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A model for lettuce industry development

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Department of Agriculture
Western Australia

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A MODEL FOR LETTUCE INDUSTRY DEVELOPMENT - VG99014

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PURPOSE

This final report of a project which commenced in January 2000 and was completed in June 2003 is intended to meet the commitment to the industry funding provider (HAL - vegetable industry levy) and the Department of Agriculture Western Australia to report the findings of the work to industry and the scientific community. The project aimed to produce an export development plan, through a collaborative process with industry, which would act as a model for other horticultural industries to follow in future attempts to identify and create export opportunities. The lettuce industry was chosen for this study because it represented a sector of the vegetable industry with great export potential but poor export performance in the last decade.

The project employed a combination of economic analysis, agronomic research and partnerships with private sector processors, growers and shippers to develop and enact a plan which resulted in new production, packing, handling and exporting technologies being identified and tested. The research team showed how innovative approaches to production and marketing can produce new opportunities for industry. It also proved that a collaborative approach to problem solving with goodwill from all sectors of industry can work, but it requires growers and companies to break free of the shackles of a 'competition at all costs' mentality. For industry outcomes of this project to be fully realised, significant investment decisions need to be made by the private sector in the supply chain and further R&D work is required to support implementation of the new technologies.

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TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

Page

TABLE OF CONTENTS

TABLE OF CONTENTS

1. MEDIA SUMMARY

The project ‘A Model for Lettuce Industry Development’ was conceived because a number of key vegetable products from Western Australia had been losing market share in traditional export markets over the last decade and exports from Australia overall were static. Many of these products were leafy crops and lettuce was possibly the worst example because the decline had occurred against a backdrop of steady growth in demand for leafy salads, worldwide. There was little evidence that the industry as a whole in Australia had done much to arrest this decline in exports. This project sought to develop a methodology for researchers and industry to work together to identify causes and solutions to problems like this one.

The aim was to develop a plan to enhance lettuce exports that was owned by industry after conducting an analysis of the problem, the competition and market opportunities. The project was largely conducted in Western Australia because that state had traditionally held a dominant position in markets for vegetables in Singapore and Malaysia due to its close proximity to these markets, but had relinquished it.

The study identified that the main reason for loss of market share was a lack of price competitiveness against supplies from the United States in these markets. Australian exporters had no advantage in sea freight cost into these markets over US exporters, and export volumes had fallen to the level that the industry in Australia was largely dependent on expensive air-freight, despite clear sailing time advantages by sea from Western Australia.

An export working group was formed which included a grower, lettuce processors and the research team. The group formulated a strategy which included the following elements:

- A ‘desktop study’ of traditional markets, our competition and new opportunities.
- Economic analysis of costs of production and exporting and scenario planning to identify key areas for improving cost competitiveness.
- Agronomic research and development to improve crop productivity, quality and ‘food safety’.
- Development and testing of innovative handling and exporting methods.

The project demonstrated that there is considerable scope for reducing ‘on farm’ production costs through better targeted plant nutrition and timing of harvest for export. Even greater savings are possible by harvesting and exporting in non-returnable bulk bins. Lettuce in bulk is acceptable for processing and potential markets exist in South East Asia and the Middle East.

The project tested the technical and economic feasibility of this concept through two trial shipments to Malaysia in 2002. Bulk shipment allowed Australian lettuce to be landed at a competitive price in this market, with the added benefits of shorter sailing times than our competition and maintenance of ‘cool chain’ integrity from the paddock to the processor.

The conclusions from the work are that a collaborative approach to problem solving in the industry can work for the benefit of the whole industry. Market opportunities in the processing sector are potentially very large and growing rapidly. The industry in Australia will need to make strategic investments to be part of that growth. Australian lettuce can be competitive in export markets in our region if the industry is prepared to innovate.

The new technologies identified in this project will enable the Australian vegetable industry to regain lost export market share in South East Asia and to capture new export markets for processing lettuce. The R&D described in this report maps out a path that industry could follow to capture these benefits.

2. TECHNICAL SUMMARY

Australian exports of head lettuce have remained static for the last decade at around 2000-2500 tonnes per annum. Australia's traditional markets have been South East Asia, Hong Kong and the Philippines. Australia's main competitor in these markets has been the United States, and in more recent times, China.

A lack of price competitiveness with the US throughout the 1980s led to an erosion of Australia's export infrastructure. The result has been that our traditional markets, which were serviced by dedicated export growers with 'forward orders' have been replaced by a culture of 'spot marketing' when the price is right. This trend has been no more evident than in Western Australia where the Singapore and Malaysian markets for lettuce and other leafy vegetables were taken for granted in the 1970s, but are no longer. This has occurred against a backdrop of favourable sea freight sailing times to these markets, a mostly favourable exchange rate and strong growth in the consumption of salads in SE Asia and the Middle East.

This 'Horticulture Australia' project was initiated in 2000 to investigate the causes of our declining export performance, to propose solutions and develop a strategy to regain lost market share. The project was named 'A model for lettuce industry development' because it sought to demonstrate how an industry in decline could turn around its fortunes by adopting a systematic planned approach supported by the industry.

The methods used to tackle this problem were a mix of multi-disciplinary partnership building, market research, economic analysis, agronomic and post harvest research conducted by a small R&D group in collaboration with willing industry participants. Specifically, the following studies were undertaken over the lifetime of the project.

- A 'desktop study' of traditional markets, our competition and new opportunities. Import statistics from Malaysia and Singapore were compiled and analysed together with informal market statistics and observations from personal contacts in Australia, Malaysia, Singapore and the Middle East.
- Economic analysis of costs of production and exporting, and scenario planning to identify key areas for improving cost competitiveness. This included a cost of production study derived from grower interviews in WA and a benchmarking analysis of production costs for lettuce from other Australian states and overseas competitors. A cost chain model for export was constructed and used to predict the impact of changes to key inputs and practices on competitiveness of exports from Australia.
- Fertiliser programs were developed for iceberg and leaf lettuces, which maximised yield and quality without using animal manures, which may compromise microbiological food safety. Independent estimates of commercial crop yields were made by conducting regular sample harvests over a one year period on six lettuce farms. The data was used in the economic models and to estimate inherent variability in the crop. This was backed up by 16 replicated field trials in two production districts aimed at developing a harvest predictor, which would maximise weight yields of processing quality lettuce while minimising production costs per kilogram.
- A bulk harvest, handling and shipping system was developed and tested in two shipments to Malaysia. The system was a product of the cost chain analysis, which showed that exporting costs could be reduced by shipping in non-returnable bulk bins instead of small cardboard cartons as is current practice. A price competitive bulk bin was designed and built which significantly reduced exporting costs by eliminating 'packing' costs in Australia. This report describes the development sequence and advantages of bulk handling, together with the technical and economic outcomes of trial shipments.

This project showed that a holistic approach to production and marketing of lettuce was able to identify significant cost savings in production and transport, and offered the potential for Australia to regain lost export market share and capture new markets. Industry now needs to adopt these practices.

Further R&D is required on 'best practice' production methods which give 'cost effective' yield increases, and more critically, technology transfer is required to ensure appropriate adoption of what has already been found. Refinement of bulk harvesting and handling methods, packages and pre cooling methods is also required.

3. GENERAL INTRODUCTION

The objectives of the project at its inception were fourfold:

1. To assess the potential to resurrect Western Australia's share of the iceberg lettuce export market.
2. To improve product quality, food safety and yield for the processing sector and assess the potential for value-added exports.
3. To develop and test methods to achieve these ends through working partnerships with growers and marketers/processors.
4. To evaluate the techniques used for their future application to other vegetable crops, e.g. celery.

The project team planned to address these four issues by working with lettuce growers and the associated industry to deliver the following:

- An industry endorsed three year plan for developing exports produced and impediments to growth identified.
- Production barriers to export overcome and production plans enacted at farm level.
- Factors contributing to poor recovery rates from shredded iceberg lettuce identified and minimised in the production process.
- Microbial contamination hazards in production of minimally processed leafy salads minimised through adoption of safe production and handling practices in the field.
- Nutritional and irrigation guidelines for high quality and high yield production of leaf and iceberg lettuce established.
- HACCP based schemes adopted by processing growers conforming with processor specifications.
- Comparative production budgets for fresh, export and processing lettuce available to growers.

As the project unfolded, the emphasis given to each of these deliverables changed in response to industry cooperation and need, as well as the emergence of unplanned opportunities which had the potential to impact strongly on the overriding objective of increasing lettuce exports.

Little time was spent in the life of the project on HACCP because private consultants were active during the early part of the project implementing customised HACCP based schemes with growers, and there was no demand for a generic scheme for the whole lettuce industry. Similarly little detailed work was done on microbial contamination but this requirement of industry was dealt with indirectly by developing fertiliser programs which did not require raw poultry manure. Widespread use of raw poultry manure as a fertiliser was considered a high risk for microbiological contamination.

Although production budgets for fresh, export and processing lettuce were prepared and publicised to growers through newsletters and conference presentations, the emphasis in the project shifted over time to developing a comparative analysis of export handling and shipping methods. This was complemented by sensitivity analysis of the economic impact of factors, which may contribute to current and future export profitability.

Greatest emphasis in the project was given to production methods, which maximised export returns, while minimising microbiological risk for the product. These included improved scheduling of harvest for export, better nutrition, without the use of poultry manure, and bulk handling practices for the end product. More emphasis was given in the project to development of the export plan and identification of market contacts who could make it happen. The project moved beyond the original scope by implementing an export plan with the endorsement of an industry working group. This involved two pilot export shipments to Malaysia and a market visit by the project leader.

The methods used to deliver the stated outcomes and the results achieved are outlined in each of the following chapters.

4. EXPORT PLAN DEVELOPMENT

Introduction

One of the cornerstone objectives of the project at its inception was to develop an industry-endorsed plan to revive lettuce exports, which would include identification of impediments to growth and strategies to overcome them. The motivation for this work was the steady erosion of Western Australia's lettuce export volumes and market share over the preceding decade and no growth in exports from Australia in total.

Material and methods

In the initial phase of the project, interviews were arranged with lettuce exporters in Western Australia, export growers and processors nominated in the project proposal. Market opportunities and potential overseas buyers were identified by opening up a dialogue about lettuce with exporters and government officers working in the trade area in Australia and overseas. A visit by a buying delegation from Taiwan was hosted early in the life of the project and a market opportunity was explored. An opportunity for exports to Kuwait was also investigated and a potential exporter was assisted in writing a funding proposal ('Supermarket to Asia' program) to explore this further.

Subsequent to these meetings, industry personnel who expressed an interest in participating in a working group were identified and meetings were held to enact a strategy. The project team under the direction of the working group collected information on export markets and our competitors from published statistics and industry contacts. A desktop study was also undertaken to assess the cost competitiveness of Western Australian and Australian producers with competitors from overseas, using published information available in the public domain. Members of the working group collected data on opportunities for 'processing lettuce' exports in South-East Asia and the Middle East.

Other aspects of the study included in-depth interviews with leading lettuce growers in Western Australia to establish a cost of production framework and methodology for data collection. The results of this work were used subsequently in a benchmarking study of production costs and to predict the sensitivity of production costs to changes in management practices and adoption of new technologies.

The results of these studies are presented in subsequent chapters, while the elements of the export development plan are presented here.

Results

Exporter, grower and processor interviews

Discussions with exporters, growers and processors were of a confidential nature and the details of contacts and some of the information supplied cannot be presented here. The consensus view from those discussions was a general despondency about the prospects of regaining lost market share for lettuce in export markets. It was generally considered that we had lost market share in the region because our landed price was no longer competitive with that from the USA (California), which had largely captured the Singapore and Malaysian markets.

In the period since the late 1980s Western Australia-based exporters and growers had shifted from being dedicated suppliers to this market by sea to 'spot marketers' using air freight. Where sea freight was used it was largely reefers of mixed products called 'shopping basket orders' by traders.

Traditional exporters showed little enthusiasm to work with us to develop the plan, while most growers interviewed supported the initiative in principle but did not want to participate actively in aspects of the project. Processors were more interested in participating and were aware of export market opportunities for the processing sector that traditional suppliers to the South East Asian wholesale sector were not. They were able to bring some of their grower suppliers along with them to help develop the plan.

Export plan development and implementation

The first step towards formal development of the export plan was a meeting between members of the project team, representatives from three lettuce processors, the Western Australian HAL committee delegate for ‘Leafy Crops’, Agwest Trade and Market Development and the HAL Industry Development Officer (IDO) for Western Australia held on 1 September 2000.

Representatives at this meeting agreed to endorse an export development plan as described below.

PLAN FOR REVIVING LETTUCE EXPORTS

Vision

To increase iceberg lettuce exports from Western Australia by 10 per cent per annum for the next decade, recovering lost export market share for the last decade.

Goal

To change the culture of current lettuce export from one of opportunistic supply driven by production surpluses to a demand driven process underpinned by dedicated suppliers operating in a supply chain alliance with exporters, processors and the importer.

Market opportunities targeted

- Food service sector in Singapore and Malaysia - shredded lettuce for restaurants, airlines, etc. Opportunity to displace US competition through innovative marketing and dedicated supply to export.
- Food service in wider region Middle East, Taiwan, Korea etc. Build on the above as a stage 2.
- Ready prepared salad products based on iceberg and fancy lettuce in emerging Singapore, Malaysia supermarkets. Participating in the trend already evident in Australia, Europe and US. Improve price competitiveness, safety and test new products.

A working group was established from this initial meeting to implement the plan, and after a series of meetings during 2001, a list of strategies was agreed upon. These strategies are shown in Table 4.1. These elements created the framework for project activities for its two and a half year duration.

Table 4.1. Export development plan strategies

Strategy	Target/group	Product	Market sector	Activity	Detail
1. Market Trend Analysis	Malaysia	Head iceberg	Supermarket	AGWEST trends study commissioned	Report presented in Chapter 5.2
	Singapore	Gourmet	Food service		
2. Real time opportunity testing	Taiwan Convenience Store delegation	Iceberg hearts for shredding	Food service	AGWEST liaison	Not cost competitive by air
	Kuwait Fast Food outlet contact			Food & Fibre Chains funding for exporter visit	Sailing time too long by sea
3. Cost Chain Profiling (Present)	WA growers	Iceberg hearts - fresh (Sea/Air)	Food service	Cost chain model	Report in Chapter 10
	WA processors				
	WA exporters	Pre-shredded - (Air/Sea)	Food service		Limited data
4. Assessing the competition	Malaysia	Iceberg for processing and export	Supermarket	Desktop benchmarking study	Report Chapter 5
	Singapore		Food service	Market visit	Report Chapter 5.1

Table 4.1. Continued

Strategy	Target/group	Product	Market sector	Activity	Detail
5. Productivity improvement	Growers	Iceberg	Export and processing	Nutrition trials to maximise head yield and harvest scheduler for optimum head weight Perth and Manjimup. Measure commercial yields	Reports Chapters 6, 7 and 8
6. Food Safety and quality improvement	Growers	Iceberg and gourmet	Export and processing	Trials to produce without poultry manure	Report Chapter 7
7. Development of supply chain partnerships	Malaysia and Singapore	Iceberg heads	Food service	Meeting product specs for Malaysian processor in partnership with exporter	Scenario testing with bulk harvesting and handling options to build a business case for investors. Reports Chapters 5 and 9
8. Scenario planning to improve price competitiveness	Growers and Exporters	Iceberg heads Pre-shredded iceberg	Supermarket Food service	Comparative economic analysis of supply chain models	Sea/air; Hearts/shredded; /bins/cartons/ bulk shipment options. Report Chapter 10
9. Market intelligence and information flow	Growers, exporters and associated trade	Iceberg heads Shredded iceberg	Food service Food service	Reports on project activities and results	Regular newsletter to stimulate grower and exporter interest and involvement. National conference papers, Chapter 11.

The export working group comprised two processors with a background in shredding iceberg lettuce, a grower who was keen to export and the project team. This group identified potential market opportunities for raw product and shredded lettuce in Malaysia and the Middle East and the focus of the group's work soon became methods to reduce shipping costs and improve landed quality. This led to an activity to find and develop a suitable bulk package for shipping export lettuce. This activity is described more fully in Chapter 9.

Discussion

The work of the export plan implementation group eventually led to trial shipments of lettuce being sent by sea to Malaysia in non-returnable wooden bulk bins for the first time ever. The method proved to be technically feasible and price competitive.

The development process involving a 'cross industry group' relied on an open and frank exchange of information by all parties to be successful. This was forthcoming and all parties brought different skills and information to bear on the problem, creating synergies which none of the parties could have created alone. Examples included being able to get shipping company assistance with trials as well as being able to sell trial produce through the processors to keep costs down. The concept proved what can be achieved when industry players cooperate rather than engaging in 'energy sapping' competition.

Recommendations

It is recommended that the working group model be used to test the potential for re-invigorating exports of other vegetable products. The great difficulty with the process is to find people of goodwill who can cooperate and share information for mutual benefit. This proved to be one of the most difficult aspects of the project. Projects like this one need to realise the full market potential of the product under study, and the link be clearly made between the R&D partnership with industry and the outcome, before others can be convinced to become involved.

5. EXPORT MARKET CHARACTERISATION AND COMPETITIVENESS

5.1 MARKET CONTACTS AND VISITS

Dennis Phillips

Introduction

A key strategy in the Export Development Plan was to collect market intelligence and identify and test market opportunities. This activity offered the potential to learn more about the export market for lettuce and a typical cost chain, as well as generating ideas on how to market the product more strategically. Contacts with potential lettuce buyers were both planned and opportunistic during the course of the project.

Material and methods

Early in the life of the project, meetings were held with the Agwest Trade and Market Development arm of the Department of Agriculture to make them aware of the project and to find market contacts. A representative from this group was invited to participate in development of the export plan. Over the course of the project, this group became a rich source of market contacts through their links to the WA Trade Commission in various countries in the region.

Market contacts made through this group included:

1. A buying delegation from Taiwan who wanted to source lettuce heads to supply a chain of convenience stores in Taiwan.
2. A buyer from Egypt who wanted lettuce to supply a chain of fast food restaurants in the Middle East, with supply through Kuwait.
3. Two lettuce processors from Singapore who specialised in airline catering and supply of shredded lettuce to a multinational chain of hamburger restaurants.

One of the members of the Export Development working group identified a lettuce processor in Malaysia supplying the McDonald's restaurant chain with shredded lettuce. This contact ultimately bought two trial export shipments in bulk bins from one of the members of the working group, using technology developed by the R&D team.

A market study tour to Malaysia and Singapore was made possible by the need to visit the market to inspect the outturn of the first experimental bulk shipment. Supermarket buyers and processors were visited in both countries during the visit to assess future market prospects for lettuce and other vegetables in bulk.

Results

Visit to WA by buying delegation from Taiwan - January 2001

Three representatives from the President 7-11 group visited Western Australia in January 2001 at the invitation of Agwest, through its 'Focus Taiwan' project. The company is the largest convenience store chain in Taiwan with a network of 2,600 stores throughout the country and a turnover exceeding $A2 billion annually. The delegation included a senior produce buyer and two project managers from the International Affairs group within the company.

The objective of the buying mission was to source a wide range of agricultural products including whole iceberg lettuce. The lettuce was required to supply the sandwich bar and lunch box trade in 7-11 stores throughout Taiwan.

A program of visits was arranged for the delegation on 30 January 2001, which included visits to a lettuce grower, an export premises and a fresh produce 'Growers Market'. At the completion of the visit, the delegation expressed interest in buying lettuce from Western Australia and contacts were made with the two exporters to negotiate supply arrangements and price.

After a period of negotiation over subsequent months, the trade did not take place because supply to Taiwan required expensive air freight and trans-shipment in Singapore. The West Australian grown product could not be landed at a competitive price with product from the US by air under these arrangements.

Figure 5.1.1. Delegation from Taiwan inspects export packing.

Figure 5.1.2. Meeting between Agwest and delegation from Taiwan.

Market enquiry from Kuwait and Supermarket to Asia application - April 2001

A processor supplying shredded lettuce to a chain of restaurants in the Middle East approached Agwest for market contacts. This buyer had the potential to import around 500 tonnes of head lettuce per annum. They were put in contact with a potential supplier representing a national exporting group. We assisted the exporter to write an application for a Federal grant from the 'Food and Fibre Chains' fund to visit the market and assess the potential to export lettuce by air and sea to that market.

The application which was part of the 'Supermarket to Asia' program progressed through the first round of assessment by the fund administrators but was ultimately unsuccessful. No further progress on this market opportunity was made.

Preliminary investigation around the subject of sea and air freight to Kuwait revealed a relative freight disadvantage for WA exporters to this market as shown in Table 5.1.1. This was partly because there was no direct air service to Kuwait at the time and air pallets had to be trans-shipped in Singapore. The sea freight sailing time to Kuwait was 21 days which was considered to be at the limit of the shelf life of the product in conventional reefers.

Table 5.1.1. Relative freight costs (per kg) to Kuwait for WA exporters compared to competitors - April 2001

Supplier	Freight rate for air pallet (200 x 14 kg cartons) US$
Western Australia	$2.91
New South Wales	$2.35
United States	$2.20
Netherlands	$2.30
Egypt	$1.20

Informal market statistics

During the course of the project information was obtained on market volumes from trade sources. As an example of the size of the market Australia could potentially supply within reasonable sailing times the following figures estimate the quantities of head lettuce used by two major multinational fast food chains with outlets throughout the region.

Table 5.1.2. Head lettuce throughput by two major fast food restaurant chains in Australia's region - 2002

Country	Quantity of raw product shredded (tonnes/month)
Japan	13,000
China	450
Korea	250
Taiwan	150
New Zealand	140
Malaysia	40
Malaysia (Chain 2)	37
Singapore (Chain 2)	19
Thailand	40
Total	**14,126**

Raw or finished product

Members of the export working group explored the potential for raw product exports as well as finished shredded product. Most of the demand throughout the region is for raw product because production facilities are already in place to supply the catering and fast food industry. Shredded lettuce goes brown rapidly after cutting and air-freight is required to get it to the market in reasonable time. Air-freight is expensive, not temperature controlled and relatively unreliable compared to sea freight.

Despite the pitfalls of exporting finished product, there is a steady low level demand for quantities to 'top up' orders and orders for boutique suppliers. Trial consignments have shown that it is more cost effective to export finished product by air than raw product because cores are removed and finished product can be vacuum packed. By comparison, an AV air container will only carry around 840 kg of raw product in cartons, while 1300 kg is achievable with vacuum packed finished product. This can save $1.50 per kg in freight cost.

The cost of exporting

Estimates of typical costs of exporting from Western Australia were able to be made after discussions with exporters and members of the export working group. It is difficult to generalise about the cost of exporting because there are many variables possible, including:

- sea and air freight in different size containers and sophistication of cooling equipment;
- different harvest and handling systems including bulk bins and small returnable bins;
- delivery and packing in a central packhouse or on-farm packing;
- different districts of origin of the produce necessitating different levels of internal road transport;
- assembly of export consignments by wholesalers who charge a commission for sourcing the product or direct supply to the exporter; and
- changes in exchange rates and freight costs with different airlines and shipping companies.

Hence, the costings which follow are indicative only and are best used to compare systems rather than being interpreted too literally.

Beginning from a base of a high cost airfreight model for exporting using small containers (AV's), waxed cartons, wholesaler sourcing and central packing, a series of scenarios for reducing costs were compared by 'desk top' analysis. This analysis provided the starting point for work described later in this report to develop a bulk package and handling system.

Estimated comparative costs of exporting Wanneroo grown lettuce (50 km from Port) to Malaysia/Singapore by different methods

Conventional model A/V (60 x 14 kg cartons)

Price to grower (raw)	x ¢/kg
Packing cost ($3.00/carton)	22 ¢/kg
Carton cost ($2.80 each)	18 ¢/kg
Agent commission (if not direct) - 15% of farm gate	9 ¢/kg
Exporter margin - 10% FOB	11 ¢/kg
Freight (includes labour to load A/V)	128 ¢/kg
Landed total	**$1.88 + x**

Conventional model air pallet (200 x 14 kg cartons)

As above	60 + x ¢/kg
Freight (includes labour to load pallet)	91 ¢/kg
Landed total	**$1.51 + x**

Conventional model 20' reefer by sea (450 x 14 kg cartons)

As above	60 + x ¢/kg
Container loading ($200)	3 ¢/kg
Land transport of container ($425)	7 ¢/kg
Freight (MA container $3000)	48 ¢/kg
Landed total	**$1.18 + x**

Bulk model 20' reefer by sea (7,000 kg)

Price to grower (includes bin preparation)	x ¢/kg
Bin cost (20@$60)	17 ¢/kg
Bin liner, floor, ties ($152.40)	2 ¢/kg
Internal freight (bins) ($100)	1 ¢/kg
Internal freight (reefer) ($425)	6 ¢/kg
Admin/Customs/Quarantine/sundries ($265)	4 ¢/kg
Exporter margin - 10% FOB	10 ¢/kg
Freight (MA container $3000)	43 ¢/kg
Landed total	**$0.83 + x**

Estimated cost of exporting Manjimup grown lettuce (300 km from port) by sea in bulk bins to Singapore/Malaysia

Bulk model 20' reefer by sea (7,000 kg)

Price to grower (includes bin preparation)	x ¢/kg
Bin cost (20@$60)	17 ¢/kg
Bin liner, floor, ties ($152.40)	2 ¢/kg
Internal freight (bins) ($150)	2 ¢/kg
Internal freight (reefer) ($900)	13 ¢/kg
Admin/Customs/Quarantine/sundries ($265)	4 ¢/kg
Exporter margin - 10% FOB	10 ¢/kg
Freight (MA container $3000)	43 ¢/kg
Landed total	**$0.91 + x**

Bulk model 40' container by sea (14,000)

As above	35 + x ¢/kg
Internal freight and genset ($1200)	9 ¢/kg
Freight (MA container $4400)	31 ¢/kg
Landed total	**$0.75 + x**

This analysis shows that a saving of as much as $1.10 per kg in freight costs can be made by exporting in bulk by sea compared to opportunistic export in small quantities by air. This saving is of an order, which would make Australian lettuce competitive throughout the year in SE Asian markets and potentially could open up the markets to continuous dedicated supply.

Export market visits Malaysia and Singapore - August/September 2002

An opportunity arose in late August 2002 to visit Malaysia to inspect the outturn of the first shipment of lettuce in bulk as described in Chapter 9.3. Following the inspection of the bulk shipment, visits were arranged with supermarket management and other processors in Malaysia and Singapore. The following is an account of the outcome of those meetings.

Discussions were held with the fresh produce purchasing departments of major supermarket chains in both Malaysia and Singapore during the visit. These included, Tops and Carrefour in Malaysia and Cold Storage in Singapore. The clear message from them all was that they wanted to buy more fresh products from Western Australia and Australia but we were often not price competitive with other suppliers and were becoming less so.

One of the supermarket chains in Malaysia was particularly interested in participating in future R&D to explore bulk shipment because they had a distribution centre which could pre-pack and were planning to enter the 'food service' sector. Another was interested in hearing more about the method and participating in future R&D, but Cold Storage in Singapore were not interested because they did not want to handle the product or pre-pack it, preferring to leave that to other local suppliers and contractors. Visits to Tesco in Malaysia and Shop n Save in Singapore were unsuccessful.

A vegetable processor was visited in Malaysia. A wide range of products were pre-packed for supermarkets but handling practices and cool chain practices were not up to Australian standards, suggesting that Australian exporters would need to be selective about who they supplied in this market.

Another processor of lettuce and vegetables in Singapore who supplied airline catering confirmed their interest in bulk shipping. They are a potential buyer of lettuce in the future but would want to be sure the system is foolproof and a continuity of supply is assured before committing themselves to orders. They confirmed that Australian leafy vegetables were preferred to other suppliers but were usually not price competitive.

Wholesale markets were visited in Malaysia and Singapore. Both facilities presented a break in the cool chain for fresh produce and were the source of significant temperature abuse of these products. The situation in Singapore was not as bad as Malaysia, but it would be in Australia's interest as a supplier of perishable products to move towards direct supply to supermarkets or quality assured pre-packers unless these wholesale facilities can be dramatically improved. Pre-packing facilities and distribution centres under the direct management of supermarkets should be given preference to minimise temperature abuse.

Opportunities for pre cut salads prepared in WA or produced from WA raw materials are not promising because of our high cost of airfreight and Malaysia's ability to supply adequate quality raw product.

Figures 5.1.3 and 5.1.4. US lettuce in Selayang wholesale market Kuala Lumpar (left) and Pasir Panjang, Singapore (right).

Figures 5.1.5 and 5.1.6. Vegetable processor in a Malaysia (left) and Selayang market in Kuala Lumpur (right).

Discussion

The overwhelming conclusion from the contact with buyers and sellers in export markets for lettuce was that Australia lacks competitiveness with its main competitors, particularly the US in these markets. Our product is preferred for freshness and quality because of our proximity to the SE Asian markets but they are very price sensitive.

The best growth opportunity for lettuce is in the processing sector, because much of the product is consumed in 'Western style' restaurants and hotels in 'ready prepared' form. It is possible to supply processors with lettuce in bulk packaging because the user is a single point destination and this industry sector has a critical requirement for maintenance of cool chain integrity throughout the supply chain.

Significant savings in shipping costs could be made by exporting lettuce in bulk, and this option needs to be explored further.

Recommendations

The results of this study confirmed the need to develop innovative methods of shipping lettuce to markets within 5-21 days sailing time from Australia if Australia is to be price competitive in the region. Supply chain alliances with end users of the product need to be established to maximise the freshness and quality advantages that we have through proximity to these markets. These relationships need to be cemented by working together with buyers to meet their product, cool chain and transport needs while reducing landed costs for Australian product.

Persisting with supply through wholesaler intermediaries in export markets who incur breaks in the cool chain is not in Australia's best interest.

5.2 SINGAPORE/MALAYSIA MARKET STUDY

Agwest Trade and Market Development

Overview

The US is the world's second largest producer of lettuce behind China, with production volumes in the 1990s increasing by about 12 percent on the average compared to the levels in the 1980s. Consumer preferences have changed resulting in lower demand (11 per cent decline from 1992-96) for head lettuce (iceberg) being offset by increased demand (74 per cent in the same period) for other lettuce (gourmet types). The popularity of Caesar salad (which contains Cos lettuce) no doubt plays a part in this (Lucier 1998).

Chinese lettuce production rose from 5,655,000 Mt in 1998 to 6,255,000 Mt in 2000 (FAO) - an increase of 10.6 per cent. Total US lettuce production was around 4,230,000 metric tonnes (Mt) in 1999 and 2000, up 5 per cent from 4,023,000 Mt 1998 (FAO).

Only 12 per cent of US head lettuce production and 6 per cent of its gourmet lettuce production is exported. The bulk of these exports goes to Canada (94 per cent and 80 per cent respectively) with the remaining 14 per cent split between Hong Kong and Mexico.

The total value of Malaysian and Singaporean lettuce imports rose by 19 per cent (~ $A3.3m) between 1999 and 2000 to $A17.3m (see Figure 5.2.1). This followed a two-year decline in the value of lettuce imports, with a drop of $A2m occurring between 1998 and 1999. The increase in imports occurred in the Singaporean market, with Malaysian imports halving over the same period.

The increase in Singaporean lettuce imports has been accompanied by a change from a near 50/50 mix of head and non-head lettuce, to a strong preference for non-head lettuce. The non-head ('other') category includes gourmet lettuce varieties and shredded lettuce. This preference did not occur in the Malaysian market.

The total value of Australian lettuce exports to Singapore and Malaysia has declined significantly (21 per cent) over four years despite a 43 per cent jump in 1998. Western Australia represented nearly 50 per cent of the lettuce export value to these countries in 1998 compared to an average of 36 per cent across the other three years (see Figure 5.2.2).

Over this same period, the US has more than quadrupled its exports of non-head lettuce to Singapore and stabilised prices to below S$2/kg, making it the second cheapest source of non-head lettuce behind Malaysia. Average Singaporean non-head lettuce import prices have declined by about 11 per cent (20 ¢/kg) over this period to around S$1.60/kg (see Figure 5.2.4).

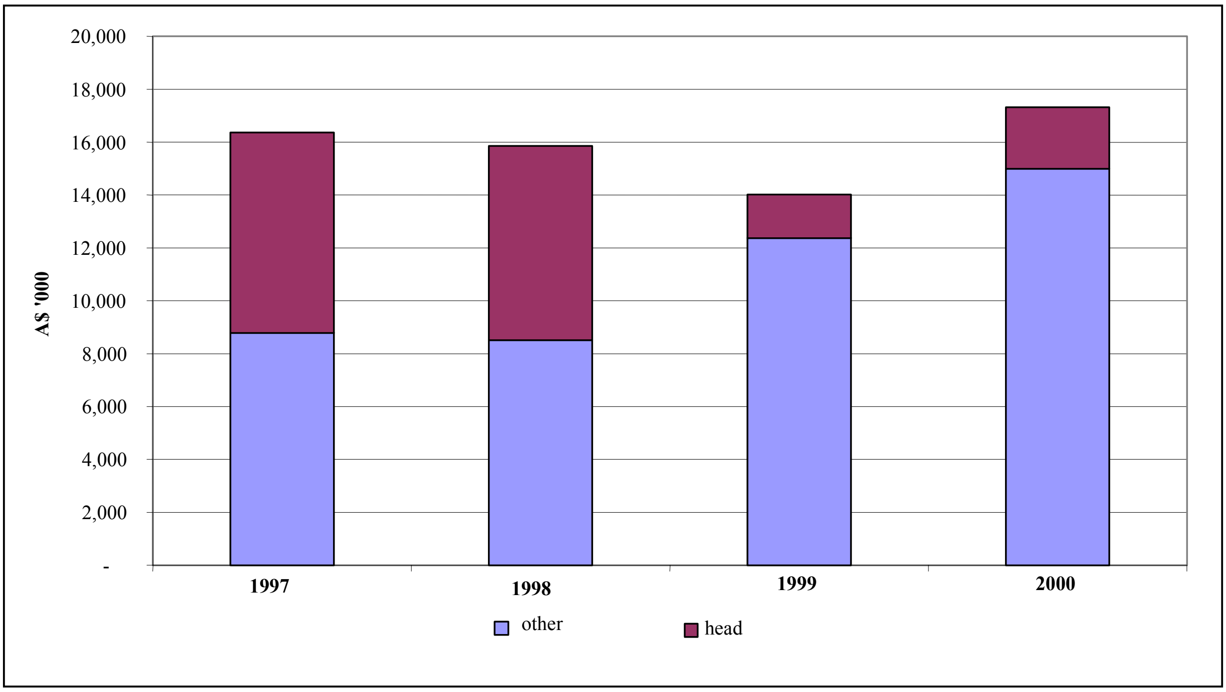

Figure 5.2.1. Value of Malaysian and Singaporean lettuce imports, 1997-2000.
Sources: Malaysian Department of Statistics and Singapore Trade Development Board.

