanisation (eg. material handling)

- To access (first hand) state-of-the-art European nursery production systems in order to select and introduce relevant technologies to Australian nurseries

- To establish the most appropriate methods of productivity improvement in the Australian Nursery Industry

The following potential benefits to the Australian nursery industry, QHI and researchers arising from the project tour were identified

- Collaboration with leading overseas research organisations and private enterprises leading to enhancement of nursery industry research and extension

- Immediate assimilation of the latest nursery industry engineering and production technology into the Australian nursery industry contributing to an overall increase in industry productivity and competitiveness

- Increased potential for further projects upon measurable improvement of productivity in the nursery industry

- Information gained during the trip will assist in the preparation of a scientific paper on the optimisation of nursery productivity

- Improved understanding of the latest developments in nursery production technologies

2 Places and organisations visited

A list of organisations visited as well as contact names and addresses is shown in appendix 2.

2.1 Research organisations

- Wageningen University (WU)

During the 1990 visit to Holland collaboration between engineering groups at RRS and WU (engineering section) was established. As a result all following visits to Holland have been organised by representatives of this organisation. During the 1991-1999 period 15 students from WU carried out practical work experience within the engineering group at RRS. As a result a number of reports and publications were written. The objective of this visit has been to encourage the sharing of information between research centres and maintain the spirit of collaboration.

During the project tour, meetings with Dr Jan Willem Hofstee at WU resulted in agreement regarding the further participation of students in practical work

experience programs at RRS and the continuing exchange of relevant information between research centres.

➢ Dutch Turf Research Centre (DTRC)

It was requested by the newly established RRS turf group's project leader Don Loch to establish contacts with the DTRC and promote future collaboration between research centres. A meeting was held with the director of DTRC Mr Franklin Versteeg. As a result of this meeting, DTRC in Holland will consult with the major commercial turf companies in Holland to seek their involvement in funding turf research activities in Australia. Further more, DTRC may provide assistance in the establishment of research facilities for the turf group at RRS. It was also arranged that Mr Vertsteeg would visit RRS and present a seminar on topics related to turf research.

➢ Warsaw Agricultural University Department of Production Management and Engineering (WAU)

During the 1991 visit to Poland and Holland collaboration between the engineering group at RRS and WAU was established. As a result, all following visits to Poland have been organised by representatives of this organisation. During the 1991-1995 period two Phd students from this university worked on DPI projects in Australia within the engineering group at RRS. As a result reports and publications were written. The objective of this visit has been to encourage the sharing of information between research centres and maintain the spirit of collaboration.

During the project tour meetings with Prof. Z Majewski, head of the Department of Production Management and Engineering, resulted in an agreement to collaborate in the development of production strategies and in the development and testing of equipment for the nursery industry.

A potential staff exchange program will also be investigated. A Memorandum of Understanding between the two research centres has been drafted.

2.2 Nursery allied industries

The following nursery allied manufacturers were visited during the project tour and meetings were held with their representatives.

- Mayer GmbH & Co. Maschinenbau and Verwaltung

  Mayer is a German company supplying various mechanisation equipment to the nursery industry. Mayer has representatives in Australia that are distributing potting machines. Mayer potting machines are produced in a factory in Hungary and are assembled and tested in Germany. During the process of evaluating potting systems in Australia a number of basic problems with adjustment of machines were observed. As a result performance was not as good as expected. As the manufacturer

demonstrated during the project tour such problems would not occur if machines were correctly adjusted. The machines observed in Australian nurseries were not adjusted correctly and staff had not an adequate understanding of how this should be done. Close cooperation, specifically the exchange of technical information was agreed on.

- Asperg Gartnereibedarf (AG)

  AG is a supplier of a wide range of equipment and tools for nursery production. The most interesting from the point of view of the Australian nursery industry are: an automated bar coding system with an on line printer designed for the dispatch of plants from nurseries.

- Demtec Demaitere International BVBA

  Demtec is a manufacturer and supplier of a very wide range of mechanisation equipment for the nursery industry and for other industries (equipment for the production of thermo-insulation made from hemp). A company relatively unknown in Australia, Demtec produces a very wide range of potting machines designed to work with pots from 70mm to 350mm. The company also produces a number of different types of equipment for potting mix handling, conveyors, transplanters and pot handling equipment. The company has not had much success with agents in Australia and is presently looking for a distributor of their products. The company is also interested in the assessment of their equipment for the Australian nursery industry by the engineering group at RRS.

- Hawe Systems Europe V.V

  Hawe specialises in the custom design and construction of internal logistics and transport systems. Hawe is working in collaboration with other companies involved in the development and production of nursery equipment and systems. The main products are mobile benches, roller conveyers, automatic transport system for mobile benches, washing machines for mobile benches and pot robots.

- Visser International Trade & Engineering BV

  Visser International Trade & Engineering B.V. specialises in horticultural technology. The unique and extensive range of equipment makes Visser the largest supplier of machines and systems to the glass house industry. The Visser Holding Group, consisting of a number of companies, is involved in automation projects.

- Machinefabrik Filler B.V.Industrieterrein

  Filler is a large company specialising in the supply of custom designed horticultural production lines. The company is involved in the design of production systems, nursery layouts, design and production of equipment and complete installation (including software) for control of this equipment.

The most common lines are sowing lines, vision-sorting lines, pricking-out lines, potting mix handling lines and internal transport lines.

- Javo Holland

  Javo is best known in Australia for their potting machines. Agents of the company are located in Sydney and Melbourne. Javo potting machines are available in many different versions but only some are sold on the Australian market. In Australia Javo potting machines are generally used for pots up to 150mm and potting of larger pots up to 200mm is carried out very infrequently on these machines. In reality Javo potting machines can be quite successfully used for potting even 300mm pots. The efficiency of Javo potting machines in Australia is considerably below the manufacturers expectations based on machine performance recorded in EU nurseries.

- CC

  CC was founded in 1976 with the purpose of organising a common packaging pool for the transport of nursery products. At present the CC company operates over 2 million trolleys and 6 million crates. The major activity is the development and operation of trolley exchange systems. This is the most modern logistics system currently operating and it greatly contributes to keeping potted plant delivery costs at low levels. CC offers long term (5 years) and short (from 1 day) hire of trolleys . The cost to hire one trolley with 3 shelves (long term) is approximately $160 in the first year and $12 in all following years. The cost to hire for one day depends on the time of year (from $.0.35 to $1.40). Trolleys can also be purchased form CC for approximately $160 and used in the exchange system for an additional $12 per annum. The system operates in 25 countries in Europe, South America and Asia.

  The company has also developed a network DD (Distributed Datanet) with the view to offer the market the ability to buy and sell flowers based on electronic commerce. The DD system comprises logistical centres where electronically purchased goods are sorted and distributed. CC is interested in further expansion of their system to USA and Australia. Such a system as offered by CC is long overdue in Australia. Prices are very attractive but it was indicated by CC that in Australia prices would be probably about 20% higher because fewer trolleys would be used than in EU. A minimum 10 000 trolleys would have to be in operation to make such a system viable in Australia.

- Zaklad Torfowy 'Karaska'

  The company is involved in the production of various grades and different pH levels (3.0 – 7.5) of peat moss designed for hand potting as well as for semi and fully automatic potting machines and associated equipment. Peat moss is compressed and packed into various bag sizes from 10l to 120l or is delivered in an uncompressed loose form. The company

supplies peat moss to some European nurseries and is interested in further expansion of their export destinations including Australia.

Discussions with manufacturers focussed on the use of their equipment in Australian nursery production and QHI's potential role in evaluating and developing their equipment for Australian production requirements.

2.3 Commercial Nurseries

Production nurseries in the EU were visited and their production systems investigated. Discussion with production managers took place and video recording of production systems was carried out. In this way the latest production technologies were evaluated from both theoretical and practical viewpoints. The names of nurseries are not shown because a confidentiality principle is followed in all cases when information on commercial production rates is quoted. Only nurseries engaged in potting production at the time of the visit are listed below. The approximate cost of production shown below is based on the average Australian labour cost $15 per hour.

❖ **Nursery 1**

- Potting system produced by - Mayer
- Equipment used:
    - Potting machine
    - Pot dispenser
    - Drills
    - Mechanical take off conveyer
    - Pot accumulator
    - Robotic arms

- Pot size 100mm
- Growing on mobile benches
- Production rate 4400 pots/hour (loading pot mix to pots and drilling only)
- Workers used (3) and duties:
    - worker 1 - general supervision, pots to pot dispenser, loading potting mix to hopper
    - workers 2, 3 - inserting plants to pots
- Production cost 1 cent/pot
- Best recorded in Australia 4.2 cents/pot

❖ **Nursery 2**

- Potting system produced by - Mayer
- Equipment used:
    - Potting machine
    - Pot dispenser

  - Drills
  - Mechanical take off conveyer
  - Pot accumulator
  - Robotic arms
  - Automatic transplanter (not used during visit)
- Pot size 100mm
- Growing on mobile benches
- Production rate 4400 pots/hour (loading pot mix to pots and drilling only)
- workers used (3) and duties:
  - worker 1 - general supervision, pots to pot dispensers, loading potting mix
  - workers 2, 3 - inserting plants to pots
- Production cost 1 cent/pot
- Best recorded in Australia 4.2 cents/pot

❖ **Nursery 3**

- Potting system produced by - Demtec
- Equipment used:
  - Potting machine
  - Pot dispensers (2)
  - Drills
  - Automatic transplanter
  - Mechanical take off conveyer
  - Trailer for moving plants to growing area (450 pots per trailer)
- Pot size 120mm
- Growing on ground in trays
- Production rate 3800 pots/hour
- workers used (3) and duties:
  - worker 1- pots to pot dispenser, general supervision, loading media to hopper
  - worker 2 - loading pots to trays
  - worker 3 - takes plant to growing area and puts down in trays
- Trailer unloading rate 0.3 sec/pot
- Production cost 1.2 cents/pot
- Best recorded in Australia 4.8 cents/pot

❖ **Nursery 4**

- Seeding system in trays - Demtec
- Equipment used:
  - Soil blocking machine
  - Tray dispensers
  - Seeding machines
  - Tray stacker
  - Fork lift with attachment for shifting trays

- Automated loading of potting-mix from storage bunker
- Tray size (holds 96 soil blocks)
- Growing on ground
- Production rate 32 000 plants/hour
- workers used (2) and duties:
  - worker 1- trays to tray dispenser, general supervision, shifting tray to growing area
  - worker 2 - putting trays on ground

- Production cost 0.1 cent per plant
- Best recorded in Australia - no records available

❖ **Nursery 5**

- Potting system produced by - Visser
- Equipment used:
  - Potting machine
  - Pot dispensers
  - Drills
  - Automatic transplanter
  - Mechanical take off conveyer
  - Pot accumulator
  - Robotic arm
  - Fork lift with spacing pot-fork

- Pot size 170mm multiple planting 3 plants per pot
- Growing on concrete floor
- Production rate 4500 pots/hour
- workers used (1) and duty:
  - worker 1- pots to pot dispenser, potting-mix to hopper, general supervision
- Production cost 0.35 cents/pot
- Best recorded in Australia 15 cents/pot

❖ **Nursery 6**

- Potting system produced by - FGM
- Equipment used:
  - Potting machine
  - Pot dispensers
  - Seeding machines
  - Gantry for shifting pots in growing gutters
  - Automated loading of potting-mix from storage bunker
- Pot size 100mm
- Growing on benches with automatically spacing gutters system
- Production rate 6000 pots/hour

- workers used (2) and duties:
    - worker 1- pots to pot dispenser, general supervision
    - worker 2 - shifting of pots to growing line

- Production cost 0.5 cents/pot
- Best recorded in Australia 2.8 cents/pot

❖ **Nursery 7**

- Potting system produced by - FGM
- Equipment used:
    - Potting machine
    - Pot dispensers
    - Drills
    - Mechanical take off conveyer
    - Pot accumulator
    - Robotic arm
    - Automated loading of potting-mix from storage bunker
- Pot size 100mm
- Growing on mobile benches
- Production rate 7200 pots/hour
- workers used (6) and duties:
    - worker 1- pots to pot dispenser, general supervision
    - workers 2,3,4,5,6 - potters inserting plants to pots
- Production cost 1.25 cents/pot
- Best recorded in Australia 5 cents/pot

❖ **Nursery 8**

- Potting system produced by - Mayer
- Equipment used:
    - 2 potting machines
    - Pot dispensers
    - Drills
    - Mechanical take off conveyer
    - Pot accumulator
    - Robotic arms
    - Automatic loading of hoppers
- Pot size 100mm
- Growing on mobile benches
- Production rate 7000 pots/hour (loading pot mix to pots and drilling only)
- workers used (1) and duty:

    - worker 1 - general supervision, pots to pot dispensers
- Production cost 0.25 cents/pot
- Best recorded in Australia 1.25 cents/pot

❖ **Nursery 9**

- Potting system produced by - Demtec
- Equipment used:
    - Mobile potting machine
    - Pot dispenser
    - Drill
    - Mechanical take off conveyer
    - Pot accumulator
    - Fork lift with pot forks
- Pot size 250mm
- Growing on ground
- Production rate 3600 pots/hour
- workers used (3) and duties:
    - worker 1- potter inserting plants
    - worker 2 - fork lift operator
    - worker 3 - potting mix loading, pots to pot dispenser, general supervision
- Production cost 1.5 cents/pot including setting up machine
- Best recorded in Australia (200mm) 12 cents/pot

3 Potential products for the Australian nursery industry

Much of the mechanisation equipment available to overseas nurseries could be introduced to Australian nurseries and would have a large impact on the overall cost of labour.

- Potting mix handling devices available on overseas markets could eliminate the time required for loading the hoppers of potting machines. They would also eliminate the time spent by workers using a shovel, etc. to free bridged potting mix in a hopper. An automated system, a fork bunker exists for automatic processing of peat based potting media.

- Potting machines are available in many different versions. Most versions are designed to handle the potting or re-potting of various pot sizes (75-350mm pots), trays and type plants. Potting machines can be equipped with take-off systems for potted plants, pot dispensers, watering systems and fertiliser dispensers. Some potting machines (Demtec) have attachments for use with poly bags. This would be especially useful in tree production nurseries.

- Tray washing machines

  A number of different types of tray washing machine built in stainless steel and designed to handle most sizes of trays available on the market. Based on rotating high-pressure nozzles approx. capacity 600 trays per hour.

- Pot handling devices

  Handling of potted plants is the most labour intensive procedure in nursery production. A number of different devices are available on the market designed specifically to address this problem. See appendix 3 for information on some of these devices.

4 General discussion – Australian and EU nurseries

The cost of labour in European Union (EU) countries is generally higher than in Australia (at around A$30/hr compared to around $15/hr in Australia) yet the overall cost of labour in nursery production is lower in EU nurseries. This means that the average Australian nursery is using more than twice as much labour for the production of the same number of plants as an average nursery in the EU. Why does such a drastic difference exist?

No industry can achieve meaningful progress if it is only willing to accept praise and not criticism. Constructive criticism of existing problems leads to the eventual development of strategies which can overcome industry weaknesses. As a result of this process a much more efficient, competitive and sustainable industry can be developed.

The objective of this chapter is to bring to the attention of the Australian Nursery Industry a number of problems that exist in the industry. Problems that are commonly recognised but very seldom officially and openly admitted to.

4.1 Market size

It is generally known within the Australian nursery industry that the production methods and equipment used here fall far short of what is required by a modern nursery to compete on international markets. The most common justification for the existing situation is the size of the domestic market. In real terms the market today for any product is as big as one wants it to be!

A good example of this can be found in Israel. Israel, with a much smaller population than Australia, has very advanced production systems that enable it to produce a very competitively priced product that has even succeeded winning access to the market in the Netherlands. Other examples that defeat the excuse of poor market size are Sweden and Belgium, which though having populations much smaller than Australia and though producing mainly

for a domestic market, use highly advanced production systems to reduce production costs and sustain healthy markets.

4.2 Information sharing

One of the major reasons behind the strength of the EU nursery industry is the high level of knowledge nursery operators possess regarding the best methods of nursery production, equipment and organisation. This knowledge is generated through the free sharing of information between nursery operators. This culture of information sharing makes the whole industry very competitive and has the effect of making it difficult for other plant producers to penetrate their markets.

In Australia the exact opposite situation prevails. Individual nurseries generally are very reluctant to share information with other nursery operators. This obsession with secrecy is sometimes taken to ridiculous lengths. Take for example the case of a nursery operator who buys new equipment and then removes all identification plates so other producers can not trace the distributor. The Australian nursery industry needs to understand the benefits of sharing information and start using the principle to its own advantage.

4.3 Demonstration of equipment and systems

Investigation of potting performance in the Australian nursery industry showed that in a number of cases nurseries using relatively expensive equipment for potting production performed no better (or only slightly better) than nurseries using hand potting systems. This clearly indicates that either the equipment used is inappropriate for the specific operation or that the organisation of production and the use of the equipment need improvement.

This concern was confirmed during the project tour. Equipment, which was commonly used in both Australian and overseas potting systems, was investigated. In the EU less workers are involved in the operation of such equipment and production stops due to machine malfunction or lack of available input materials are minimal. As a result EU nurseries achieve much higher production performance.

The major reasons for the high performance of EU nurseries are:

- sound organisation of production systems
- equipment used is appropriate for production
- equipment is competently operated and adjusted
- production areas are logically laid out
- input materials used are good quality and appropriate for the equipment used

The all to common sight in Australian nurseries of a worker using a shovel to free bridged potting mix in a hopper is never seen in overseas nurseries where properly designed media hoppers and automatic media transport equipment prevail.

Many demonstration field days and associated activities are organised and presented for Australian nursery industry members on nursery sites. The fact is that most of these activities are performed in commercial operations that do not necessarily represent state-of-the-art technology or methods in a specific area. While field day organisers are grateful for the cooperation of all nurseries, it is regrettable for the industry that often nurseries with better equipment, systems and solutions are very reluctant to share their knowledge through field day events.

In view of the lack of information sharing in the Australian nursery industry there exists is a real need for an independent establishment that can professionally demonstrate state-of-the-art equipment, systems and methods of nursery production to nursery operators. To be successful such an establishment would require close cooperation with allied nursery industries (Australian and overseas) and input from professional organisations and personnel.

4.4 Training

A very basic knowledge and understanding of the principles of nursery production may be enough to produce plants. But let's face it, practically anyone can produce a plant if they want to. The real difference between the so called 'backyarder' and the professional nursery operator is that the nursery operator should have a much greater knowledge of their field. This means, in addition to knowledge of plant growth requirements they need to be aware of how to set up and run nursery operations including: best site, best layout, best production system, best equipment, best methods, best training, etc.

This information can only be obtained through training programs run by highly professional personnel who understand in depth all of the issues concerned. It is not enough to give some basic training and leave out more complex issues hoping that nursery operators can address problems as they occur. They have to be told very clearly how to act in specific situations and how the best solution can be achieved. Incomplete training and/or training that is not based on the latest knowledge may create more problems than it solves.

By relying on training that does not give specific advice on specific issues or that is based on an inadequate understanding of the issues facing nurseries, production will not be able to run at optimum levels. In fact, in most cases it will never achieve such levels because the benchmarks they seek are inaccurate. The overall effect of such training is to limit the ability of nurseries to improve their competitiveness and reinforce the tendency to keep production information secret.

4.5 Economics of investment

The average cost of land and structures for nursery production are lower in Australia than in EU countries. The natural growing conditions here are better

than in Europe and less heating is required. Therefore the cost of production should be lower and profits higher as the prices of the final product are similar in both locations. In reality the high cost of labour offsets potential benefits.

The cost of labour can be greatly reduced by investing in mechanisation equipment. The average amount of capital invested into nursery production equipment is much higher overseas than in Australia. Investment into advanced mechanisation systems in Australia is not popular because information on up to date equipment and professional service of such equipment are not readily available.

The need for facilities that could demonstrate equipment and train people in the use of advanced mechanisation equipment is obvious. Appendix 4 gives examples of how investment can affect production cost.

5 Conclusions and Recommendations

Various cost-effective methods and systems for increasing nursery productivity which could be easily adopted by the Australian nursery industry were investigated during the project tour. The major areas of this investigation are related to:

- appropriate planning and organisation of production in the existing nursery production environment
- efficient use of existing equipment
- worker motivation

Investigation of production methods in European nurseries shows that:

- Effective information and training systems are essential tools for developing and maintaining high levels of production efficiency in the nursery industry
- Specialisation within the nursery industry does play an important part in their ability to achieve cost-effective production.
- Very efficient production can be achieved in nurseries producing a relatively large number of different plant types (200-300 types) in different pot sizes and using similar production methods to those used in Australia, through the use of appropriate production organisation and mechanisation equipment

Links with various manufacturing and research organisations have been established that may lead to close future cooperation between QHI and its overseas counterparts. The potential for such cooperation with research groups in the Netherlands (Wageningen Agricultural University and the Dutch Turf Research Centre) and in Poland (Department of Production Management and Engineering Warsaw Agricultural University) is now being examined.

Important contacts with major nursery equipment manufacturers in Europe were developed. There are a number of overseas manufacturers that have expressed interest in introducing their technology to Australia. However, most of the equipment and technologies developed for the European nursery industry can not be directly adopted by the Australian nursery industry without some modification. It is essential, therefore, that development, evaluation and then demonstration of equipment to Australian nursery operators is carried out in order to select the most suitable designs.

It is proposed that QHI should take a leading role in the provision of services to assess, develop and demonstrate high productivity nursery systems by creating a demonstration nursery facility at Redlands Research Station.

Appendix 1 Itinerary

Date	Place	Purpose of visit
7.6.2000	Katowice/Heidenhein	Travel from Poland to Germany to conduct study tour
8.6.2000	Heidenhein	Meeting with representative of Mayer GMGH & Co, assessment of equipment, visit to nursery
9.6.2000	Asperg	Meeting with representative of Gartnereibedarf EG, assessment of equipment supplied by company
10.6.2000	Asperg-Moorosdale	Travel to Netherlands & Belgium to continue study tour
13.6.2000	Moorosdale	Meeting with representative of Demtec International, assessment of equipment, visit to nursery
	Wageningen	Travel to Wageningen
14.6.2000	Wageningen	Meeting with representative of the University, discussion on future cooperation
	Amhem	Meeting with Research Station Recreation Sports Grass, discussion on potential cooperation
	Bergschenhoek	Meeting with representative of Hawe System Europe, assessment of equipment, visit to nursery
15.6.2000	Gravendeel	Meeting with representative of Visser International, assessment of equipment, visit to nursery
	Barendrecht	Meeting with representative of Filler Holland; assessment of equipment, visit to nurseries
16.6.2000	Noordwijkerhout	Meeting with representative of Javo Holland, assessment of equipment
	Potrum	Travel to Germany
17.6.2000	Potrum, Arhus	Travel to Denmark
19.6.2000	Odense	Meeting with representative of CC Containers demonstration of system and equipment, visit to nursery
21.6.2000	Rosa Danica	Visit to nursery, assessment of equipment for plant handling and dispatch

21.6.2000	Rosberg	Visit to nursery, assessment of equipment for plant handling and dispatch
23.6.2000	Arhus, Hamburg, Warsaw	Travel to Denmark to Germany and Poland
24.6.2000	Warsaw	Meeting with representative of University, discussion on future cooperation, visit to nursery, assessment of equipment, visit to peat moss production plant for nursery industry
25.6.2000	Warsaw/Katowice	Return to Katowice.