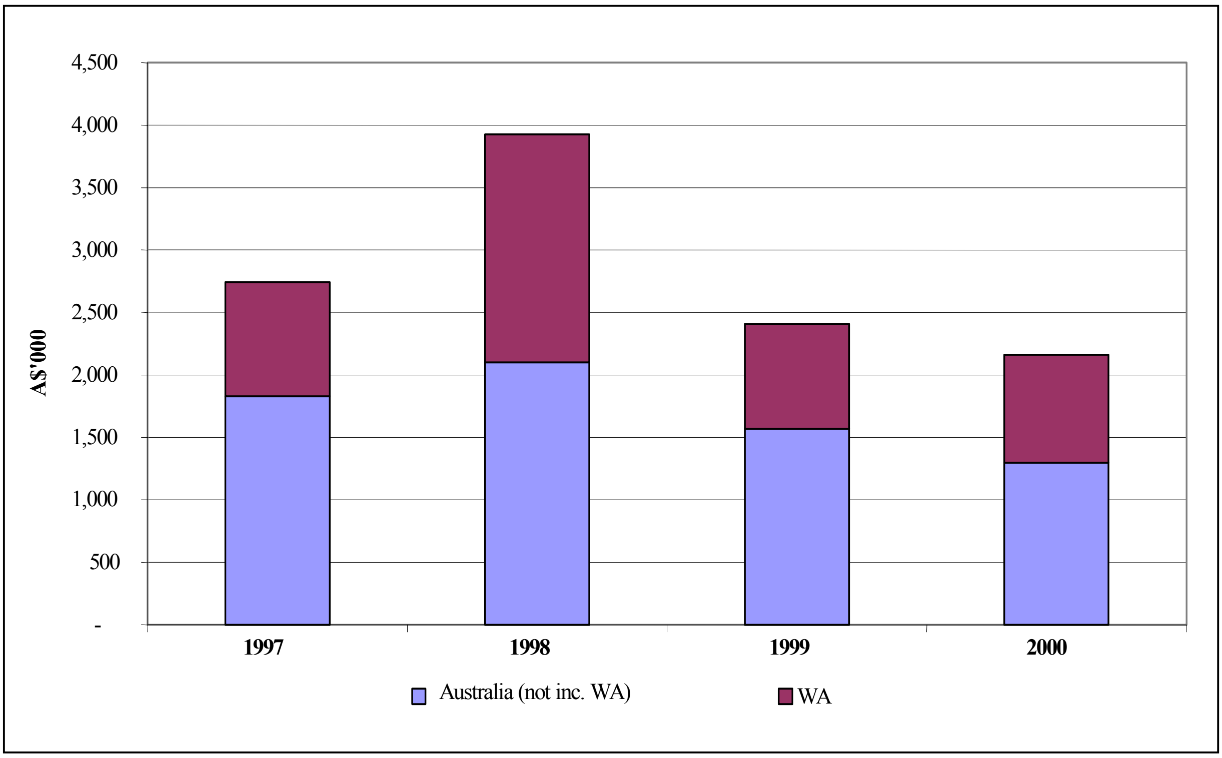

Figure 5.2.2. Total value of WA and Australian lettuce exports to Malaysia and Singapore.
Source: Australian Bureau of Statistics (ABS).

Singapore

Singapore's lettuce imports have grown by 15 per cent from S$12.5m in 1997 to S$14.3m in 2000. The make-up of these imports has changed dramatically, with the proportion of head lettuce falling from 54 per cent in 1997 to 6 per cent in 2000 (see Figure 5.2.3).

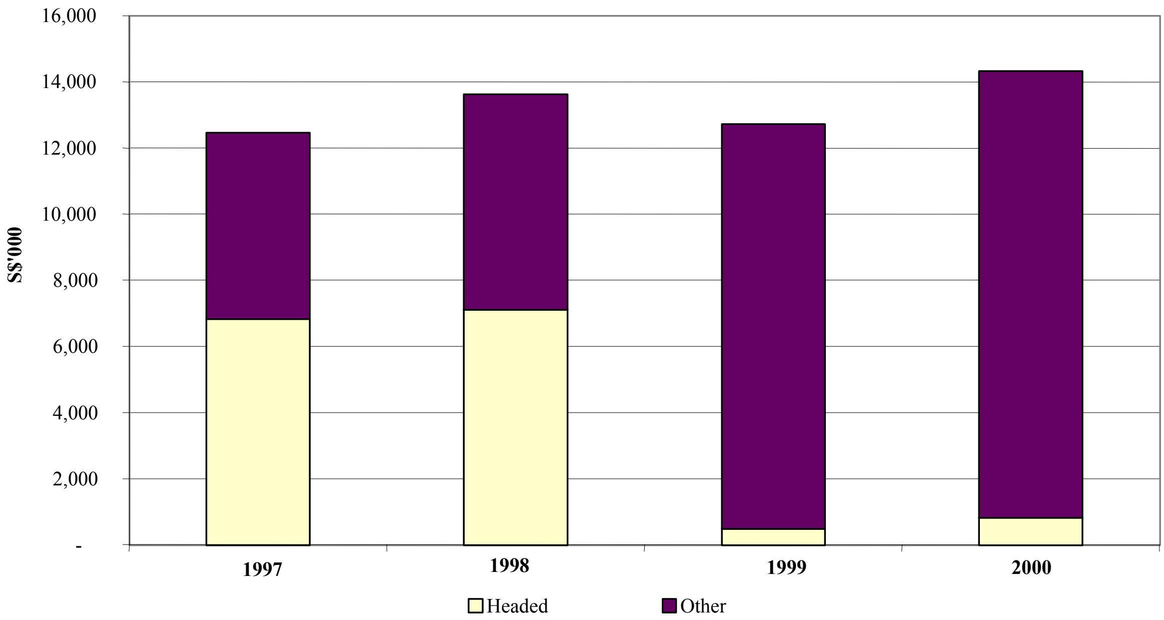

Figure 5.2.3. Total value of Singaporean head and other lettuce imports, 1997-2000.
Source: Singapore Trade Development Board.

'Other' lettuce

Singapore's average monthly import prices for non-head lettuce have peaked between the September and March quarters in three of the four years between 1997 and 2000. Two out of these three price peaks occurred in the December quarter. Figure 5.2.4 shows how the average quarterly import price has declined progressively from around S$1.80/kg in 1997 to around S$1.60/kg in 2000.

In July 1998, the United States overtook Australia as Singapore's primary import source for 'other' lettuce (see Figure 5.2.5). This is most likely due to a reduction and stabilisation of import prices from the United States, which occurred at the same time. US export prices fell to below $2/kg in July 1998 and have averaged S$1.57/kg since then (see Figure 5.2.6).

Malaysia and the Netherlands are the third and fourth largest exporters of non-head lettuce to Singapore (see Figure 5.2.5). Malaysia has the lowest export prices while the Netherlands export prices are the highest out of the top four import sources (see Figure 5.2.6). The reasons for the high prices of lettuce from the Netherlands may include high land opportunity costs, complex and costly shipping routes, or may be due to high quality or value added produce. This is an area requiring further research.

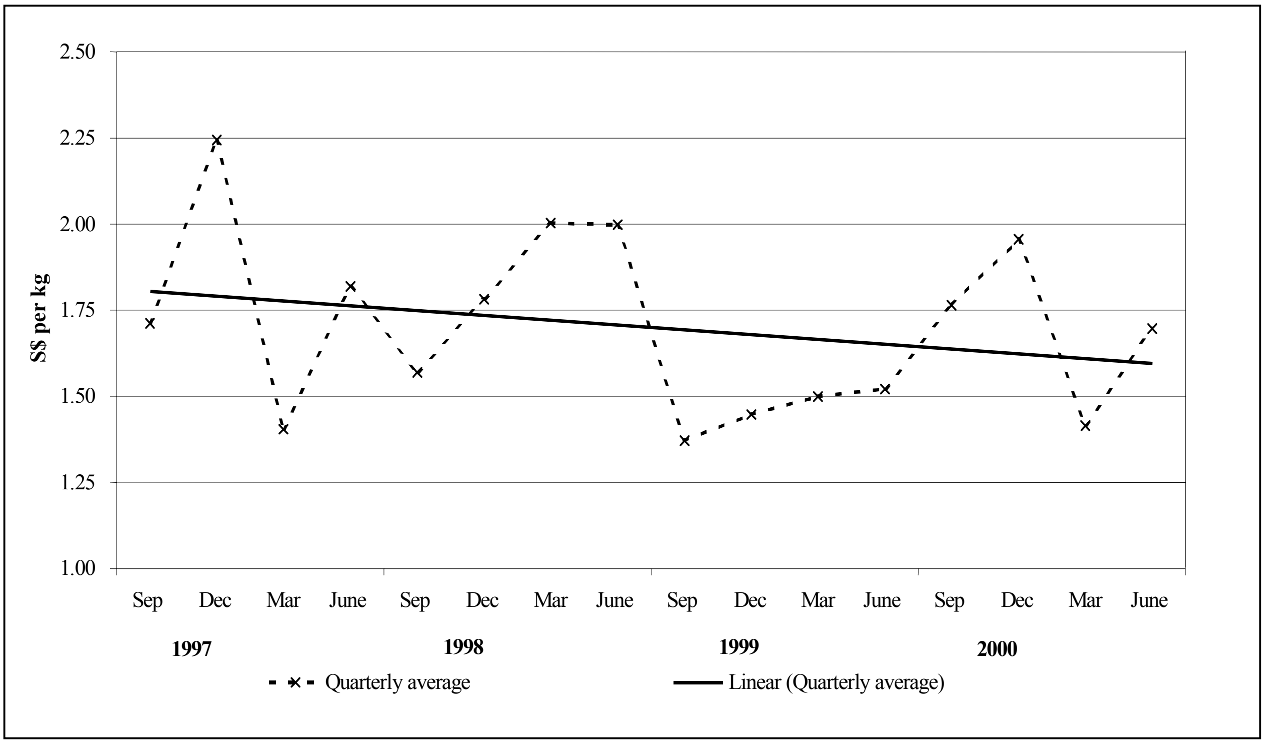

Figure 5.2.4. Quarterly average 'other lettuce' import prices, Singapore, 1997-2000.
Source: Singapore Trade Development Board.

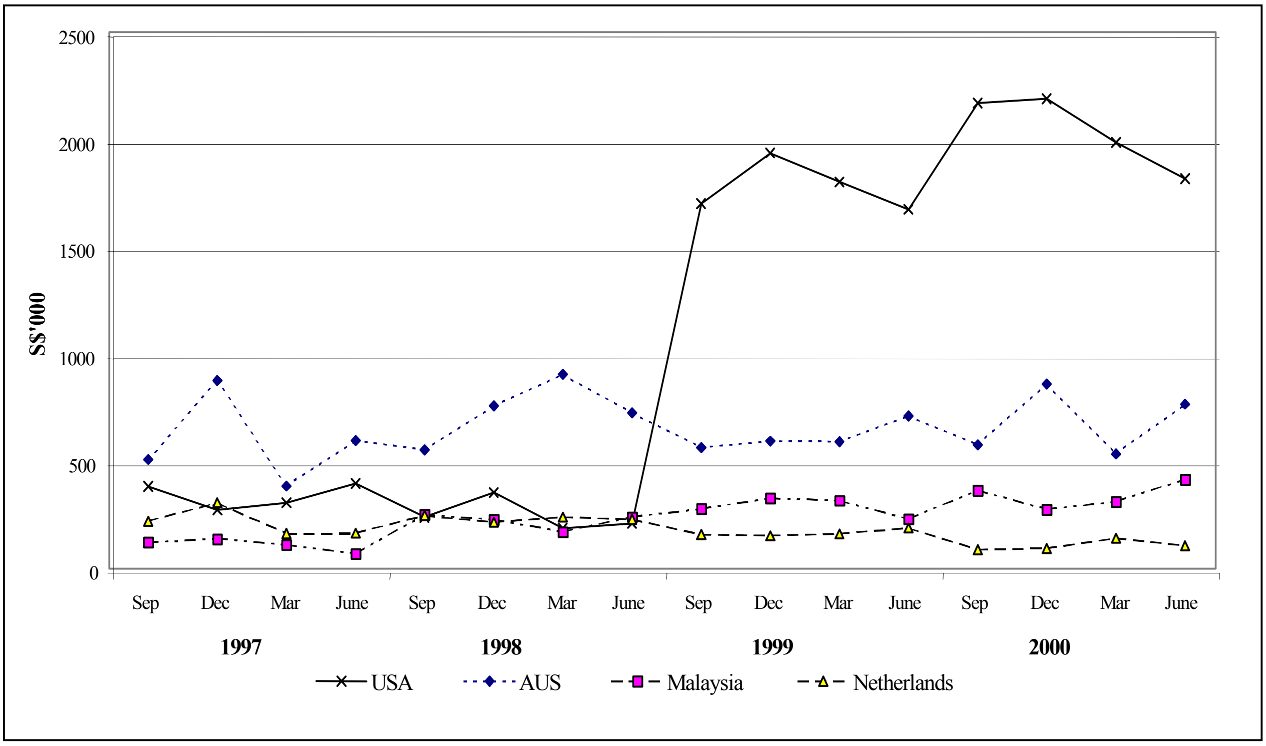

Figure 5.2.5. Quarterly Singapore 'other lettuce' import values, top four import sources, 1997-2000.
Source: Singapore Trade Development Board.

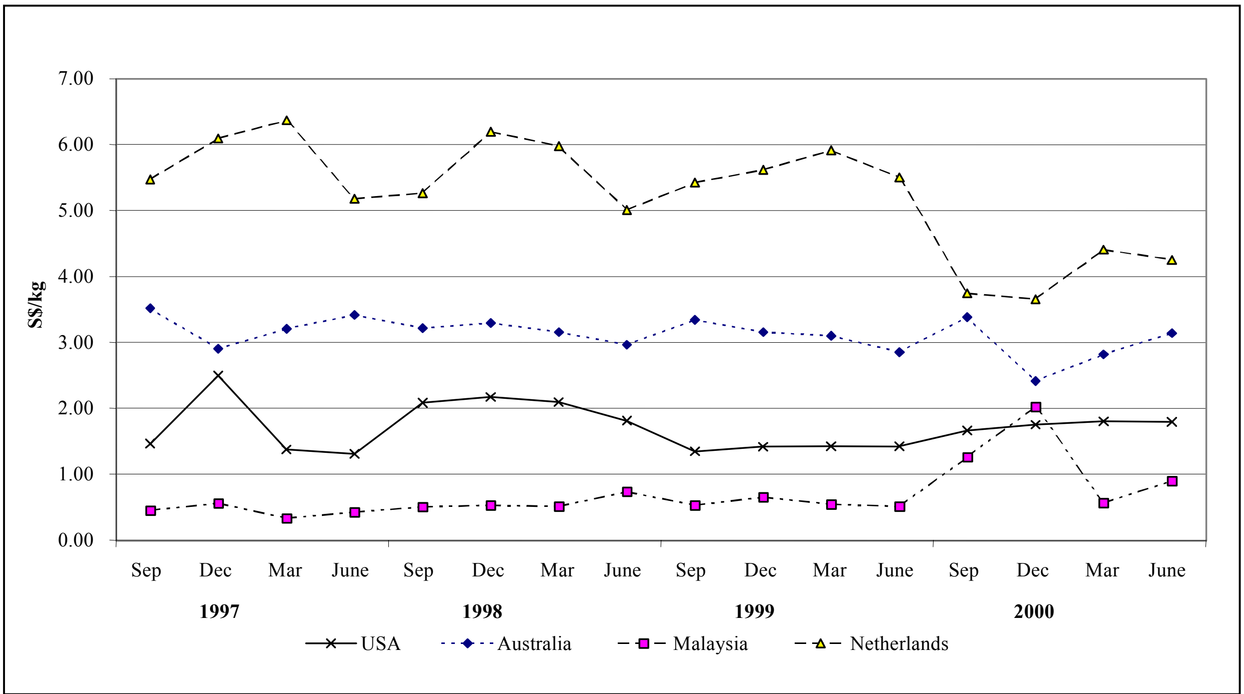

Figure 5.2.6. Average quarterly Singapore 'other' lettuce import prices, top 4 import sources, 1997-2000.
Source: Singapore Trade Development Board.

Head lettuce

Head lettuce import prices in Singapore could not be determined due to the absence of import quantity data. Western Australian head lettuce exports to Singapore were used to derive Figure 5.2.7. Western Australian export prices have declined progressively since the June quarter of 1997, with a greater than 50 per cent decline in average prices over the four years to 2000.

Singapore's head lettuce imports dropped significantly at the beginning of 1999, while 'other' lettuce imports from the US grew to fulfil demand (see Figure 5.2.5). The actual forms of 'other' lettuce imports are assumed to be shredded and gourmet leaf lettuces.

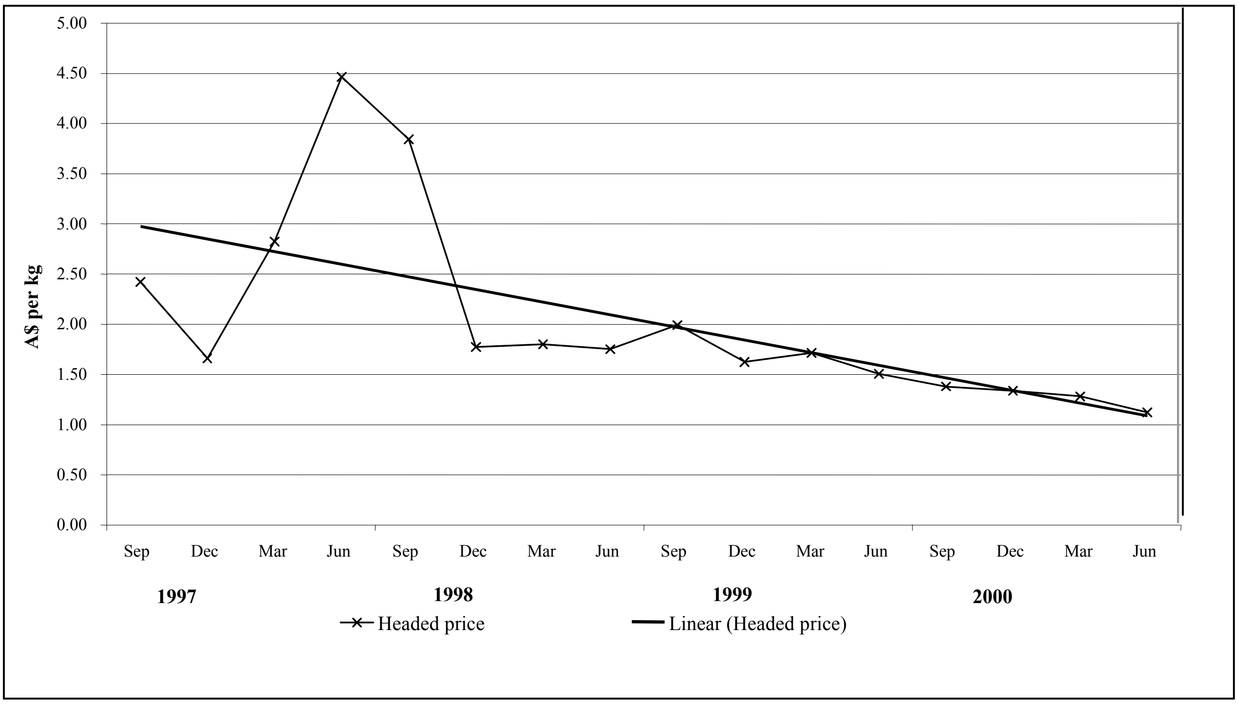

Figure 5.2.7. Quarterly average WA head lettuce export price to Singapore, 1997-2000.
Source: ABS

Since January 1999, Malaysia has overtaken Australia as the primary source of imported head lettuce, apart from May 2000 when imports from China exceeded all others (Figure 5.2.8). There may be a substantial component of re-export of lettuce originating from other countries (e.g. the US) in raw or processed form (unconfirmed).

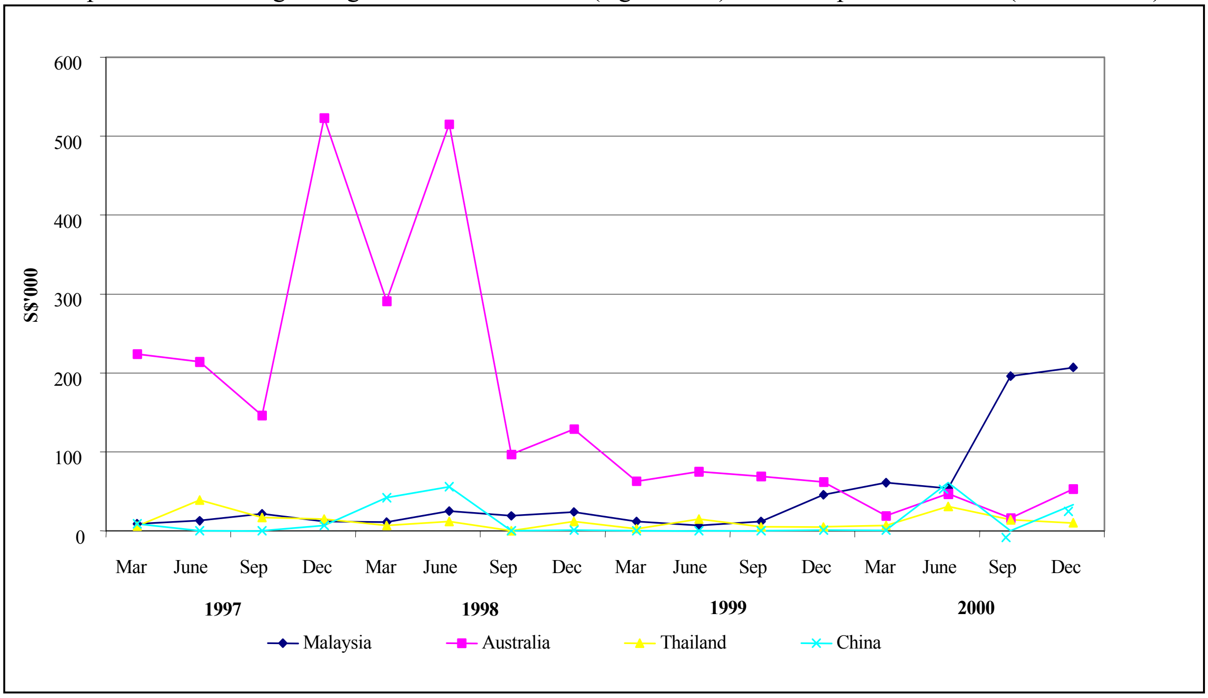

Figure 5.2.8. Value of Singaporean head lettuce imports, 1997-2000.
Source: Singapore Trade Development Board.

Malaysia

The total value of Malaysian lettuce imports halved from around 11.9 m Ringitt (RM) in 1997 to approximately RM 5.8 m in 1999, but have shown signs of recovery, growing by around 11 per cent to nearly RM 6.5 m in 2000 (see Figure 5.2.9).

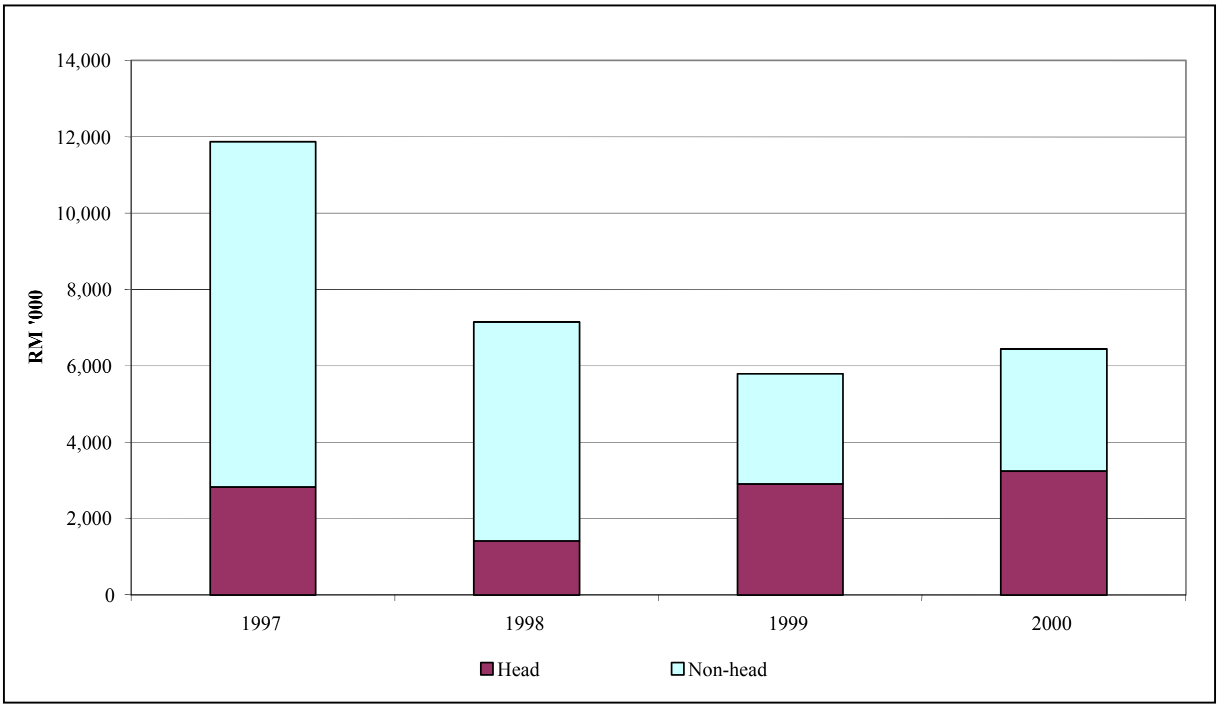

Figure 5.2.9. Value of Malaysian lettuce imports, 1997-2000.
Source: Malaysian Department of Statistics.

Malaysian lettuce sources have changed from being dominated by the US and Australia in 1997, to a mix of five countries in 2000. The US has taken over from Australia as the largest value supplier of lettuce to Malaysia, while China has emerged as an important source in the last two years, further diminishing Australia's market share. Vietnam and New Zealand have also emerged as significant suppliers of lettuce to Malaysia (see Figure 5.2.10).

'Other' lettuce

The near two-thirds reduction in the total value of Malaysian non-head lettuce imports from around RM 9 m to nearly RM 3.2 m over last four years has had the greatest influence on the total reduction in Malaysian lettuce imports (see Figure 5.2.9). The US has overtaken Australia as the major non-head lettuce source over the same period (see Figure 5.2.11). This reflects the low prices of non-head lettuce from the US (see Figure 5.2.12).

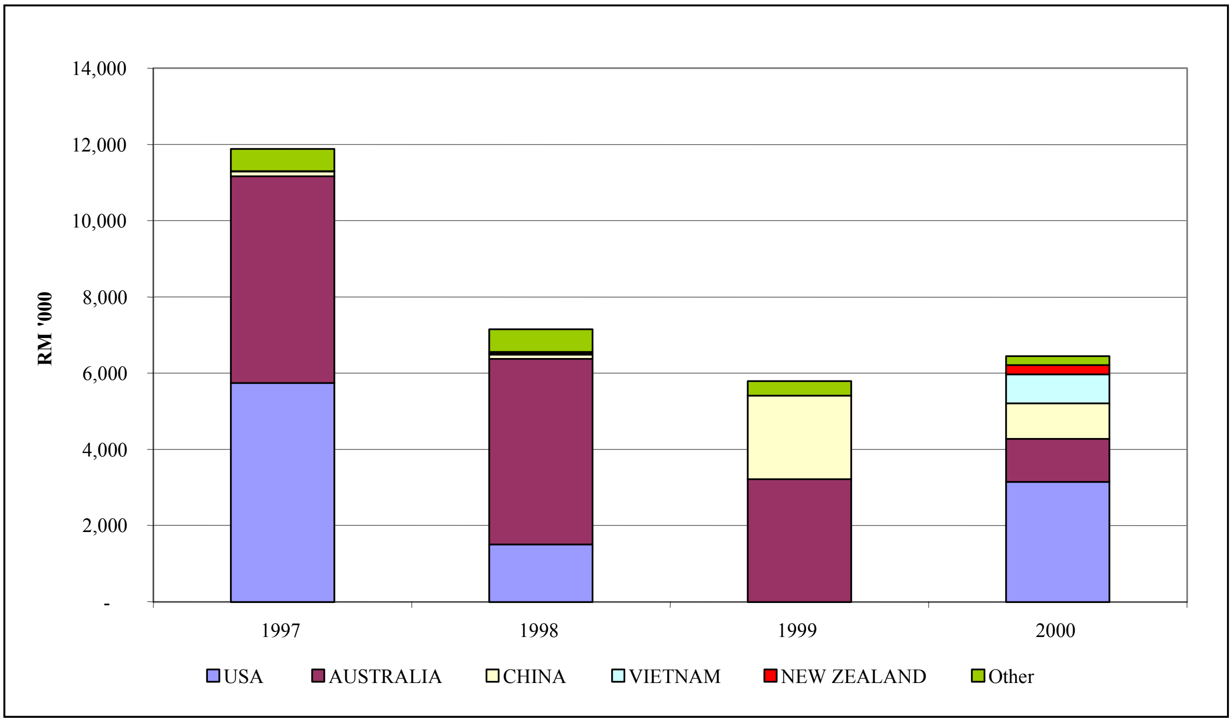

Figure 5.2.10. Total Malaysian lettuce import values by source country, 1997-2000.
Source: Malaysian Department of Statistics.

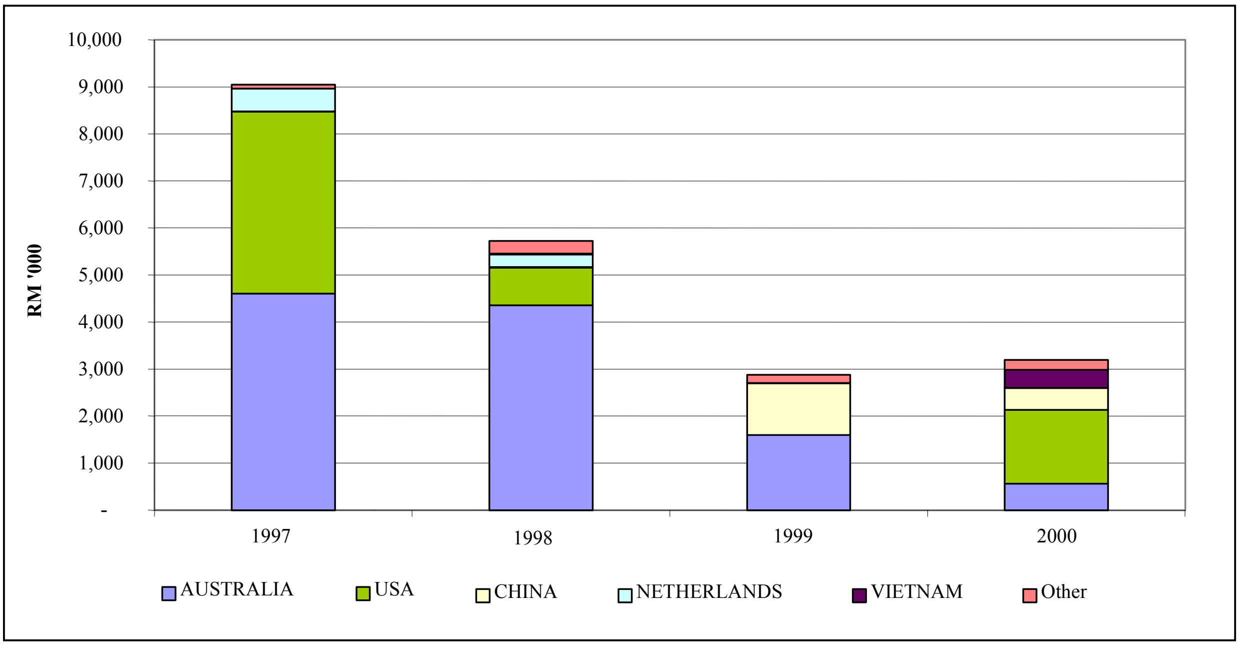

Figure 5.2.11. Annual values of Malaysian imports of 'other' lettuce from top five sources, 1997-2000.
Source: Malaysian Department of Statistics.

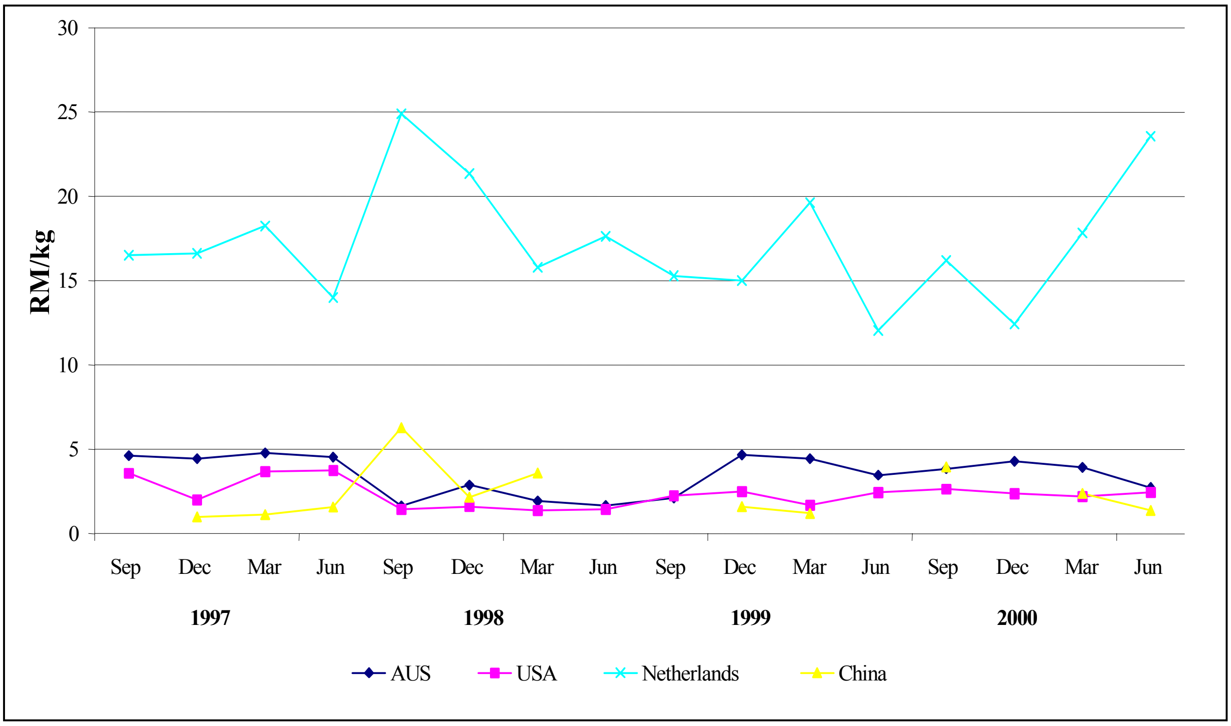

Figure 5.2.12. Price of Malaysian 'other' lettuce imports from top four sources, 1997-2000.
Source: Malaysian Department of Statistics.

Head lettuce

The US has been the dominant exporter of head lettuce to Malaysia since 1997, apart from 1999 when Australia was the dominant exporter to Malaysia (see Figure 5.2.13). The value of US exports of head lettuce to Malaysia fell from nearly RM 1.9 million in 1997 to nearly nothing in 1999, then rebounded to RM 1.57 million the following year. This is thought to be the consequence of flooding in production districts in California in late 1988.