Appendix 2 Addresses:

Research organisations

Name	Address	Telephone/Fax	Potential Area of Corporation
Dr.ir. J.W. Hofstee Universitair Docent	Wageningen Universiteit Agrotechnologie en Voedingswetenschappen Agrarische bedrijfstechnologie 6703 HD Wageningen Bezoekadres: Gebouwnummer 309 Bomenweg 4, Wageningen	Tel: 0317 4841944829 80 Fax: 0317 4848 19 email: jan.willemhofstee@user.aenf.wag.ur.nl internet: www.aenf.wageningen-ur.nl	Student training
M. Sc. F. Versteeg Head Research and Development	Turf Research Centre Instituut voor Sportaccommodaties Papendallaan 31 PO Box 302 NL 6800 AH Arnhem The Netherlands	Tel: +31 26 483 4613 Fax: +31 2648346 30 email: franklin.versteeg@noc-nxf.nl	Turf Research
Prof Dr Zbigniew Majewski	Warsaw Agricultural University Department of Production Management and Engineering Nowoursynowska 166 02-787 Warsaw, Poland Home: Wiolinowa 7/29 02-785 Warsaw, Poland	Tel: 22 843 07 43 Fax: 22 843 07 43 email: majewskiz@alpha.sggw.waw.pl Tel: 22 641 88 93	Development of production strategies

Allied industries

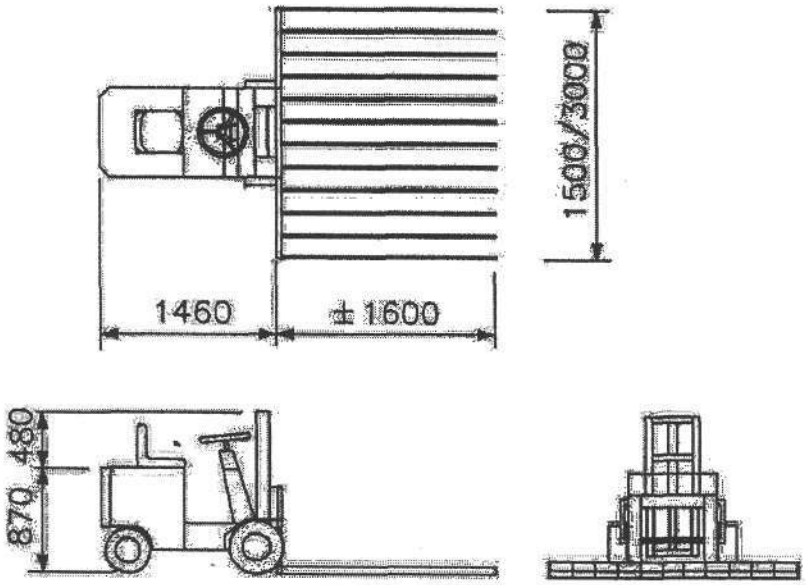
Name	Address	Telephone/Fax	Potential Area of Corporation
Hans-Dieter Newmann	Mayer GmbH & Co. Maschinenbau and Verwaltung Postsrabe 30 D-89522 Heidenheim	Tel: 0 7321 9594-21 Fax: 0 732195 94-97 Mobile: 01 71 97893 01	Automation of nursery production
Volker Breitner Sales Director	Mayer GmbH & Co. Maschinenbau & Verwaltung Postsrabe 30 D-89522 Heidenheim	Tel: 0 73 21 9594-47 Fax: 0 73 21 95 94-97 Mobile: 01 71 97893 02	Automation of nursery production
Volker Neutard	Asperg Gartnereibedarf eg D-71679 Asperg Alleenstrabe 70 Private: 69214 Eppelheim Weimarer Strabe 5	Tel: 0 71 41 662 50 Fax: 66 25 17 Mobile: 01 71 24163 10 Tel: 0 62217663 57 Fax: 76 98 10	Nursery equipment and materials
Stephan Schniz Leiter Marketing	Asperg Gartnereibedarf eg D-71679 Asperg Alleenstrabe 70	Tel: 71416625 28 Fax: 0 71416625 17 email: Sschniz@GBA.de Im internet: www.GBA.de	Nursery equipment and materials
Geert Desmadryl Sales Representative	Demtec Demaitere BVBA Roeselaarsestraat 171 B-8890 Moorslede Belgium	Tel: 32 0 51 7770 36 Fax: 32 0 51771113 email: demtec@ping.be BTW BE 406 542 143	Automation of nursery production
Pieter van Der Meij Sales Manager	Hawe Systems Europe V.V. Oosteindsepaid 8 2661 EP Bergschenhoek Holland Private: Koningsvaren 3 2631 VD Nootdorp	Tel: 010 52127 55 Fax: 010 52176 16 Tel: 015 310 53 48	Automation of nursery production
Bunnik Plants	Albert van't Hartweg 64 2665 Mj Bleiswijk	email: www.bunnikplants.nl	Plants production
Hans Preesman Vertegenwoordiger	Visser International Trade & Engineering BV Mijlweg 43 PO Box 5103 3295 zg 's-Gravendeel Holland	Tel: int.+ 31 78673 9800 Fax: int+ 3178-673 3434 website: www.visserite.com email: h.preesman@visserite.com Mobile: int.+31 532566 21	Automation of nursery production
Hans de Vet Export Manager	Machinefabriek Flier B.V. Industrieterrein "Dierenstein" Zuideinde 120, 2991 LK Barendrecht Postbus 200, 2990 AE Barendrecht	Tel: 0180-615055 Fax: 0180 618083	Automation of nursery production

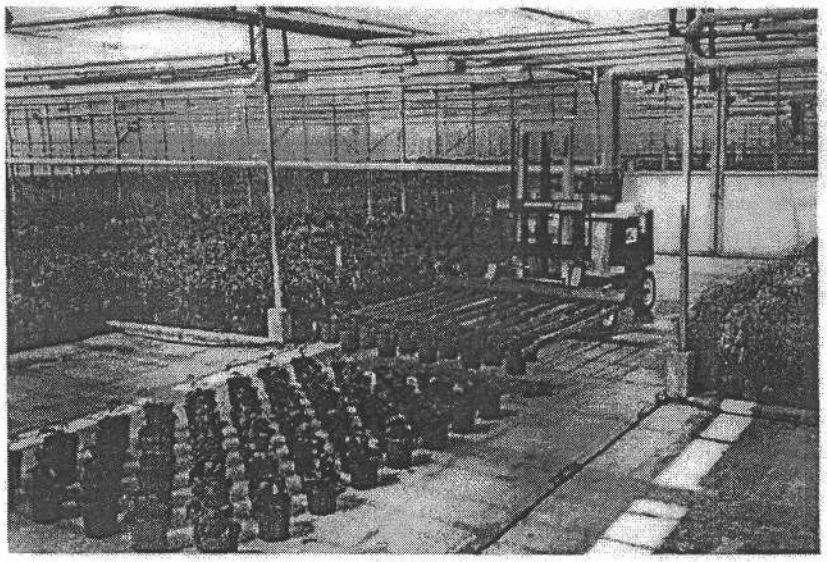
Name	Address	Telephone/Fax	Potential Area of Corporation
G.N.J. Mooyman vertegenwoordiger	Javo Holland Postbus 21 2210 AA Noordwijkerhout Westeinde 4	Tel: 0252 3431 21 Fax: 0252 3774 23 email: javonl@wxs.nl	Automation of nursry production
Berno Holmgaard Jensen Managing Director	CC Private: Lilleskovvej 63A DK-5690 Tommerup	Fax: +45 64 7635 03	Development of dispatch and useful transportation systems
Perian Hansen Sales Manager	Gloria Mundi Krydderurter Rosborg Krydderurter AS Braendekildevej 43 DK-5250 Odense SV	Tel: +45 63 9633 30 Fax: +45 639633 10 Mobile: +45 236091 02 email: PH@Krydderurter.dk	Plant production
mgr inz. W.Flejszer	Green Market Szkolka Drzew I Krzewow Ozdobnych ul. Miedniewicka 14 96-100 Skierniewice, Poland NIP 836 10 01 315	Tel/fax 046 833 1802 Tel 0-601 3453 29	Plant production
Henryk Skowronski	Zaklad Torfowy 'Karaska' 05-092 Warszawa - Lomianki ul. Partyzantow 35	Tel/fax 022 75 12 269 Tel: 0602 3538 41	Pit moss processing and treatments
Stephan Schniz Leiter Marketing	Asperg Gartnereibedarf eg D-71679 Asperg Alleenstrabe 70	Tel: 071 41 662528 Fax: 071 41 6625 17 email: Sschniz@GBA.de	Nursery equipment and materials

Appendix 3 Equipment for potted plant handling

SPACE-O-MAT

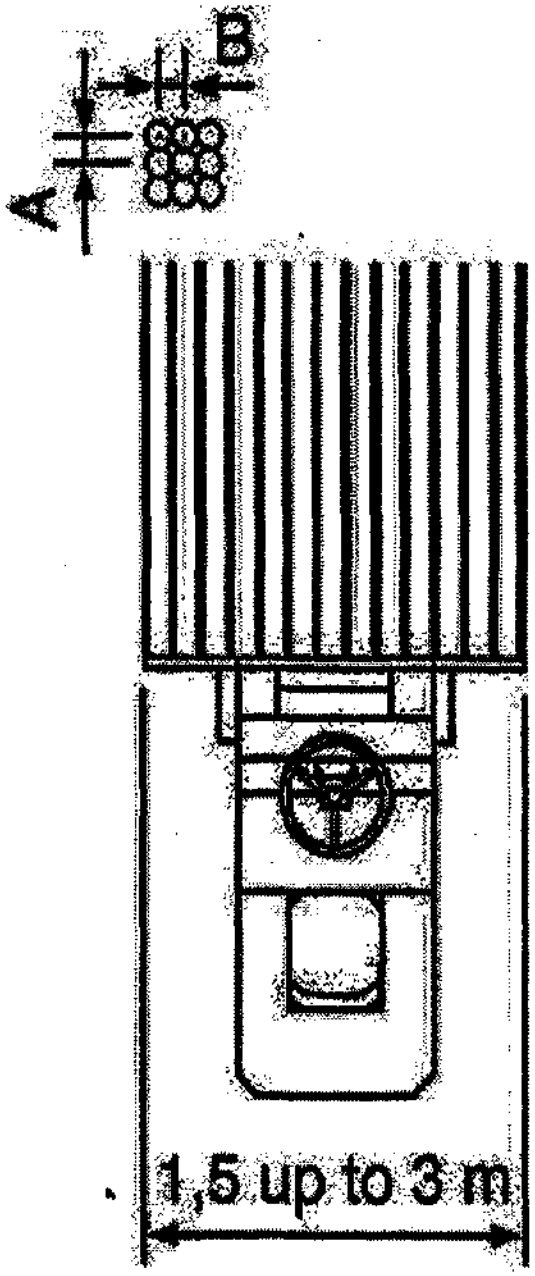
Electric fork-lift truck, built to operate on concrete floors, for the spacing out of potted plants. Provided with computer steering to set plant spacing distances.