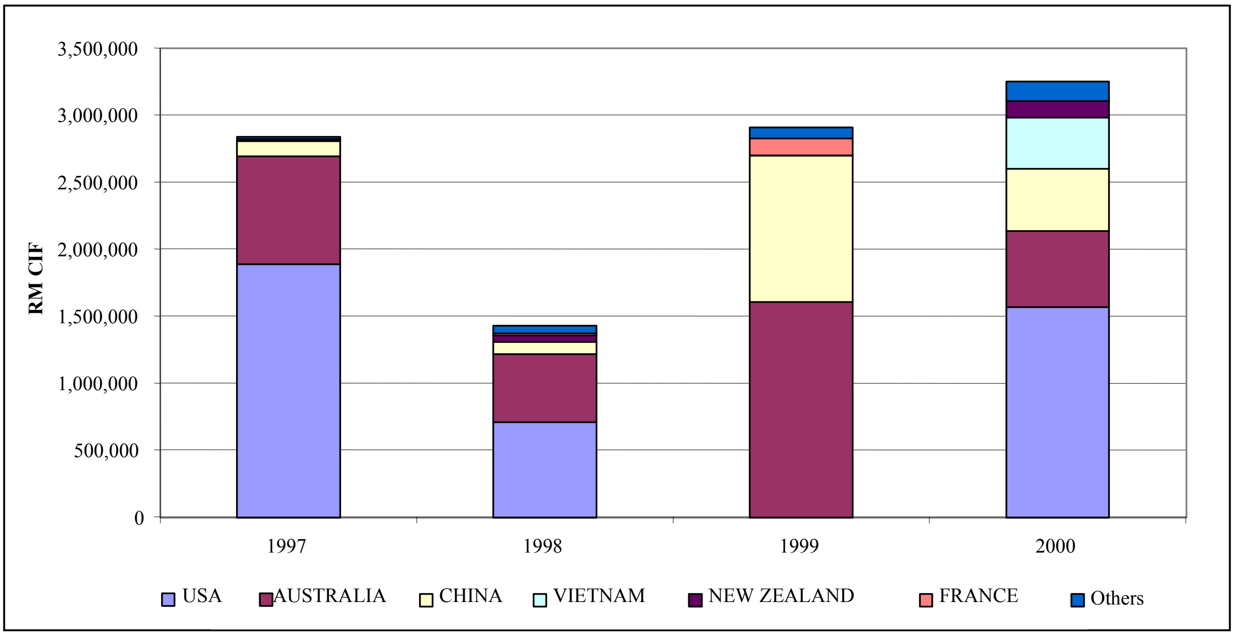

Figure 5.2.13. Total annual value of Malaysian head lettuce imports, by country for values > RM 100,000.
Source: Malaysian Department of Statistics.

Australia has been the second largest supplier of head lettuce to Malaysia in three out of the four years to 2000, and was the largest in 1999. China has consistently been the third largest exporter of head lettuce to Malaysia in the last four years apart from the 1999 anomaly, with a 10-fold increase in it's exports to Malaysia.

Average monthly import prices over four years show premiums of around RM 2.5/kg between November and January, however this trend is heavily influenced by the very high prices at the end of 1999. Average import prices rose above the four-year average in 1999/2000, with the linear trend showing an 83 per cent increase in prices over the four years (see Figure 5.2.14).

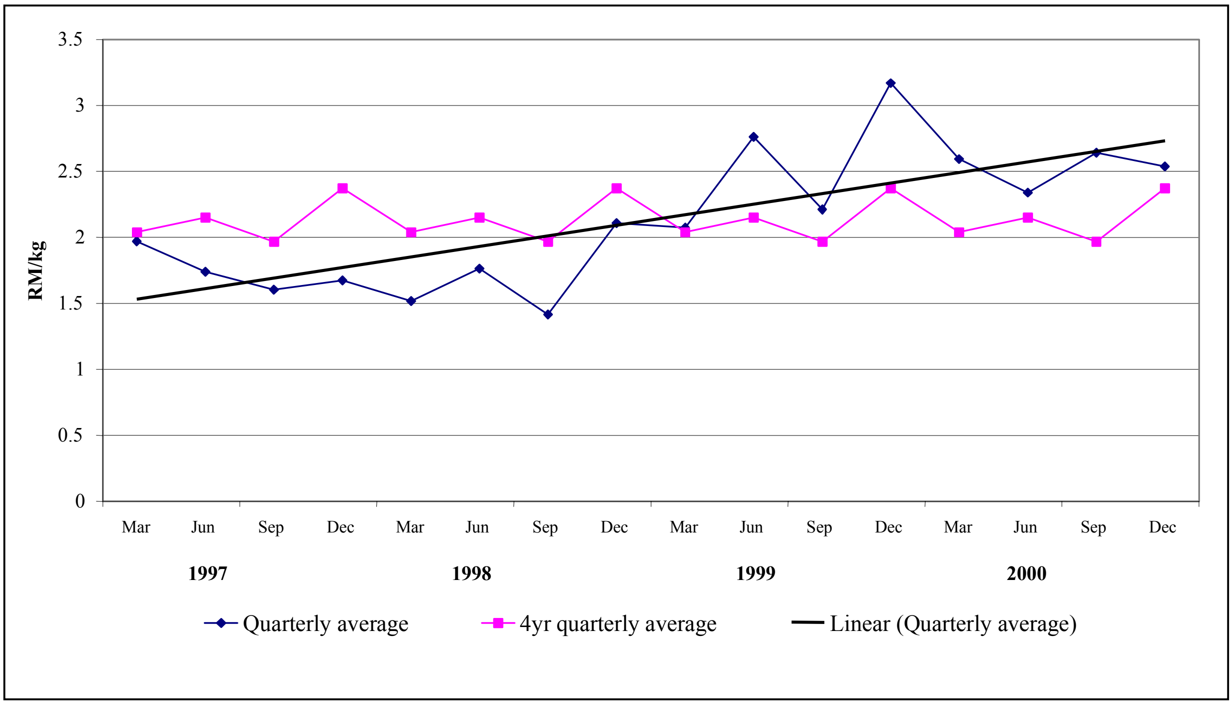

Figure 5.2.14. Average quarterly Malaysian head lettuce import prices, 1997-2000.
Source: Malaysian Department of Statistics.

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5.3 WESTERN AUSTRALIAN COST OF PRODUCTION STUDY

Peter Gartrell

Introduction

As described earlier, discussions with exporters and growers revealed that the main reason for the steady loss of market share for Western Australian head lettuce in South-East Asia was a lack of price competitiveness in the export market place.

Empirical evidence suggested that our cost of production was too high. This coupled with competitors' freight advantages appeared to preclude Western Australian lettuce producers from these markets except in periods of high price.

The overriding objective of the project was to realise the export competitiveness of Western Australian and Australian lettuce. To achieve this end, it was important to understand the components of production and marketing which contributed most to this cost problem and to assess the potential for reducing them. An on-farm cost of production study was undertaken to collect this information with selected producers.

The primary aim of this study was to characterise the cost of production 'on-farm' for the industry as it was, and to assess the effect that these 'on-farm' costs would have on export competitiveness. At the time this study was conducted, most lettuce producers in Western Australia focussed primarily on the domestic fresh market, with the smaller processing and export sectors of secondary interest. This necessitated that the results from the study were skewed towards domestic fresh market production and needed some extrapolation to estimate the export impacts. From this study, the key cost of production parameters could be identified. These parameters could then be tested and extrapolated to derive probable best practice and resultant cost of production.

Materials and methods

To establish a cost of production for the existing industry a number of producers were invited to participate in a survey involving personal interviews. The data collected from each producer interview was entered into a cost of production model.

The lettuce production system appeared to have three periods of production that were readily identifiable. These production periods are the summer, winter, and spring/autumn. Environmental constraints and pest pressures largely dictate these periods. Participants contributed their lettuce program performance, direct and allocated overhead costs on this basis. The data was collated into a gross margin and allocated overhead framework. The framework was as follows:

- Income/yield
- Preparation and establishment cost
- Crop management
- Harvest
- Post Harvest
- Overhead
- Enterprise margin

These anticipated costs and incomes were then used to identify the incomes, costs and returns for each hectare. The same parameters were also established on a unitary basis, these being per unit (head or bin) and per kilogram. The costs in the framework were allocated into 10 different categories as follows:

- Labour
- Fertiliser
- Irrigation
- Chemical
- Machinery operating
- Agent fees
- Seedlings/seed
- Transport
- Bin hire
- Other

Most producers were primarily focussed on the domestic market supply of head lettuce. Many had small levels of sales into the processing industry. These sales were generally considered a marginal retainer or opportunistic option due to the price contract level. Many believed that the lettuce industry could not compete with exports to the South-East Asian market. Most believed US supply price was too competitive.

Lettuce was seen as a good rotational crop for other vegetable production. It has a relatively short crop rotation and offered a disease break for brassica crops. Most producers considered that the lettuce crop's primary failing was inconsistent yield and price. Essentially poor yields across the industry reduced supply and raised prices. One producer proclaimed "you always get the best price for your worst product" because of the supply and demand dynamics. The reasons for yield variability are many and varied. Most common were disease and climactic effects. Many producers believed that varietal management and scheduling was critical to success.

As a result of a domestic market focus, most Western Australian producers think and plan on a 'bin' basis. A 'bin' is 12 heads of lettuce. This can vary a little in practice but this is the target and the norm for many producers.

The results were aggregated for all producers. The surveyed producers were reasonably similar in their lettuce enterprise structure. A range of data was collected.

For the purposes of this report the Summer crop production period is from Early December to Late March, Winter is from June to mid September, Autumn and Spring is from late March to end of May and mid September to early December. Autumn and Spring periods are aggregated due to the similarity in production performance. These production periods are outlined in Figure 5.3.1.

Prices (for the bin unit) were taken from monthly averages from the Canning Vale (Perth, Western Australia) wholesale market from 1996 to 2000. The small amounts of processing were priced at the contract prices at the time. Figure 5.3.1 shows the price variability across the year. Typically winter prices were highest and summer prices lowest. This is commensurate with supply patterns in the market.

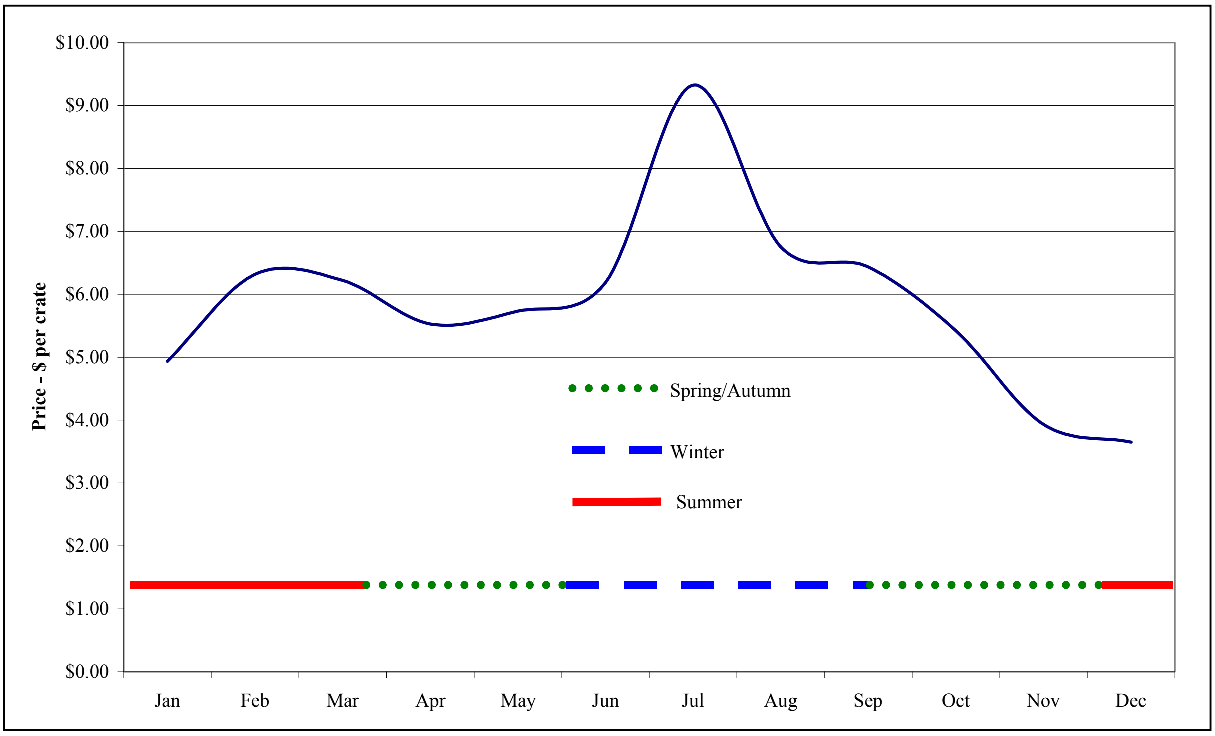

Figure 5.3.1. Canning Vale (Perth, Western Australia) wholesale market price average and seasonal crop timing period.

Results

Grower survey

In line with the domestic wholesale market focus Table 5.3.1 outlines seasonal costs and returns on a 'per bin' basis. Costs of production, yield and price show some correlation. As the yields improve and risk is reduced, price falls and costs are diluted by higher yield.

Table 5.3.1. Seasonal and annual average income, yield and cost on a 'per bin' basis

	Summer	Winter	Autumn/Spring	Total
Income	$5.29	$7.13	$5.46	**$5.89**
Bins per hectare	3,903	3,879	4,017	**3,924**
Preparation and establishment	$1.26	$1.31	$1.19	**$1.26**
Crop management	$0.30	$0.37	$0.28	**$0.31**
Harvest	$0.69	$0.64	$0.57	**$0.64**
Post harvest	$1.46	$1.96	$1.34	**$1.57**
Overhead allocation	$0.60	$0.68	$0.63	**$0.64**
Total costs per bin	**$4.30**	**$4.95**	**$4.01**	**$4.41**
Margin	$0.98	$2.19	$1.45	**$1.47**

The component costs show that labour is the most significant cost of production (Figure 5.3.2). Transport, agents fees, bin hire and seedlings ranked as significant costs. 'Other' costs are primarily the allocation of overheads. These costs are an apportionment of cash (e.g. rates, licences, insurance, etc.) and provisional (e.g. tractor replacement) costs.

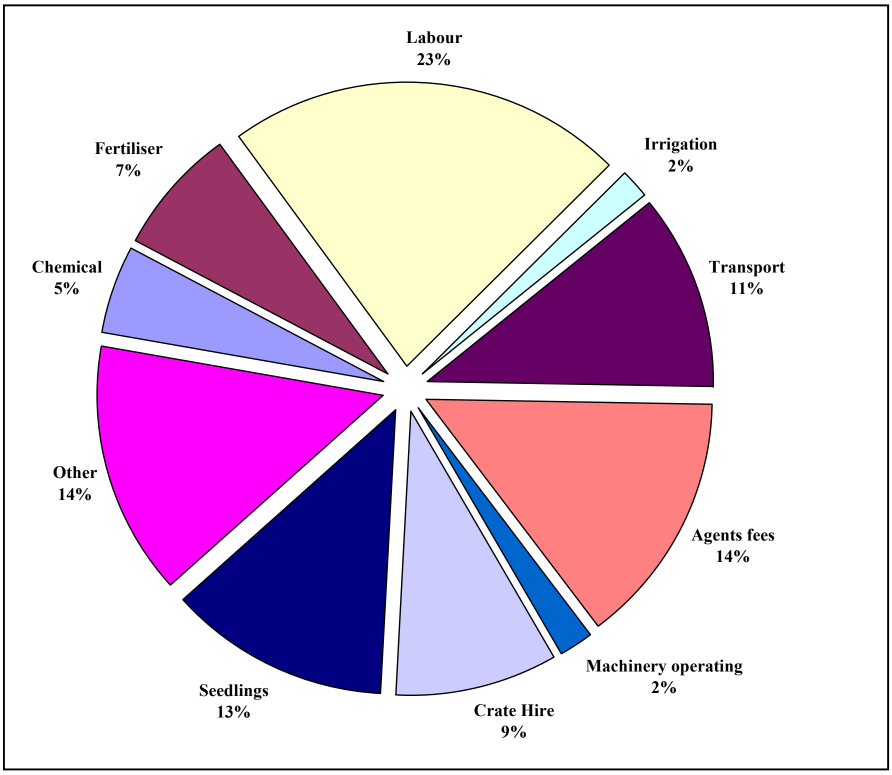

Figure 5.3.2. Component cost breakdown for average annual cost of lettuce production.

To derive an export conversant unit the bin based results were converted to a per kilogram basis. These were calculated using expected head weights for each seasonal period. This varied slightly between producers. On average, the winter period head weight was estimated at 800 grams per head. Summer was assumed to be 750 grams and all other periods were approximately 780 grams per head.

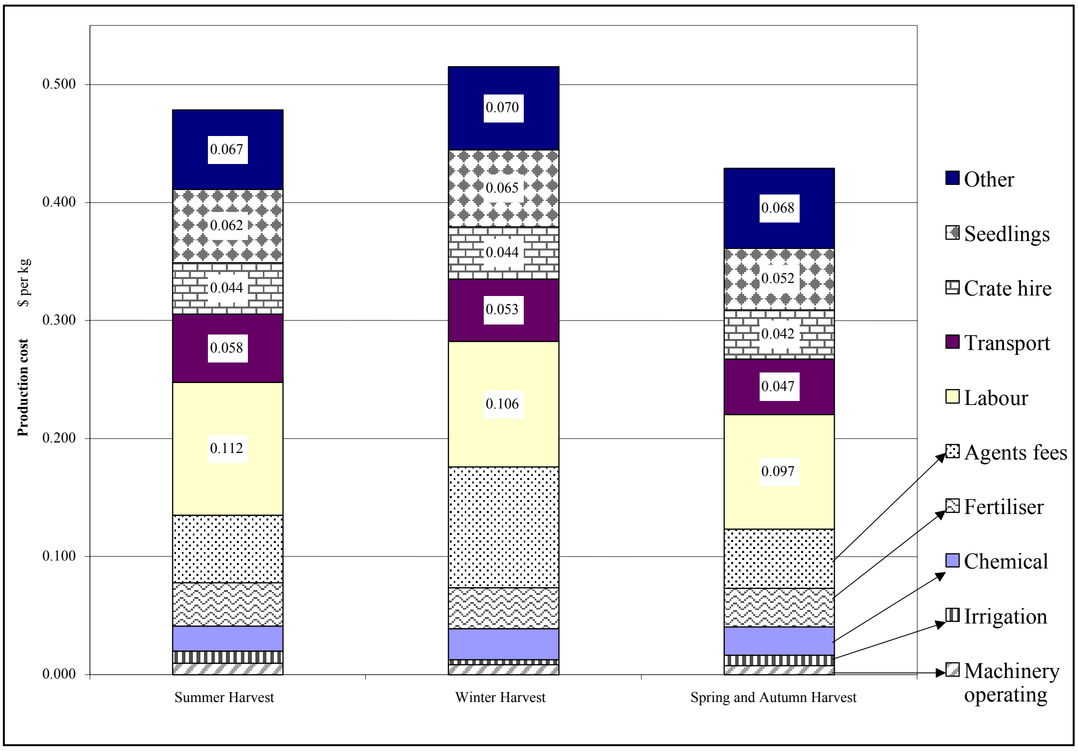

Figure 5.3.3. Estimated seasonal component cost of production ($ per kg).

On a weight basis the **annual average head weight** was expected to be approximately **775 grams per head**. The shift from a bin basis to a weight basis realises a 4 per cent cost improvement for winter and a similar fall for a summer crop. The spring/autumn period realises an improvement of around 1 per cent per crop.

Cost of production varied significantly between seasons (Figure 5.3.3). The range was from a low of 42.9 cents per kilogram in autumn/spring to 51.5 cents in winter. Summer costs of 47.8 cents per kilogram were slightly higher than the annual average of 47.5 cents.

There was a significant range of costs between producers (Figure 5.3.4). These were largely attributed to yield expectations. Fertiliser and chemical programs were different but resulted in similar costs. Other significant variances included direct sales (no agent fees), direct seeding versus seedlings, harvest labour time and economies of scale.

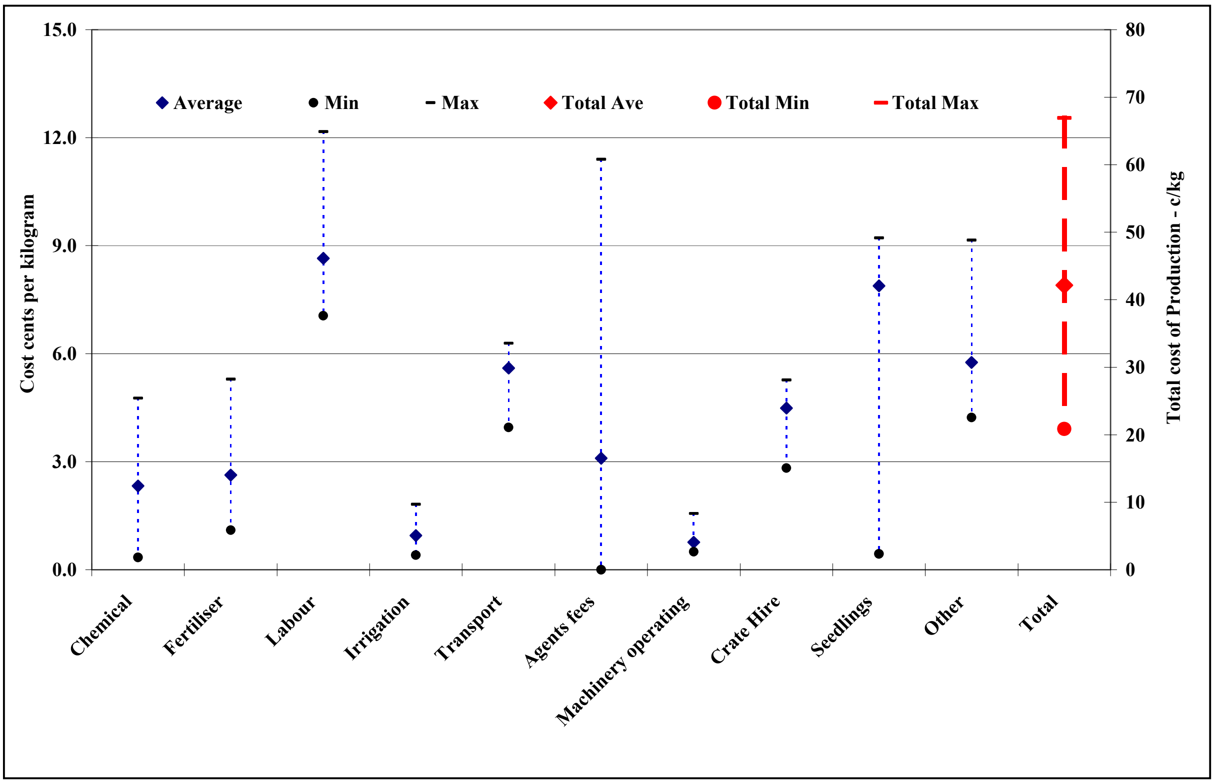

Figure 5.3.4. Component cost of production variability among growers surveyed.

With producers having a focus on the domestic fresh market, the pricing signals are on a bin basis not head weight. Producers are therefore focussed on product size or frame in order to fill a bin. After considering the survey data, our level of confidence in grower's estimates of head weight was low.

Table 5.3.2. Average production cost per hectare by season for the surveyed growers ($ per hectare)

Costs timing/item	Summer harvest $	Winter harvest $	Spring/Autumn $	Total $
Preparation and establishment	4,926	5,086	4,777	4,935
Crop management	1,154	1,425	1,123	1,226
Harvest	2,678	2,464	2,308	2,510
Post harvest	5,685	7,584	5,368	6,157
Overhead allocation	2,357	2,624	2,546	2,493
Total costs	**16,800**	**19,184**	**16,123**	**17,320**
Chemical	744	975	904	859
Fertiliser	1,293	1,294	1,232	1,277
Labour	3,952	3,957	3,654	3,870
Irrigation	357	163	328	292
Transport	2,037	1,972	1,764	1,940
Agents fees	2,006	3,813	1,883	2,503
Machinery operating	342	311	287	317
Bin hire	1,530	1,650	1,571	1,579
Seedlings	2,183	2,426	1,954	2,190
Other	2,357	2,624	2,546	2,493

It should be noted that producers typically were optimistic in their estimation of yields and head weights and meticulous records were rarely kept of these variables. The yields and returns on a longer term average basis could be less than is reflected in this survey. It could be argued that risk of crop failures or significant reductions has not been factored in to accurately reflect the reality of the enterprise. Producers indicated that significant crop failures characterise the enterprise. This acceptance could explain the low pre-harvest investment relative to other crops and the erratic price environment. Table 5.3.2 shows that pre-harvest or up-front investment was on average \$6,160 per hectare or 36 per cent of expenses. This varied between seasons from \$5,900 to \$6,511 per hectare or 10 per cent.

A notable difference between producers was the planting density per hectare. Plant numbers ranged from 48,000 to 52,000 per hectare. Given that bins of 12 lettuce heads are the sales base, it is difficult to increase yields in a market which pays by number with static planting densities. Rising costs have therefore reduced returns over time.

Of the producers surveyed none had comprehensive records of crop performance. This could largely reflect the complex nature of their enterprise and the unpredictable nature of the crop performance and its price.

In order of significance the key parameters for enterprise performance and efficiency were:

- yield;
- price variability;
- post-harvest costs;
- labour efficiency/cost; and
- general input costs.

'Best bet' production and export model

To examine the likely impact of these factors on the business of growing and exporting lettuce it was decided to incorporate the survey findings in a hypothetical case study model. Utilising the data collated, performance data from the yield survey (Chapter 6) and associated costs, a model of production for year round supply of export lettuce was constructed. This hypothetical 'best bet model' was required to investigate and test options for the development of a competitive production and exporting strategy.

This model was used to derive a cost of export supply. This was in turn used to test if the production and product management system was competitive. The model assumed that lettuce was produced in the best geographic location for yield and quality in each of the identified seasons. Manjimup in the cooler southern area was chosen for summer production in order to minimise tip burn and bolting risks. Gingin, north of Perth, was chosen for winter production with its relatively warmer winters, to reduce foliar disease risk and to shorten maturity times. The traditional growing areas surrounding Perth were considered to be best suited to the autumn and spring time periods. These are not exclusive production zones but were chosen because infrastructure was present in all districts to allow the crop to be grown and transported efficiently at the time of the study.

The Malaysian and Singaporean fresh markets have been traditionally considered as the primary export target. The model aimed to cost head lettuce 'ready for export' to these destinations in conventional cardboard cartons.

The only change to the grower survey model was that average plant numbers were increased from 50,000 to 60,000 per hectare. Head weights were assumed at the level identified in the survey. This is a substantial shift in the cost and returns structure. Generalised fertiliser and pest management programs were assumed.

Table 5.3.3 shows that the cost will range from 81 to 86 cents per kilogram to average 82.6 cents per kilogram. This is derived from the model cost structure. The costed result is for lettuce delivered in an export ready state. An export ready state is in cartons at the pack-house ready for shipment.

The yield assumption made for this scenario was based on 42 tonnes per hectare of saleable yield from the 60,000 plants per hectare of which 90 per cent were harvestable, at a head weight of 775 grams each.

The cost of pack-house handling and cartons was 44.1 cents per kilogram representing over 50 per cent of the cost. No provision was made for the cost of containers from the farm gate to the pack-house. It was assumed that a closed link container (bin) ownership was employed at no cost to the grower. If the returnable hire bin system was employed (as is current practice) the cost would increase by approximately 4.1 cents per kilogram.

Table 5.3.3. Cost of production by season and location for the 'best bet' model crop in cartons

Costs	Summer - Manjimup $/kg	Winter - Gingin $/kg	Spring/Autumn - Wanneroo $/kg	Average $/kg
Prepare/establish	0.158	0.119	0.123	0.132
Crop management	0.033	0.065	0.059	0.054
Harvest	0.095	0.102	0.105	0.101
Post-harvest	0.486	0.443	0.443	0.455
Overheads	0.090	0.082	0.083	0.085
Total costs	**0.862**	**0.811**	**0.812**	**0.826**

After preliminary research though field monitoring and whole of system evaluation, the production and export model was broadened to explore a different field handling and export method.

Bulk harvest and handling

The fundamental change in the new model was the assumption of bulk harvesting. This involves picking and packing in-field into bulk bins that are then cooled and loaded directly into shipping containers for export. These are export ready at the farm gate. This method eliminates the double handling incurred by the conventional system ie harvesting and field loading followed after cooling by packing into cartons. Sample purpose built wooden bins were made and proved to be marginally cheaper than the conventional cardboard cartons on a per kilogram of product basis.

An analysis of the likely costs for the bulk handling method was conducted using the survey cost of production model as a base but with some more conservative assumptions that we felt may better reflect the long term average condition. The conventional export model assumed an average head weight of 775 grams. A more conservative target of 600 grams per head was adopted for testing the bulk model. Previous plant populations of 60,000 were increased to 72,000. The average recovery rate was revised downward to 75 per cent from 90 per cent. This is a saleable yield of 32.4 tonne per hectare in the new model, down approximately 9.6 tonnes per hectare compared to the grower survey figure.

On average, bulk bins held 335 kilograms of lettuce net, or the equivalent of 24 cartons (14 kilograms each). Cost per kilogram of lettuce in the bulk bins in the model is 19.4 cents compared to 20.0 cents per kilogram for cardboard cartons. Table 5.3.4 shows the significant decrease in post harvest costs of almost 50 per cent with the bulk method. Other increases in post harvest costs include the handling and cooling costs of the bulk product on farm, compared to cartons at the exporter's premises. Whilst this may add to costs, due to the extra capital cost of the on-farm coolstore, the benefit is likely to be improved product quality resulting from prompt removal of field heat from the produce.

Figure 5.3.5 shows a comparison of production costs for lettuce in bulk versus cartons (conventional) in export ready form, i.e. the product packed and shipment ready.

Table 5.3.4. Yield and costs for conventional and bulk handling models

Costs	Conventional model t/ha	Bulk model t/ha
Paddock yield	46,629	43,200
Saleable yield	41,966	32,400
Preparation and establishment	0.132	0.240
Crop management	0.054	0.036
Harvest	0.101	0.159
Post-harvest	0.455	0.227
Overhead allocation	0.085	0.098
Total costs	**0.826**	**0.760**

Some of the efficiencies gained in the post harvest cost category for bulk handling are lost by perceived harvest inefficiencies associated with bulk bins. An example of efficiency loss in exportable bulk bins is the extra pro rata time taken to fill bins which are 1200 mm deep compared to the more comfortable depth of 300 mm deep bins used in the conventional model. Time to harvest was increased by about 20 per cent for the exportable bulk bins. The per hectare labour demand increased from 230 hours in the conventional model to 280 in the bulk bin model. Given the assumption of harvest efficiency loss, the costs increase from 10.1 cents per kilogram for conventional to 15.9 cents for bulk export (Table 5.3.4).

We cannot be sure that these extra costs for bulk harvesting compared to harvesting in bins is real or accurate but the inferred cost increase is a result of more conservative assumptions for the bulk model. The post harvest component saved is the cost of packing. This was assumed to be $3 per carton or 21 cent per kilogram for the conventional model.

The assumption of lower yields for the bulk model exacerbated in-field production costs. Increasing the plant population to 72,000 per hectare also increased seedling cost per hectare by $540 or 20 per cent.

A combination of higher seedling costs and higher fertiliser costs resulted in an increase in the cost of crop establishment for the bulk model. This coupled with lower projected yields increased costs from 13.2 cents per kilogram to 24 cents (Table 5.3.4). This is an increase in cost of $1200 per hectare or 40 per cent.

Fertiliser programs vary between locations quite significantly with higher phosphorus demands in the South West region compared to Perth leading to significant cost increases. Overhead cost allocations increase with the bulk handling option. This is solely due to the reduction in yield.

The key issues identified by this analysis include:

- yield;
- fertiliser program;
- harvest performance; and
- post-harvest handling.

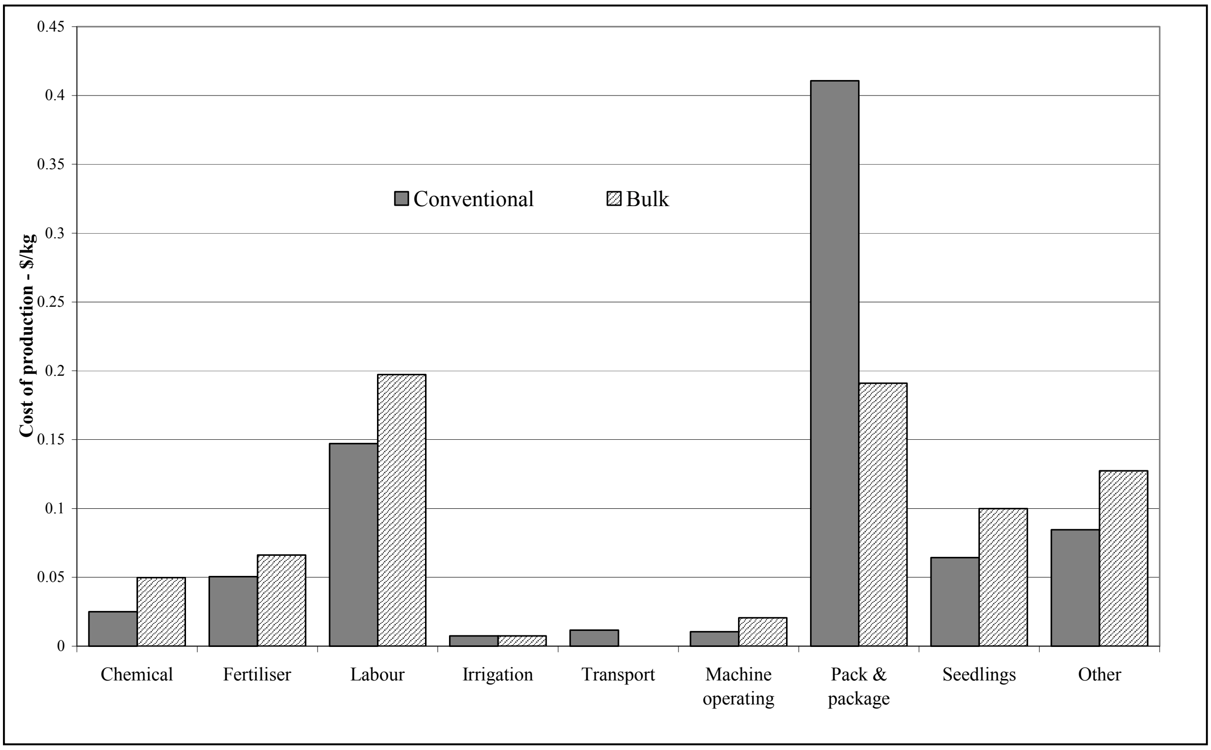

Figure 5.3.5. Cost of 'export ready' product by cost item ($ per kg).

Discussion

The overall cost of production of an 'export ready' product was lower for lettuce harvested and handled in bulk bins than the conventional carton method despite more conservative yield assumptions for the bulk model than those used for the conventional model.

This analysis shows that the yield capacity of the enterprise is critical. Attention to head weights and plant numbers is essential to production cost reductions for an export or processing targeted enterprise. By contrast, the domestic fresh sales system is one-dimensional with a response to plant numbers only because the product is sold by number. Whilst plant numbers incur additional cost, strategies which optimise head weight at a fixed plant density add little extra cost. For example, delaying harvest by a few days can dramatically increase head weights at little extra cost, but there are increased risks of quality disorders associated with this strategy.

Improvements in yield from growing better varieties and timing of harvest could significantly reduce risk and consistently raise head weights and recovery rates. For example, for the bulk handling option a 10 per cent improvement in average head weight (to 660 grams) and an increase in field recovery percentage (to 82.5 per cent) would result in the cost of production falling by approximately 6 cents per kilogram. In this example, small but achievable changes can have a significant impact on the cost of production.

Labour efficiencies for harvest may be achieved with improvement in harvesting logistics and use of mechanical aids. Labour is one of the most significant and rapidly increasing input costs. Attention to the harvest efficiencies is a worthy target in cost reduction.

Farm overhead costs are very dependent on business structure and companion crop activities. Whilst lettuce is not dominated by machinery capital investment, it is responsive to all capital utilisation efficiencies and scale of production. This is a fundamental to all business activities.

Packing and packaging realise the most significant single cost saving for the bulk handling and shipping model. This method offers significant potential to high volume users such as processors and chain retailers but it is not suitable for smaller buyers who are unable to sell the product in this form or repack it. Bulk shipping also adds significant improvements in freight costs. This has not been included in this comparison. The cost dilution is expected to be in the order of 20 per cent cheaper. Given that the South-East Asian CIF cost comprises 30 to

35 per cent post-harvest costs, this is a substantial cost saving of around 17 cents per kilogram. Of the 9.7 cents per kilogram of overhead costs, 2.4 cents or $780 per hectare is dedicated to management and professional services.

Recommendations

Investment in research, development and management are essential for enterprise profitability and improvement. All components of the production system are important whether they impact on cost, quality or surety of product. It is simple to target significant cost items and yield to derive competitive improvements, however attention to every detail is imperative to attain and maintain comparative advantage.

5.4 BENCHMARKING PRODUCTION COSTS

Peter Gartrell

Introduction

In order to establish an industry's price competitiveness it is important to establish the product specifications and costs of production from competing suppliers. The exercise involves compiling and comparing production costings for fresh head lettuce from competitors and others.

Materials and methods

Methodology and formats for the collection and presentation of such data vary considerably. Data was derived from published literature and data available on the Internet. This information was then entered into the model that was developed from the cost of production survey in Western Australia described in chapter 5.3. It was difficult to obtain complete data that can be easily compared due to differences in methods of collection and representation of the data and differences in end user specifications for the product.

Information was gathered for Queensland, New South Wales, New Zealand and California. All scenarios were based on costings for lettuce in cartons ready for sale at the farm or pack house. Costs from overseas producers have been converted into Australian dollars.

Results

Figure 5.4.1 shows that with the Western Australian domestic production model derived from the survey extrapolated to supply export was extremely uncompetitive. Saleable yields for the Western Australian model were 36 tonne per hectare, which was 4 tonnes greater than the average of all other data sets. Of all cost categories, the harvest and post harvest categories provide the most significant difference. The costs of harvest were similar to that of Queensland and New South Wales but twice that of New Zealand. The Californian data presented a total contract to pick and pack. The Western Australian survey was the only one not to pick and pack in the field.

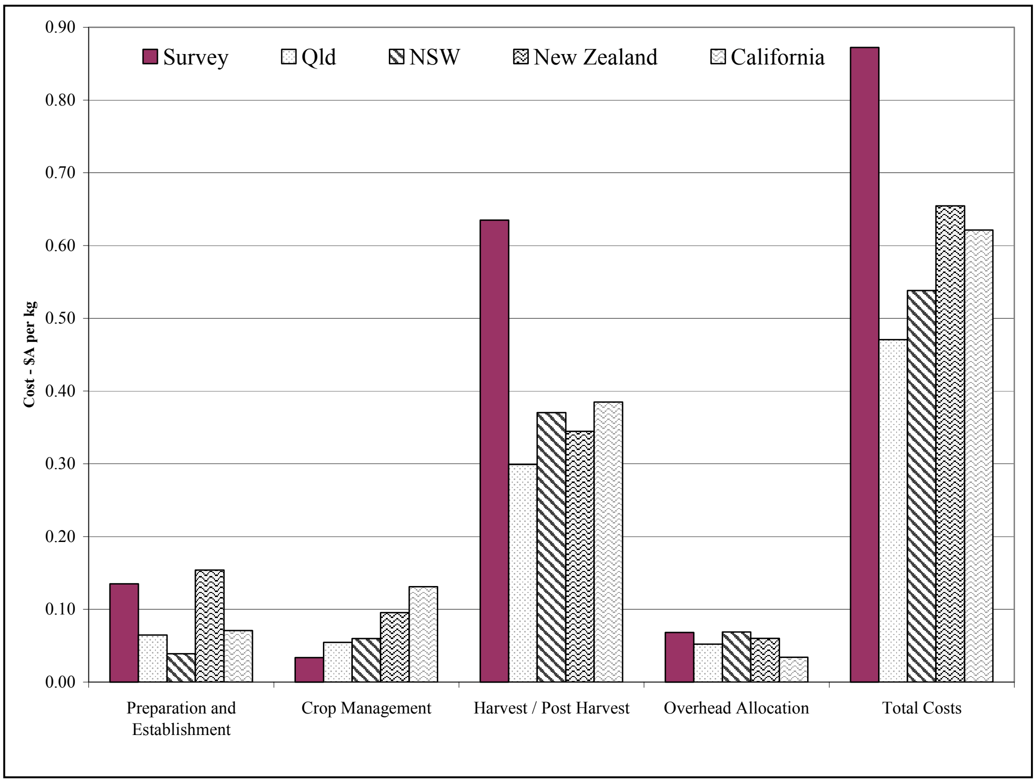

Figure 5.4.1. Cost of production data for Western Australian survey and other producing areas.

The survey model also assumes bin costs prior to packing and incurs an agent fee. This is an inefficient way to supply the export market. To compare a more targeted export supply regime the conventional 'best bet' model is applied in Figure 5.4.2. The new model in bulk is also included.

Yields for the bulk and other suppliers are similar. The head weights are quite varied which is compensated with assumed plant numbers (Table 5.4.1). Some of the total yield figures may well be the saleable yield in a case where 100 per cent are harvested. Head weights are quite different between the bulk and other Australian State data. In the case of New South Wales and Queensland, these head weights probably include considerably more outside leaf than the Western Australian bulk model because the product is destined for the fresh retail market. While these head weights are achievable it could be argued that this is not achievable across a number of crops over a whole season.

Table 5.4.1. Yields, average head weights and plant numbers per hectare

	Survey	Carton	Bulk	Qld	NSW	NZ	US
Total yield-kg	38,601	46,629	43,200	45,000	26,400	45,600	33,682
Saleable-kg	36,502	41,966	32,400	36,000	26,400	31,920	33,682
Head wt-kg	0.775	0.775	0.600	1.000	1.000	0.800	0.800
Plant number	49,704	60,000	72,000	36,000	26,400	57,000	42,102

Direct seeding is assumed by the New South Wales and Californian models. This further complicates the plant numbers analysis. This also reduces costs significantly, but it could be argued that it increases risk and maturity times as well as the rotation intervals and land utilisation efficiency. Crop uniformity and harvest efficiency may be adversely affected by this method and cash flow is slowed down. The increase in risk may out weigh the associated cost given the low pre harvest investment. Pre-harvest costs for the West Australian model are approximately $7500 per hectare compared with other supplier averages of $5,400. The New South Wales model suggests a sunk cost of only $2,613 per hectare.

Overhead costs are significantly higher for the bulk model. This could be attributed to a lack of economies of scale.

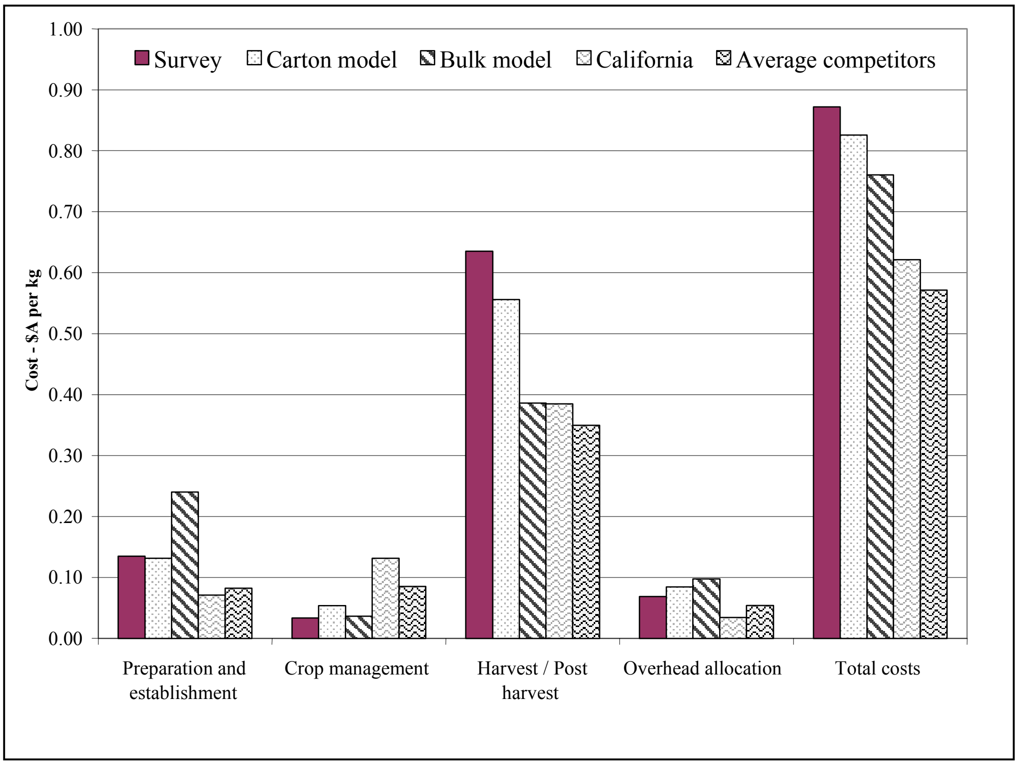

Figure 5.4.2. Cost of production for various Western Australian models compared to other suppliers.

The preparation and establishment costs were significantly higher for the Western Australian models. Chemical and fertiliser account for the majority of this cost (Figure 5.4.3). Chemical cost is approximately double that of most counterparts. This could be due to the soil fumigation cost and the attitude to crop risk. The fertiliser costs for Western Australia are significantly higher than the other suppliers. The Western Australian bulk model has a fertiliser budget of $2100 per hectare compared to an average of other suppliers of $560. This could be attributed to soils, rotations, over zealous forecasts of crop requirements and/or mismanagement. Significant levels of fertiliser and chemical are applied at or pre planting.

The cost of labour is also much lower for other Australian States (Figure 5.4.3). Estimates of 100 hours per hectare per harvest appear a little optimistic. Californian labour is lower due to harvest costs being incorporated into a pack and package contract rate.

Irrigation costs are quite low for all suppliers except California.

Transport cost for the bulk model and California are incorporated into the post farm costs making them appear to have lower costs.

Machinery operating costs are relatively similar except for New Zealand, which is higher.

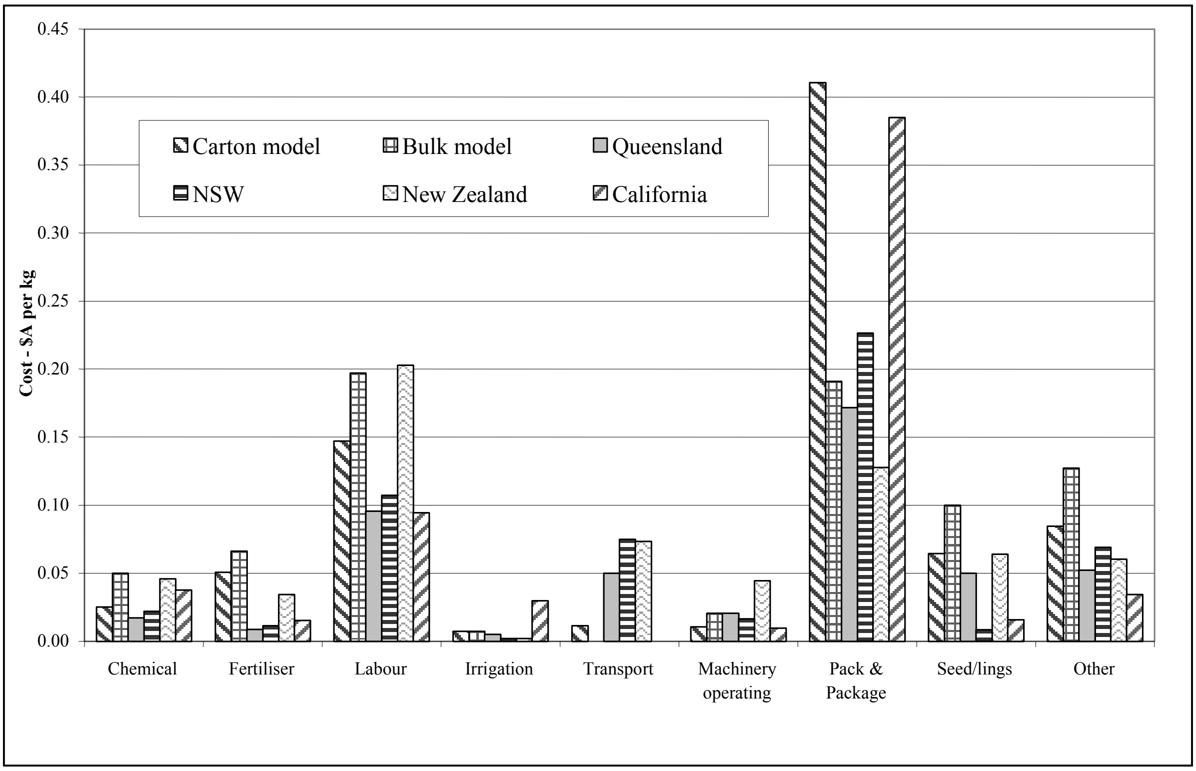

Figure 5.4.3. Cost of production for selected expenditure groups.

Discussion

It could be argued that the Western Australian production is not comparatively competitive. Whilst this may be true, the bulk model realises cost competitiveness in the export transport category. This alone does not account for the cost of production performance. The Western Australian environment does provide some additional costs with relatively poor soils and other factors.

The extreme differences are more likely to be due to the data collation process. Attitude to risk when compiling data can place an extreme bias on results. With all desktop studies it is often difficult to decipher the truth behind the figures. The cost of doing this study with more accuracy is cost prohibitive. The study does pose some questions in relation to yield, head weights, harvest and post harvest practices in Western Australia. Fertiliser and chemical programs could also be the objects of scrutiny. Economies of scale in California are also a known factor that needs to be taken into consideration when making comparisons with competing supplies.

5.5 EXPORTING METHODS AND COSTS

Peter Gartrell

Introduction

It is essential to understand and evaluate the whole cost chain in any business venture. The cost of production study is the first step in evaluating the competitiveness of the Western Australian lettuce industry. Additional freight and handling costs must be understood to examine the competitive position.

The aim of the analysis presented here was to derive a CIF cost for lettuce. For this example, the Malaysian market has been chosen as a destination for the product. This is a historically important market for Western Australian vegetable exports. Geographic proximity offers freight cost and timing advantages for Western Australia.

This study will examine CIF costs for traditional production into cartons against the new 'model crop' in a bulk handling system. It will also examine the comparative costs of sea and airfreight services.

Costs are divided into the following categories:

- grow and harvest;
- post-harvest handling;
- packing;
- packaging;
- cooling/storage;
- administration and customs;
- freight to port; and
- export freight charges.

Materials and methods

The first scenario uses the survey results of the apparent current industry position. It is assumed that the producer supplies produce to a pack house or agent in 72 litre or 84 litre returnable bins holding up to 24 heads each. The product is cooled ready for packing. No agent fees are applied, but a packing and packaging contract price is added. This product is cooled and loaded into the sea container or airfreight container and transported to the departure point. All quarantine, administration and other associated costs are added. Loading, insurance, freight charge and other associated shipping costs are incorporated into the container rate.

The following outlines key physical and cost assumptions:

- Freight rates are quoted in $US and converted to $AUS at $US 0.62. The airfreight rate is quoted at $2,650 for an air pallet to Malaysia. An air pallet holds 200 cartons or 2.8 tonnes.
- Administration, quarantine and customs charges are quoted at $265 per unit.
- Post harvest handling includes the cost of bins and loading of containers.
- Carton weight is estimated to be 14 kilograms.
- Carton cost is quoted at $2.80 or 20 cents per kilogram.
- Packing cost is quoted at a contract rate of $3.00 per carton or 21.4 cents per kilogram.
- Growing costs from the Western Australian grower survey are applied with adjusted head weights and pack outs to reflect expected crop performance. This increases growing costs by approximately 19.6 cents per kilogram.
- Agent and exporter fees are excluded from the analysis.

Results

Exporting cartons by air pallet

Figure 5.5.1 outlines the cost structure for lettuce landed by air pallet to Malaysia. It clearly shows the significance of transport costs of 91.4 cents per kilogram or 46 per cent of CIF cost. Packing and packaging add a further 21 per cent or 41.4 cents per kilogram. Assuming the head weights and pack outs derived from the survey causes the growing costs to fall to 17 per cent or 31 cents per kilogram. The total cost is extrapolated to be $2.00 per kilogram CIF Malaysia.

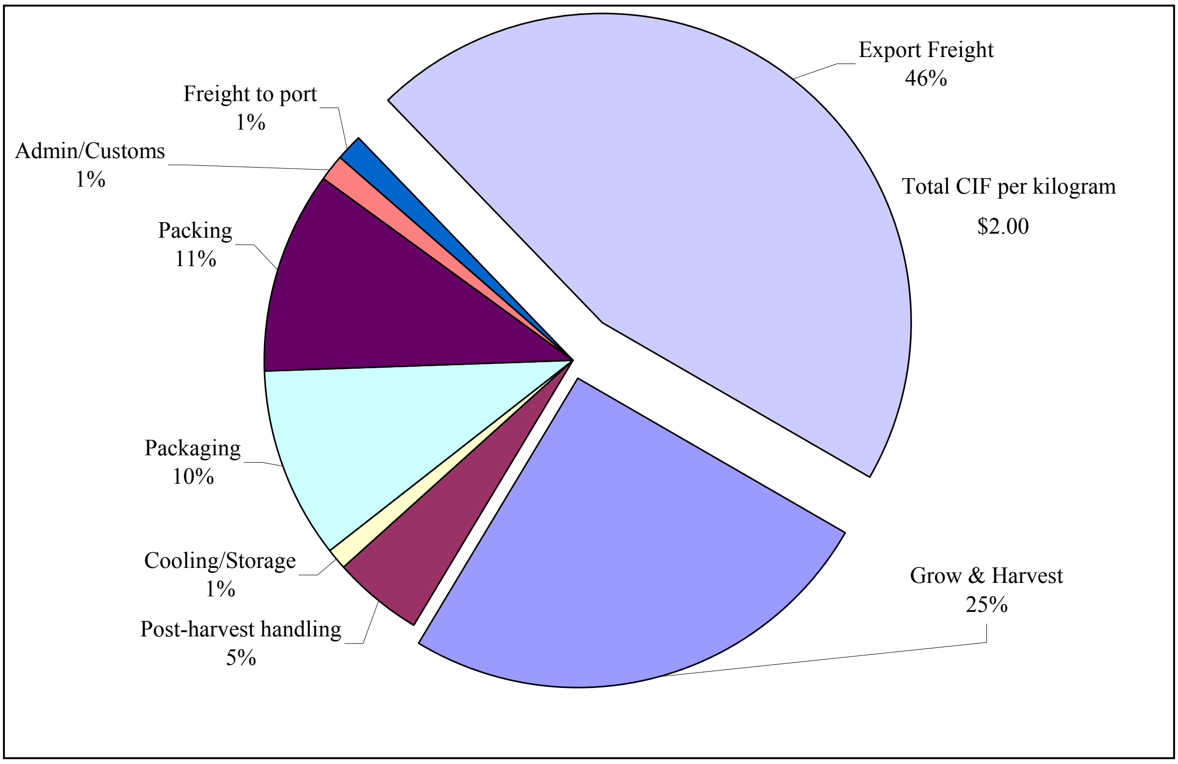

Figure 5.5.1. CIF cost structure for current industry airfreight export product in cartons to Malaysia.

Exporting cartons by 20' sea container (reefer)

Previously stated assumptions for airfreight apply to sea freight in 20-foot containers. Changes to this include container costs and capacity. The sea container has an assumed capacity of 400 cartons or 5.6 tonnes. At a cost of $2200 per container this equates to 39.3 cents per kilogram or 25 per cent of total CIF cost (Figure 5.5.2). Freight to departure is assumed to be marginally less per kilogram. Landed cost per kilogram is estimated to be 45 cent per kilogram less than air freighted produce. Using the original yield forecast from the survey, the CIF cost would be $1.43 per kilogram. Growing and harvest costs would decrease from 33 to 22 per cent of CIF cost.

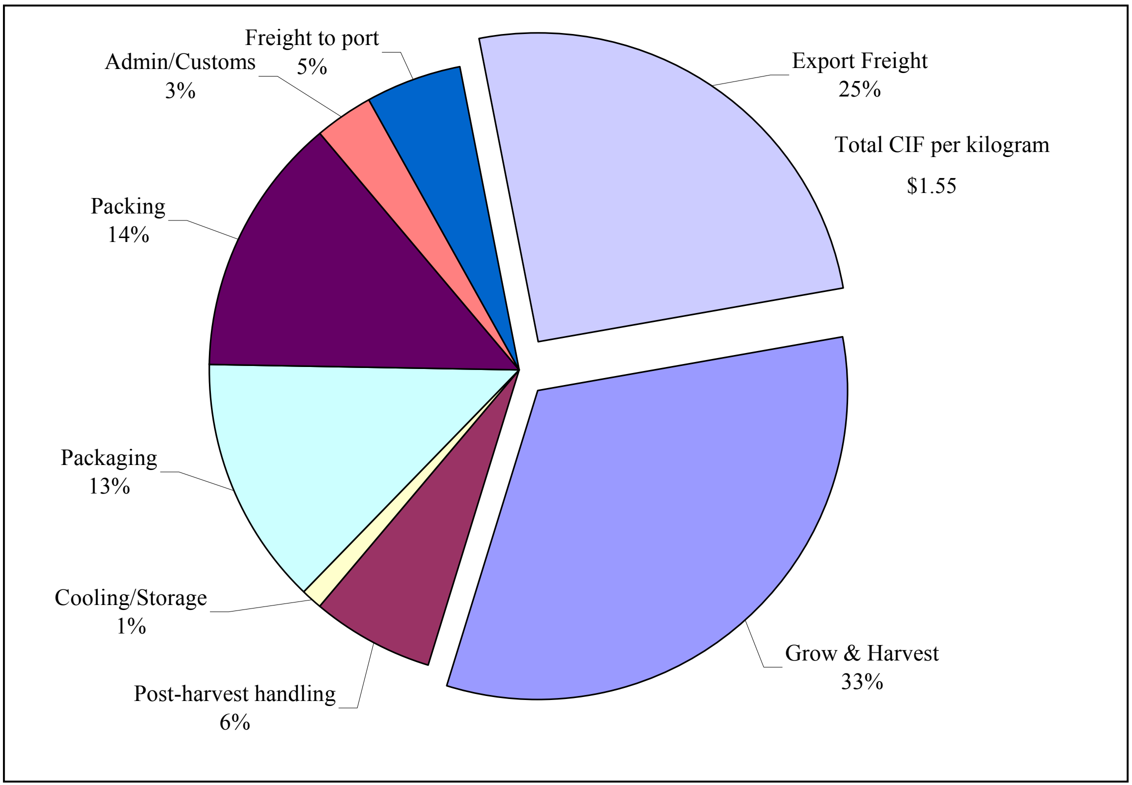

Figure 5.5.2. CIF cost structure for current industry costs in 20' sea freight containers of product in cartons to Malaysia.

Exporting in bulk bins by sea in 20' reefers

The bulk-handling model transported in 20-foot sea containers realises a CIF cost of $1.20 per kilogram (Figure 5.5.3). The survey cost of production is substituted with a 'best bet' program. Pre-harvest costs increase from $6,160 to $8,953 per hectare with the 'best bet' system. Harvest costs are assumed to increase from 11.2 to 15.9 cents per kilogram or $2,551 and $5,138 per hectare for the adjusted survey and bulk system respectively.

A significant change is in the packing and harvest categories. This is due to infield packing into the bulk bins. These bins are then cooled and loaded into sea containers for shipping. This eliminates double handling for both transport and handling. Post harvest handling costs are reduced by the elimination of bin usage, loading, unloading and transport. Pallet jacks and fork lifts are used to load the container on-site. Costs that have been omitted in this analysis are capital investment to cool product and handle bulk into containers. The ability to perform these activities may require little to no investment dependent on current resources.

Packaging costs remain relatively unchanged despite the fundament change in type. The cost of purchasing and furnishing the bulk bin is estimated to cost $65 per unit or $196 per tonne.

The cost of cooling is estimated to be 50 per cent higher. This is only an estimate and will vary with equipment, season and handling system. It is assumed to cost $30 per tonne for this exercise.

The most significant change in cost is in associated container costs. Container weights increase from a carton based 5.6 tonnes to a net bulk package weight of difference in the bulk-handling model is 6.7 tonnes. This realises a 20 per cent improvement in container based costs. Cost per tonne falls from a carton based $393 to the bulk system of $329.

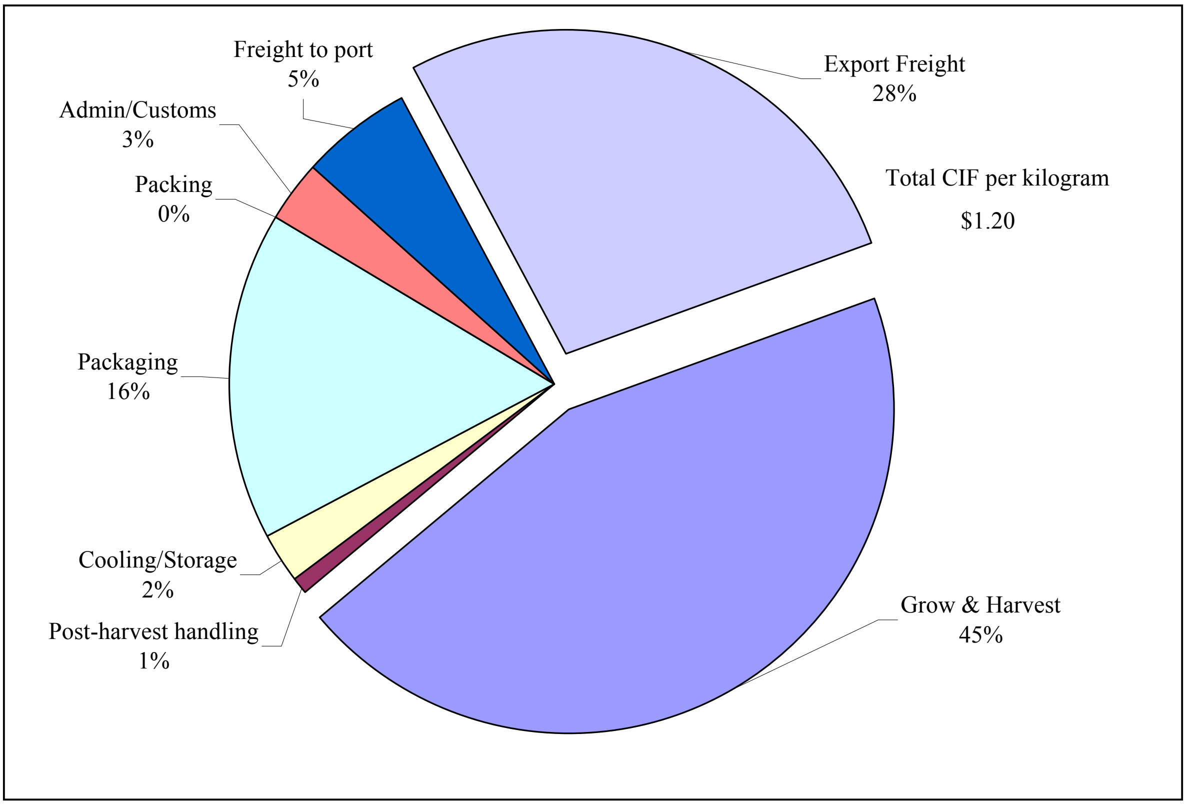

Figure 5.5.3. CIF cost structure for best practice industry costs in 20' sea freight containers of product in bulk to Malaysia.

Exporting in bulk bins by sea in 40' reefers

A further option for sea freight is to handle produce in 40-foot containers. The size of market and capacity of port facilities can be restrictive with this mode. Assuming this is appropriate, the bulk freight container based costs decrease by 23 per cent or 9.7 cents per kilogram.

Figure 5.5.4 examines the 40-foot sea freight option with the adjusted survey data in cartons and 'best bet' production system in cartons and bulk. The 'best bet' bulk and carton growing systems add some cost. The 'best bet' into cartons is expected to incur 10 per cent less costs during harvest.

In most other areas the bulk system reduces costs per kilogram. The most significant difference is in packing as indicated in figure 5.5.4. Instituting the 'best bet' system with out adopting bulk handling would realise approximately 3 cents per kilogram improved CIF cost. The addition of the bulk system would reduce CIF cost by approximately a further 31 cents per kilogram.

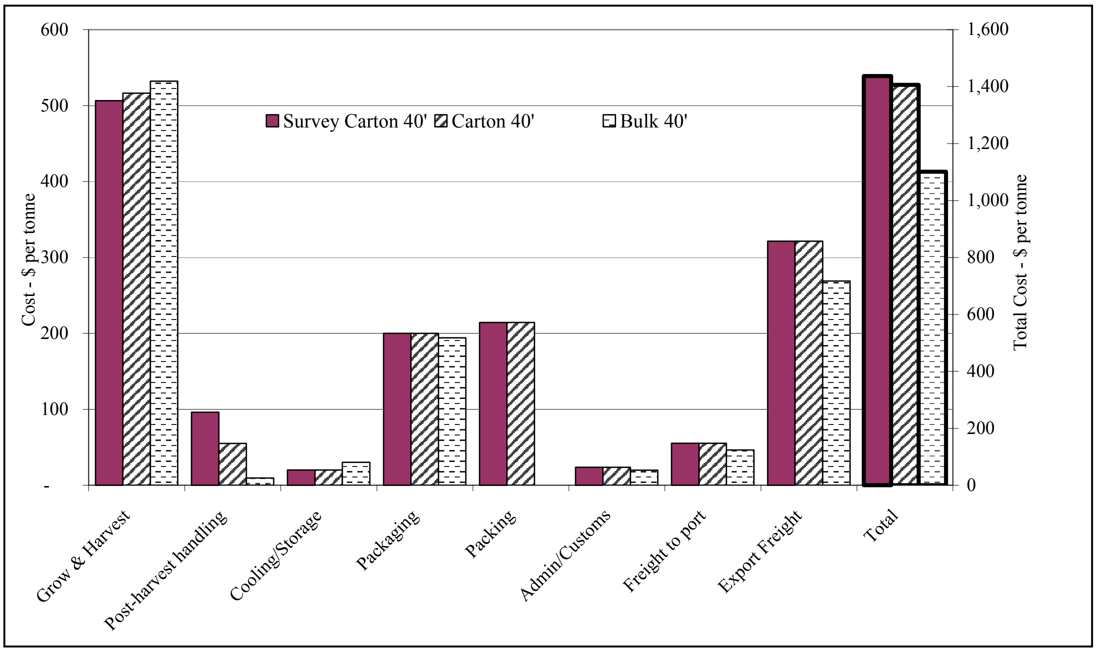

Figure 5.5.4. CIF cost structure for current industry costs in 40' sea freight containers of product in bulk to Malaysia.

The adjusted survey data uses the survey results with adjusted head weights and saleable yield percentages to reflect what is a more probable performance level with the cost structures of surveyed growers. The 'best bet' model culminates from a program derived from the field research performed. This data was then applied to the carton and bulk handling methodologies.

Figure 5.5.5 shows the cost items and totals for adjusted survey practice in cartons versus 'best bet'. The totals best demonstrate the potential improvements in CIF cost performance. The common practice would be the cartons in a 20-foot reefer at approximately $1.55 per kilogram based on this model. The target would be to achieve the CIF cost of $1.10 per kilogram from the 'best bet', bulk produce in 40-foot sea containers. In this analysis, any price margin above $1.10 realised in the market place is available to be shared between grower and exporter as their profit margins.

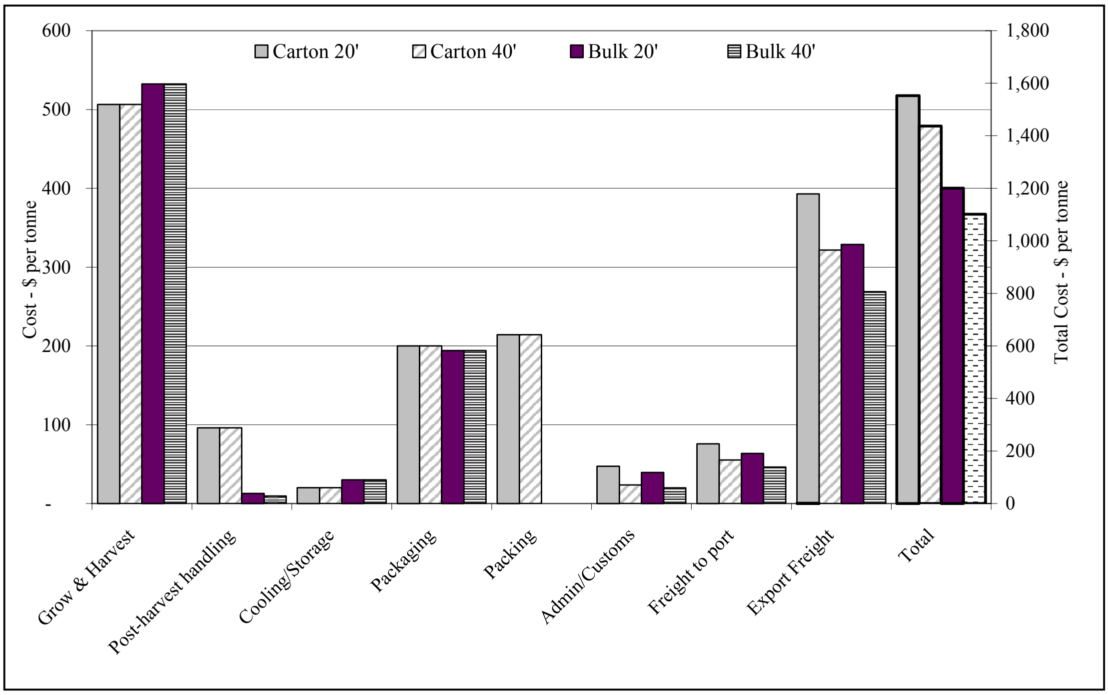

Figure 5.5.5. CIF cost structure for carton based current industry and bulk based to Malaysia.

Discussion and recommendations

In conclusion, export CIF costs can be significantly reduced with attention to the production and product handling process. Head weight and plant numbers relate directly to yield and hence dilution of production costs. The head weights also impact on freight efficiency. Field packing is required to reduce double handling and the associated added cost. It is preferable that the production base and the market are able to handle 40-foot sea containers to maximise cost competitiveness.

6. COMMERCIAL YIELDS AND CROP UNIFORMITY

D. Phillips, A. Reid and L. Teasdale

Introduction

Interviews conducted with growers to build the cost of production model described in Chapter 5.3 showed that none of the growers interviewed had adequate records of lettuce crop yields representing seasonal differences. The information provided on yields was at best a 'guesstimate'. The economic model for export constructed from this data showed that yield and head weight were critical to profitability of processing and export.

It was considered important to get better data on yield by making independent assessments of real commercial yields over the course of a typical growing season to improve the quality of the model and economic forecasts derived from it.

We needed to know how yields varied:

- between varieties;
- between growers; and
- between different times of the year.

The degree of within crop variability is also an important determinant of yield potential. The study posed the question "Is within crop variability a result of grower management or are some lettuce varieties and times of harvest simply more variable than others?"