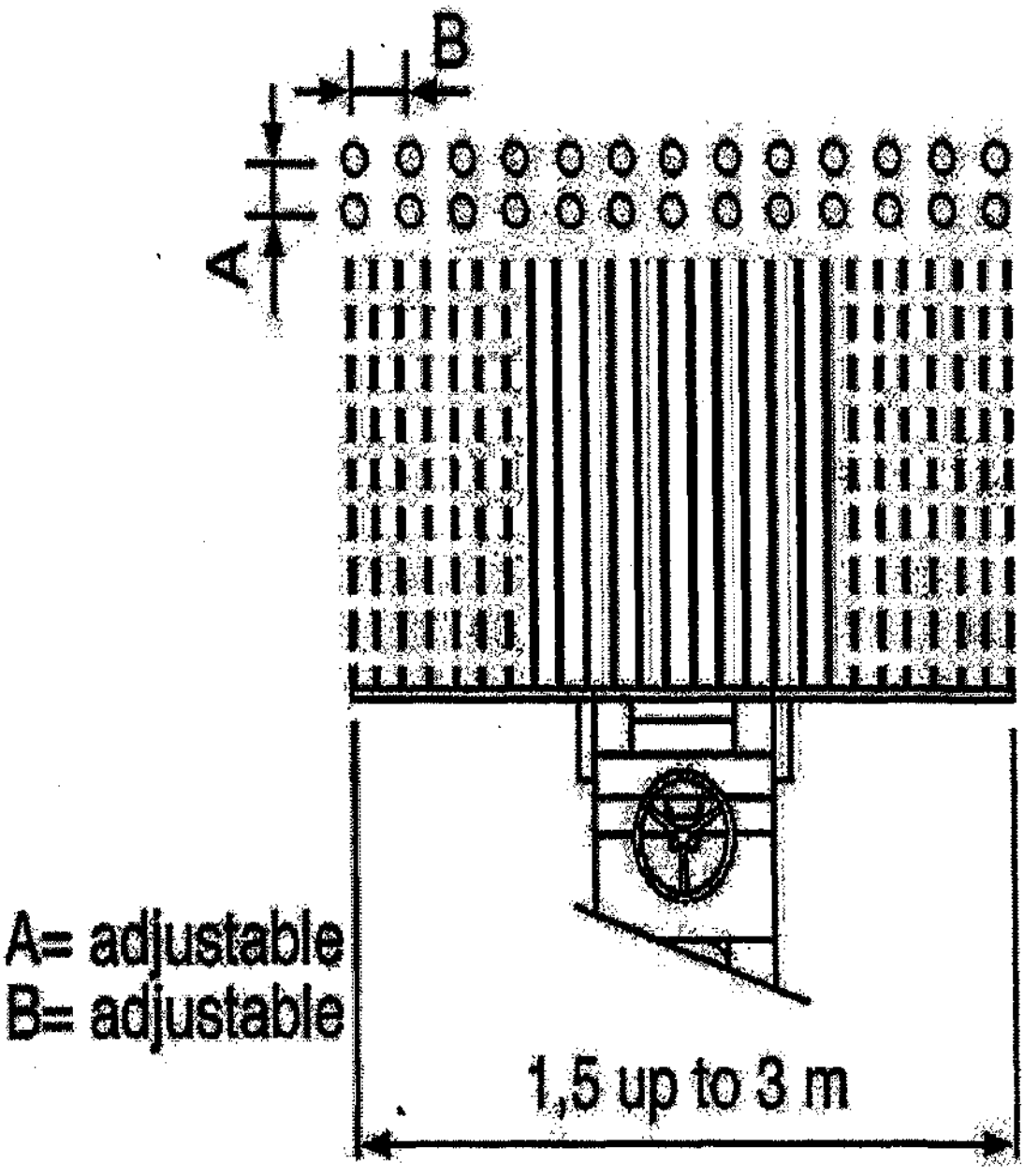


POT TRANSPORT FORKS

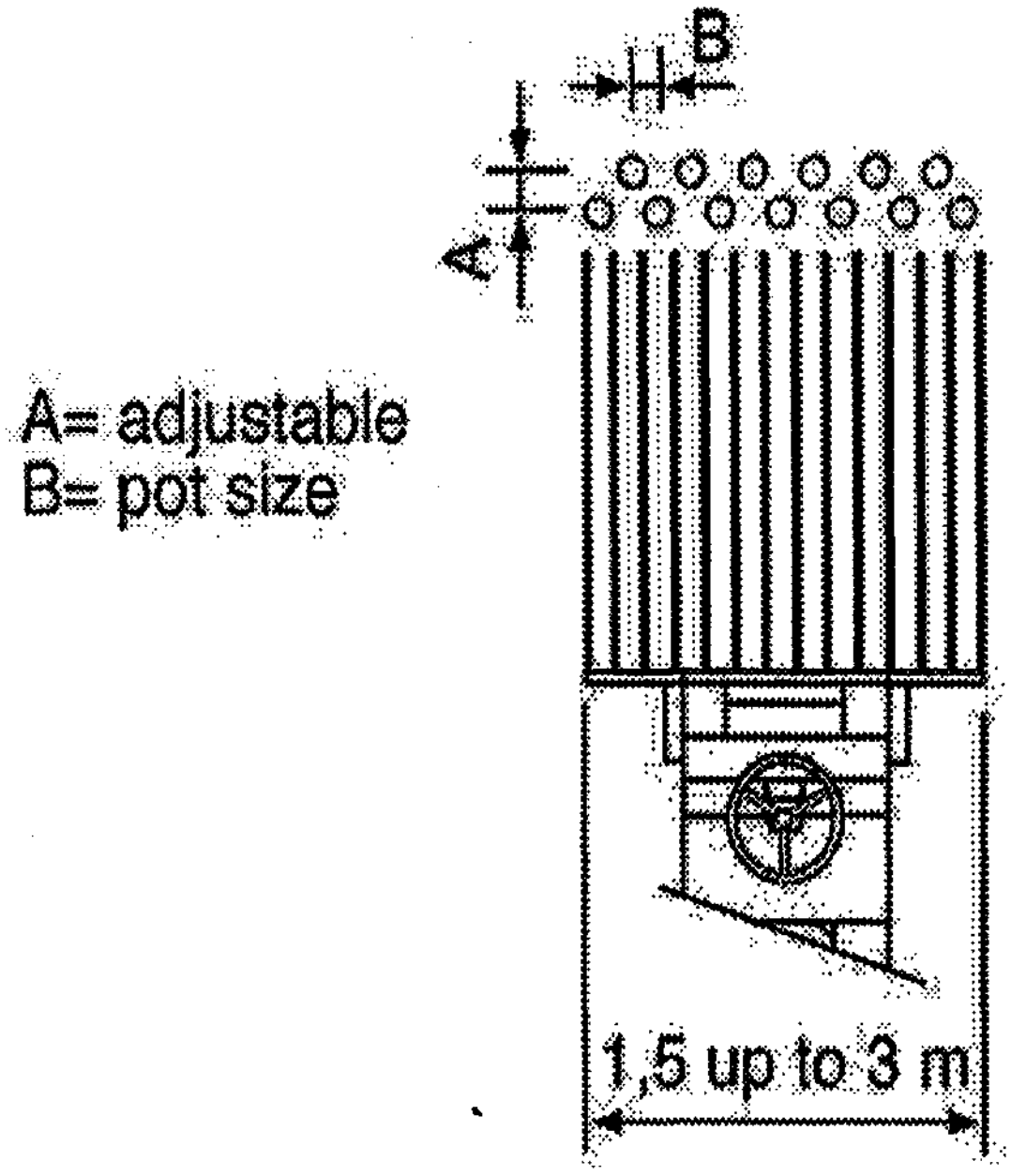
Pot transport fork
Frame width 150 cm, tooth length 150 cm



Pot spacing fork L (length)
Frame width 200 cm, tooth length 150 cm



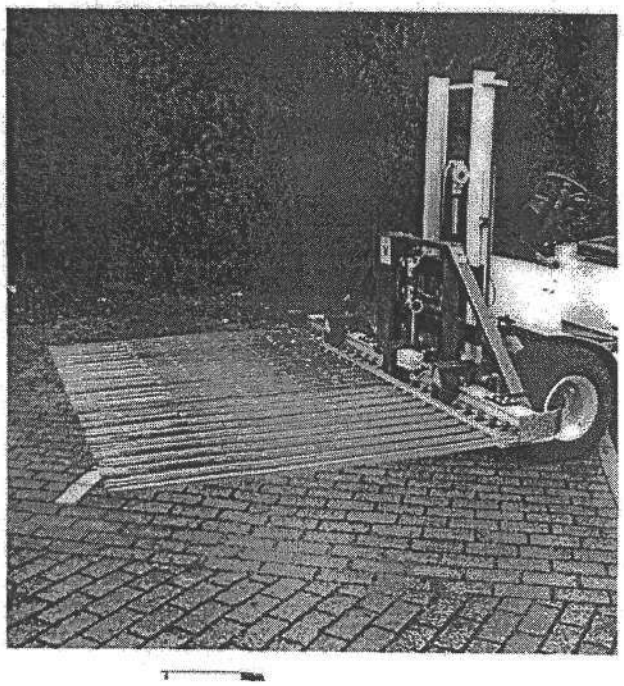
Pot spacing fork WL (width and length)
Basic frame adjustable in width from 150 to 300cm, tooth length 150 cm. Suitable for pots with a diameter up to 17 cm.



SPACE-O-MAT HD-II

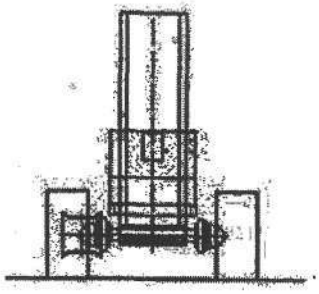
Space-O-Mat HD-II (heavy duty)

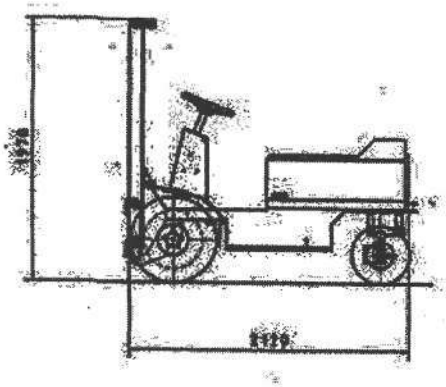
Computer controlled fork-lift truck for transporting and semi-automatic spacing of all kind of potted plants both indoors and outdoors.

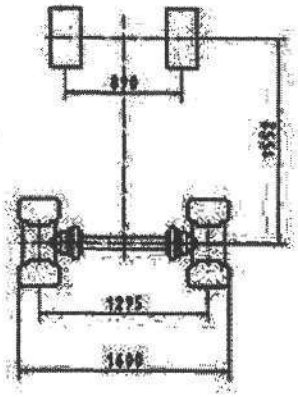


This model is developed for use on hard and soft surfaces.

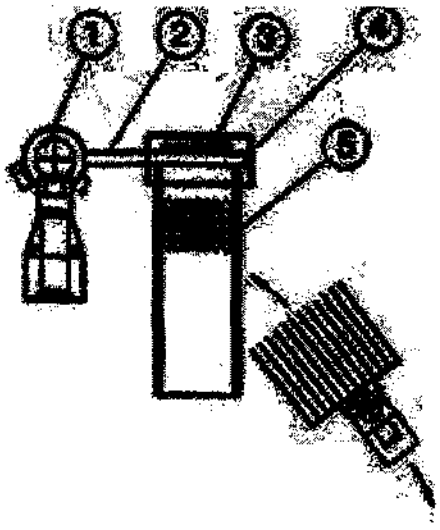
Driven by diesel/electric power. The computer steering in combination with the spacing forks can space plants (once or twice) in almost any number of plants per square meter. Suitable for pot sizes 10.5 to 30 cm. Also can be used as normal fork lift.







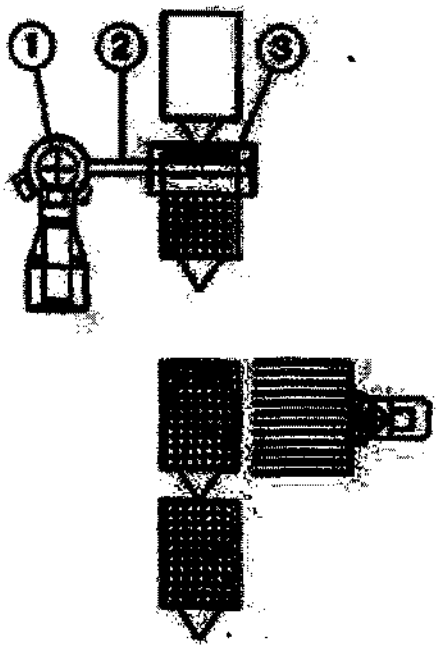
AUT. SPACE-O-MAT SYSTEMS



SYSTEM A
Automated pot loading on conveyor belt

Pos. 1)	Pot filling machine
Pos. 2)	Buffer conveyor belt, L=0,5 m, W=15 cm, adjustable speed
Pos. 3)	Positioning conveyor belt, L=160 cm, adjustable speed
Pos. 4)	Pot transfer device incl. switchbox
Pos. 5)	Conveyor belt, length = 6 m, width ≈ 1,65 m. With endstop

AUT. SPACE-O-MAT SYSTEMS



SYSTEM B
Automated pot loading on carriages

Pos. 1)	Pot filling machine
Pos. 2)	Buffer conveyor belt, LxW = 50x15 cm, adjustable speed Positioning conveyor belt, L=160 cm, adjustable speed
Pos. 3)	Pot transfer robot incl. feeding system for carriages

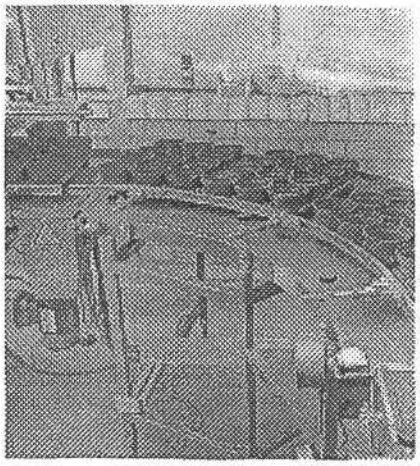
ROUND CONVEYORS

Frame
The frame is fitted with a steel slider bed to support the belt. The support frame consists of square profiles, is adjustable in height and is mounted to the lower side of the conveyor.

Guiding of the belt
The conveyor belt is guided by means of sets of guide rollers mounted to the outside edge of the belt. Each set consists of two ball bearings covered with a nylon running surface. This guarantees a low internal resistance, low noise and is almost maintenance free.

Conveyor belt
The conveyor belt consists of segments with hot spliced fingerjoints. The top cover PVC or PU as desired.

Conical rollers
Conical rollers are mounted to the frame with adjustable bearing units. The drive roller is coated with high friction material.