Materials and methods

Commercial lettuce growers were asked to participate in a survey of crop yields. The survey began in December 2000 and at the time, there were three growers involved. By June 2001 there were five properties included in the study. The survey was completed in December 2001. All five properties were located in the Wanneroo, Carabooda and West Gingin growing areas.

On every property, consecutive iceberg lettuce plantings were monitored separately. Plots of 40 lettuce were chosen and pegged out in a block within commercial crops at the time of planting. Approximately one planting at each grower site was chosen per week and these were observed throughout their life and records taken of crop loss and diseases/disorders. At approximately the same time that the whole crop was harvested by the grower, the plots were harvested and recorded by the project officer. Heads were cut as they would be for export or processing, with little outside leaf adhering to the head and the weight of all heads was recorded separately. The decision on when to harvest was effectively made by the grower.

The data collected allowed for estimates of yield by weight to be compiled for all sites and times of harvest and for estimates of crop variability to be calculated.

Results

Results from the 141 plantings monitored over the course of the survey, showed there was a large variability in mean head weights from one planting to the next, both within a property and also between the properties monitored, irrespective of the variety being grown.

On individual properties, crops ranged from good to bad, with different levels of variability in head weight within each crop.

In most cases, a high percentage of all 40 heads planted were cut and yield variability was thus reflected in mean head weight at harvest. Figure 6.1 shows that mean head weights rose steadily over the course of the survey from May to December harvest for the group of four growers. Low weights before July were probably the result of the project officer harvesting a few days too early so as not to interfere with the commercial harvest. Subsequent work showed how sensitive lettuce head weight and yield are to choice of harvest date, due to the rapid bulking up rate of heads close to harvest.

After July, this error was largely corrected and harvests were delayed as late as possible before commercial harvest. After this, high head weight yields were consistently achieved by growers A and D. The survey concentrated on only growers A and D after August because of the work load involved to harvest all sites.

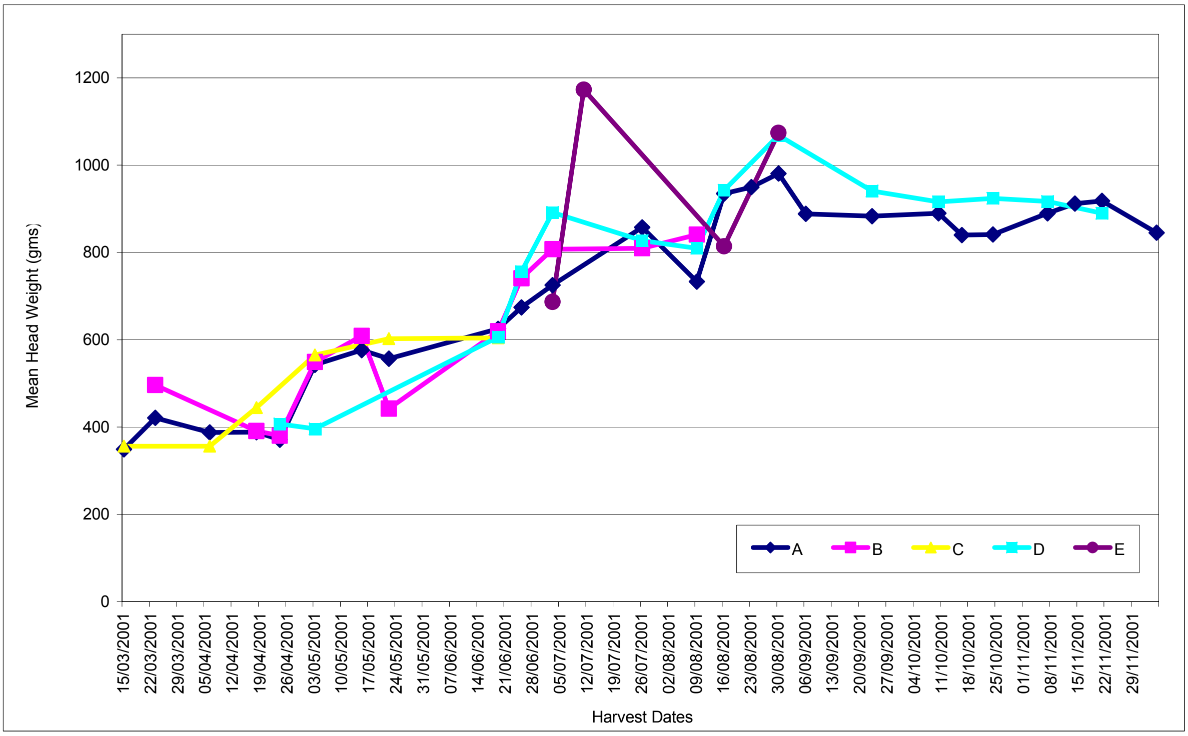

Figure 6.1. Mean head weight for the five properties monitored during the survey period.

Variability of head weight

Irrespective of the absolute head weight yields achieved at each date of harvest, there was a consistent trend at all grower sites for high variability between the largest and smallest heads cut at each harvest date. This was a feature of transplanted lettuce that this study highlighted which stimulated more detailed investigation in subsequent chapters of this report.

Figure 6.2 shows the range of head weights typically encountered from 'once over' harvests at all grower sites over the course of the study.

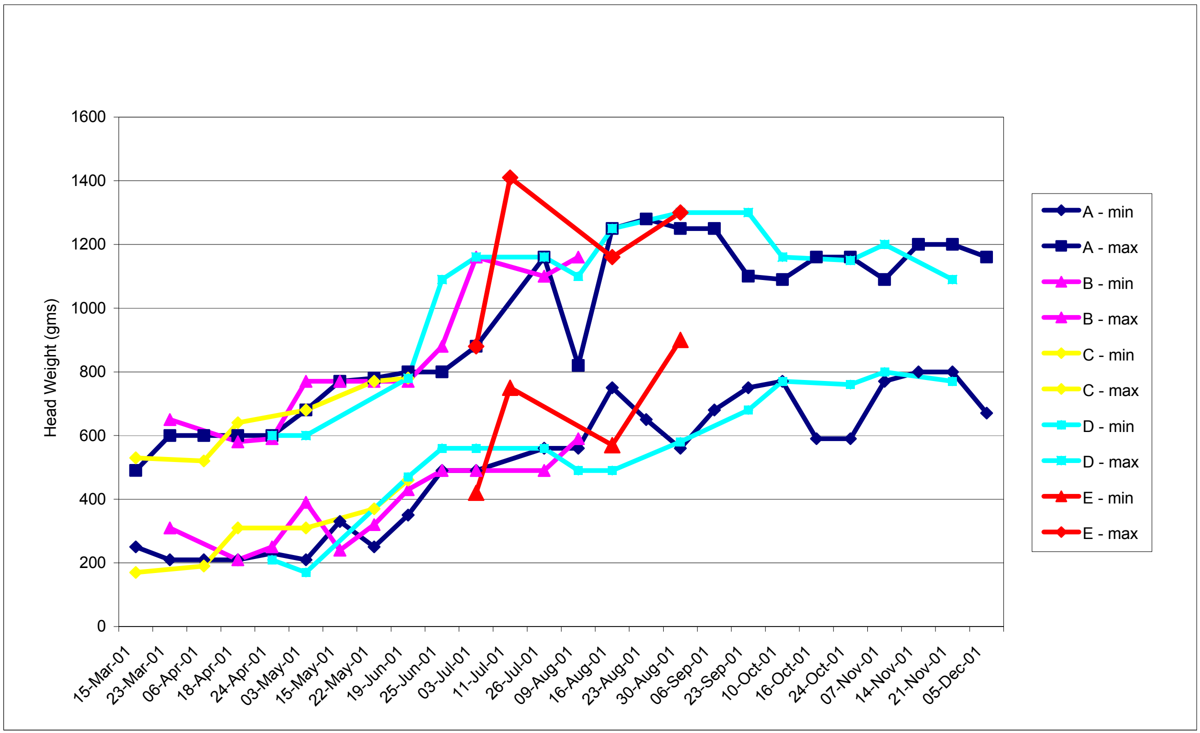

Figure 6.2. Minimum and maximum head weights at harvest for each survey property.

Figure 6.3 shows the mean head weights for one grower over the monitoring period and the calculated 95 per cent confidence interval for the mean at each date. Some of the changes in variability over time were due to changes in variety being grown, but it was not possible to separate the effects of harvest date, grower management and variety on the variability recorded.

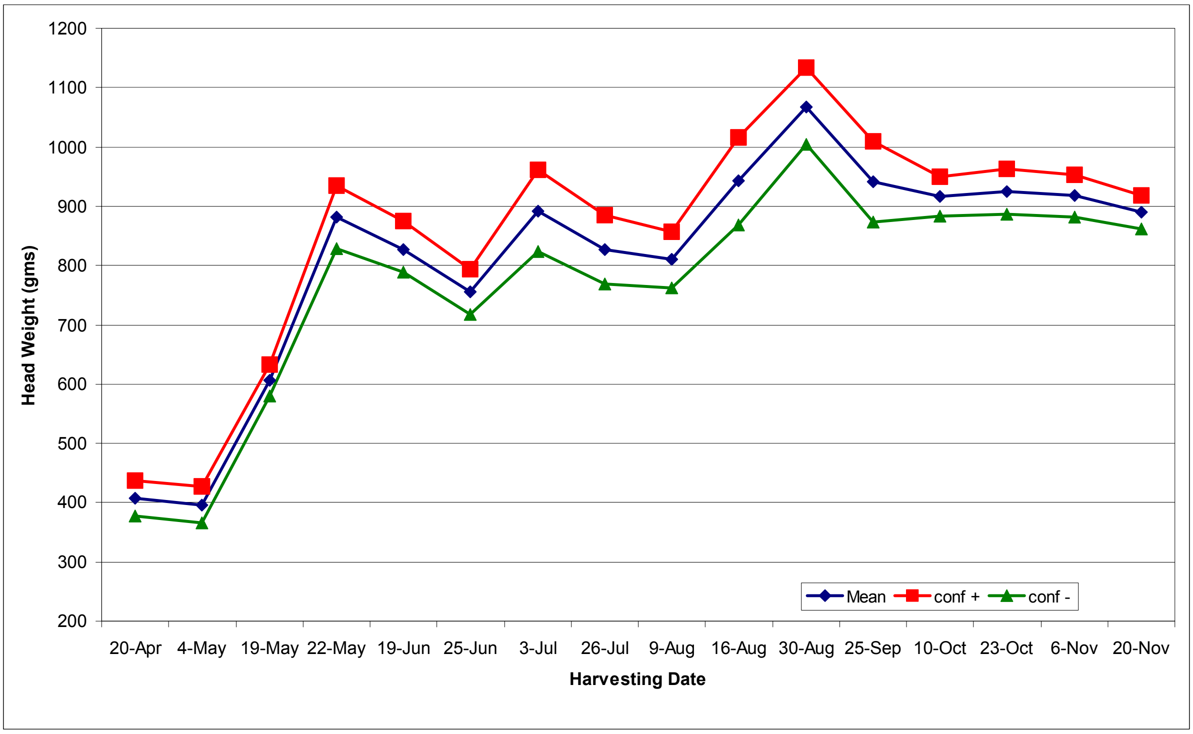

Figure 6.3. Mean head weights from Property D, with 95 per cent confidence intervals over the survey period.

The effect of the high level of variability between heads was a range of up to 150 grams per head within the 95 per cent confidence interval for estimation of the mean. This level of uncertainty makes estimation of profitability of the enterprise very difficult.

Conclusion

This survey showed that mean head weights from commercial crops could consistently exceed 800 grams with good management and careful choice of time of harvest. The work highlighted the importance of correct choice of harvest date to yield and profit in an enterprise where lettuce is paid for by weight.

Results from this survey showed that head weights at harvest are highly variable within a crop and between crops and properties for the five properties monitored. The reasons for this variability are considered to be a mix of:

- variation in seedling size and weight at planting possibly influenced by seed vigour or germination date;
- grower management practices;
- variety;
- seasonal effects; and
- an interaction of all of the above.

It is critical for the success and profitability of export and processing enterprises that this variability be minimised. The effect of fertiliser practice on this is explored in Chapter 7.1 and the effects of variety and time of planting in Chapter 8.

Recommendations

The study highlighted the need for more detailed investigation on the causes of head weight variability at harvest. In particular, genetic, physiological and seedling production aspects need to be studied, in order to realise the true yield potential of this crop.

7. PRODUCTIVITY AND FOOD SAFETY

D. Gatter and D. Phillips

7.1 BEST PRACTICE NUTRITION FOR ICEBERG LETTUCE

Background

Lettuce has a very high requirement for phosphorus fertiliser (about four times as much as cabbage and cauliflower), a moderate requirement for nitrogen (half as much as cabbage) and a moderate requirement for potassium (Greenwood *et al*. 1974). Despite requiring high to moderate levels of nutrients to produce high yield, removal of nutrients by the crop is among the lowest of all vegetable crops (Lorenz and Maynard 1980) because it is a relatively inefficient feeder.

A transplanted lettuce crop increases its weight as much as six fold in the two weeks after planting, and even in the last week before harvest, heads can double in weight (Teasdale *et al.* 2000). A fertiliser program for the crop needs to take account of these changes and recognise the relative weakness of the root system and inefficiency of fertiliser uptake (Welch *et al.* 1983), particularly when the crop is young.

Poultry manure has been very successful as a fertiliser for this crop because it is bulky, has a high NPK nutrient content and a slow release characteristic. When broadcast before planting, it creates instant fertility throughout the root zone during **the critical establishment phase**. The growth response observed is primarily a response to nitrogen, which is steadily released to the crop at luxury levels over a 21-28 day period.

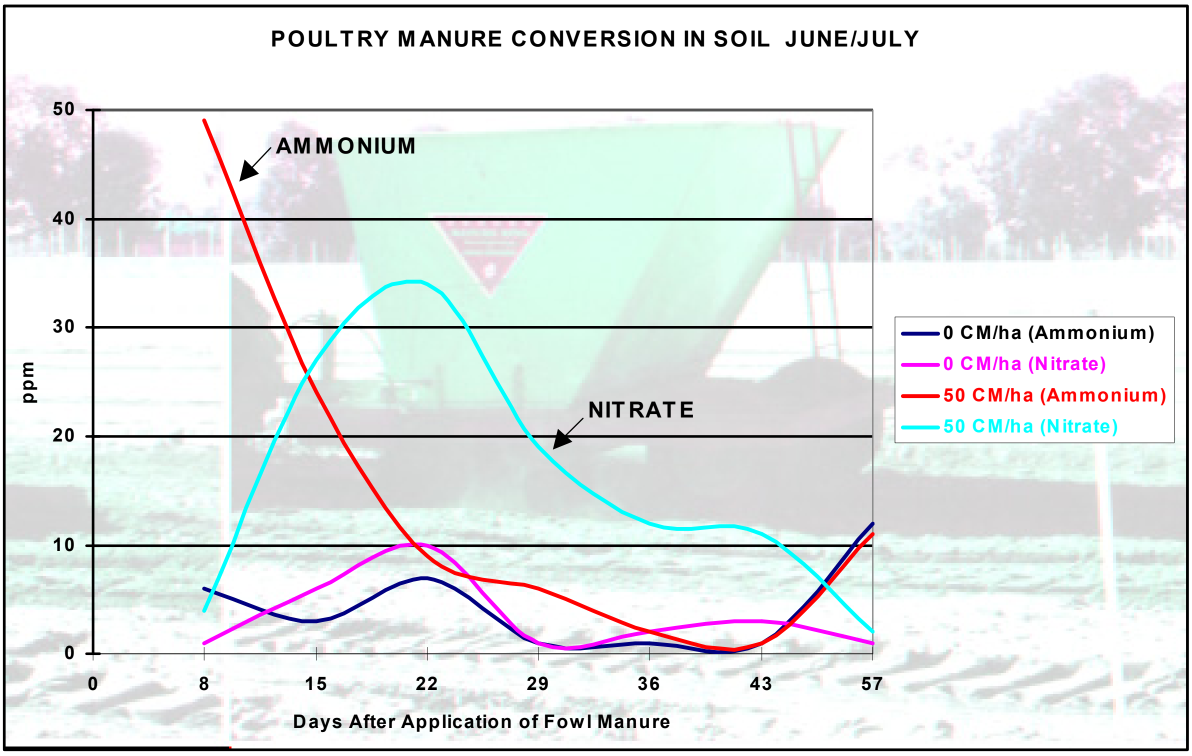

Figure 7.1.1. Poultry manure application (cubic metres/ha) to soil and subsequent release of nitrogen (D. Phillips and N. Gersbach unpublished).

Material and methods

To achieve the same result with other fertilisers requires precise and regular placement of leachable nitrogen in the shallow root zone.

Fertiliser rates in the **two to four weeks before row closure** need to be very high to accommodate the rapid increase in plant weight during that period when plant weight is doubling each week. Rates **close to harvest** do not need to be high to achieve high yields as long as the earlier growth stages have been optimal.

Traditional programs used by growers on sandy soils of the Swan Coastal Plain which include pre-planting application of poultry manure usually result in far too much leachable nitrogen being applied early in the crop's life, while far too much potassium is often used later than necessary. The high phosphorus needs of the crop are rarely recognised or specifically treated because long-term poultry manure use at high rates tends to maintain a good residual supply of this nutrient in the soil. These practices can result in high nutrient losses through leaching which pollutes groundwater and, in some cases, lakes and rivers.

The use of raw animal manures as fertiliser for short maturity leafy crops is also perceived by many to present an unacceptable microbiological risk. This is particularly so with the trend towards minimal processing of lettuce and the popularity of pre-cut packaged salad mixes and shredded lettuce used in the fast food industry. Instances of food poisoning related to these products have been recorded in Australia and overseas (Solomon *et al.* 2002 and Anon 1998) and the industry needs to find safer ways of producing these crops.

This report describes a sequence of experiments and observations conducted in commercial lettuce crops on sandy soils of the Swan Coastal Plain over a two-year period which resulted in a fertiliser recommendation for this crop. The bulk of the work was done with transplanted lettuce from cell packs but some of the preliminary development work was done with direct sown crops. The two propagation methods will be reported separately here.

The aims of this work were:

1. to develop cost effective fertiliser programs for iceberg lettuce which maximise marketable yield, head weight and quality, and are also practical, easy to apply and accurate in placement;
2. to reduce fertiliser cost and leaching losses associated with groundwater degradation; and
3. to minimise the risk of microbial contamination of iceberg lettuce by removing raw animal manure from the production process.

Fertiliser products, methods of application and rates tested are described and tabulated at each stage of the development sequence. Comparative yield outcomes for each individual trial or planting are tabulated in a separate table (see Table 7.1.9) and finally a 'best practice' recommendation for the use of mineral fertilisers on field grown lettuce is made.

Part A: Direct sown crops and development of soluble fertiliser spray application methods: June - October 2000

Primary criteria for the development of fertiliser programs were accuracy of placement, ease of application and practicality, i.e. ease with which growers could adopt the practice.

Introduction

Placement options we considered in the crop establishment phase after showing were fertigation, broadcasting or banding of granular fertiliser and boom spraying. We decided on the latter because it is potentially more accurate and better targeted than other methods when crops are establishing and have a small root system that can explore only a limited volume of soil. Most growers have boomspray equipment and farm employees find the equipment easy to use.

An important consideration for boomspray application was that the fertilisers and concentrations applied did not cause contact injury to plants when left on the foliage without irrigation wash-off. This was important for two reasons, the first being that the need for irrigation wash-off may inhibit grower adoption because it is an extra operation they would have to remember to perform or instruct employees to perform. The second reason is that the objective was to retain applied nutrients in the shallow root zone for as long as possible after application and irrigation while spraying or immediately after may move nutrients too far, too quickly on these sandy soils.

Thus the initial spray treatments that were applied to lettuce plants in the field over a wide range of maturities and to seedlings in trays was an investigation to determine which soluble fertilisers and application rates (solution concentrations) could be safely used without wash-off and provide adequate plant growth.

Materials and methods

On 16 June 2000, spray applications of solutions containing ammonium nitrate, magnesium sulphate and potassium sulphate were made to several small plots of lettuce plants of varying stages of maturity within a commercial crop in the Gingin area. The crop was direct sown with the cultivar Oxley. Plants were 10 to 72 days old at the time of application. Applications were made using a single fan jet knapsack sprayer at 200-300 kPa pressure. Observations and assessments were made one week later.

On 26 and 28 June 2000, spray applications of solutions containing ammonium nitrate, calcium nitrate, magnesium nitrate and potassium nitrate in various ratios were applied to young lettuce plants in seedling (cell packs) trays in a laboratory. The seedlings were obtained from a commercial supplier and were about 6 weeks old. Observations and assessments were made for several days.

From 30 June to 13 October 2000, the authors returned to the commercial property and conducted a series of trials in collaboration with the grower. Small plots of direct sown lettuce (cultivars Oxley, Titanic and Silverado) within commercial crops were marked out and sprayed with solutions of calcium nitrate, magnesium nitrate and potassium nitrate at various rates.

Also, a larger plot of 0.5 ha was allocated so that the grower, using his own equipment, could conduct a commercial-scale fertiliser spray trial to test the techniques developed earlier. This site received no pre or post plant application of poultry manure. Within this area, several small plots were marked out and treated with further applications of sprayed and banded mineral fertilisers. Observations and measurements of phytotoxicity as well as growth responses were made including final harvest weights.

Table 7.1.1. Fertiliser sprays applied to lettuce plants in a commercial crop

Trial date	Fertiliser mix			Applications and duration	Spray volume L/ha	Application rates (kg/ha)		
	1 +	2 +	3			1	2	3
16/06/00	NH_4NO_3	$MgSO_4$	K_2SO_4	1 spray only at various rates	500 or 1000	35 - 180	2 - 20	10 - 50
30/06/00	$Ca(NO_3)_2$	$Mg(NO_3)_2$		1 spray only at various rates	500 or 1000	22 - 88	12 - 25	
21/07-6/10/00	$Ca(NO_3)_2$	$Mg(NO_3)_2$	KNO_3	1 spray only at various rates on several small plots	500 or 1000	25 - 100	10 - 30	2.5 - 40
27/07-6/10/00	$Ca(NO_3)_2$	$Mg(NO_3)_2$	KNO_3	15 sprays on one larger (0.5 ha) plot	500	25	10	5

Table 7.1.2. Fertiliser sprays applied to lettuce plants in trays

Trial date	Fertiliser mix			Applications	Application rates (g/L)		
	1 +	2 +	3		1	2	3
26/06/00	NH_4NO_3			1 spray only at various rates	14.0 - 70.0		
26/02/00	$Ca(NO_3)_2$			1 spray only at various rates	30.8 - 154.0		
28/06/00	$Ca(NO_3)_2$	$Mg(NO_3)_2$	KNO_3	1 spray only at various rates	33.5 - 84.0	25.3 - 63.0	12.6 - 32.0

Results

In most cases, some plant damage was observed soon after a sprayed application of soluble fertilisers. It was decided to define a method for rating phytotoxic effects. Acceptable damage was most often seen as small scorch marks, minor marginal chlorosis or small water spots or stains on leaves. The plants were not noticeably set back in growth or development and often recovered within one week so that symptoms had disappeared.

Unacceptable damage was that which a commercial lettuce grower would rate as such and ranged from large scorched areas on leaves, collapsed or flaccid leaves through to plant death of several plants in a treatment.

Sprayed solutions of ammonium nitrate, magnesium sulphate plus potassium sulphate caused unacceptable damage to plants in the field at all concentrations. Damage ranged from slight to severe scorch on most leaves resulting in up to 100 per cent plant deaths in some plots. Younger plants (10 to 29 days old) were more susceptible than older plants (32 to 72 days) and higher concentrations caused more damage.

Sprayed solutions of ammonium nitrate alone also caused unacceptable damage to seedlings in trays and to young plants in the field. The use of NH_4NO_3, $MgSO_4$ and K_2SO_4 was discontinued in all trials after 26 June 2000.

Solutions of calcium nitrate, magnesium nitrate and potassium nitrate caused much less plant damage than the sprays of sulphate and ammonium fertilisers. Lettuce plants were able to tolerate surprisingly high concentrations of sprayed nitrate fertilisers without apparent long term damage. During cooler months, young lettuce plants 35 to 50 days old (direct sown) were able to tolerate fertiliser spray solutions containing up to a total of 120 g/L of nitrate based fertilisers applied at 500 L/ha.

Phytotoxicity, usually observed within two days of spraying, presented as slight to mild scorching of margins and tips of older leaves (see Figures 7.1.2 and 7.1.3). Young plants generally coped better than older plants. Plants recovered quickly, often without any trace of damage and grew normally. However, on one occasion in July 2000, a small plot of 65 day old lettuce plants (cultivar Oxley) that had been sprayed with a solution containing 142.5 g/L of nitrate fertilisers in 1000 L/ha developed a heavy infection of bacterial dry leaf spot (*Xanthomonas campestris* pv. *vitians*). By early September this plot had a much greater incidence of the disease than the surrounding crop. The disease appeared to have been exacerbated by damage caused by the fertiliser spray.

Figure 7.1.2. Mild chlorosis of leaf on young lettuce.

Figure 7.1.3. Minor marginal scorch on young lettuce.

Young lettuce seedlings in cell pack (punnet) trays (one to six weeks old) also tolerated sprays of some nitrate based fertilisers but not sprays of ammonium nitrate. Fertiliser spray combinations of $Ca(NO_3)_2$, $Mg(NO_3)_2$ and KNO_3 up to a total of 80 g/L caused minor, but acceptable leaf damage such as small scorch marks and minor marginal chlorosis. Above that concentration, phytotoxic effects would likely be unacceptable. In some cases damage was observed as water soaked spots, flaccid leaves and collapsed tissue and in severe cases plant death. This type of damage was usually observed two days after spraying, suggesting that a soil osmotic effect was causing delayed plant damage.

From 27 July to 6 October 2000, the grower applied a total of fifteen sprays of soluble nitrate fertilisers to a 5000 m^2 commercial block of lettuce containing two cultivars, Titanic and Silverado. The plants were 15 days old (direct sown) at the time of the first application and were 86 days old at the last spray. Fertilisers used were calcium nitrate, magnesium nitrate and potassium nitrate. The usual application was 25 kg of $Ca(NO_3)_2$ + 10 kg of $Mg(NO_3)_2$ + 5 kg of KNO_3 in 500 litres of water per hectare.

The fifteen sprays applied a total of 88 kg/ha of N to the site. These fertilisers, when applied to the winter lettuce crop as a twice-weekly spray starting soon after emergence, appeared able to sustain acceptable plant growth from the cotyledon stage up to row closure, without plant damage.

During the course of the fertiliser spray trials it became apparent that twice weekly sprayed fertiliser applications alone would be insufficient to produce maximum lettuce head weights at time of harvest. The grower was consulted and it was his opinion that fertiliser side dressing applications need to be made at a relatively earlier stage to lettuce crops to ensure maximum harvest potential. It was agreed that side bandings of prilled and granular fertiliser should be applied to small plots within the 5000 m^2 spray trial area in an attempt to boost harvestable yields for those plants, and draw a comparison between treated and untreated plots (see Table 7.1.9, comparative yield results).

Several small areas of about 10m^2 each were marked out within the site. On 14 and 20 September (just before row closure) applications of calcium nitrate, potassium nitrate and superphosphate at several rates and combinations were made by banding granular and prilled forms of the fertiliser along plant rows.

At crop maturity the lettuce from these plots were harvested and weighed separately and yields were compared across treatments. Table 7.1.3 compares a typical commercial fertiliser schedule that was in regular use at the property at the time with the best performing mineral fertiliser only treatment. The grower commercial crop yielded head weights of about 900 g each at this time of year. The best performing treatment (mineral fertiliser sprays and bandings only) produced head weights of 766 g.

The best mineral fertiliser only treatment used about a third of the amount of nitrogen used by the commercial program and produced smaller but still marketable heads.

Table 7.1.3. Comparison of fertiliser programs

Fertiliser applications	**Application rates kg/ha**			
Typical grower program (June 2000)		**N**	**P**	**K**
Superphosphate	80.0	0.0	7.3	0.0
Ammonium nitrate	820.0	278.8	0.0	0.0
Nitrophoska Perfect®	650.0	97.5	14.3	107.9
Poultry manure	3200.0	96.0	48.0	57.6
Totals		**472.2**	**69.6**	**165.5**
Mineral fertiliser program (best treatment, September 2000)				
Superphosphate	1000.0	0.0	91.0	0.0
Calcium nitrate sprays	394.0	61.1	0.0	0.0
Magnesium nitrate sprays	165.0	18.2	0.0	0.0
Potassium nitrate sprays	70.0	9.1	0.0	26.8
Potassium nitrate banded	600.0	78.0	0.0	229.8
Totals		**166.4**	**91.0**	**256.6**

Part B: Transplanted crops and development of application methods: November 2000 - June 2002

Stage 1. Evaluation of fertiliser drench treatments

Introduction

When young lettuce plants are still in seedling trays (cell packs) and ready for transplanting out, their nutritional demand is relatively low but a high degree of control is possible over fertiliser rate, application method and cost because the whole crop is in a small, confined area. The aim of this work was to investigate the use of seedling tray drenches and nutrient dipping (immersion in nutrient solution) so that young plants were supplied with luxury levels of nutrients to ensure rapid establishment in the field after transplanting.

The same criteria applied as for the work with direct sowing, in that a primary objective was 'ease of adoption by the grower'. Hence we again sought treatments that avoided contact injury to plants when applied without 'wash off'.

Materials and methods

From 30 April 2001, at the property of a commercial grower in the Wanneroo district, the first in a series of experiments was undertaken to trial the use of potassium nitrate and technical grade (low biuret) urea as seedling fertiliser drenches.

Young lettuce plants in seedling trays were drenched with solutions of greenhouse grade potassium nitrate at either 40 g/L or 80 g/L or with a solution containing 40 g/L KNO_3 plus 11.2 g/L technical grade (low biuret) urea. Low biuret urea was used because it is less phytotoxic than ordinary urea.

Drenches were applied in a hand held watering can. Approximately 500 mL of solution was sufficient to treat a tray of 100 seedlings. Seedlings drenched with water only were used as a control (nil) treatment. The seedlings were then immediately planted out into a trial area within a commercial lettuce crop. The trial was inspected the next day and observations for phytotoxic damage and growth response were made. Observations continued on a weekly basis until harvest.

Details of trial date, lettuce variety and fertiliser applications are provided in Table 7.1.4.

Table 7.1.4. Fertiliser drenches applied to lettuce seedlings in trays

Trial date (Transplant date)	Lettuce cultivar	Fertiliser mix		Application	Application rate (g/L)	
		1	+ 2			
30/04/2001	Oxley	KNO3		One only	40 - 80	
5/06/2001	Oxley	KNO3		One only	40 - 80	
24/09/2001	Magnum	KNO3		One only	40	
2/11/2001	Raider	KNO3		One only	40	
2/11/2001	Raider	KNO3	Low biuret urea	One only	40	11.2

Results

A solution of 40 g/L KNO_3 provides 5.2 g/L of N and this, in turn, provides each individual seedling with about 0.026 g of N when the drench is applied at 500 mL to 100 plants. The solution is readily absorbed by the potting mix in the seedling trays and remains available to the seedlings after transplanting. Young lettuce plants appear to rapidly uptake this luxury level of N and are able to make strong growth early in crop life.

Where a potassium nitrate drench is included as part of a complete fertiliser schedule, it should be applied early in the day when temperatures are lower and the seedlings planted out soon after on the same day. The fertiliser solution should not be immediately washed or irrigated off. Some leaf absorption of nutrients will take place and it is important to not wash the nitrate solution out of the root zone of the young plants too quickly.

In all cases the low rate of drench (40 g/L of KNO_3) caused only minor plant damage. Small amounts of leaf margin scorching and yellowing were observed, usually within 24 hours of application, but was not considered unacceptable. Symptoms of plant phytotoxicity usually disappeared quickly and the plants grew normally without any apparent long-term adverse effect.

In all cases, treated plants (KNO_3 drench) were observed to be bigger and greener than the undrenched (nil treatment) plants and they maintained this advantage through to harvest (see Table 7.1.9, comparative yield results).

After observing the results of the experiments at his property, the grower modified his own fertiliser regime to include a fertiliser dip that was very similar to the technique described earlier. Instead of applying the solution as a drench, the grower briefly immersed lettuce seedlings in a bath containing a KNO_3 solution (40 g/L) before transplanting.

His opinion was that the technique was a valuable inclusion to his fertiliser program and may have contributed to quicker establishment of his commercial crops. On one occasion however, he reported problems with lettuce seedlings wilting in trays before transplanting after applying the fertiliser drench at 40 g/L. He had at the time (September 2001) acquired seedlings from a new supplier who used a much coarser grade of potting mix in the seedling trays. This new potting mix was much lower in peat, much faster draining and the individual tray cell volumes were smaller than previous seedling trays. The seedlings recovered within 24 hours and the crop grew normally after that.

The potassium nitrate drench at 40 g/L may therefore not be suitable for all seedling or potting mixes and it is recommended that a trial batch be tested in each case or that a more dilute solution (20 g/L KNO_3) be used where plant damage is anticipated.

The high rate of potassium nitrate drench (80 g/L) usually caused small amounts of leaf margin scorching and also caused some plants to become temporarily wilted or flaccid. This effect did not last long with most plants recovering within 24 hours and then continuing to grow normally without obvious ill effect. The high rate drench treatment also did not appear to provide any yield benefit over the low rate (see Table 7.1.9, comparative yield results). The high rate drench is not considered to have a wide enough safety margin and is not recommended for commercial use.

Similarly, the combination drench (40 g/L KNO_3 plus 11.2 g/L technical grade urea) caused minor leaf margin scorching on about 75 per cent of treated plants. The damage was somewhat delayed with symptoms appearing about 48 hours after application. The damage did not appear to be permanent as ten days after the application all plants were growing normally without obvious phytotoxic damage.

The combination KNO_3 plus urea drench cannot be recommended at this stage as it does not appear to have a wide enough safety margin to be accepted commercially.

Stage 2. Development of fertiliser spray treatments

Introduction

When young lettuce seedlings are transplanted, they require adequate or better levels of nutrition to make strong growth early in crop life. The first two weeks are vital in order to achieve maximum yield. If plant nutrition is inadequate in this period then the plants can never 'catch up'. Late applications of fertiliser will not compensate for poor early growth and maximum yield will not be achieved.

The young seedlings require nutrition in or near the root zone, which is small at this stage. The aim of fertiliser spraying is to supply targeted amounts of soluble nitrate type fertilisers, some of which will be leaf absorbed and some of which will be taken down to the root zone by following irrigation.

It had been determined from previous work with direct sown crops, as described in Part 'A' of this report, that $Ca(NO_3)_2$, $Mg(NO_3)_2$ and KNO_3 offered the best prospect of maintaining adequate early crop growth, as a replacement for raw poultry manure, and are safe to use over young plants.

Materials and methods

From November 2000 until April 2002, at the property of a commercial grower in the Wanneroo district, a series of nine experiments was undertaken to further evaluate the use of $Ca(NO_3)_2$, $Mg(NO_3)_2$, KNO_3 and also low biuret urea as fertiliser sprays for transplanted lettuce crops.

Each trial site was an area of 48 m^2 within a 500 m^2 bed of iceberg lettuce. The sites were prepared by the grower using a modified fertiliser program and without any application of poultry manure. A restriction on the use of poultry manure was in place after 1 September 2001. Eight, unreplicated plots (treatment areas) of 6.0 m^2 each were marked out in the site and contained about 44 plants each.