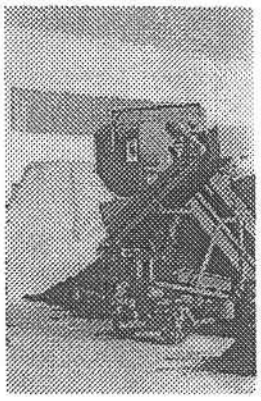


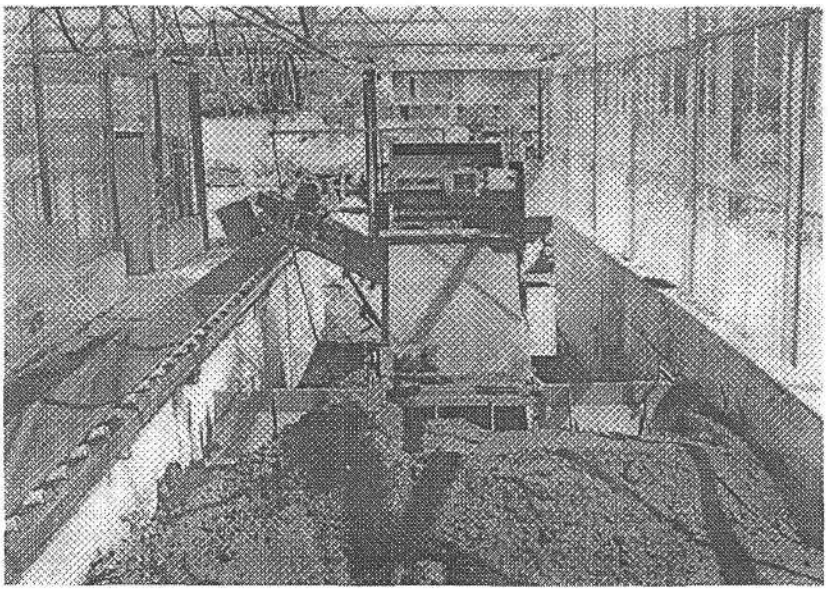
Drive
The round conveyor can be equipped with two standard types of drives
a) motor reductor with chain drive
b) wormdrive

Options
- Frequency controller to obtain a variable speed
- Waterproof drive
- Non-standard measures and angles
- Non-standard belt types
- Conveyor belt with profile on surface
- Side guiding
- Underguiding when used overhead
- Transport system

SD '92 SOIL DIGGER

SD'92 soil diggers
Robust automatic soil digger, suitable for operation between 2 walls. Digger conveyor belt, width=80 cm. Provided with buckets, pre-diggers with extra screws. Cross conveyor belt, L=2,5 m
Switch box and soil transfer device.
Max. SG soil=600 kg/m3. P=10,5 kW





Options for SD'92:
Rail with cable guide end cable, eg. soil bunker with a length of 20 m.
Trough conveyor belt, roller supporting, (max. 50m). Excl. mounting supports for placing on Basic L= 3m.

PLANTVISION GRADING SYSTEM

PlantVision grading system
With the help of advanced vision technology currently a high number of crops can be sorted by this grading system. The system recognises colours and distinguishes different classes of plants according to desired definitions.

There are numerous possibilities for using this vision grading system. It can be applied when sorting half-grown or full-grown plants

Possibilities of sorting:
- sorting on measures (height, width, leaf area)
- sorting on maturity
- sorting on form.

When sorted on form or measures, the plant will be rotated in a pot-holder. After making 8 recordings it calculates the average value and decides which class the plant belongs to.

The advantages of PlantVision are:
- higher uniformity because of 100% consistency within the system
- higher quality because of uniformity during growth (by sorting half-grown plants)

Appendix 4 Economics of investment

An example of how investment in the nursery can affect the cost of labour as well as the overall cost of production is shown below. There are various ways to evaluate the economics of any production system and all of them depend on certain assumptions. For the purpose of this exercise a simple annual model is used that is often applied in overseas nurseries when decisions on investment are to be made.

For this example the following assumption are made:

- hourly labour cost is $15 per hour
- life of equipment is 10 years (no salvage value)
- real interest rate on investment 6%
- electricity cost $0.15/kWh
- the average maintenance cost of equipment during its life is 2% per annum of the investment's value.

Two aspects of the investment are investigated as shown in table 1:

- The pay back period
- The overall cost of production

The existing system is as follows:

- Nursery production 1 000 000 pots per annum (eg. 140mm pots)
- Production in the existing hand potting system is 2000 pots per hour
- A total of 10 people are involved in present production (6 potters, 3 workers putting pots down in the growing area including driver and one supervisor).

Four different options are considered in order to reduce the overall cost of production.

Table 1. Economic evaluation of potting production for different investment options.

	Present system **Hand potting**	**Option 1** Potting machine only	**Option 2** as option 1 + pot dispenser	**Option 3** as option 2 + pot take off & self loading trailer	**Option 4** as option 2 + spacing fork with associated equipment
Total production (Pots/annum)	1 000 000	1 000 000	1 000 000	1 000 000	1 000 000
Production rate required (pots/hour)	2000	2000	2000	2000	2000
Total staff required	10	8	7	6	4
Total equipment cost ($)	0	26 000	30 000	38 000	75 000
Total labour cost ($/hour)	151	120	105	90	60
Total Running cost (labour + maintenance +electricity) ($/annum)	75 454	60 895	53 475	46 135	31 875
Total annual cost ($/annum)	75454	64275	57375	51075	41625
Pay back period (pots to be produced)		2 000 000	1 583 000	1 500 000	1 916 000

An objective decision on whether an investment is economically viable or not can only be made on the basis of an evaluation that considers all nursery production options. Figure 1 and figure 2 graphically represent the result of the evaluation.

Option 1: Potting machine only

Option 2: Potting machine with fertiliser dispenser

Option 3: Potting machine with pot dispenser, and automatic take off, and self loading trailer

Option 4: Potting machine, pot dispenser, automatic take off, self loading trailer, spacing fork.

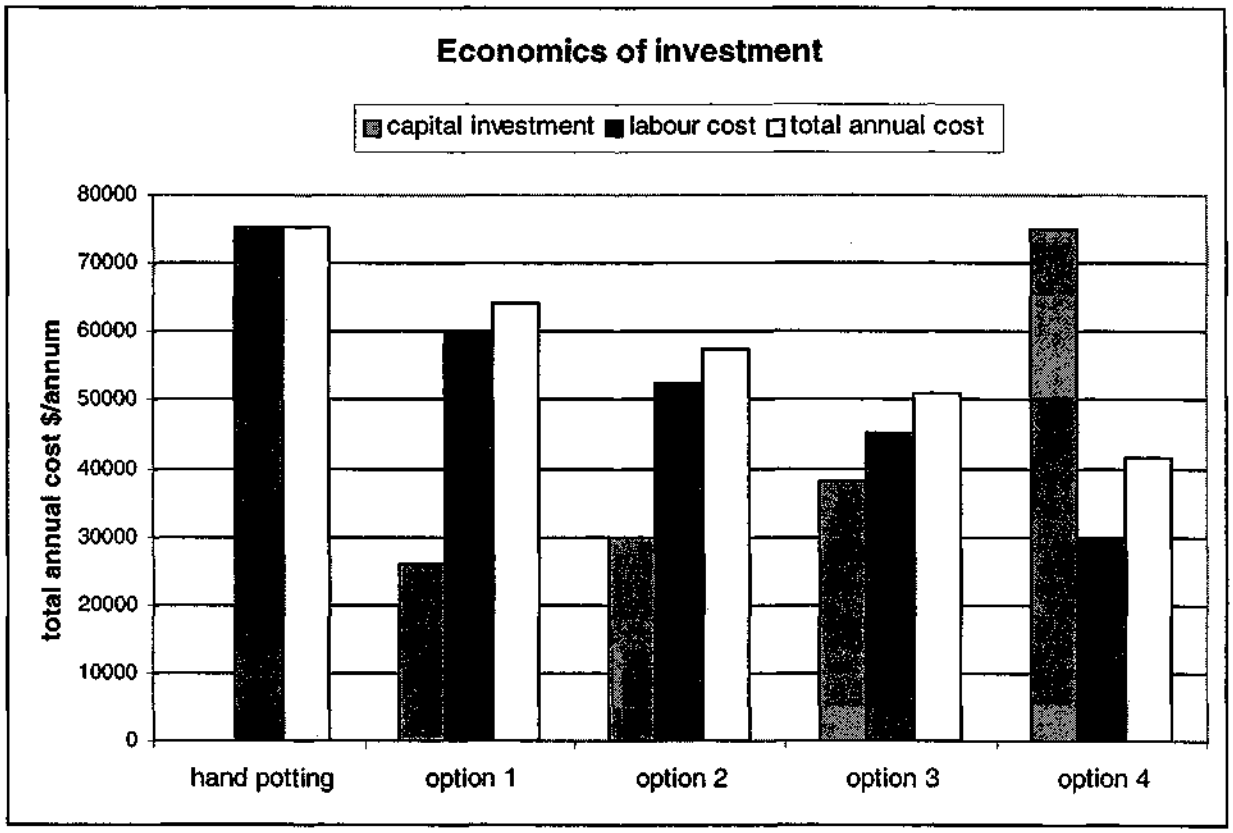


Figure 1. Evaluation of annual production cost in relation to investment made.

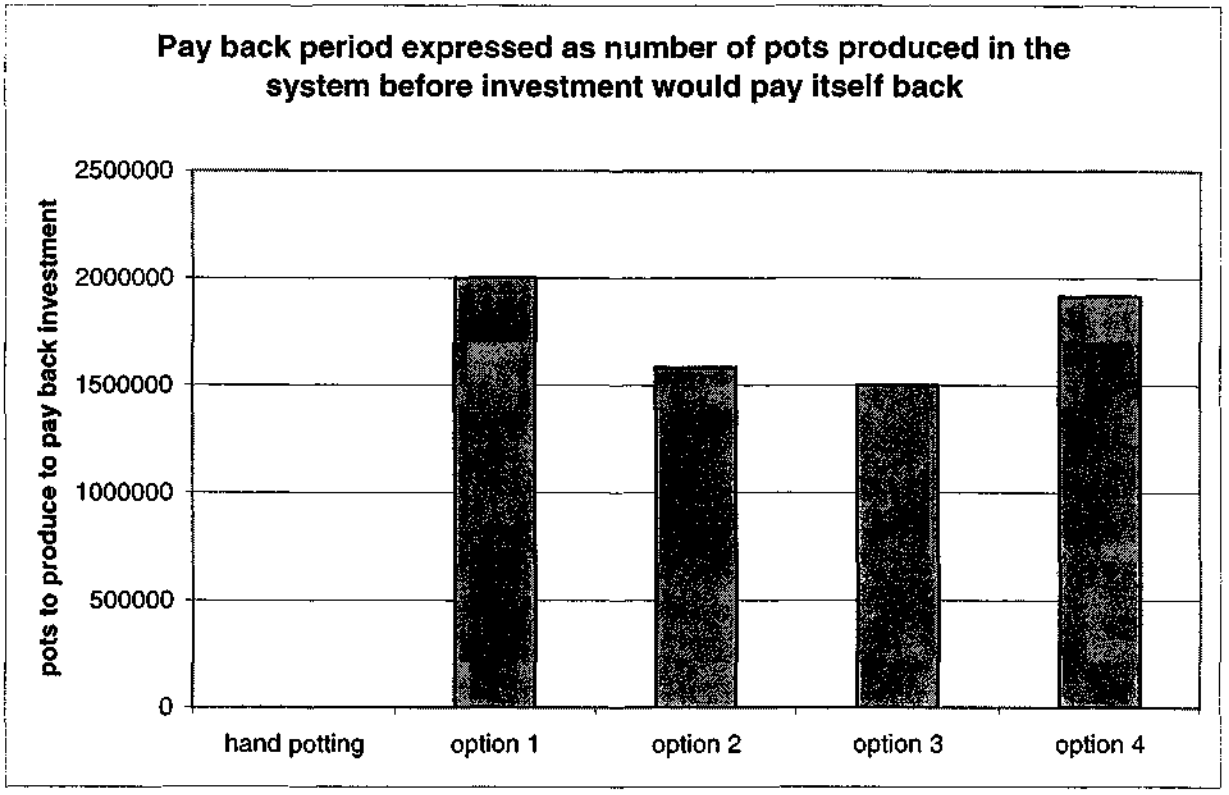


Figure 2. Minimum quantity of pots produced to pay back investment

ATTACHMENT 3

REDUCING POTTING LABOUR COSTS

INTRODUCTORY TRAINING COURSE

W. Radajewski, D. Brown, T. Franklin

Department of Primary Industries
Queensland Horticulture Institute
Centre for Amenity and Environmental Horticulture
International Centre for Nursery Excellence

Horticulture Australia Limited

DPI QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

Nursery Industry Association of Australia

CONTENTS

Introduction

Wholesale nurseries produce plant products that enhance the lifestyle of millions of people around the world. They are also commercial enterprises which operate in the strict expectation of making profit.

In order for nurseries to prosper, their production systems must be *designed, organised* and *operated* in a manner that ensures production costs remain low and profits remain high.

When this fails to happen, production efficiency fails, labour costs rise and nursery profits suffer. Research has found that nurseries with low production efficiency typically display low levels of Occupational Health and Safety (OH&S), low levels of staff motivation and problems maintaining consistent plant quality.

Nursery management, nursery staff and plant buyers all have the right to expect that the production systems they deal with operate at maximum possible levels of production efficiency.

This training course aims to help nursery staff and nursery management:

- understand the principles of efficient potting production
- identify problems in potting production
- benchmark potting production efficiency
- understand how to introduce improvements to a potting system

The course is intended as an introduction to the process of improving potting production efficiency. Training courses to assist nursery management in the specific identification of problems in potting production and the development of specific solutions will be available from the International Centre for Nursery Excellence established by the Queensland Department of Primary Industries at Redlands Research Station.

What is potting production?

Potting production is much more than placing a plant into a pot and adding water. It is a combination of many tasks undertaken over the 3 potting production stages of:

- preparation for potting
- potting
- after potting.