Fertiliser solutions were made up on site with pre-weighed fertiliser and the same irrigation water used by the grower. The solutions were applied to small (6.0 m^2) plots. Volumes were 600 mL per plot (1000 L/ha) requiring two passes over a plot with a single fan jet knapsack sprayer at 200-300 kPa pressure. Sprayed applications of fertilisers commenced one or two days after transplanting. The concentrated fertiliser solutions were not washed or irrigated off the foliage until the next scheduled irrigation.

Visual assessments were made weekly for phytotoxic effects and growth responses. At harvest time the grower allocated a plot sized area of his commercial crop to be harvested for comparison with the eight small plots. All available heads (without frames) were cut and weighed individually so that a mean and standard deviation of head weight could be calculated for each treatment. Details of trial date, lettuce variety and fertiliser application are provided in Table 7.1.5.

Figure 7.1.4. Typical trial site, February 2001.

Table 7.1.5. Fertiliser sprays applied to lettuce trials in a commercial crop

Trial date	Cultivar	Fertiliser mix			Application and duration	Spray volume	Application rate (kg/ha)		
Transplanted		1 +	2 +	3		L/ha	1	2	3
30/10/00	Raider	$Ca(NO_3)_2$	$Mg(NO_3)_2$	K_2SO_4	Weekly for 3 weeks	1000	25	10	5 - 40
8/01/01	Raider	$Ca(NO_3)_2$	$Mg(NO_3)_2$		Weekly for 2 weeks	1000	25	10	5
26/0201	Magnum	$Ca(NO_3)_2$	$Mg(NO_3)_2$	KNO_3	Weekly for 2 weeks	1000	25	10	5
30/04/01	Oxley	KNO_3		KNO_3	Daily, 3 times a week or weekly for up to 5 weeks	1000	40		
5/06/01	Oxley	KNO_3			Daily, 3 times a week or weekly for up to 5 weeks	1000	40 - 60		
25/09/01	Magnum	KNO_3	Urea low biuret		Daily or twice a week for up to 4 weeks	1000	0 - 40	0 - 22.5	
2/11/01	Raider	KNO_3	Urea low biuret		1 or 2 sprays a week for up to 4 weeks	1000	0 - 40	0 - 56	
24/01/02	Raider	KNO_3	Urea low biuret		Daily spray or weekly spray for up to 4 weeks	1000	0 - 40	0 - 50	
8/04/02	Magnum	KNO_3			Two sprays a week for 2 weeks	1000	20 - 40	0 - 22.5	

Results

A fertiliser spray solution containing 25 kg of $Ca(NO_3)_2$, 10 kg of $Mg(NO_3)_2$ plus 5 kg of KNO_3 when applied in 1000 L of water per hectare will provide about 5.6 kg of N. A single weekly spray at this concentration applied for two or three weeks soon after transplanting appeared unable to supply sufficient nutrition to young lettuce plants to allow them to make maximum growth early in crop life. The marketable yield achieved at harvest time in the three trials conducted in the summer period of November 2000 to February 2001 was in each case less than that of the equivalent commercial crop produced by the grower on the property (see Table 7.1.9, comparative yield results).

Observations made in the first three weeks of each crop during this time, confirmed that, although the trial plants seemed to be healthy and growing normally, they were often slightly smaller than plants in the nearby grower crop of the same age. This early disadvantage carried through to harvest and acceptable yields were not achieved.

It was evident that young lettuce plants require more frequent spray applications or early side banded applications (or both) in order to promote vigorous early growth. Prior to a district wide ban on the use of poultry manure (September 2001), it was not uncommon for commercial growers to apply side banded poultry manure at rates of up to 20 m^3/ha and as early as five days post transplant to summer lettuce crops.

Adjustments were made to subsequent trials, commencing with the April 2001 transplanting. Spray applications and frequency were increased to between one and five times a week for up to five weeks. Consequently, weekly application of N was between 5.6 and 26.0 kg/ha, for this group of trials. Observations made over this period showed that in many cases the best performing (highest yielding) treatments produced appreciably bigger and greener plants than the nearby commercial crop. In each trial, at least one of the treatments was able to match or out yield the corresponding commercial crop on the grower's property at the time.

It was found, in trials planted at 30/04/01 and 5/06/01, that to achieve satisfactory market yield of transplanted lettuce, it was necessary to apply between 22.0 and 52.0 kg/ha N **in the first two weeks** of crop life as part of a balanced fertiliser schedule. This application could be made in a practical way by using sprayed applications of soluble nitrate type fertilisers on a regular basis.

Trials planted after 25/09/01, tested whether the frequency of application of N or the weekly total application was more important. The results suggested that similar results could be achieved with as little as one spray per week of low biuret urea as long as the weekly total nitrogen application was of the order of 23 kg/ha (N).

Stage 3. Development of mineral fertiliser side banding treatments

Introduction

Strongly growing lettuce plants require relatively high rates of nitrogen and potassium fertiliser in the period of two to four weeks before row closure to achieve full yield potential. Healthy plants appear able to rapidly uptake any or all of the three major nutrient elements, N, P and K, from freshly applied fertilisers.

A lettuce crop that achieved rapid establishment and optimum early growth will benefit from side banded fertiliser applications. A crop that has been slow to establish or has made poor early growth can not ‘catch up’ and heavy fertiliser applications late in crop life are largely wasted.

A wide range of commercially available mineral fertilisers are suitable for banding application to young lettuce. Mineral fertilisers, in contrast to animal manures, have a known guaranteed nutrient content. Additionally, the total nutrient application can be carefully controlled by managing rate, placement and timing of application. Banding was chosen as the most practical method of applying fertiliser after crop establishment because the crop has a root system capable of intercepting it and placement is accurate and rates are flexible.

This investigation into the banded application of mineral fertilisers was part of an integrated and managed approach to plant nutrition with the aim of producing market quality lettuce year round. This undertaking also stipulated that these applications and methods should be cost effective, practical and could be taken up by a commercial grower without compromising yield.

Materials and methods

Side banded fertiliser applications were made to all trials from November 2000 to April 2002. Fertiliser was pre weighed and applied by hand to the plots between pairs of rows on four row beds. In all cases applications were made, on a weekly basis, to crops before row closure in an effort to maintain strong growth and achieve maximum yield. Fertilisers were selected and applied to supply high rates of N and K. Initially, application rates were chosen that were similar to those in use by commercial growers at the time.

As the series of trials progressed, a wider range of fertilisers were trialed as well as a greater range of application rates, in an effort to ‘fine tune’ this stage of the fertiliser schedule. It was found that many readily available granular and prilled mineral fertilisers were suitable for banding application to lettuce. It was possible to select several lower cost fertilisers, apply them regularly, with precision and not sacrifice crop quality or yield.

Table 7.1.6. Fertiliser side bandings applied to lettuce in a commercial crop

Trial date	Fertiliser combinations and application rates (kg/ha)							
	Note: Fertiliser side bandings were applied weekly to a maximum of 5 applications over 5 weeks.							
	NH_4NO_3	KNO_3	K_2SO_4	$Ca(NO_3)_2$	$CaNH_4NO_3$	NPK special®	Urea	KCl
Nov. 2000		600 - 900		300				
Jan. 2001	200 - 550	500 - 1000						
Feb. 2001	0 - 600	0 - 750	0 - 400	0 - 1260	0 - 750	0 - 1650		
May 2001	800	500						
Jun. 2001	1000	500						
Sep. 2001	800	500						
Nov. 2001	600	500						
Jan. 2002	0 - 400	0 - 500		0 - 450	0 - 500		0 - 300	0 - 380
Apr. 2002	0 - 400	0 - 900		0 - 750			0 - 300	0 - 1140

Results

The research indicated that high rates of N and K are required in the interval before row closure to maintain the rapid increase in plant weight that is necessary to achieve high yields. Ideally, side banded application of fertiliser should commence at about 10 to 14 days after transplanting and continue weekly until about row closure. All of the tested fertilisers from table 7.1.6 above appeared able to provide adequate nutrition to strongly growing lettuce plants as long as other factors were not limiting.

The authors had good success with the use of potassium nitrate as the first side banding at a rate of 500 kg/ha followed one week later with an application of ammonium nitrate at 200 kg/ha. Potassium nitrate has several advantages in that it can be applied easily and accurately, is highly soluble and provides both N and K in one dose.

Other fertilisers can be used in place of ammonium nitrate as long as the N application rate is about the same. Ammonium nitrate applied at 200 kg/ha provides 68 kg of N and Nitrophoska Blue® applied at 600 kg/ha will provide about 72 kg of N.

These rates of fertiliser can be applied with safety from about mid April to mid November. Outside of this period or when temperatures are expected to exceed 30°C the bandings should be given in split applications, twice weekly (for example KNO_3 at 250 kg/ha twice in a week to a total of 500 kg/ha). Soil should be wet when banded fertiliser is applied to avoid crop damage.

In mid winter there may be as many as five bandings required before row closure and in summer it can be as few as two. At these rates, a total of 160 to 350 kg/ha of N and about 200 kg/ha of K will be applied over the crop life.

Figure 7.1.5. Typical trial site on grower property. Mineral fertilisers compared with banded poultry manure (brown bands).

Leaf sampling

Introduction

In conjunction with the fertiliser spray and banding trials, regular leaf sampling for petiole sap testing was undertaken. This work investigated a method of rapid sap analysis with the intention of methodically measuring nutritional status. It was thought that plant nutrient levels would be indicative of applied fertiliser treatments.

Materials and methods

When trial plants were of sufficient size, fully expanded young wrapper leaves were collected before fertiliser applications. For each trial, three consecutive weekly or fortnightly samples were taken. To minimise damage, single leaves only were carefully removed from samples of plants within each treatment, transported in cooler boxes and laboratory processed within 24 hours. Detached petioles were rinsed in DI water, crushed to extract sap and the sap tested using a Merck Rqflex ® reflectometer and test strips for Nitrate-N, Phosphate-P and K.

Results

Leaf sampling and rapid petiole sap testing provided a valuable tool for monitoring plant nutritional status late in crop life. Healthy lettuce plants seem able to rapidly uptake N, P and K from side banded applications of fertiliser quite late in crop life (before row closure) and petiole sap nutrient levels can fluctuate markedly. Sap testing one week after fertiliser application revealed corresponding increases in petiole sap levels for the applied element.

Table 7.1.7. Petiole sap measurements: first sample

Trial date	Cultivar	Harvest	Sample date	Petiole sap NO_3-N mg/L		Petiole sap PO_4-P mg/L		Petiole sap K mg/L	
				Grower crop	Trial (best tmt)	Grower crop	Trial (best tmt)	Grower crop	Trial (best tmt)
Nov 2000	Raider	12/12/00	23/11/00	450	130	106	85	3450	2750
Jan 2001	Raider	15/02/01	31/01/01	556	328	133	99	3400	2950
Feb 2001	Magnum	10/04/01	21/03/01	451	466	106	73	3550	3725
May 2001	Oxley	9/07/01	30/05/01	563	642	106	73	4700	4625
Jun 2001	Oxley	29/08/01	18/07/01	372	375	111	91	5150	5250
Sep 2001	Magnum	16/11/01	17/10/01	467	490	106	87	4850	4475
Nov 2001	Raider	18/12/01	22/11/01	208	268	34	52	3350	3900
Apr 2002	Magnum	17/06/02	23/05/02	463	330	88	121	4150	4550

Table 7.1.8. Petiole sap measurements: last sample

Trial date	Cultivar	Harvest	Sample date	Petiole sap NO_3-N mg/L		Petiole sap PO_4-P mg/L		Petiole sap K mg/L	
				Grower crop	Trial (best tmt)	Grower crop	Trial (best tmt)	Grower crop	Trial (best tmt)
Nov 2000	Raider	12/12/00	7/12/00	116	113	124	125	3200	3600
Jan 2001	Raider	15/02/01	14/02/01	101	380	117	117	3450	3975
Feb 2001	Magnum	10/04/01	4/04/01	66	382	116	119	2925	2675
May 2001	Oxley	9/07/01	27/06/01	273	262	112	78	3600	3275
Jun 2001	Oxley	29/08/01	15/08/01	197	60	125	93	2800	2475
Sep 2001	Magnum	16/11/01	14/11/01	262	435	104	107	2650	3050
Nov 2001	Raider	18/12/01	6/12/01	341	373	85	87	3020	2840
Apr 2002	Magnum	17/06/02	6/06/02	354	235	91	91	3250	4100

Final harvest yields

Introduction

The grower provided advice as to the correct time of harvest for each trial. Absolute head weights recorded in these trials are not relevant because trials were often harvested a day or two earlier than optimum for logistical reasons that did not interfere with the grower's bulk harvest. The important measure was the relative yield advantage created by the treatments.

Materials and methods

At harvest time, the grower allocated a plot sized area of his commercial crop to be harvested for comparison with the eight plots (eight treatments) of each trial. A treatment plot contained about 44 plants. Eight treatments plus one grower plot provided a theoretical total of about 400 plants for measurements.

At harvest, all available plants, that is plants that had produced a marketable head, were cut and weighed individually. In each case, lettuce heads were trimmed to export standard without frames (head wrapper leaves). Plants that had not hearted, were very small or seriously affected by disease were counted and recorded but not harvested or weighed. Data collected in this manner provided the opportunity to find mean and standard deviation of head weight for each treatment. This data is described in detail in chapter eight of this report.

Results

The results for the final harvest of all trials in the sequence are presented in Table 7.1.9. The table does not show the results of all treatments but compares the yield estimate from the grower's surrounding crop to the best yield from the trial plot treatments at each date. The method used in this series of trials to increase yields over time was to progressively take the best treatment forward from each trial to the next and compare it to a new set of treatments which offered potential to increase yields further, save labour, reduce costs or all three.

Table 7.1.9 shows a progressive increase in relative yields of the trial treatments compared to the grower method. It was not until April 2001 that the best trial treatment gained a yield advantage over the grower method. After this time, subsequent trials aimed at making the alternative treatments more practical and cheaper for the grower.

After September 2001, poultry manure was banned from use and the grower adopted our best trial treatment at that time. We retained the best treatment from the April 2001 trial throughout all subsequent trials as the benchmark or control treatment for yield. This treatment, although high yielding, was labour intensive and unlikely to be adopted by growers without modification.

Table 7.1.9. Yield outcomes from 10 trials conducted on a grower property compared to the grower's crop yields at each date

Planting date	Lettuce cultivar	N application by grower kg/ha	Grower yield mean head wt grams	N application in trial kg/ha (best treatment)	Trial yield mean head wt grams (best treatment)
24/06/2000	Titanic	472	900 (estimate)	167	766
30/10/2000	Raider	1335	636	95	541
8/01/2001	Raider	1335	392	209	462
26/02/2001	Magnum	1335	717	212	569
30/04/2001	Oxley	659	655	459	659
5/06/2001	Oxley	659	556	527	542
25/09/2001	Magnum	564	791	443	898
2/11/2001	Raider	564	851	323	885
24/01/2001	Raider	564	464	181	513
8/04/2001	Magnum	350 (estimate)	604	140	604

Discussion

This series of field trials conducted on several commercial lettuce growing properties during the period June 2000 to April 2002 compared a range of soluble mineral fertilisers combined with several application methods in unreplicated plots. The results of the series showed the following:

- Pre plant application of highly concentrated potassium nitrate solutions applied as a drench to lettuce seedlings in punnet trays (cell packs) was found to be highly effective in assisting plant establishment in the critical early period of crop life.
- Pre-plant (incorporated) applications of phosphorus, magnesium and trace element fertilisers should be applied on an as needs basis as indicated by soil test and are preferable to post plant applications for these elements.
- Post transplant applications of some soluble nitrate type mineral fertilisers and technical grade (low biuret) urea applied as concentrated foliar sprays were effective in maintaining vigorous growth in young lettuce plants. Applications need to be made one to two times a week for two weeks immediately after transplanting and not immediately washed off by irrigation.
- Spray applications of ammonium nitrate, magnesium sulphate and potassium sulphate made to young lettuce seedlings both pre-plant and post plant caused unacceptable phytotoxic damage and are not recommended.
- Applications of granular mineral fertilisers applied as side banded applications from about 14 days after planting until row closure were made to maintain rapid plant growth. Mineral nitrogen (N), phosphorus (P) and potassium (K) fertilisers can be selected from a wide range of readily available commercial fertilisers to minimise cost and these can be applied at rates to match growth response and environmental conditions. Accuracy of application in both rate and placement of fertiliser is important. Poorly placed fertiliser will result in uneven crop growth and may cause plant damage if placed too close to young plants.
- Lettuce plants respond strongly to these applications and rapid uptake of nutrients can be detected by using plant petiole sap analysis methods. Sap testing using a Merck Rqflex ® reflectometer and test strips proved to be an effective monitoring method late in the life of the crop and verified rapid uptake of banded nutrients after application. By using a known set of standards, plant nutritional status of N, P and K in petiole sap can be closely monitored. It was found, however, that this method of rapid sap analysis late in crop life was not a good predictor of final yield. Optimum crop yields were only achieved if vigorous growth was maintained in the first two weeks of crop life.
- It was also found that petiole sap nutrient levels were drastically affected by plant water stress. For example, a mildly water stressed lettuce plant will record a much higher level of petiole sap nitrate than an equivalent unstressed plant. This phenomenon can cause incorrect diagnoses of leaf sap analysis.

Recommendations

A recommended fertiliser program derived from the trial series is shown in Table 7.1.10. The recommendation reflects the level of incremental improvement in yield and cost that we were able to make in the time frame available but is by no means definitive. Further efficiencies and economies are likely to accrue from better placement methods and further work on banding rates in particular. The recommendation reflects a practical alternative to manure based fertiliser programs which is relatively cheap, effective, practical to implement while minimising unnecessary labour operations and nutrient loss to the environment.

Table 7.1.10. Best practice fertiliser recommendation derived from the trial series for iceberg lettuce

Crop stage	Fertiliser application	Comment
Pre-plant Broadcast applications	Phosphorus (P), e.g. double phos	Up to 2500 kg/ha based on soil test and crop history
	Potassium and magnesium, e.g. K-Mag®	Up to 200 kg/ha based on soil test and crop history
	Trace elements	Recommended rate once annually
Transplanting Seedling drench in trays	Potassium nitrate (KNO_3) greenhouse grade.	40 g/L and about 500 mL of solution per tray of 100 seedlings just before transplanting.
First two weeks of crop life Boomsprays in field	KNO3 plus Urea (special grade, low biuret type)	20 kg KNO3 plus 22.5 kg urea in 1000 L per ha. Spray twice a week after transplanting for up to 3 weeks.
Day 13 after transplant Banding at high rates	KNO3	500 kg/ha. A lower cost alternative first banding fertiliser is KCl at 380 kg/ha plus urea at 150 kg/ha
Up to row closure Subsequent weekly bandings	Ammonium nitrate	200 kg/ha weekly. An alternative weekly banding: NPK mixed fertiliser at 600 kg/ha

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7.2 BEST PRACTICE NUTRITION FOR LEAF AND COS LETTUCE

Introduction

Gourmet lettuce is a generic term to describe all types of lettuce other than heading 'iceberg' types and includes cos, butterhead, coral, festival, oakleaf and radicchio as well as endive in the context of this work. These types of lettuce are widely used to create mesclun mixes and other pre-packaged prepared salads. Preparing salads in this pre-packaged form potentially enhances the risk of microbiological spoilage or food safety hazard if there are flaws in production, processing or handling systems.

This project aimed to minimise the microbiological risk (real or perceived) associated with growing these lettuce types with raw poultry manure as part of the production process. In Western Australia raw poultry manure has been widely used for growing these crops in field situations and is no longer considered desirable or safe by lettuce processors or their customers.

Fertiliser practices for producing this crop with poultry manure have also resulted in unacceptably high levels of nutrient use and wastage which has contributed to ground water pollution. Nitrogen in the nitrate form is the nutrient of greatest concern as a pollutant in most situations.

This project aimed to identify appropriate nutrition practices, which manage food safety and pollution risks while maintaining or enhancing crop yield and profit.

Materials and methods

Commercial crops of several different types of gourmet lettuce and one variety of chicory were sprayed with solutions of soluble chemical fertilisers to determine safe levels of spray concentration and suitability of chemical fertiliser sprays as complete or partial replacement for poultry manure applications. In addition, follow up applications of fertiliser in banded form were made to several types of gourmet lettuce to ensure that market standard crops were produced.

The work was conducted in four phases over four trials in an 18-month period (September 2000 to February 2002) at the property of a commercial grower in the Wanneroo district of Western Australia. It should be noted that some phases overlapped others across this series of trials.

- Phase 1. Screening of foliar applied fertilisers for toxicity and growth response to small plots of gourmet lettuce within commercial crops.
- Phase 2. Application of soluble nitrate fertiliser as a drench to seedlings in trays.
- Phase 3. Boomspray application of 'best rate' foliar applied fertilisers to a commercial crop.
- Phase 4. Side banded application of prilled and granular fertiliser to selected small plots within commercial crops.

PHASE 1. SCREENING OF FOLIAR APPLIED FERTILISERS

Trial 1. September 2000 - small plots in Spring

The first trial site was a 500 m^2 bed of gourmet lettuce containing 11 types with two transplanting dates (8 and 21 September 2000) on the property of a commercial grower in Wanneroo, Western Australia. The site received an application of poultry manure in May 2000 but had no recent pre-plant applications prior to the commencement of this trial.

Twelve small plots of 5.0 m^2 (6.6 x 0.75) each were marked out within the site and contained either one or two varieties. The twelve small plots were divided equally across both transplant dates (six each).

On 21 September 2000 all small plots were sprayed with a solution of $Ca(NO_3)_2$, $Mg(NO_3)_2$ and KNO_3 in the ratio of 25:10:5 by weight in water at the rate of 40 kg/ha in 1000 L/ha. Solutions were prepared on site with pre weighed fertiliser and irrigation water. Volumes were 500 mL per plot requiring two passes with a knapsack sprayer with a single fan jet nozzle at 200 to 300 kPa pressure.

The small plots were inspected on 25 September for signs of phytotoxicity and growth responses. Damage to plants was rated as either acceptable or unacceptable.

Acceptable damage was most often seen as small scorch marks, minor marginal chlorosis or small water spots or stains on leaves. The plants were not noticeably set back in growth or development and often recovered within one week so that symptoms had disappeared.

Unacceptable damage was that which a commercial grower would rate as unacceptable, possibly making the plant unmarketable. It ranged from large areas of scorching on leaves of most plants, yellowing of leaf margins, collapsed or flaccid leaves through to complete plant death of several plants in a treatment.

Table 7.2.1. Fertiliser spray evaluation: Trial 1 - 21/09/2000

Fertiliser spray application schedule	
Transplant date 1 (8/09/2000) Gourmet lettuce type or variety	**Transplant date 2 (21/09/2000)** Gourmet lettuce type or variety
Green coral	Chicory
Balisto	Red festival
Red festival	Balisto
Red coral	Cos (cosmic)
Revolution	Revolution
Chicory	Frill ice
Green festival	Green coral
Shiraz	Shiraz
Frill ice	Green festival
Cos (cosmic)	Red coral
	Red radicchio (cirrus)

Trial 2. February 2001 - small plots in Summer

The second trial site was a 360 m^2 bed of gourmet lettuce containing several types with four transplanting dates (27/02/2001, 15/03/2001, 12/04/2001 and 10/05/2001) on the same commercial property in Wanneroo, Western Australia.

The site had no recent pre-plant applications of poultry manure prior to the commencement of this trial. Agricultural lime was applied to the site one week prior to planting as part of the grower's normal preparation and soil pH adjustment.

Small plots of about 6.0 m^2 (5.0 x 1.25) each were planted out by the grower in the site at the same time as his normal commercial crop for that time of year and contained one variety each.

Small plot spraying with soluble fertiliser solutions commenced on 8 March 2001. All small plots were sprayed with either: (1) a solution of $Ca(NO_3)_2$, $Mg(NO_3)_2$ and KNO_3 in the ratio of 25:10:5 (40 kg/ha) by weight in water; or (2) a solution of KNO_3 at the rate of 60 kg/ha. Applications were at 1000 L/ha using a hand held knapsack sprayer with a single fan jet nozzle at 200 to 300 kPa pressure.

The small plots were visually inspected weekly commencing on 15 March 2001 for evidence of phytotoxicity and growth response. All types and varieties were closely inspected for tolerance to fertiliser sprays and any damage was rated as either acceptable or unacceptable.

Figure 7.2.1. First trial site, October 2000.

Figure 7.2.2. Second trial site, April 2001.

Table 7.2.2. Fertiliser spray evaluations: Trial 2 - 8/03/2001 - 15/05/2001

Fertiliser spray application schedule and gourmet lettuce type			
Transplanted 27/02/2001	**Transplanted 15/03/2001**	**Transplanted 12/04/2001**	**Transplanted 10/05/2001**
1st spray: 8/03/2001	1st spray: 15/03/2001	1st spray: 19/04/2001	1st spray: 15/05/2001
Red coral	Chicory	Beacon radicchio	Green festival
Chicory	Cos	Green festival	Junior cos
Revolution	Baby cos	Red coral	Red coral
Green festival	Red coral	Cos	Chicory
Red festival	Frill ice	Green coral	Revolution
Shiraz	Shiraz	Frill ice	Balisto
Baby cos	Red festival	Chicory	Red festival
Frill ice	Green festival	Red festival	Cos
Green coral	Revolution		Green coral
Beacon	Green coral		Shiraz
	Beacon radicchio		Frill ice

PHASE 2. APPLICATION OF POTASSIUM NITRATE AS A SEEDLING DRENCH

July 2001 Trial

The grower provided 20 trays of gourmet lettuce seedlings of twelve different types. Each tray contained 100 seedlings. Just prior to transplanting, solutions of greenhouse grade Potassium nitrate in water were made up on-site at three different rates (80 g/L, 40 g/L and 0 g/L (nil treatment)) and applied by watering can to the trays. About 500 mL of solution was sufficient to treat one tray.

Because of the physical constraints of the trial it was not possible to apply all treatments to all types. Four trays were given a nil drench (water only), five trays were drenched at 40 g/L and eleven trays were drenched at 80 g/L. Seedlings were transplanted out into small plots of about 100 plants each on a site provided by the grower (Wanneroo) on 13 July 2001. Inspections of the plots for evidence of phytotoxicity or growth response commenced one day after transplanting and continued weekly.

Table 7.2.3. Fertiliser drench applications to seedlings in trays: Trial 3 - 13/07/2001

Nil (water only)	**KNO3 40 g/L**	**KNO3 80 g/L**
Gourmet lettuce type	Gourmet lettuce type	Gourmet lettuce type
Green festival	Green festival	Green festival
Shiraz	Shiraz	Cos
Green coral	Cos	Green coral
Revolution	Buttercrunch	Revolution
	Red festival	Red festival
		Buttercrunch
		Red coral
		Frill ice
		Red radicchio
		Tango
		Chicory

PHASE 3. BOOMSPRAY APPLICATION OF FERTILISERS TO FIELD CROPS

Trial 1. September 2000 - Foliar nitrates

The first trial in this sequence of experiments was established in September 2000. After the initial spray treatments (Phase 1. Screening of foliar applied fertilisers) and crop inspections, the grower agreed to apply weekly boomspray applications of soluble fertiliser to the trial site.

Using his own equipment, the grower applied a weekly boomspray solution of calcium nitrate, magnesium nitrate and potassium nitrate over the whole 500 m^2 bed in which the trial was located. The grower purchased the fertilisers and pre-dissolved them in water before tank mixing. The rates used were: $Ca(NO_3)_2$ - 1.25 kg, $Mg(NO_3)_2$ - 0.50 kg and KNO_3 - 0.25 kg in 50 L of water. Boomspray applications commenced on 26 September 2000.

The twelve small plots from phase 1 (above) were then given an additional weekly spray application commencing 28 September 2000, of the same fertiliser solution, by knapsack and rated visually for growth response or phytotoxic side effect. The final spray application was made on 26 October 2000.

The consequence of this fertiliser spray regime meant that the twelve small plots received a total of eleven spray applications and the remainder of the crop in the site received five spray applications.

Table 7.2.4. Fertiliser boomspray applications: Trial 1 September to October 2000

Trial area	**No. of spray applications $Ca(NO_3)_2 + Mg(NO_3)_2 + KNO_3$**	**Total nitrogen applied in sprays kg/ha**
12 small plots	11	61.9
Grower crop (trial site)	5	28.1

Trial 2. February - May 2001 - Foliar nitrates and potassium nitrate

The second trial in this sequence of experiments was established in February 2001 and continued through four consecutive planting dates. After the initial spray treatments (Phase 1. Screening of foliar applied fertilisers) and crop inspections, it was decided to apply weekly spray applications of soluble fertiliser to the entire trial site and that they would commence soon after each transplanting date.

At this time the grower was unable to use his boomspray equipment over the trial area. The site that had been allocated for this trial was too narrow to allow unrestricted use of the tractor mounted boomspray. As an approximation of commercial application, all spray applications were made with a backpack sprayer with single fan jet nozzle at 1000 L/ha and 200 to 300 kPa pressure.

Spraying commenced on 15 March 2001. All plants were sprayed with either a solution of $Ca(NO_3)_2$, $Mg(NO_3)_2$ and KNO_3 in the ratio of 25:10:5 (40 kg/ha) by weight in water or a solution of KNO_3 at the rate of 60 kg/ha. Plots were inspected weekly for growth responses and other side effects.

The consequence of this fertiliser spray regime meant that the four consecutive plantings received different numbers of spray applications and different amounts of sprayed fertiliser.

Table 7.2.5. Fertiliser boomspray applications: Trial 2 March to July 2001

Trial transplanting	No. of spray applications $Ca(NO_3)_2 + Mg(NO_3)_2 + KNO_3$	No. of spray applications KNO_3 (60 kg/ha)	Total N applied in sprays kg/ha
27/02/2001	6	0	33.8
15/02/2001	8	0	45.0
12/04/2001	3	2	26.9
10/05/2001	1	7	60.2

Trial 3. July 2001 - Foliar potassium nitrate

The third trial in this sequence of experiments was established in July 2001 and harvested in September 2001. After the initial seedling drench treatments (Phase 2, application of KNO_3 as a seedling drench) and crop inspections, it was decided to further evaluate the use of potassium nitrate as a boomspray application over gourmet lettuce in the field.

The trial site containing the 12 gourmet lettuce types and plots of drenched seedlings was about 140 m^2 in area but unsuitable for use with the grower's tractor mounted boomspray. All spray applications were made with a backpack sprayer with single fan jet nozzle at 1000 L/ha and 200 to 300 kPa pressure.

The trial was transplanted on 13 July 2001 and fertiliser spraying commenced on 20 July 2001. All sprays were greenhouse grade KNO_3 in water at a rate of 60 kg/ha in 1000 L/ha.

A total of six sprays were applied to the crop (all plots and all types) and the final spray was applied on 24 August 2001. The total amount of nitrogen applied to the trial in sprays was 46.8 kg/ha (N).

Trial 4. February 2002 - Foliar potassium nitrate and urea

The fourth trial in the sequence was transplanted on 6 February 2002. Investigations into the suitability of potassium nitrate plus low biuret urea as sprayed fertiliser applications were made.

The grower provided a site of about 90 m^2 in area and this was planted out with twelve varieties (or types) at the same time as his normal commercial crop for that time of year.

The trial area (all plots and all types) was sprayed using the same backpack sprayer and all applications were 40 kg/ha KNO_3 plus 5 kg/ha low biuret urea. Low biuret urea (special or technical grade) is safer to use over growing plants because it has a lower level of phytotoxic impurities than ordinary urea.

The first spray was applied on 7/02/2002 and a total of five sprays applied (final spray, 6/03/2002). The total amount of nitrogen applied to the trial in sprays was 37.5 kg/ha (N).

Figure 7.2.3. Fourth trial site, February 2002.

Table 7.2.6. Trial 4 - February 2002

Gourmet lettuce type (or variety)
Red festival
Cos
Flare
Italian oak
Shiraz
Chicory
Revoluntion
Frizzmo
Red ferrari
Green coral
Red coral Concorde
Endive

PHASE 4. SIDE BAND APPLICATION OF FERTILISERS

Trial 1. September 2000 - Potassium nitrate banding

The first trial in the sequence was transplanted on 8 and 21 September 2000 and harvested on 4 November 2000. Over this eight week period regular crop inspections and assessments of plant growth and vigour were made. With cooperation and assistance from the grower, judgments were made periodically about applying extra fertiliser to those types and varieties that were assessed as requiring side banded applications.

By the 19 of October, observations made during the course of the trial had clearly identified the varieties that required fertiliser side dressings to achieve acceptable growth at this time of year (see Table 7.2.7).

On 23 October (prior to row closure) an application of prilled potassium nitrate at 300 kg/ha was made to small plots of three varieties from the second transplanting (21 September). The fertiliser was hand applied as a single band between pairs of rows on a four row bed.

The grower agreed to make assessments and report on the performance and marketability of all varieties in the trial at harvest time.

Table 7.2.7. Fertiliser sideband applications: Trial 1 - October 2000

Transplant date 2 (21/09) Gourmet lettuce type	Side band application KNO_3 - 300 kg/ha	N applied as sidebanding kg/ha	K applied as sidebanding kg/ha
Balisto	1	39.0	114.9
Cos (cosmic)	1	39.0	114.9
Red radicchio (cirrus)	1	39.0	114.9

Trial 2. February - May 2001 - CAN and potassium sulphate banding

This trial was initiated in late summer of 2001 and included four dates of transplanting as shown in Table 7.2.8. The first transplanting (27/02/2001) was expected to produce harvestable plants in about six week's time. After consultation with the grower and with the experience gathered from the first trial (September 2000) it was decided to make side banded fertiliser applications to several varieties or types earlier in crop life. The grower advised that it was his normal practice to apply combination NPK type fertiliser at a rate of about 400 kg/ha as a side banded dressing soon after transplanting at this time of year.

Agreement was reached with the grower and commencing on 29 March 2001, applications of fertilisers were made to several plots in the trial area. Commercially available granular and prilled nitrogen and potassium fertilisers were selected for use in this trial. Calcium ammonium nitrate at 200 kg/ha or 250 kg/ha and potassium sulphate at 400 kg/ha were applied to several types and varieties as recommended by the grower.

In the previous trial (Trial 1 September 2000), potassium nitrate had been used as the side banded fertiliser. It has several advantages in that it is highly soluble, easy to apply in the prilled form, provides both N and K in a single application and appears to be rapidly taken up by strongly growing lettuce plants.

In an effort to reduce fertiliser cost, cheaper forms of N and K fertiliser were selected for this trial because it was anticipated that increased rates of fertiliser would be applied in some cases.

The grower agreed to make assessments and report on the performance and marketability of all varieties in the trial at harvest time.

The final side band application (transplant date 4) was made on 14 June 2001. The number of side banded applications increased with later planting as shown in Table 7.2.8 because growth rates became slower with the approach of winter. This increase in number of applications is reflected in a progressive increase in N and K rate with time as shown in Table 7.2.9.

Table 7.2.8. Fertiliser sideband applications: Trial 2

Transplant date	Harvest date	No. of side bandings applied
27/02/2001	14/04/2001	2
15/03/2001	3/05/2001	3
12/04/2001	18/06/2001	3 or 4 depending on type
10/05/2001	7/07/2001	5

Table 7.2.9. Fertiliser sideband application details: Trial 2 - 29/03/2001 - 14/06/2001

Transplant date and gourmet lettuce type	Side band applications $CaNH_4NO_3$ kg/ha	Side band applications K_2SO_4 kg/ha	Total N applied as side banding kg/ha	Total K applied as side banding kg/ha
Baby cos	500	400	135.0	166.0
Chicory	500	400	135.0	166.0
Chicory	750	400	202.5	166.0
Cos	750	400	202.5	166.0
Beacon radicchio	750	400	202.5	166.0
Chicory	1000	400	270.0	166.0
Cos	1000	400	270.0	166.0
Beacon radicchio	1000	400	270.0	166.0
Red coral	750	0	202.5	0.0
Red festival	750	0	202.5	0.0
Junior cos	1000	400	270.0	166.0
Chicory	1000	400	270.0	166.0
Frill ice	1000	400	270.0	166.0
Balisto	1000	400	270.0	166.0
Red festival	1000	400	270.0	166.0
Cos	1000	400	270.0	166.0

Trial 3. July 2001 - CAN banding in winter

The third trial in this sequence was sited in an area of low soil fertility and had not received an application of poultry manure for several years. The grower had also been unable to apply a pre-plant application of phosphorus fertiliser to the site and it was therefore decided to apply superphosphate and K-Mag® to the trial area soon after transplanting.

The trial site was about 140 m^2 in area and contained 20 small plots of gourmet lettuce of 12 varieties or type. It was decided to apply a uniform schedule of side banded fertilisers to all plots in the trial area.

The trial was transplanted on 13 July 2001 and side band fertiliser applications commenced on 20 July. A total of five applications were made and the final application was on 24 August 2001.

Table 7.2.10. Fertiliser sideband application details: Trial 3 20/07/2001 - 24/08/2001

Date	Fertiliser side bandings kg/ha	Total N applied kg/ha	Total P applied kg/ha	Total K applied kg/ha
20/07/2001	K-Mag® 200			
20/07/2001	Superphosphate 1000			
27/07/2001	Calcium ammonium nitrate 200			
3/08/2001	Calcium ammonium nitrate 200			
17/08/2001	Calcium ammonium nitrate 200			
24/08/2001	Calcium ammonium nitrate 200			
		216.0	91.0	36.6

Trial 4. February 2002 - CAN banding in summer

The fourth trial in the sequence was transplanted on 6 February 2002 and was about 90 m^2 in area. It contained 12 small plots of gourmet lettuce of 12 varieties or type. The site had a long cropping history but had not received an application of poultry manure since May 2000.

At this time of year, crop life is very short. The period from transplanting to harvest is about six weeks, depending on variety. It was decided to apply a uniform schedule of side banded fertilisers to all plots in the trial area.

Table 7.2.11. Fertiliser sideband application details: Trial 4 14/02/2002 - 21/02/2002

Date	Fertiliser side bandings kg/ha	Total N applied kg/ha	Total K applied kg/ha
14/02/2002	K-Mag® 200		
14/02/2002	Calcium ammonium nitrate 200		
21/02/2002	Calcium ammonium nitrate 200		
		108.0	36.6

Results

Regular visual assessments were made at every stage in each trial. All plots were inspected for evidence of phytotoxic damage or growth responses and affected plants were rated and counted.

At crop maturity, the grower harvested the varieties in the trial sites separately and assessed them on a comparative basis. Individual head weights were not recorded. Instead, varieties were rated for their percentage 'cut', uniformity, colour and suitability for processing. The assessment also included comments on maturity problems, storing potential and fertiliser requirements.

PHASE 1. SCREENING OF FOLIAR APPLIED FERTILISERS

Trial 1. September 2000 - Small plots in Spring

Of the eleven types that received the initial fertiliser spray application (21/09/2000), six showed no obvious effects, four displayed minor but acceptable phytotoxic damage and one variety (Balisto) suffered unacceptable damage.

Table 7.2.12. Fertiliser spray evaluation: Trial 1 21/09/2000

Fertiliser spray evaluations	
Gourmet lettuce type or variety	**Observations**
Chicory	Unaffected
Red festival	Slight leaf margin yellowing on old leaves
Balisto (buttercrunch)	Unacceptable leaf margin yellowing and scorching on old leaves
Cos (cosmic)	Slight margin yellowing and slight scorch marks on old leaves
Revolution	Unaffected
Frill ice	Unaffected
Green coral	Very slight leaf margin scorch
Shiraz	Unaffected
Green festival	Slight leaf margin yellowing on old leaves
Red coral	Unaffected
Red radicchio (cirrus)	Unaffected

Figure 7.2.4. Fertiliser spray damage on young gourmet lettuce, Balisto.

Trial 2. February 2001 - Small plots in summer

Of the eleven types that received an initial fertiliser spray application (see Table 7.2.2), five showed no obvious effects, five displayed minor but acceptable phytotoxic damage and one variety (Green coral) suffered unacceptable damage.

Table 7.2.13. Fertiliser spray evaluation: Trial 2: 8/03/2001 - 15/05/2001

Fertiliser spray evaluations	
Gourmet lettuce type or variety	**Observations**
Chicory	Slight leaf margin scorch on old leaves in 75% of plants
Red festival	Unaffected
Cos	Unaffected
Cos (baby)	Unaffected
Revolution	Slight leaf margin scorch on old leaves in 50% of plants
Frill ice	Slight leaf tip scorch on old leaves in 100% of plants
Green coral	Unacceptable leaf scorching and some yellowing of all plants
Shiraz	Slight leaf margin scorch on old leaves in 75% of plants
Green festival	Slight leaf margin scorch on old leaves all plants and some yellowing
Red coral	Unaffected
Beacon radicchio	Unaffected

Figure 7.2.5. Fertiliser spray damage on young gourmet lettuce, Green coral.

PHASE 2. APPLICATION OF POTASSIUM NITRATE AS A SEEDLING DRENCH

July 2001 Trial

The high rate drench fertiliser application (80 g/l KNO_3) caused unacceptable damage to four types. The types Red radicchio, Tango, Green coral and Red festival all suffered moderate leaf margin scorching and some flaccid/wilted leaves on all plants treated. The damage to the plants was observed on the day following the drench application. The other seven types that received the high rate drench suffered minor but acceptable leaf margin scorching to most plants treated.

The low rate drench (40 g/L KNO_3) caused minor but acceptable damage to some plants of the five types treated. The type Red festival however had slight but acceptable damage to 90 per cent of the plants treated. The grower reported that this variety is very tender and can be damaged easily.

No damage was observed in the untreated plots. All plots established well and appeared to grow with good vigour but about one month after transplanting the plants in the undrenched plots were noticeably smaller than those in drenched plots.

Figure 7.2.6. Eleven trays of seedlings drenched with KNO_3 at 80 g/L prior to transplanting.

PHASE 3. BOOMSPRAY APPLICATION OF FERTILISERS TO FIELD CROPS

Trial 1. September 2000 - Foliar nitrates

Ten of the eleven types sprayed with the 4 per cent solution of $Ca(NO_3)_2$ + $Mg(NO_3)_2$ + KNO_3 were able to tolerate twice weekly sprays for up to five weeks. Importantly, the regular boomspray applications did not exacerbate any of the phytotoxic effects as noted earlier in the results section, Phase 1, Trial 1.

The variety Balisto (buttercrunch) was very sensitive at this time of year to boomspray fertiliser applications at the applied rate. Outside leaves on most plants were very tender and often scorched.

Of the varieties that received two boomspray applications a week, five exhibited a positive growth response. It was not possible to record yields or head weights at harvest time but from visual observation, the plants were larger and greener than those plots that received only one spray a week.

The five varieties that exhibited a positive growth response were Cos (cosmic), Chicory, Balisto, Green coral and Green festival. These varieties also coincided with the varieties that the grower independently remarked on as requiring side banded fertiliser to achieve full yield potential.

Trial 2. February 2001 - Foliar nitrates and potassium nitrate

Most of the varieties in all four plantings were able to tolerate weekly spray applications of fertiliser. The longest growing plots (transplant date 4) received eight spray applications without obvious adverse effects: one spray of 4 per cent solution of $Ca(NO_3)_2$ + $Mg(NO_3)_2$ + KNO_3 and seven sprays of 6 per cent KNO_3.

The variety Green coral was too tender in March to tolerate fertilisers sprays at these application rates.

Many varieties grew reliably across all four plantings, indicating that boomspray fertiliser application can be a useful component of a complete fertiliser regime for this crop. Notably, the fourth transplanting produced high quality crops with good marketability and high percentage cuts (75-90 per cent) in all eleven types.

Those varieties or types that were considered by the grower to have grown too slowly or produced uneven crops in March and April were Red coral, Red festival, Chicory, Shiraz and Green coral.

Trial 3. July 2001 - Foliar potassium nitrate

All types appeared to tolerate a weekly spray of KNO_3 at 60 kg/ha without phytotoxic damage. These sprays did not exacerbate any of the phytotoxic effects noted earlier in results section, Phase 2, Trial 3. The plants that were damaged by the high rate drench recovered quite quickly (within three weeks) and made good growth.

From visual observations during the trial, it seemed that the plants in the trial area had grown as vigorously as the growers' own commercial crop nearby.

At harvest time, three varieties, as assessed by the grower, had grown too slowly and produced low percentage cuts (50-80 per cent) with poor head sizes. They were Green coral, Frill ice and Revolution.

All other varieties produced good quality crops, high percentage cuts (75-90 per cent) and marketable heads.

Trial 4. February 2002 - Foliar potassium nitrate and urea

The fertiliser spray application used in this trial was 40 kg/ha KNO_3 plus 5 kg/ha low biuret urea. The variety Red festival displayed some minor scorching of outer leaves and the grower reported that this variety is very tender at that time of year. Green coral displayed unacceptable phytotoxic damage to outer leaves. All other types tolerated the five weekly spray applications.

At harvest, eleven of the twelve types (including Green coral) produced marketable crops with high percentage cuts (75-90 per cent). The grower reported that during harvesting and processing the damaged leaves on Green coral could be trimmed so that marketable product would be salvaged.

The type Cos produce small unmarketable heads and 50 per cent recovery (cuts).

PHASE 4. SIDE BAND APPLICATION OF FERTILISERS

Trial 1. September 2000 - Potassium nitrate banding

The side band fertiliser application, made to three varieties in this trial, was 33 days after transplanting. None of these three varieties produced a market standard crop. In the growers assessment, side band fertiliser applications need to be made earlier in crop life. At this time of year, some varieties will reach maturity too quickly, produce uneven plants or not produce market standard crops unless they are provided with early side band fertiliser dressings.

At harvest time, a crop of gourmet lettuce may be selected for fresh market sale (whole heads) or for processing (salad mixes or pre-packaged preparations) depending on demand and plant size. Generally, smaller, lighter plants are not suitable for market sale but will still be saleable for processing.

Five of the eleven varieties or types produced market standard crops after receiving only spray applications of fertiliser. These were: Frill ice, Shiraz, Red coral, Revolution, and Red festival.

Table 7.2.14. Types that did not produce market standard crops: Trial 1

Gourmet lettuce type/variety	Grower assessment and comments 4/11/2000	
Cos (cosmic)	65% cut	Uneven crop. Matured too quickly. Requires side banding.
Chicory (salad king)	0% cut	Went to seed. Matured too quickly. Requires side banding.
Balisto (buttercrunch)	60% cut	Matured too quickly. Poor size. Requires side banding.
Green festival (kristine)	75% cut	Matured too quickly. Poor size. Requires side banding.
Green coral (locarno)	90% cut	Good weight and marketability but matured too quickly.
Red radicchio (cirrus)	60% cut	40% went to seed. Prefers cooler weather. Requires side banding.

Trial 2. February 2001 - CAN and potassium sulphate

The first three transplantings in this trial had high infection levels of tomato spotted wilt virus, which affected the market standard of many varieties at harvest time. However, many were still suitable for processing.

The fourth transplanting produced a high standard crop. All eleven types were suitable for market sale and processing. Percentage cut and marketability (grower assessment), was between 75 and 90 per cent.

Figure 7.2.7. Spotted wilt virus infection: (1) Green festival. (2) Beacon radicchio, March 2001

Table 7.2.15. Types that did not produce market standard crops: Trial 2

Gourmet lettuce type/variety	Grower assessment and comments
Transplanting 1	**Assessment date 14/04/2001**
Cos (cosmic)	70% cut Not suitable for market sale but OK for processing.
Chicory (salad king)	75% cut Too small for market sale but OK for processing.
Red festival	OK for processing. Bolted early. Too small for market sale.
Green festival (kristine)	OK for processing. Too small for market sale.
Green coral (locarno)	90% cut Good weight and marketability but matured too quickly.
Shiraz	80% cut Good size, colour and uniformity for processing only.
Frill ice	0% cut Too small. Deformed appearance later in crop life.
Red coral	60 % cut Nice appearance and good for processing only.
Baby cos	80% cut OK for processing but too small and light for market sale.
Transplanting 2	**Assessment date 5/05/2001**
Chicory (salad king)	75% cut Too small for market sale but OK for processing.
Frill ice	60% cut OK for processing. Poor shape later in crop life.
Transplanting 3	**Assessment date 18/06/2001**
Chicory (salad king)	Too small for market sale. Very uneven plant size but OK for processing.
Green coral (locarno)	OK for processing but too small for market.
Red coral	OK for processing only. Pale in colour.
Beacon radicchio	Severe spotted wilt virus infection.

Trial 3. July 2001 - CAN banding in winter

Nine of the twelve varieties or types produced market standard crops with high percentage cuts (80-90 per cent) and good head sizes.

Table 7.2.16. Types that did not produce market standard crops: Trial 3

Gourmet lettuce type/variety	Grower assessment and comments
Frill ice	60% cut OK for processing but too small for market sale. Difficult to grow at this time of year.
Revolution	80% cut OK for processing. Too small for market sale.
Green coral (locarno)	50% cut Good for processing but too small for market sale.

Trial 4. February 2002 - CAN banding in summer

Eleven of the twelve varieties or types grown in this trial produced market standard crops with high percentage cuts (75-90 per cent) and good head sizes.

Table 7.2.17. Types that did not produce market standard crops: Trial 4

Gourmet lettuce type/variety	Grower assessment and comments
Cos	50% cut OK for processing. Requires pre-plant fertiliser application and high rates side banded early in crop life.

Discussion

The commercial grower provided valuable assistance at all stages in the series of trials conducted at his property in Wanneroo, Western Australia. His comments and evaluation of crop growth and vigour during the course of each trial were used to make adjustments to fertiliser rates and applications where possible. His assessments of final crop yield and marketability of varieties and types at harvest time, to a large extent, influenced the planning and decision making for each subsequent trial.

The results showed that many gourmet lettuce types and varieties could be grown successfully and produce market standard crops at all times of year without poultry manure. It was not possible to identify an optimum fertiliser strategy for each individual variety but it appeared that certain varieties could be grown at some times of the year by applying only boomspray applications of fertiliser on a regular basis early in crop life. Other varieties benefited from an integrated regime that included pre-plant fertiliser drench, boomspray applications and side banded dressings.

Because the aim of the work was to produce market standard gourmet lettuce crops, using only mineral fertilisers, no attempt was made to maintain soil organic matter by applying soil amendments during the course of these experiments. The cost benefit of doing so should be assessed on an individual basis by growers as an 'add on extra' after optimising plant nutrition by the methods identified.

Recommendations

The recommendations for growing gourmet lettuce without poultry manure are described in four steps and are set out in Table 7.2.18.

Table 7.2.18. Best practice fertiliser recommendation

Crop stage	Fertiliser application	Comment
Pre-plant Broadcast applications	Phosphorus (P), e.g. Double Phos	Up to 2500 kg/ha based on soil test and crop history.
	Potassium and magnesium, e.g. K-Mag®	Up to 200 kg/ha based on soil test and crop history.
	Trace elements	Recommended rate once annually.
Transplanting Seedling drench in trays	Potassium nitrate (KNO_3) greenhouse grade.	40 g/L and about 500 mL of solution per tray of 100 seedlings just before transplanting. Note: Some varieties are very tender, notably Green coral and Red festival. They may exhibit mild scorching of outer leaves a day or two after treatment. When serious scorching is anticipated, lower concentrations of drench can be applied, i.e. 20 g/L.
First two weeks of crop life Boomsprays in field	KNO_3 plus Urea (special grade, low biuret type)	40 kg KNO_3 plus 5 kg urea in 1000 L per ha. Spray two or three times a week after transplant.

Table 7.2.18. Best practice fertiliser recommendation

Crop stage	Fertiliser application	Comment
Fertiliser side banding at high rates	Calcium ammonium nitrate 250 kg/ha or Ammonium nitrate at 200 kg/ha Note: Potassium nitrate at 300 kg/ha can be applied as **the second banding** if a potassium fertiliser was not applied pre-plant.	Fertiliser is banded between pairs of rows on a weekly basis starting one week after transplant. The application period may be as short as two weeks for fast growing types in summer. For winter application and for slower growing varieties such as Cos types, Balisto Buttercrunch and Red radicchio, four applications may be necessary.

8. SCHEDULING HARVEST FOR EXPORT AND PROCESSING

Aileen Reid and Dennis Phillips

Introduction

A key element of the export development plan described earlier was to find ways that growers could reduce costs of production for export, in order to become more competitive in this market. Increasing marketable yields and reducing field losses are obvious ways of achieving this objective. One of the strategies we have identified to increase marketable yields is to schedule harvest better than we do now. In simple terms, this means harvesting at the right time to maximise head weights of an acceptable size and density range for processing, while not compromising quality.

For local market, head (iceberg) lettuces are paid for by the bin (number), while for processing and export, they are paid for by weight. This has huge implications for the grower. Growers servicing the local market need only grow a lettuce whereby 12 will fill a bin. They will not necessarily be paid more for growing a bigger and better lettuce. However for processing there is a price incentive for the grower to produce more weight, and specifically head weight, per unit area.

The most critical aspect of lettuces for processing is density, followed by size. Lettuces for processing should also have a core that is easily removed (not too long or bent) and be free of tipburn and internal browning (see Figure 8.1). Since processing lettuce is paid for by weight, then in general, bigger is better. However, the trade-off is density. Lettuce that is too dense (see Figure 8.2) will not shred well - the shreds do not separate and remain in clumps, and the core will be too time consuming to remove. Lettuce that is under-dense may still be acceptable to the processor but does not maximise return to the grower.

Figure 8.1. LE169 - acceptable quality for processing.

Figure 8.2. Oxley - too dense for processing.

With the cooperation of processors, we were able to identify the point at which head weight suitable for processing is maximised without quality disorders. This is also the point at which grower $ returns are maximised.

The choice of varieties suitable for processing has involved some guess work, because very little work has been done specifically on varieties for processing (shredding) anywhere in Australia. In some time slots, such as February and March planting, we attempted to minimise the time that the less favoured summer varieties were used and bring forward the more favoured spring (Salinas) types.

The first section of this chapter deals with trials at two locations to evaluate the best varieties for different times of plantings and methods to ensure optimum yields. The second part deals with the more specific aspects of producing lettuce with the correct attributes for the processing market.

VARIETIES AND TIME OF PLANTING

Material and methods

Commencing in December 2001, a series of trials was planted at Manjimup and Medina research stations. These aimed to provide guidelines for growers on optimum harvest times for a range of varieties of iceberg lettuce for processing. At Medina there was a total of 12 monthly plantings, which started in December 2001. At Manjimup, plantings were only in those months in which it is was considered that lettuce from Perth would be subject to tipburn, i.e. November to February.

Two varieties were compared at each planting, changing throughout the year and comprising an industry standard and a likely successor. Plots in each planting were harvested six times at intervals from 1-3 days apart to encompass a range of maturities from slightly immature through to over-mature. Measurements made at each harvest show how lettuce head size and weight increase with delayed harvest.

Table 8.1. Schedule of varieties used in each planting at the two locations

Month	Actual planting date		Varieties			
	Medina	Manjimup	Medina		Manjimup	
December	26/11/01	27/11/01	Raider	Sheeba	Raider	Sheeba
January	abandoned	15/01/02	Raider	Sheeba	Raider	Sheeba
February	05/02/02	07/02/02	Marksman	Silverado	Marksman	Titanic
March	28/02/02		Marksman	Silverado		
April	28/03/02		Oxley	LE169		
May	02/05/02		Oxley	LE169		
June	04/06/02		Oxley	LE169		
July	04/07/02		Oxley	LE169		
August	05/08/02		Marksman	Silverado		
September	05/09/02		Magnum	Casino		
October	03/10/02		Magnum	Casino		
November	01/11/02	06/11/02	Magnum	Sheeba	Magnum	Casino

Site preparation: Medina

For the plantings from December to April inclusive, double superphosphate (2000 kg/ha), K-Mag® (200 kg/ha) and MIXED trace elements (150 kg/ha) was applied prior to fumigation and rotary hoed in to a depth of 150-200 mm. From May onwards the rate of double superphosphate was increased to 2500 kg and was applied with the K-Mag® and trace elements, one month before planting.

Metham sodium (500 L/ha) was applied to each site each site 14 days prior to transplanting. Nemacur® was applied at 24 L/ha immediately prior rotary hoeing the site for aeration seven days later and followed by 3 mm of irrigation. The beds were then marked and levelled ready for transplanting.

Seedlings for the trial were bought in from specialist nurseries. Seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting. Seedlings were planted at 4 rows per bed with 300 mm between rows and 330 mm between plants. Each plot had a row of buffers at each end.

Immediately after transplanting Kerb® was applied at 3 kg/ha and followed with 3 mm irrigation. All plots were irrigated three times per day for three days to a total of 9 mm per day depending on the weather.

Post-plant fertiliser

Nitrogen and potassium were applied via a boom spray (20 kg/ha potassium nitrate plus 22.5 kg/ha urea per 1000 L/ha) without wash-off, the day after planting and repeated twice a week for three weeks.

Fourteen days after planting a program of banding fertiliser was commenced. This changed according to time of year and is tabulated below. The principle used was banding till row closure, therefore during the cooler months when the lettuce was growing more slowly, more bandings were applied.

Table 8.2. Post-plant fertiliser schedule for lettuce trial plantings at Medina Research Station

Date of planting	KNO_3	Urea	NH_4NO_3	NPK Blue®
26 Nov. 2001	One banding (500 kg/ha) 7/12	Two bandings 7 days apart (200 kg/ha), 7/12 and 14/12		
5 Feb. 2002	One initial banding (500 kg/ha), 18/12	One banding (200 kg/ha), 18/12		
28 Feb. 2002	One banding (400 kg/ha), 15/3	One banding (130 kg/ha), 22/3		
2 Apr. 2002	One banding (400 kg/ha), 17/4			One banding (600 kg/ha), 24/4
2 May 2002	One banding (400 kg/ha), 20/5			One banding (600 kg/ha), 27/5
4 Jun. 2002	One banding (300 kg/ha), 18/6		Two bandings (200 kg/ha), 2, 9/7	One banding (600 kg/ha), 25/6
4 Jul. 2002	One banding (300 kg/ha), 16/7		Two bandings (200 kg/ha) 30/7, 6/8	One banding (600 kg/ha), 23/7
31 Jul., 6 Aug. 2002[1]	One banding (300 kg/ha), 13/8		Two bandings (200 kg/ha) 27/8, 3/92[2]	One banding (600 kg/ha), 20/8
6 Sept. 2002	One banding (300 kg/ha), 19/9			One banding (600 kg/ha), 25/9
3 Oct. 2002	One banding (300 kg/ha), 15/10		One banding (200 kg/ha), 22/10	One banding (600 kg/ha), 20/8
1 Nov. 2002	One banding (300 kg/ha), 13/11			One banding (600 kg/ha), 19/11

[1] The two varieties in this planting were planted one week apart. Listed dates of fertiliser application are for the first variety planted. The schedule for the other variety was identical but seven days later.

[2] One banding only of NH_4NO_3 for the later planted variety.

Pest and disease control

At seven days after planting and every seven days thereafter for five weeks, the following pesticides were applied in combination:

- Permethrin (Ambush®) @ 15 mL/ha.
- Mancozeb (Dithane M45®) @ 2 kg/ha; and
- Pirimicarb (Pirimor®) @ 750 g/ha.

Downy mildew control was commenced in July until September using a rotation of Acrobat® and Fruvit® applied at seven day intervals from just before row closure.

Site preparation: Manjimup

Due to soil type, site preparation at Manjimup differed slightly from that at Medina. Double superphosphate (2500 kg/ha), Keiserite (200 kg/ha) and Superspud® (1000 kg/ha) was broadcast in a strip prior to planting. Nemacur 400® was applied at 24 L/ha seven days prior to planting. Five days before transplanting Stomp® was applied at 3 L/ha and followed with 12 mm of irrigation.

Seedlings for the trial were bought from the same source as for the Medina plantings. Seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting with the exception of the first planting. The seedlings were transplanted to give four rows under the tractor at 300 mm between rows and 350 mm between plants. There was one buffer row at each end of the plot.

Immediately after transplanting Kerb® was applied at 4.5 kg/ha. Plots were irrigated one to three times a day for three days to a total of 9 mm per day depending on the weather.

Post-plant fertiliser - all plantings

Nitrogen and potassium was applied via a boom spray (20 kg/ha potassium nitrate plus 22.5 kg/ha urea per 1000 litres per hectare), the day after planting and repeated twice a week for three weeks. The fertigations were washed in.

Fourteen days after planting and every seven days thereafter until row closure ammonium nitrate (200 kg/ha) only, was banded between the rows.

Pest and disease control

At seven days after planting and every seven days thereafter until harvest, the following pesticides were applied in combination:

- Permethrin (Ambush®) @ 15 mL/ha.
- Mancozeb (Dithane M45®) @ 2 kg/ha; and
- Pirimicarb (Pirimor®) @ 750 g/ha.

Figure 8.3. Overview of trials at Medina Research Station.

Figure 8.4. Harvesting lettuce trial at Manjimup Research Station.

Results - Medina plantings

December planting

Lettuce head dimensions were not recorded for harvest 2 and there are no results for harvest 4. Overall lettuce quality was good, there was no tip burn, internal browning or bolting. However, Raider was not liked by the processors.

January planting

This planting was abandoned due to a high rate of Tomato Spotted Wilt infection from a nearby trial.

February planting

Marksman appeared not to be in its ideal timeslot. Many of the heads were puffy and mis-shapen and overall they did not heart well. Silverado also appeared to not be in its ideal timeslot and was only harvested three times due to bolting.

March planting

Both varieties were of satisfactory quality.

April planting

The Oxley in this planting were very poor quality. They were highly variable and the bulk of them did not heart. The LE169 were far more uniform in the field. Samples taken to processors were well received. Head size was good, and there was a much higher proportion of head to wrapper leaves which means less wastage for processing. Overall, a much more attractive variety.

Because of differences in maturity the LE169 harvest commenced prior to that of Oxley.

May planting

The Oxley were still very poor quality, variable and with a high rate of not hearting. The harvest period was extended due to a slow rate of maturity. The last two harvests of LE169 showed a high rate of infection with downy mildew.

June planting

The plantings were very uneven due to uneven fertiliser banding. Downy mildew was still present on LE169 but relatively under control with spray program. A couple of cold snaps required the crop be irrigated for frost protection.

July planting

The incidence of downy mildew on LE 169 was quite high. The crop of Oxley was highly variable, many shaped like Cos lettuce and others not hearted. Oxley was also somewhat behind the LE 169 in terms of growth. At the third harvest there was quite a lot of marginal burning on the outer leaves - not affecting the head itself. Again the incidence of downy mildew on LE 169 was very high and even affecting inner leaves of some heads. A frost on 9 September slightly damaged the outer leaves.

August planting

A much better crop than July. The presence of big vein is responsible for most of the small lettuces but the unaffected heads were of good size. Silverado was easily identified from its small core and wrapper leaves that flip back at the top. Marksman has a somewhat elongated core.

September planting

Magnum performed well and achieved good head weights. Casino recovery was poor, mainly due to quite uneven reps. Casino also started to bolt after the third harvest so may not have been in its ideal time slot.

October planting

There was a high incidence of weevils and caterpillar damage in the final harvests. Many lettuce in the last two harvests were starting to rot as a result of being over-mature. Some Tomato Spotted Wilt Virus present.

The lettuces were probably not as good as those from the September planting. After harvesting commenced, they headed up slowly for the first week and then quickly went over-mature and started bolting. Both varieties were quite variable - one rep especially of Casino was well behind the rest in terms of maturity. Again it was felt this was not the best timeslot for Casino.

November planting

Sheeba performed well and achieved reasonable head weights but was not so well received by the processors. Magnum was slower to mature and commenced harvesting later than Sheeba but was found to be bolting as early as the first harvest though final recovery was quite good.

Figures 8.5a-j depict the bulking up rate of lettuce for each planting at Medina Research Station.

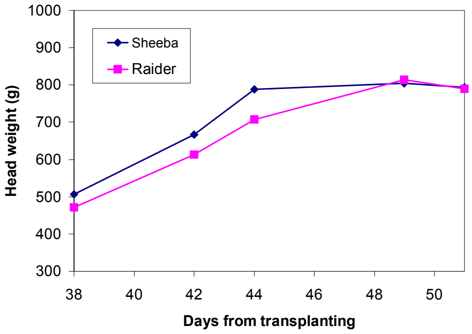


Figure 8.5(a). Bulking up rate of two lettuce varieties planted at Medina in December.

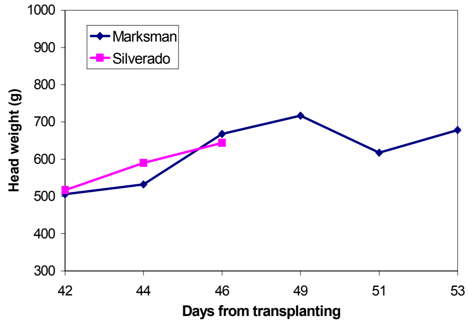


Figure 8.5(b). Bulking up rate of two lettuce varieties planted at Medina in February.

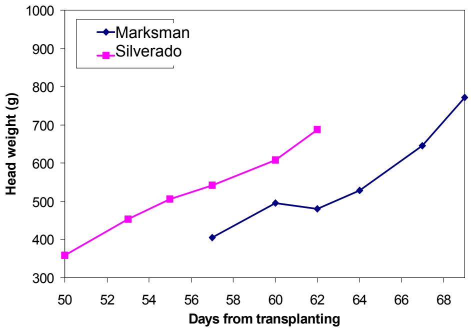


Figure 8.5(c). Bulking up rate of two lettuce varieties planted at Medina in March.

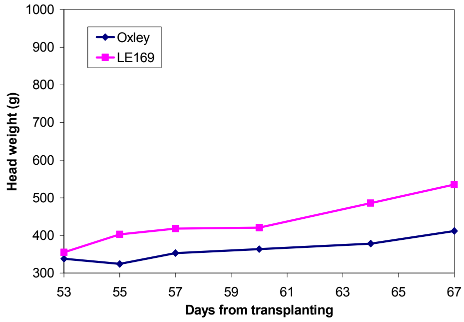


Figure 8.5(d). Bulking up rate of two lettuce varieties planted at Medina in April.

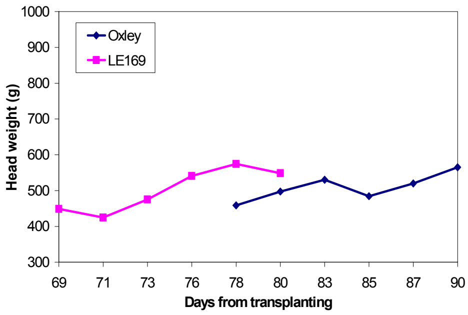


Figure 8.5(e). Bulking up rate of two lettuce varieties planted at Medina in June.

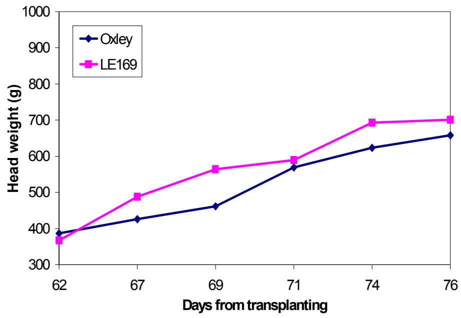


Figure 8.5(f). Bulking up rate of two lettuce varieties planted at Medina in July.

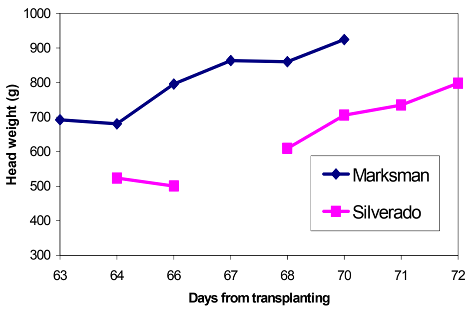


Figure 8.5(g). Bulking up rate of two lettuce varieties planted at Medina in August.

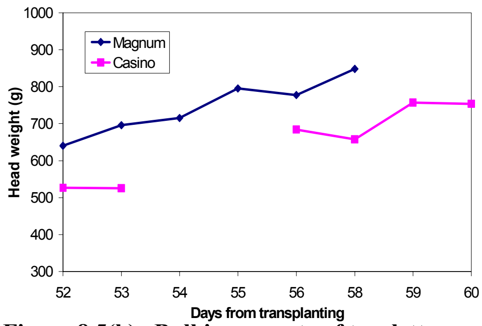


Figure 8.5(h). Bulking up rate of two lettuce varieties planted at Medina in September.

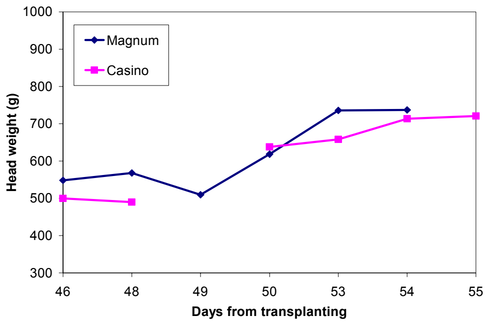


Figure 8.5(i). Bulking up rate of two lettuce varieties planted at Medina in October.

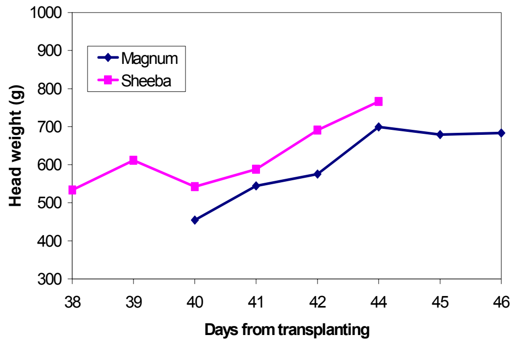


Figure 8.5(j). Bulking up rate of two lettuce varieties planted at Medina in November.

Results - Manjimup plantings

December planting

Both varieties grew well and no bolting occurred. Sheeba was preferred over Raider by the processors. Raider tends to be more elongated.

January planting

Both varieties grew well and head weights were very similar. Sheeba, in particular, was starting to bolt by the last two harvests. Raider had slightly more tipburn in the latter harvests. In both cases, due to over-maturity.

February planting

Marksman appeared to be the better variety in this planting. Titanic was bolting, especially by the latter harvests.

November planting

Overall Casino performed better than Magnum. There was quite a bit of variability between the replicates and this reflected the fact that for some reason the plots on the southern side did not do as well as those on the northern side. The optimum harvest seemed to be about No. 3 but some plots on the northern side appeared to be at their optimum about a week before that. It was a staggered harvest with Magnum commencing on the 20 December and finishing on the 31st and Casino commencing on the 23 December and finishing on 2 January. There was some garden weevil damage indicated by GW which rendered some heads unmarketable which prompted a protective Dominex® spray on the bulk lettuce around the trial area.

Figures 8.6a-d depict the bulking up rate of lettuce from each planting.