A sample of the range of potting production tasks might include:

- preparing the growing area to put down plants (eg. blocking up, raking gravel, dusting herbicide, setting stringlines, cleaning concrete)
- preparing the potting area (eg. setting up equipment, cleaning work surfaces)
- maintaining potting equipment (eg. servicing and adjusting potting machine)
- maintaining potting area (eg. cleaning the potting area after production)
- delivering potting materials to the potting area (eg. potting media, plastic pots, fertiliser, bins, stakes, trailers, plant stock)
- selecting and grading plant stock to be used in potting
- loading potted plants to nursery transport (eg. trailer, hand trolley, electric cart, conveyor)
- watering in potted plants
- applying pre-emergence herbicide to potted plants
- transporting potted plants to growing area
- spacing potted plants on the ground in growing area
- returning with empty trailer to potting area

<u>List 10 tasks in each of the 3 stages of potting production</u>

PREPARATION	POTTING	AFTER POTTING

What is Potting production efficiency?

In an efficient potting production system *everyone* benefits. The nursery operates with minimum production labour costs so management is positioned to maximise profits; staff can perform their tasks in an environment designed to maximise levels of OH&S, worker comfort and worker motivation; and the plant buyer receives high quality plants.

In an efficient potting production system:

- plants are produced at minimum potting labour cost per pot
- plants meet all the quality expectations of buyers
- production occurs with maximum levels of OH&S and worker comfort
- production occurs with minimum levels of materials wastage
- outlay on production equipment is justified in terms of investment return

Factors affecting potting labour costs

Some of the factors which increase potting labour costs are difficult to avoid. They could be features of the type of production a nursery undertakes and changing them to reduce costs may not be a realistic option. For example:

- certain types of plants are more time consuming to pot than others
- potting to large sized pots generally takes longer than potting to small pots. Potting into large sized pots increases the time needed to handle the potted plant and increases the frequency potting materials (eg. potting media, fertiliser, pots, etc.) need to be replenished.
- as the difference between the size of the propagation container and the size of the pot decreases potting becomes more time consuming. (eg. when potting up from a 140mm pot to a 175mm pot the space in the 175mm pot narrows and takes more time to fill with media).
- plant stock grown in tubes can take longer to remove and insert to the pot than plant stock grown in cell trays. Then there is the additional task of disposing of each tube.

Yet, even allowing for the fact that plant types, propagation containers and pot sizes do affect potting time, it does not explain why some nurseries are consistently paying far more than their competitors to produce potted plants.

A study of 52 Australian wholesale nurseries found the average labour cost of potting up a 140mm plant varied from
4 cents per pot to 22 cents per pot.

As shown above, some of the factors affecting potting labour cost can't be avoided. However, the affect of many other factors can be minimised. Especially when they are the result of a nursery's decisions in the design, organisation and operation of its potting system. In this case decisions can be reviewed and, if necessary, changed, in order to reduce potting labour costs.

It is estimated that:

- inefficient organisation of potting procedures, often combined with the use of an inappropriate potting system and equipment as well as poor material handling methods, is responsible for approximately 65-85% of excessive potting labour costs
- inadequately trained staff with low levels of skill and motivation is responsible for approximately 10-20% of excessive potting labour costs

List potting production factors that a nursery might not be able to change in order to reduce its potting labour costs

Evaluating a potting production system

Don't under-estimate the complexity of a potting system. When attempting to evaluate the production efficiency of a potting system, all of the following aspects should be carefully considered:

- management of the potting system
- management of labour
- selection of equipment and methods of material handling
- communication
- Organisation of the work station
- Potting techniques
- Operating knowledge
- Break downs and malfunctions
- Automation of tasks
- Speed of operation
- Worker related issues

Management of the potting system

Management of the potting system includes such things as the initial selection of the potting system used, organising the layout of the potting area, deciding when and where watering plants will occur, how plants are spaced in the growing area, how fertiliser is applied, whether production will be *non-interrupted* (potting continues while plants are put down in the field), *interrupted* (potting stops while plants are put down in the field) or a combination of both, etc.

Management of the potting system may not always be a carefully considered response to production factors. The type of potting system used could be the result of chance events such as buying a particular potting machine at a bargain price, or inheriting a potting system from the previous owner. Like the potting system used, the layout of the potting area can also be determined by chance. Potters may walk relatively long distances to pick up small quantities of potting materials (empty pots, plant stock, fertiliser, etc.), and remove potting outputs (potted plants, empty tubes or trays, etc.) only because the location of inputs and destination of outputs has never been evaluated from the point of view of production efficiency.

Research shows that various potting systems can all achieve benchmark levels of potting labour cost. This indicates that different potting systems can operate with equal efficiency if they are properly managed, are suitable for the type of plant production at the nursery and the potting area is laid out to allow for the efficient delivery of inputs and outputs. High potting labour cost figures on the other hand reveal inefficient potting production and show that some nurseries are using potting systems which are unsuitable for their type of production and/or are not being adequately managed and/or have poorly designed potting areas.

List some problems that can occur in the management of the potting system

List some solutions to problems in management of the potting system

Management of labour

Management of labour includes the allocation of tasks to potting staff, preparing task rotation schedules, establishing production quotas, training staff, devising staff motivation strategies, etc. The most profitable situation for a nursery is to use the minimum number of staff to reach production targets. However, medium and large-sized nurseries can tend to over staff their potting operations. In many nurseries certain potting staff are not consistently, productively employed. For example, if a person's task is to drive plants to the field, put them down and return to the potting area for the next load, that person will not carry out any productive work (aside from cosmetic duties) if the next trailer to be taken to the growing area has not been completed by the potters.

The problem of staff waiting to begin their primary tasks stems from a lack of synchronisation between the completion of one task (eg. the potters' task to pot up a trailer load of plants) and the beginning of another (eg. the driver's task to take the trailer to the field, put plants down and return the empty trailer to the potting area). The reluctance of waiting staff to help out in tasks which they consider to be outside their job description contributes to the problem. The solution to the problem is to review the overall potting system and locate where synchronisation of tasks can be improved by either allocating real and productive tasks to waiting staff and/or by improving production efficiency within the various stages of the potting process to decrease the time gap between dependent tasks.

Obviously it is difficult to get the synchronisation of dependent tasks just right as timing can be thrown out as potting or putting down time increases or decreases due to potting different species of plants, using different pot sizes, putting plants down in different areas of the nursery, etc.

To avoid the situation where lack of synchronisation creates non-productive time, production buffers should be used. Production buffers could take the form of extra trailers for potters to continue potting (instead of waiting for an empty trailer to return from the growing area), sending one of the potters into the growing area to help with plant unloading or changing from non-interrupted potting production to interrupted potting production - eg. 2 people pot a trailer load of plants and then both go to unload the plants before returning to the potting area to pot another trailer load of plants.

List some problems which can occur due to the management of labour

List some solutions to problems in the management of labour

Selection of equipment and methods of material handling

Material handling and equipment refers to the method and the equipment used for moving the materials (inputs and outputs) used in potting. A great variety of methods for material handling are used by nurseries. Empty pots are delivered to the potting bench by hand, trolley or trailer; media is brought to the bench by the shovel load or using a front end loader; potted plants are carried to the trailer by hand or placed in trays and loaded by conveyor; plant stock is brought considerable distances by hand, one tray at a time or delivered in large quantities by automatic conveyor to the potting bench.

Many nurseries could instantly reduce their potting labour costs by reviewing their handling methods and taking steps to ensure whenever material is delivered to or removed from the potting area it is done quickly and in quantities representing a significant period of potting production. For this to occur, the location of inputs and outputs needs to be reviewed; the quantities in which inputs and outputs are delivered needs to be reviewed; the suitability of equipment used in materials handling needs to be reviewed; and staff need thorough production information to accurately plan the type and quantity of materials to be delivered.

List some problems occurring due to methods of materials handling

List some solutions to problems in materials handling

Communication

A lot of information needs to be processed before potting can begin:

- What stock is to be potted?
- How much of the stock is to be potted?
- Where is the stock located?
- What size, type and colour pots are to be used?
- How many people will be potting?
- Who will be doing which tasks?

- If equipment is necessary, is it available and serviceable?
- Is suitable growing medium available?
- Which fertiliser will be used; is there sufficient; how will it be applied?
- Which planting stock should be rejected?
- Where are the potted plants going?
- Do they receive a herbicide application?
- Does the growing area need to be prepared?
- How much water should they get prior to being put down?

When information is unavailable to potting staff, production time is wasted while they seek instruction. When potting staff have all information necessary, then work can begin promptly and continue without interruption. In smaller nurseries where managers often participate in the potting process, decisions on potting production can be communicated instantly to potting staff. In medium and large nurseries the relay of information may be longer as it travels from production manager to potting supervisor to potting staff.

To reduce the potential for communication failure disrupting potting production, nursery management should set up a reporting system to monitor available quantities of potting materials (media, pots, stock, etc.), ensure potting materials are ordered ahead of time and available in the potting area and ensure that all necessary information has been communicated to all relevant potting staff before production starts. When this occurs, staff become largely self managing and production stops will be reduced.

List some examples of the information required for potting

List some problems resulting from poor information communication

List some solutions to problems occurring in information communication

Organisation of the work station

The work station includes the actual potting work bench (hand or machine setting) and the surrounding area. As the work station is the focus for the movement of potting inputs and outputs, it is essential that room for the storage of these materials during potting exists and that access to them during potting is not impeded.

A poorly organised work station has a distinct affect on the production efficiency of machine potting systems. As potters work at the speed of the machine there is little time to select inputs and remove outputs without falling

behind. Compensating for a poorly organised work station by reducing machine operating speed or lowering the production quotas of staff is not a solution to the problem. The only solution is to improve the organisation of the work station to enable more efficient potting production.

An unavoidable fact of hand potting systems is that the presence of potting media makes it hard to find flat space to stand pots, place plant stock, fertiliser etc. If a potting work bench is poorly organised, potters can spend considerable time carrying out many small actions moving potting materials (stock, pots, fertiliser, empty tubes, trays, etc.) about on the bench as they seek access to potting media. Work space can be optimised by keeping materials for potting off the potting bench but close to potters (eg. stands or conveyors in for plant stock, bins for disposal of tubes, utilising unused space under potting bench to store other potting inputs and outputs).

List problems in work station organisation for hand & machine potting systems

List some solutions to problems in work station organisation

Potting techniques

Potting can be undertaken in a variety of ways. For example, in hand potting:

- a large quantity of pots can be filled with media, loaded to a trailer or bench and then have plant stock inserted to each pot (batch production)
- a small quantity of pots can be filled with media at the work bench and stock inserted to each pot (batch production)
- an individual pot can be filled with media at the bench and stock inserted into the pot (continuous production).

Significant differences were detected between the productivity of potters (hand potters and those operating potting machines) working in the same nursery. This variation can be put down to the better work station organisation, motivation and potting technique of the more productive potters.

Over time, potters often develop their own particular potting technique and method of organising the work station. However, these techniques and methods might not always be the most efficient or most comfortable options available. Nurseries should review the productivity of individual potters and where possible use more productive potters to train others in techniques which are proven to be injury safe and productive.

List problems arising due to potting technique

List solutions to problems arising due to potting technique

Worker skill

Worker skill in operating potting machines is generally observed to be sound in the straight forward operation of potting equipment. However, a lack of skill can be observed when accurate adjustments need to be made to equipment (eg. conveyors, potting machines) to cater for changes in operating circumstances such as occur when changing pot sizes, moving the machine to another location in the nursery or coping with different moisture content levels in potting media.

The importance of staff skill levels is not limited to the operation of potting machines. Staff need high skill levels in all areas they are likely to encounter in their work. When potting staff do not know how to carry out a certain task, production is slowed while they seek out assistance or, what can be even worse, plant quality is affected if they attempt the task without advice.

Potting staff should all know the potting requirements of different species (eg. water, herbicide, fertiliser, pruning, media, pot size, pot colour), how to identify and grade different plant stock, where potted plants are to be placed in the growing area, etc.

List some problems which can arise due to poor worker skill levels

List some solutions to problems arising through poor worker skill levels

Break downs and malfunctions

The research on which this course is based involved observation of many potting machines at work, however no machines actually broke down while researchers were recording potting data. Machine malfunctions, however, were quite frequently observed. Common potting machine malfunctions included:

- empty pots jamming in the pot dispenser
- empty pots jamming in potting machine
- empty pots jamming in the media outlet
- potted plants falling over as they are swept onto the conveyor
- media filled pots jamming in the machine
- potting media bridging in the external hopper
- potting media sticking to the sides of the machine's internal hopper

- potting media clogging the internal paddles of potting equipment

Pot dispenser malfunctions were a common source of production stops for Mayer machines and those Javo machines with automatic pot dispensers. The causes of pot jamming included:

- using second hand pots or pots with non-standard profiles
- staff unable to determine why pots were jamming
- staff unable to correctly adjust elements on the potting machine

In hand potting, equipment malfunction was mainly limited to the extremely common problem of hopper bridging (when the media obstructs itself from flowing). In fact, this malfunction was common in the majority of potting systems using hoppers (ie. all except standard potting bench). When a hopper bridges, production time is affected as someone works to restart the media flow using a shovel, length of wood, rubber mallet, etc. The reasons for hopper bridging include, poorly designed hoppers, hoppers made of materials which restrict media flow, hoppers with pitted, rusted or painted interiors, and using media with a high moisture content.

The high frequency with which malfunctions occur highlights how a lack of thorough operating knowledge (knowing how to both operate and adjust the machine, regulate the moisture content of media, etc.) can affect production efficiency.

List common areas of malfunctions on potting machinery

List common areas of malfunction in hand potting

List solutions to problems of malfunctions in machine and hand potting

Mechanisation of tasks

In machine potting the tasks of inserting pots to the machine and inserting fertiliser to pots generally involve one person full time and the constant nature of these tasks makes it difficult for the pot or fertiliser inserter to contribute to any other tasks. The initial cost of buying or building a pot or fertiliser dispenser would quickly be repaid by reducing the number of staff needed to operate the potting machine.

When hand potting, adding fertiliser to each pot adds several seconds per pot to the potting process. Nurseries that use an automated fertiliser dispenser or

buy potting media with fertiliser already mixed in, have an immediate advantage over nurseries that add fertiliser by hand during potting.

Some nurseries will not buy media with fertiliser mixed in. They are concerned about premature fertiliser release if potting is delayed, fertiliser not being in the optimum position in the pot to serve plant growth, etc. Other nurseries are very happy using media with fertiliser mixed in and manage to deal with all these concerns with no apparent affect on plant quality.

Each nursery should review its potential for mechanisation and, where an option for reducing costs exists, review its suitability for the nursery in an objective manner.

List some problems arising when a nursery fails to mechanise

List some production mechanisation solutions to machine potting systems

Optimum speed of operation

In some cases, when the potting staff is not being fully utilised, the efficiency of potting (ie. the labour cost per pot) can be greatly improved by reducing the speed at which the potting machine works. When machine speed is reduced, the number of people required to operate the machine can also be reduced as staff can now manage extra tasks and the potting tasks can be spread over fewer people. The daily production of pots will obviously be slightly decreased but this will be offset by a reduction in labour costs.

In hand potting, the optimum operating (potting) speed is one that can be sustained for lengthy periods of production. Potting at a very fast rate initially only to fall away during the day due to tiredness will be less productive than maintaining a steady potting speed throughout the day. When establishing production quotas for hand potters and machine potters, nursery management should base its targets on sustainable operating speeds and ensure that the potting work environment features maximum levels of OH&S and worker comfort.

List some solutions to problems arising in the area of optimum speed of operation in machine potting systems and hand potting systems

Worker related issues

Worker related issues refers to worker safety, worker comfort, worker motivation and worker skill levels. Poor safety standards will lower staff motivation, make tasks difficult to perform and increase the incidence of work place injury. Low worker comfort levels will hamper workers' ability to carry out tasks, will contribute to injuries, and will have a negative impact on worker motivation..

> It was found that well motivated workers who understood how to carry out their tasks and worked in an environment with high levels of OH&S and worker comfort were a feature of all nurseries with low potting labour costs

Worker safety

Safe handling of potting media

Reports commissioned by the Nursery industry have concluded that the unprotected handling of potting media carries the potential for the transmission of infectious disease. The advice from the Nursery Industry Association of Australia is that all people working with or in the vicinity of potting media should wear gloves and face masks. Nurseries that do not ensure staff follow safety guidelines for handling potting media risk being judged negligent in fulfilling their duty of care to staff.

Safe herbicide application

Many potters place granular pre-emergence herbicides onto plants after potting. Instructions for the safe handling of all herbicide products are clearly displayed on product packaging and should be followed.

> Researchers noted that workers commonly did not wear the recommended safety protection and did not always apply the herbicide away from the immediate potting area where herbicide residue could come in contact with other workers

Safe operation of machinery

The operation of potting machines involves staff coming into close and sometimes direct contact with moving machinery parts. Apart from normal operation of the machine, interaction also occurs when adjustments are carried out on the machine, when maintenance is carried out, as machines are moved from one potting location to another and when staff attempt to fix malfunctions and breakdowns during potting. As many of the potting machines used in nurseries are quite old, commonly lack warning labels and operating instructions and are prone to malfunctions, nursery management and staff need to be especially vigilant when using these machines.

From a safety point of view it is essential that any person using the potting machine (or any piece of equipment in potting) is fully familiar with the operation of the equipment and also knows the safety procedures to follow when attempting to fix malfunctions and make operating adjustments. Conspicuous warning signs should be placed on danger spots on machinery. Clearly written operating instructions displayed on potting machines can help keep staff conscious of safe operating procedures. Older potting machines may not carry any operating instructions or warnings. The nursery should clearly write the operating instructions and mark the danger areas on such machines to reduce the potential for injury.

Hearing protection

Loss of hearing is one of the most common reasons for worker compensation claims in Australia and New Zealand with around 14,000 claims for noise induced hearing loss lodged each year. Loss of hearing is not only caused by sudden exposure to explosive levels of sound or by prolonged exposure to very high levels of sound but can also be caused by prolonged exposure to sound levels of around 85 decibels. Working at a potting machine eight hours a day for a number of years could have a detrimental affect on the hearing of potting staff if they do not wear ear protection.

> Researchers found that very few potting staff wear ear protection despite working with or in close proximity to potting machines, tractors, front-end loaders, etc.

Nursery management should be aware that prolonged exposure to relatively low level noise can result in hearing loss and investigate the noise levels produced in the potting area, seek feedback from potters on levels of discomfort and provide hearing protection where required.

Maintaining potting equipment in a safe state for use

Equipment used in potting is subject to a lot of wear and tear and as the condition of things such as wire trays, potting machines, trailers, tractors, hoppers, etc., deteriorate they not only reduce the efficiency of production they also begin to pose a safety risk to potting staff. For example, when handling broken wire trays the sharp wire ends can catch at hands and clothing. If old vehicles used for internal transport have jagged body panels,these can pose a risk to workers. Trailers with broken metal rails or broken wire mesh bases can cut staff loading and unloading pots.

Although the potential for injury exists in all workplaces, the likelihood of an injury occurring will increase significantly if equipment is allowed to fall into disrepair. Nurseries can limit the potential for such injuries occurring by staying alert to possible sources of injury, regularly maintaining potting equipment and replacing any equipment that has become dangerous to use.

<u>List some examples of common worker safety issues in nurseries</u>

<u>List examples of solutions to common worker safety issues in nurseries</u>

Worker comfort

Worker comfort is one of the most important, yet one of the most consistently neglected factors determining production efficiency. All work requires effort but there is nothing wrong with creating an environment that allows the work to be carried out with a minimum of effort.

An uncomfortable work environment places unnecessary physical demands on potting staff that will limit their productivity. For example, a worker using inappropriate tools in a cramped work station with poor lighting, exposed to wind or rain will obviously tire more rapidly, be more susceptible to work related injuries, be less motivated to perform and ultimately be less productive than a worker performing the same task in less stressful surroundings. Any improvements that a nursery makes to levels of worker comfort can be expected to have a positive influence on overall productivity.

Protecting staff from the elements

Nurseries usually display a very high awareness of the need to protect workers from the sun and most nurseries provide sun screen and require workers to wear a hat and shirts with sleeves when in the field. However, opportunities for increasing worker comfort through the provision of mobile shade/rain/wind structures are frequently available, especially in situations where potting takes place in the open air or in open sided structures.

Moving media on benches

Moving media on potting benches (standard, modified and mobile benches) is often carried out by workers using shovels while standing at ground level. Shovels are not designed for moving soil forward along a horizontal plane. Hoes or rakes are far more suitable tools for moving media in this situation. This example highlights the importance of nurseries providing staff with the most appropriate tools to carry out their tasks.

Prolonged standing on hard surfaces

Leg fatigue will be experienced after only one to two hours standing on a hard surface. Standing for long periods on hard surfaces places stress on the plantar muscle (sole), increases venous pressure in the legs, can lead to spurs growing on the heels and places stress on the lower back. All potting staff who are standing for significant periods of time should be provided with proper ergonomic matting to cushion their feet and legs (some rubber mats are uneven and therefore unsuitable) and should be encouraged to wear cushioned sole inserts in their shoes (especially when work boots are worn).

Many nurseries investigated provided rubber matting for potters standing for long periods on hard surfaces. However, a significant number were without such matting and the area of matting at other nurseries was too small, limiting the potters' ability to move their position during potting.

Nurseries could also benefit by trialing the use of stools (special ergonomic 'sit stands' are available which take most of the weight of a stationary worker without them actually sitting down at the job) for workers who are engaged in prolonged standing tasks. Foot stands, which are placed in front of the worker and can be used to take the weight off one leg are also beneficial in increasing worker comfort.

List some common examples of poor worker comfort

List solutions to examples of poor worker comfort

Worker motivation

When designing a potting production system, worker motivation is just as important a consideration as materials handling or organisation of the potting area. Motivated workers will help an efficient potting system perform to its potential and make a less than efficient system perform much better than it has a right to. Unmotivated workers can counteract the benefits of the most efficient system.

Surprising at it may seem, the majority of people do not list money as the chief reason they turn up for work. A sense of belonging, achievement, recognition, job satisfaction, self respect, friendships are all examples of the positive emotions which help keep staff interested and committed to performing their responsibilities in a diligent manner day in and day out.

Understanding and maintaining worker motivation requires personal communication between management and staff. Not all nursery managers may have the time or inclination to discover the needs and wants of each staff member. Some nurseries have a high employee turn-over which makes management wary of investing too much time in individual staff members.

High employee turn-over can also make management react against the advice to understand and build the motivation of workers. Yet, high employee turn-over can often be attributed to low levels of worker motivation. The motivation of workers is clearly an extremely important consideration for managers intent on developing an efficient production system.

Aspects of potting production that can affect worker motivation include levels of health and safety and worker comfort. Attending to these issues is the basic starting point for nurseries seeking to improve staff motivation. When staff are able to carry out their tasks in a safe working environment with high levels of worker comfort, they appreciate that management is professional in its role and concerned for the well being of staff.

List some of the problems arising from low staff motivation

List some potential solutions to improve staff motivation

Benchmarking potting production efficiency

The benchmark costs below are based on the lowest potting labour costs recorded from potting production systems in 52 nurseries in QLD, NSW and VIC. In the semi-automated and automated potting systems the benchmarks are based entirely on production data recorded from 10 European nurseries. All benchmarks were calculated using an hourly wage rate of $15 Australian.

Potting labour cost benchmarks (cents/pot)

	Pot size				
	100mm	125mm	140mm	175mm	200mm
Hand potting	6.26 - 6.73	6.69 - 7.19	12.27 - 13.19	17 - 18.27	23.87 - 25.66
semi-mechanised	6.09 - 6.54	6.29 - 6.76	11.17 - 12	14.45 - 15.53	19.1 - 20.53
mechanised	4.99 - 5.36	5.03 - 5.41	8.71 - 9.36	10.84 - 11.65	13.37 - 14.37
semi-automated	1.07 - 1.15	1.16 - 1.25	1.26 - 1.35	1.36 - 1.46	1.45 - 1.56
Automated	0.29 - 0.32	0.34 - 0.37	0.37 - 0.4	0.39 - 0.42	0.44 - 0.47

Hand potting refers to potting on a bench, table, trailer top, etc
semi-mechanised refers to machine that helps potter fill pot with media
mechanised refers to potting on a machine that fills pots with media, drills a hole in the media filled pot for insertion of plant stock (and may also automatically unload the pot from the potting machine, and have automatic fertiliser and pot dispensers)
semi-automated refers to a mechanised system that includes automatic loading of nursery transport with the potted plant
automated refers to a mechanised system that automatically loads potted plants to nursery transport and automatically unloads and spaces potted plants in the growing area

In the pot size columns, the low values represent benchmark costs for potting plants with low potting difficulty and the high values represent benchmarks for potting plants with high potting difficulty. Nurseries should choose which value represents the potting difficulty of the majority of plants they produce. An average degree of plant potting difficulty can be found by taking the average value of the minimum and maximum benchmarks.

Benchmark labour costs refer to the total potting production process, that is:

- collecting and preparing all input materials including plant stock for potting
- preparing the potting area and equipment
- potting the plants
- loading potted plants to nursery transport
- watering plants in
- delivering potted plants to the growing area
- unloading potted plants and putting them down in the growing area

Only the work time of people who were visibly present and physically involved in the potting process was included in the calculation of benchmarks. For example, if a potting supervisor took an active role in potting production their time was included, but if the potting supervisor was absent during potting their time was not included.

The benchmark figures represent potting labour costs that could be achieved by all nurseries. The benchmarks are quite suitable for a nursery to use to establish their level of potting production efficiency and determine the amount of labour cost savings they can expect to achieve through improving their potting production systems to benchmark levels.

The International Centre for Nursery Excellence (ICNE) run by the Queensland Department of Primary Industries maintains a dynamic benchmarking index of nursery production labour costs. The index is continually being updated with production data submitted by ICNE wholesale nursery members. The index allows ICNE members to compare their production efficiency with other nurseries and access information on how the best performing nurseries equip, design, and manage their production systems.

What is the benchmark potting labour cost in cents per pot for production of difficult to pot plants to 175mm pots in a potting system using hand potting?

What is the benchmark potting labour cost in cents per pot for production of easy to pot plants to 140mm pots in a semi-mechanised potting system?

Describe a potting system you are familiar with, nominate a pot size and plant potting difficulty and find the appropriate benchmark potting labour cost.

Calculating your potting labour costs

The potting form can be used to carry out a simple evaluation of the cost of potting in cents per pot at your nursery. It is best to use the form when variables (eg. pot size, number of staff potting, plant type being potted, weather, etc.) are stable and represent the most common production conditions at your nursery.

Results will be more accurate if potting staff record the details (start time, end time, number of staff, pot size, quantity produced) as they work. For a more accurate total potting labour cost figure, record production data which is the equivalent of at least 5 potting days.

Potting labour cost in cents per pot is calculated by multiplying the total time worked by the hourly wage rate in cents and dividing the result by the number of pots produced. For example, if a nursery pays an hourly rate of $14 and 5 staff take 1 hour to produce 1000 x 140mm pots then a total of 5 man hours has been worked at a cost of $14/ hr which equals $70 or 7000 cents. 7000 cents divided by 1000 pots equals a potting labour cost of 7 cents per 140mm pot.

Nurseries can use their own hourly wage rates when calculating the labour cost of potting. Remember, however, that the benchmark figures are calculated on an hourly wage rate of $15. In order to be able to compare your potting labour costs to the benchmark costs you must use an hourly wage rate of $15 in your calculations. Just remember that the result will not represent the true cost of potting labour cost at your nursery, only the cost relative to the benchmark figures.

Potting production involves 3 areas:

1. Preparation for potting (includes all work involved in getting ready for potting up until the time the first pot is ready to be produced)
2. Potting (from the time the first pot is produced to the time the potted plant is placed onto trailer, conveyor, etc.)
3. After potting (the time from when the potted plant is placed onto transport up until the time it is placed down into the growing area)

These 3 areas taken together represent total potting. If the total number of people involved in potting is always constant the nursery can use the potting form to calculate its total potting costs by:

- Circle preparation, potting and after potting on a new form then record start time and staff numbers from the beginning of preparation for potting
- When potting production is finished (ie. when the last potted plants have been placed down in the growing area) record end time, total time, pot size, and quantity of pots produced.

A nursery can also record time and staff numbers and quantity produced separately for each of the 3 areas of potting production and add the results together to give total potting labour costs:

- circle preparation for potting on a new potting form then record start time, end time, number of staff, total time and quantity potted (this figure will only be known after potting has finished)
- circle potting on a new potting form then record start time, end time, staff numbers, total time, pot size and quantity potted
- circle after potting on a new potting form then record start time, end time, number of staff, total time, pot size and quantity potted
- add the costs of the 3 stages to find total potting labour costs.

This method will give a more accurate result when the number of staff involved in the 3 stages differs or when the 3 stages are not carried out consecutively. For example when preparation for potting involves 2 people, potting involves 4 people and after potting involves 2 people or when preparation is carried out the day prior to potting.

POTTING FORM preparation and/or potting and/or after potting

Date	Start time	End time	Number of staff	Total time	Pot size	Quantity potted

Identifying problems

Unfortunately, it is impossible to design one efficient potting production system which would suit every nursery. Each nursery needs to define their best operating conditions on the basis of circumstances at their nursery.

Research has found however, that optimisation factors do exist in potting which should be taken into consideration when a new potting system is created or improvements introduced to an existing system.

The optimum production system is created when: -

The worker has

- a safe and comfortable working environment
- sound work motivation
- good work skills

Plant stock is used so that

- the development of roots and foliage is in the prime potting stage
- the quantity to be potted per event is maximised
- the number of species to be potted per event is minimised

Containers are used so that

- the number of types of propagation container used is minimised
- the number of sizes, types and colours of potting containers used is minimised
- the ratio of propagation container size to potting container size is approximately greater than 0.5 (eg. 50mm tube to 100mm pot)

Potting procedures and treatments occur so that

- manual placement of fertiliser into pot is minimised
- quantities of plants watered in one event is maximised
- quantities of plants pruned in one event is maximised
- quantities of plants receiving application of herbicide is maximised

Potting system operates so that

- work station design reflects nursery's average potting production requirements
- potting area location is central to growing area
- distances between potting area and input storage are minimised
- coordination of potting tasks within potting system is self governing

- quantities of potting inputs and outputs handled at one time (eg. empty pots, potted plants) are maximised

Machine operating speed is adjusted so that

- the ratio of operating speed to the number of staff involved minimises non-productive time

Communication follows a

- clear and rapid system providing all production information to potters

Potting technique

- based on the techniques of workers with best production rates is applied in production

Most of these optimisation factors can be applied immediately to potting systems, however some factors, eg. the ratio of potting machine operating speed to number of staff, coordination of potting tasks, etc., can only be defined through experimentation in individual potting systems.

Problem checklist

The following checklist will also be useful to carry out a rapid diagnosis of a potting production system. While observing potting production in progress place a tick in either the YES or NO box for each question.

An answer of YES indicates that:

- potting labour costs are higher than necessary
- the potential exists for reducing labour costs
- the nursery should investigate the issue in more detail.

1. Is the potting area too cramped for production to be easily carried out?	YES	NO
2. Do other production areas encroach on potting production space?	YES	NO
3. Could the potting area be better located in another part of the nursery?	YES	NO

4. Could the arrangement of elements within the potting area (potting bench, media hopper, trailers for loading potted plants, stores of materials, etc) be changed to improve potting production? YES NO

5. Could the distance potting materials are delivered be reduced by relocating the source of inputs and/or the destination of outputs? YES NO

6. Are staff constantly observed walking to and fro for limited quantities of potting materials? YES NO

Suitability of equipment used

7. Do production figures make other potting systems more suitable options than the one now used (ie. could hand potting be replaced by machine potting)? YES NO

8. Could the frequency of trips for potting inputs and outputs be reduced if the capacity of trailers, trolleys, etc., was larger? YES NO

9. Is the design of trailers, trolleys, etc., unsuitable for the nursery terrain and the manner in which they are used by staff in potting production? YES NO

10. Does the media hopper frequently bridge (require constant attention to dislodge obstructed flow)? YES NO

Allocation of tasks

11. Do some staff appear to be more productively employed than others? YES NO

12. Could tasks be distributed between fewer staff? (this may involve a reduction in the speed of production. eg. slowing down a potting machine to allow less staff to operate it) YES NO

13. Do some staff carry out the same tasks all the time ? (eg. certain staff always pot and certain staff always load pots) YES NO

14. Are tasks carried out in an illogical order? (eg. watering occurs before lifting plants therefore they become much YES NO

heavier to lift, surface application of fertiliser occurs before watering flushing out large quantities of fertiliser)

15. Could tasks be carried out at a different stage of potting production to involve less people or reduce some staff waiting to begin their primary task? YES NO

16. Could some tasks be mechanised? YES NO

17. Could some tasks be removed altogether by using new technology or changing the way the nursery has traditionally carried out tasks? (eg. consider buying fertiliser and media ready mixed instead of adding fertiliser during potting, watering plants in the field instead of at the potting area) YES NO

Coordination of tasks

18. Are workers non-productive while waiting for someone else to finish a task? YES NO

Potting technique used

19. Are some potters conspicuously slower than other potters? YES NO

20. Could specific training in potting technique and organisation of work station speed up the production of some potters? YES NO

Risks posed by equipment

21. Do workers operate noisy machinery without hearing protection? YES NO

22. Do workers come into close contact with machinery? YES NO

23. Are some potting staff untrained/inexperienced in the operation of machinery? YES NO

24. Does potting equipment have high injury risk areas which area unlabelled? YES NO

Risks posed from materials in the potting environment

25. Are herbicides & potting media handled without gloves and mask?	YES	NO
26. Do things such as trays, pots, casual water etc. make movement through the potting area difficult?	YES	NO
27. Does the way in which tasks are carried out seem likely to pose a risk of injury to workers? (constant lifting, turning, awkward posture at the work station etc.)	YES	NO
28. Do staff complain of sore feet, backs, etc. from prolonged standing?	YES	NO
29. Could anti-fatigue matting be used to reduce fatigue in standing potters?	YES	NO
30. Could ergonomic tools be used to make potting tasks easier? (eg. pot lifters for loading and unloading pots, ergonomic stools for working at the potting bench)	YES	NO
31. Do tools used make the task difficult to carry out?	YES	NO
32. Are workers exposed to the elements?	YES	NO
33. Does work station design make it difficult for workers to easily carry out their tasks?	YES	NO
34. Is lighting in the potting area inadequate?	YES	NO
35. Do staff constantly seek instruction on how to carry out tasks?	YES	NO
36. Is time lost due to problems experienced by staff adjusting the potting machine?	YES	NO
37. Does potting production fall when certain key staff are absent?	YES	NO
38. Would workers react favourably to an incentive scheme for meeting or exceeding daily production quotas?	YES	NO
39. Are workers easily distracted from their tasks?	YES	NO

40. Do some workers appear less interested than others in working productively? YES NO

41. Do some workers consistently complain about conditions, management decisions, work load, etc? YES NO

42. Can some steps involved in getting materials into or out of the potting process be eliminated? YES NO

43. Can the quantities in which materials are handled be increased? YES NO

44. Could production information given to potting staff be made more thorough to allow for the more efficient delivery of potting inputs? (eg. in greater quantities per delivery event) YES NO

Introducing improvements

Before introducing any improvements to your potting system you should first double check your original data and conclusions to confirm the problems you have identified are legitimate. It is also recommended you seek advice from a recognised nursery production consultancy service before going ahead with introducing any improvements. The cost of seeking advice from a consultant is nothing compared to the cost of creating a potting system that does not deliver the labour cost performance you were expecting.

The International Centre for Nursery Excellence (ICNE) run by the Queensland Department of Primary Industries offers a free production efficiency consultancy service to its wholesale nursery members. Annual membership in the ICNE costs $55 per wholesale nursery (price for 2001 to 2002 membership year).

If the solutions to be introduced affect the way in which potting staff carry out tasks, nursery management will need to consult with staff and provide them with training in the operation of the new system. When staff are actively involved in the process of improving production efficiency from the outset, they are more likely to understand the reason for changes and develop a sense of ownership in the new system. Before attempting any improvements in production efficiency, discuss with staff the nursery's need to meet industry benchmarks to remain competitive and make them aware of the actual benchmark cost your nursery is aiming to achieve.

Attempts to reduce labour costs can be interpreted by potting staff as a threat to their job security or as criticism of their work rate. Consultation with staff before, during and after introducing changes to the production system will help ensure they react positively to the changes and work productively in the new system. Make sure adequate training is provided to staff and sufficient time is allowed for them to become familiar with working in the new system. During the familiarisation period seek feedback from staff to ensure they are physically and emotionally comfortable with the changes.

Depending on the extent of changes to the original system, it can take some time for staff to become familiar with the new system. To avoid falling short of production quotas, changes should not be introduced during the nursery's peak production periods. Introductions can be carried out in stages or in one go depending on the complexity of changes.

List some steps which should be taken before introducing improvements

Testing improvements

After potting staff have been trained in using the new production system, have had sufficient time to become familiar with it and have made any personal adjustments necessary, the efficiency of the new production system will need to be tested. This involves recording production data from the new potting system and calculating the total cost of potting in cents per pot then comparing this against the total potting cost recorded for the original system. Make sure the new data represents an average period of production and matches the production circumstances of the original data (eg. same level of plant potting difficulty, same pot size, same potting tasks, similar level of experience in potting staff, etc.).

If the potting system has been carefully evaluated and potential improvements carefully considered and referred to an outside production consultant for verification before they are implemented, there is a very high degree of likelihood that the potting labour cost savings predicted for the new system will be reflected in the new production data.

If potting labour costs are worse than expected you will need to carry out some or all of the following:

- check original and new production data calculations for mistakes
- review circumstances of production during recording of original data and new data
- record production data for the new system once again
- retest the data against the original production data
- review the causes identified as contributing to the initially defined problems.