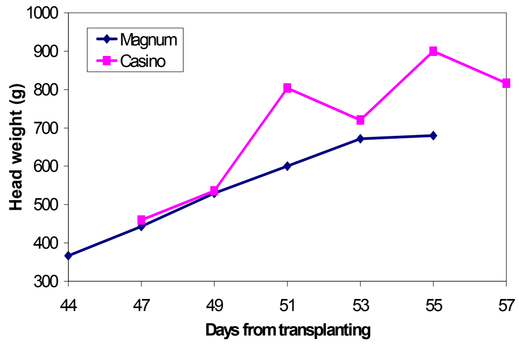


Figure 8.6(a). Bulking up rate of two lettuce varieties planted at Manjimup in November.

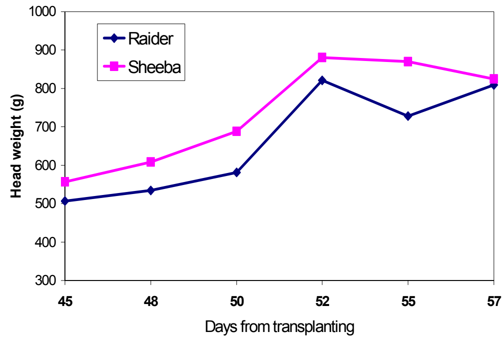


Figure 8.6(b). Bulking up rate of two lettuce varieties planted at Manjimup in December.

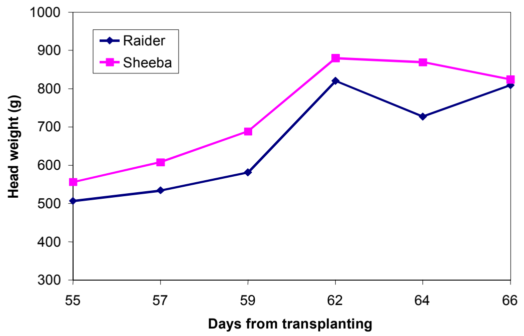


Figure 8.6(c). Bulking up rate of two lettuce varieties planted at Manjimup in January.

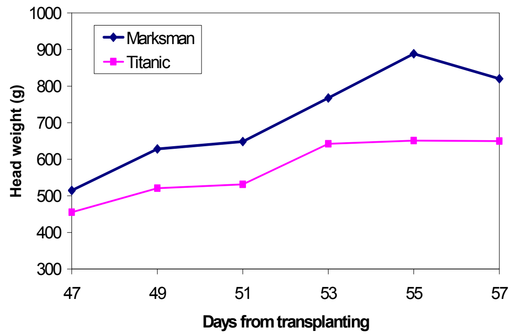


Figure 8.6(d). Bulking up rate of two lettuce varieties planted at Manjimup in February.

INVESTIGATION AND ANALYSIS OF ATTRIBUTES FOR PROCESSING LETTUCE

Core size

Materials and methods

The proportion of core to head is important as it impacts on the recovery rate for the processor. A smaller proportion of core is more desirable. Nine varieties of lettuce were used in this series of experiments. Core weight and core percentage was derived for each head harvested. The results were analysed using a log transformation.

Results

There were significant differences between varieties ($p < 1$ per cent). Overall, Oxley had the smallest proportion of core. Sheeba, Raider and Casino had the largest. The maximum difference amounted to just over 2 per cent of head weight or for an 800 g lettuce, about 20 g. Whilst statistically significant, on a lettuce price of 70 cents per kilo this amounts to only $17/tonne and therefore is not a significant factor in cost or production.

Table 8.3. Summary and analysis of lettuce core from trials at Medina and Manjimup Research Stations

Variety	Number of samples	Mean core weight	Per cent core by weight (mean of all samples)	Mean core weight (scores 3, 4, 5 only)	Per cent core by weight (scores 3, 4, 5 only)
Oxley	863	19.13	3.997[a]	18.78	3.99
LE 169	1406	23.41	4.667[b]	25.38	4.8784
Silverado	788	27.68	4.943[bc]	31.57	5.539
Titanic	96	25.04	5.154[cd]	41.72	6.866
Marksman	1147	34.75	5.441[de]	37.03	5.475
Magnum	608	28.17	5.461[de]	38.06	5.976
Casino	527	32.26	5.770[ef]	41.46	6.272
Raider	1065	39.04	5.983[f]		
Sheeba	1172	40.76	6.054[f]	33.43	5.298

ANOVA on $\log_{10}$ transformed data.

PREDICTION OF DENSITY

Materials and methods

One of the objectives of the work was to try and derive some kind of empirical measure of lettuce head density as it pertains to processing. The current method is subjective and consists of palpating heads in the field. Given that lettuce heads are basically spherical, one estimate we tried was to measure density using a mathematical formula (density = mass/volume). Mass was head weight in kilograms. This was divided by our estimate of the volume of the lettuce head. First we measured head width and length. If the head was not round we measured width in two directions at right angles and averaged it, then applied the formula for volume of a sphere ($4/3\pi r^3$).

Each lettuce head in a series of lettuce variety by time of harvest split plot trials was assessed for quality using a subjective score (hereinafter called 'density score'). Two objective measurements of lettuce density were also made on each lettuce. Density 1 used the gross lettuce head weight while density 2 used the head weight minus the core weight.

Over the duration of the trial we also recorded our subjective measure of density on a scale (see Table 8.4). For the purposes of statistical analysis this was converted to an ordinal scale of 1-7.

Table 8.4. Rating system for subjective density measurement of lettuce and its conversion to an ordinal score on the right

Rating	Interpretation	Score
<<	Very immature and under-dense	1
<	Under dense	2
< OK	Slightly under-dense but still acceptable	3
OK	Optimum density	4
OK >	Slightly over-dense but still acceptable	5
>	Over dense	6
>>	Very dense	7

A linear mixed model was fitted to the objective density data using the REML procedure in GenStat. The model included fixed effects for variety, density score and variety x density score, and random effects for trial, replicates within trial, main plot error and subplot error. The fixed effects allow for different linear relationships between density and density score for each variety. The model also allowed for a different residual variance for each variety since the physical differences between varieties might have some effect on this. Note that the statistics R^2 is not available for these models.

Residuals in the model were checked for normality and constant variance using residual plots.

Results

Density1

Density scores were transformed using a logarithm to stabilise variance. Five outlying density values were removed as were densities for Oxley in the May planting at Medina which seemed to be anomalous. A plot of the relationship between Log_eDensity1 and density score (Figure 1) indicates that some varieties have higher densities ($p < 0.001$) than others and that there is a linear relationship between Log_eDensity2 and density score ($p < 0.001$). The slope of the regression line changes with variety ($p < 0.001$).

Figure 8.7. Silverado at optimum density.

Figure 8.8. Titanic with long core due to bolting.

Figure 8.9. Marksman at optimum density but lopsided.

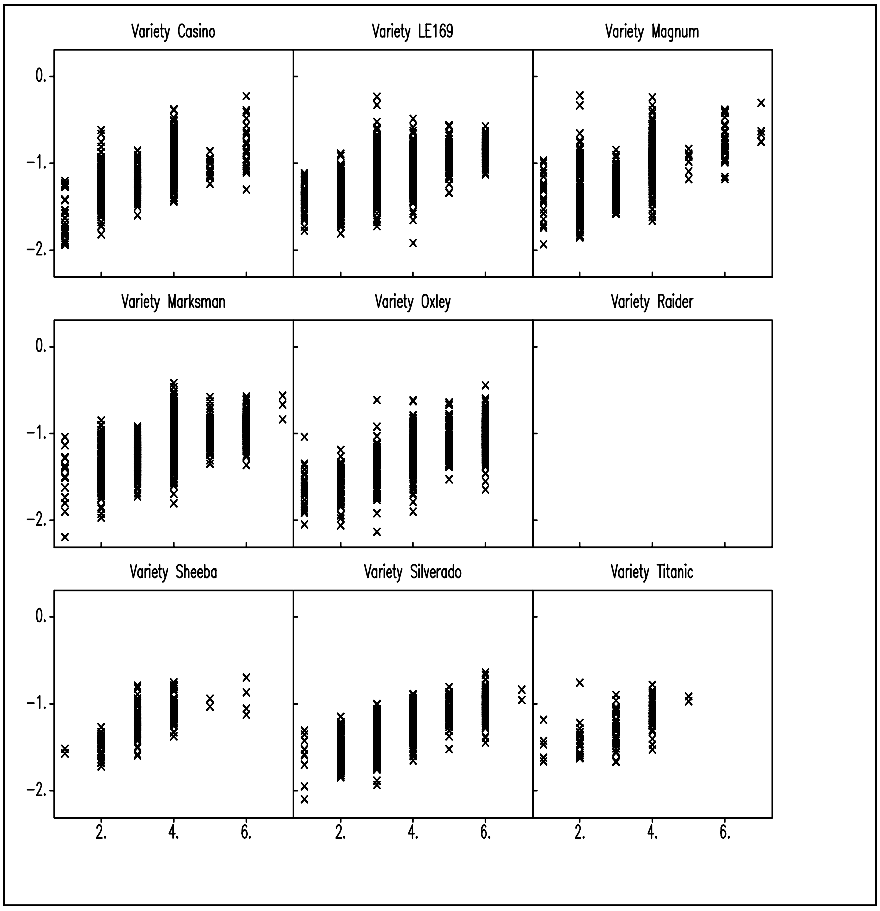


Figure 8.10. Log$_e$Density1 vs density score.

Because it appeared that there might be slight differences in residual variance between varieties, linear mixed models were fitted to the data for each variety (Table 8.5). Errors of prediction when predicting density score from density2 have not been calculated but, from the graphs, will clearly be of the order ± 1 or ± 1.5 for most varieties.

Table 8.5. Linear regressions for each variety

Variety	**Linear regression**	**Significance**
Silverado	Log$_e$Density1 = - 1.283 + 0.106 x density score	< 0.001
Titanic	Log$_e$Density1 = - 1.221 + 0.131 x density score	< 0.001
Sheeba	Log$_e$Density1 = - 1.204 + 0.141 x density score	< 0.001
Oxley	Log$_e$Density1 = - 1.202 + 0.146 x density score	< 0.001
Magnum	Log$_e$Density1 = - 1.174 + 0.109 x density score	< 0.001
Marksman	Log$_e$Density1 = - 1.134 + 0.112 x density score	< 0.001
LE169	Log$_e$Density1 = - 1.133 + 0.122 x density score	< 0.001
Casino	Log$_e$Density1 = - 1.107 + 0.097 x density score	< 0.001

Density2

Density scores were transformed using a logarithm to stabilise variance. Five outlying density values were removed as were densities for Oxley in the May planting at Medina which seemed to be anomalous. A plot of the relationship between Log_eDensity2 and density score (Figure 8.11) indicates that some varieties have higher densities ($p < 0.001$) than others and that there is a linear relationship between Log_eDensity2 and density score ($p < 0.001$). The slope of the regression line changes with variety ($p < 0.001$).

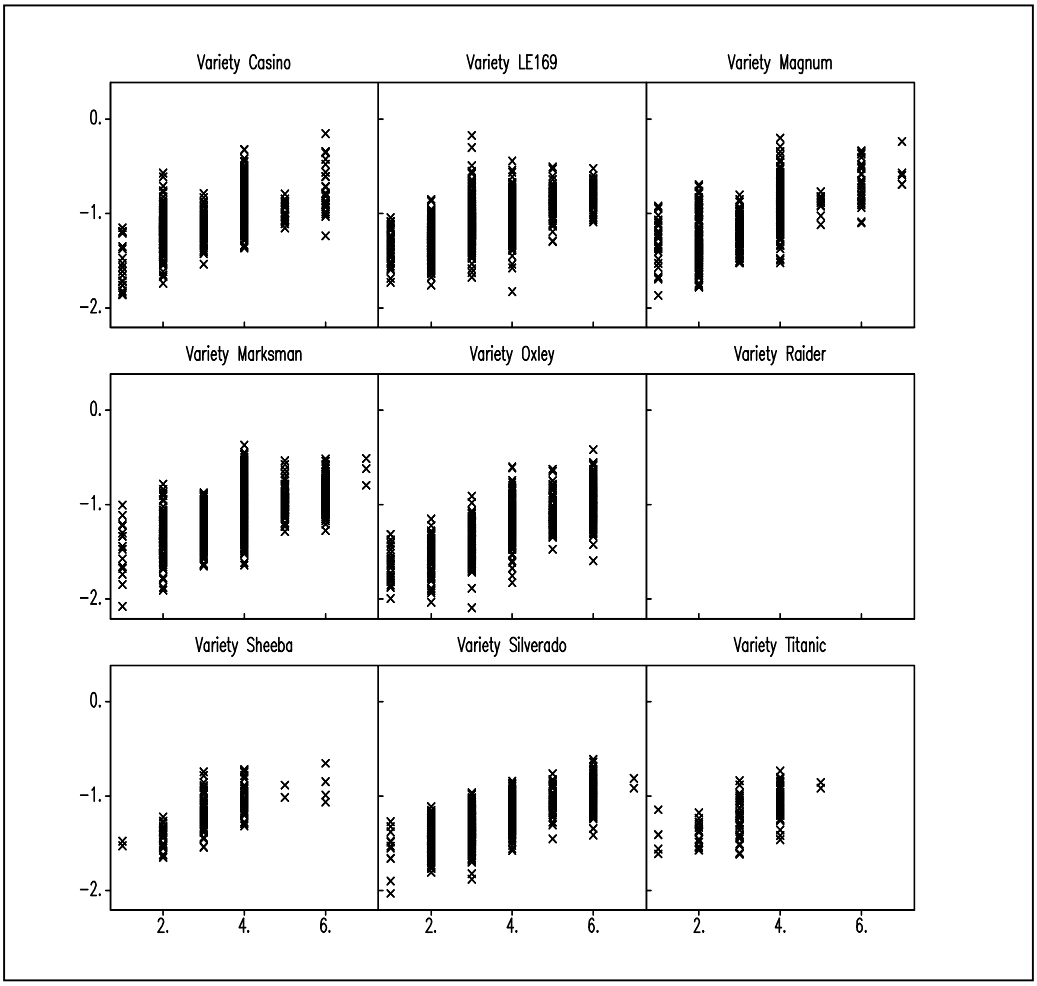


Figure 8.11. Log_eDensity2 vs density score.

Because it appeared that there might be slight differences in residual variance between varieties, linear mixed models were fitted to the data for each variety (Table 8.6). Errors of prediction when predicting density score from Density2 have not been calculated but, from the graphs, will clearly be of the order ± 1 or ± 1.5 for most varieties.

Table 8.6. Linear regressions for each variety

Variety	Linear regression	Significance
Silverado	Log_eDensity2 = - 1.228 + 0.106 density score	< 0.001
Titanic	Log_eDensity2 = - 1.184 + 0.143 density score	< 0.001
Oxley	Log_eDensity2 = - 1.160 + 0.154 density score	< 0.001
Sheeba	Log_eDensity2 = - 1.154 + 0.139 density score	< 0.001
Magnum	Log_eDensity2 = - 1.114 + 0.122 density score	< 0.001
LE169	Log_eDensity2 = - 1.084 + 0.122 density score	< 0.001
Marksman	Log_eDensity2 = - 1.078 + 0.112 density score	< 0.001
Casino	Log_eDensity2 = - 1.046 + 0.097 density score	< 0.001

Conclusion - density measures

Although there is no objective measure of the comparison of density1 and density2 as a predictor of density score, it is clear from the graphs that there is very little difference between the two.

A prediction of density score from an objective measure of density will be within 1.5 units of the assessed score 95 per cent of the time. This is not accurate enough to be an acceptable substitute at this point in time for the subjective score.

A better measure of head density than an arithmetical calculation may help to improve the accuracy of prediction of density score. Until a better method can be devised, estimation of the suitability of lettuce heads for processing will have to remain subjective.

PREDICTION OF OPTIMUM HARVEST TIME

One of the aims of this work was to be able to predict the optimum harvest window according to variety and time of year. As previously explained, each planting was picked over six separate harvests. Depending on the time of year, this generally covered a two week period, however during summer this was as little as six days. Lettuce head weights generally increased at rates up to about 50 g per day in the cooler months, but up to 100 g per day in summer. In the latter stages of lettuce growth, head dimension remains constant so this means density is increasing, often dramatically, during this period.

Materials and methods - predicting harvest

Initially, only head width and length were measured but as the trial proceeded it was decided that some subjective measure of density was needed to compare with our derived empirical measure. Therefore from February on, at each harvest, both subjective and objective measures of head density were made. Lettuce was deemed 'marketable' in any of the grades 3, 4 or 5.

Results - predicting harvest

The graphs in Figure 8.12 (i) to Figure 8.12 (xxx) show the bulking up rate of lettuce heads in terms of the weight of lettuce that was marketable at each harvest date. The total weight harvested from each plot at each date is depicted (black line), as well as the weight in grades 4 (red line) and grades 3 plus 4 plus 5 (blue line). Table 8.6 is a further compilation of this data which is summarised and tabulated in terms of the yield per hectare that would have been harvested at each date. For some varieties and times of year, the window of opportunity for harvest was as little as one day. At other times of the year, there may have been a whole week where the crop could have been harvested. At critical times of the year where the crop is growing fast, a judicious delay in selection of harvest date can make a difference of as much as 13 t/ha in yield (February planting of Marksman - days 47 to 49, or July planting of LE 169, days 69 and 71). At 70 c/kg this is an additional $9,100/ha in income for no extra work.

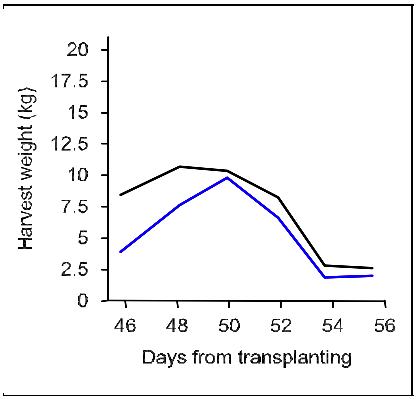


Figure 8.12(i). November planting of Casino at Manjimup.

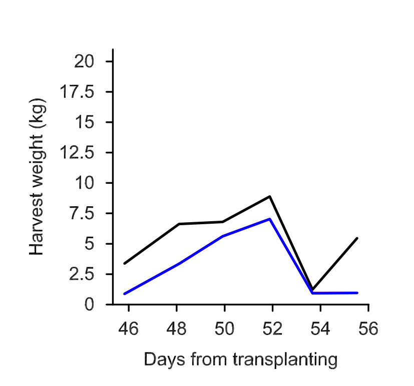


Figure 8.12(ii). November planting of Magnum at Manjimup.

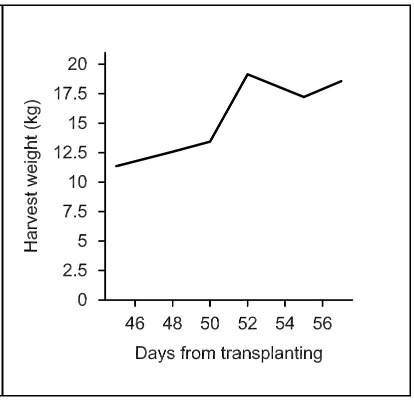


Figure 8.12(iii). December planting of Raider at Manjimup.

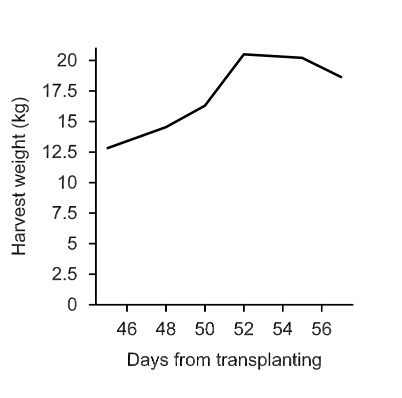


Figure 8.12(iv). December planting of Sheeba at Manjimup

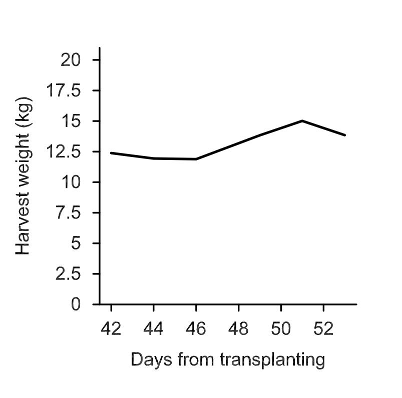


Figure 8.12(v). January planting of Raider at Manjimup

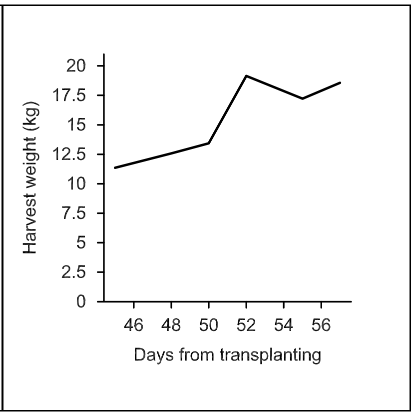


Figure 8.12(vi). January planting of Sheeba at Manjimup

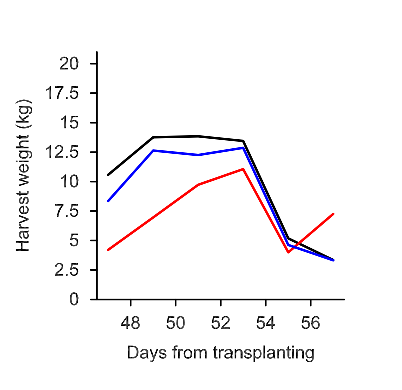


Figure 8.12(vii). February planting of Marksman at Manjimup.

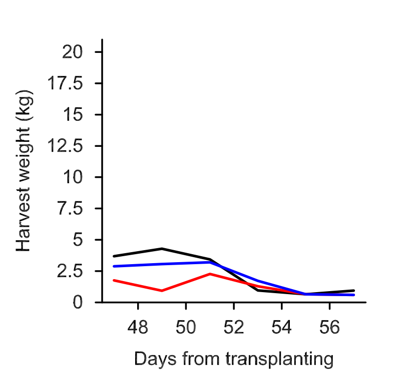


Figure 8.12(viii). February planting of Titanic at Manjimup.

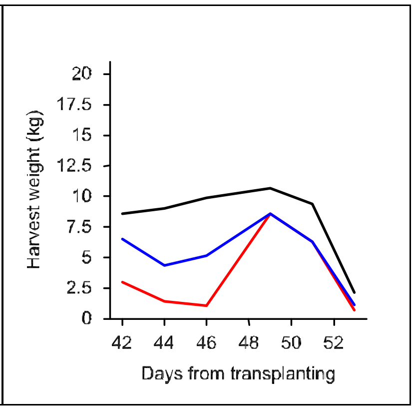


Figure 8.12(ix). February planting of Marksman at Medina.

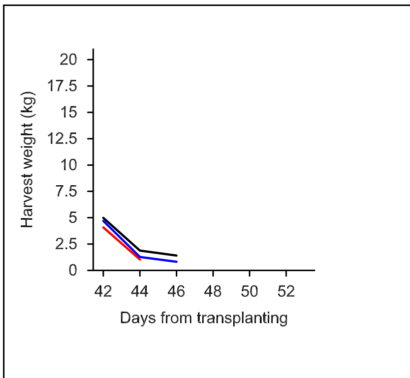


Figure 8.12(x). February planting of Silverado at Medina.

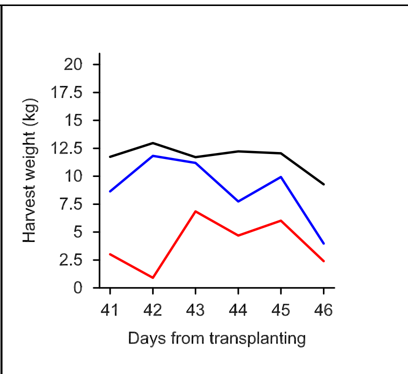


Figure 8.12(xi). March planting of Marksman at Medina.

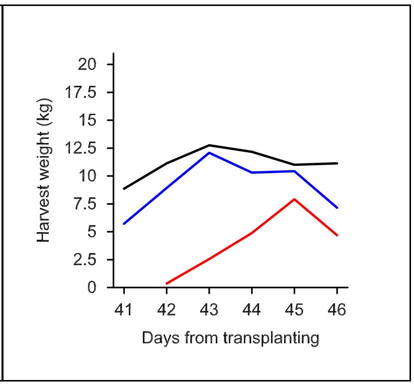


Figure 8.12(xii). March planting of Silverado at Medina.

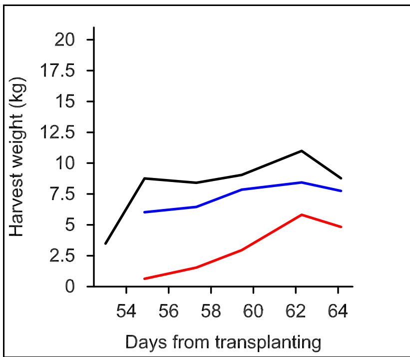


Figure 8.12 (xiii). April planting of LE169 at Medina.

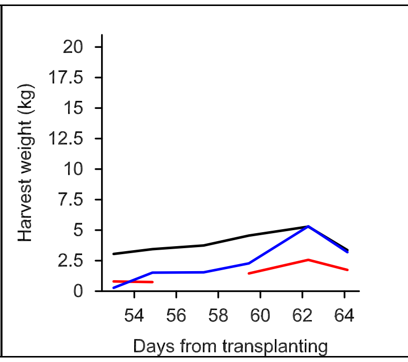


Figure 8.12 (xiv). April planting of Oxley at Medina.

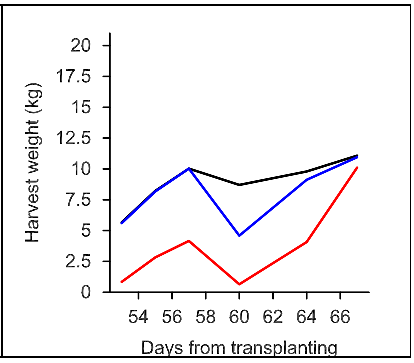


Figure 8.12 (xv). May planting of LE 169 at Medina.

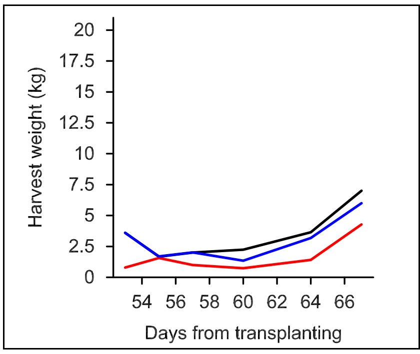


Figure 8.12(xvi). May planting of Oxley at Medina.

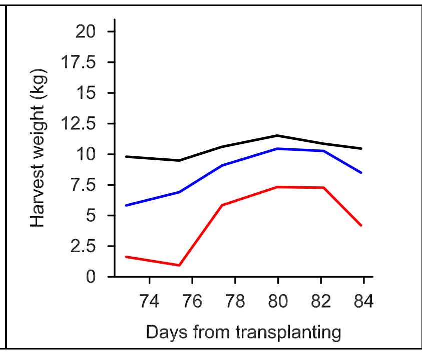


Figure 8.12(xvii). June planting of LE 169 at Medina.

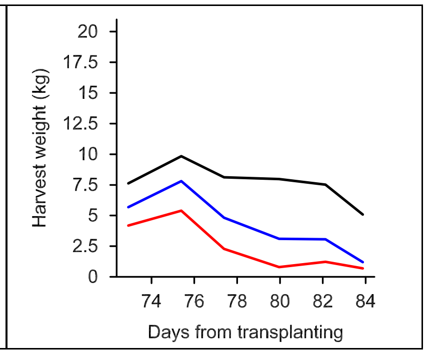


Figure 8.12(xviii). June planting of Oxley at Medina.

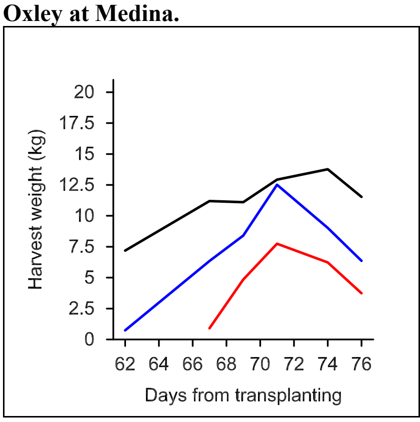


Figure 8.12(xix). July planting of LE 169 at Medina.

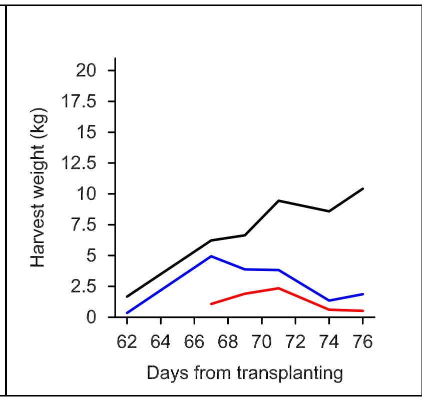


Figure 8.12(xx). July planting of Oxley at Medina.

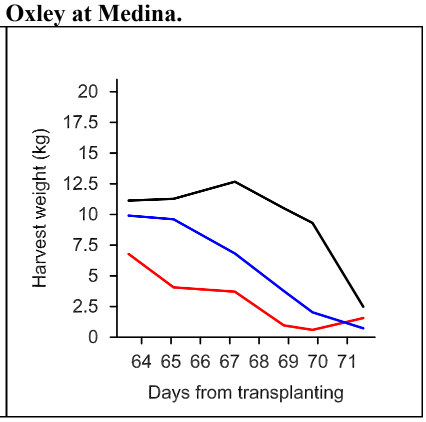


Figure 8.12(xxi). August planting of Marksman at Medina.

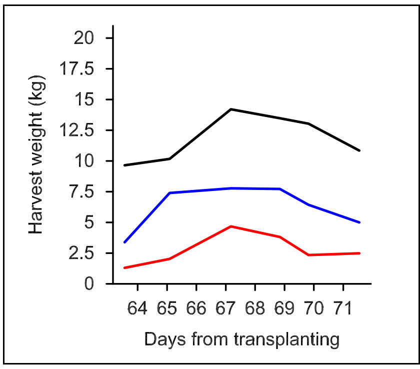


Figure 8.12(xxii). August planting of Silverado at Medina.

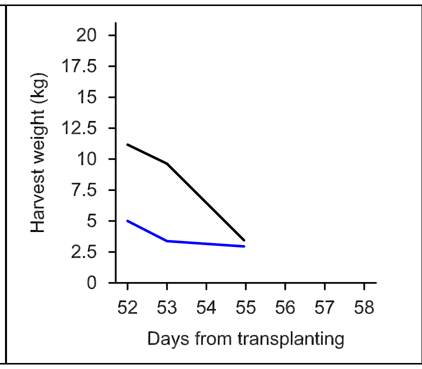


Figure 8.12(xxiii). September planting of Casino at Medina.

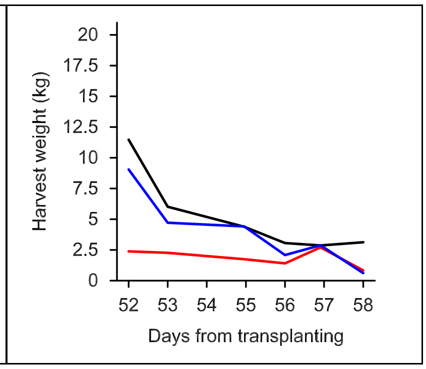


Fig. 8.12(xxiv). September planting of Magnum at Medina.

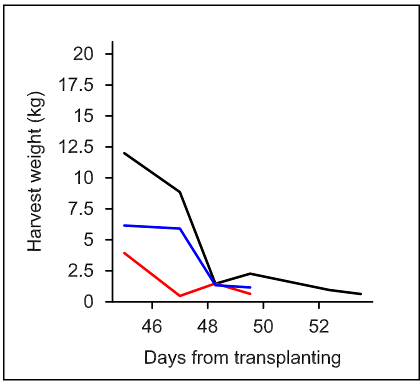


Figure 8.12(xxv). October planting of Casino at Medina.

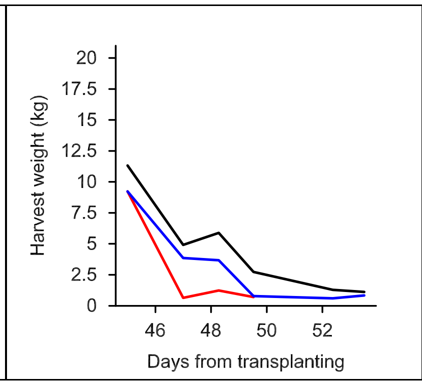


Figure 8.12(xxvi). October planting of Magnum at Medina.

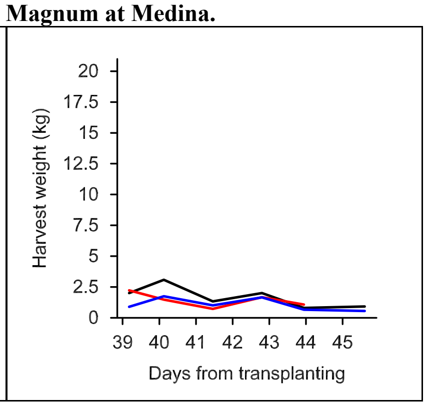


Figure 8.12(xxvii). November planting of Magnum at Medina.

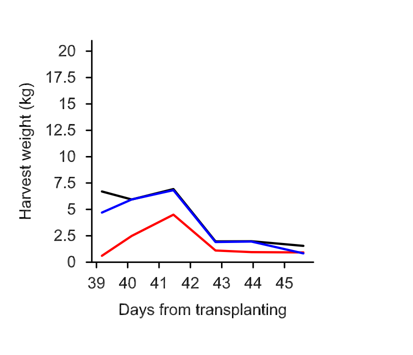


Figure 8.12(xxviii). November planting of Sheeba at Medina.

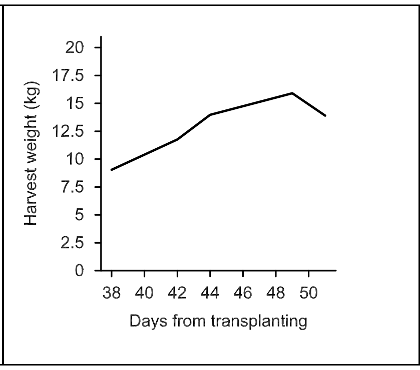


Figure 8.12(xxix). December planting of Raider at Medina.

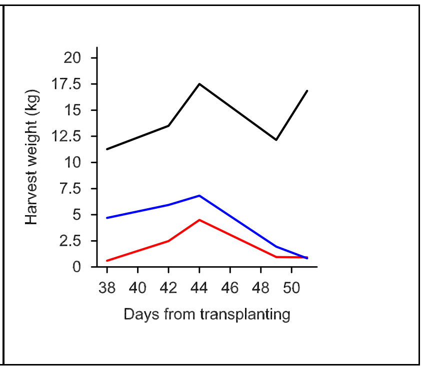


Figure 8.12(xxx). December planting of Sheeba at Medina.

Figures 8.12(i) to 8.12 (xxx). **Weights of lettuce harvested per plot (from a maximum of 24 heads per plot. Total lettuce weight (black), weight from grades 4 only (red) and weight of grades 3, 4 and 5 (blue) are depicted.**

Table 8.6. Harvest weights of heads with density scores 3-5 (tonnes per hectare) by location and variety. Days to maturity are in brackets

	Variety	Harvest number						Window for harvest (days)
		1	2	3	4	5	6	
Manjimup								
November	Casino	12.45	24.21 (49)	31.13 (51)	20.90 (53)	5.89	6.40	5
	Magnum	2.79	10.64 (47)	17.83 (49)	22.34 (51)	2.96	3.02	5
February	Marksman	26.47 (47)	39.25 (49)	38.89 (51)	40.84 (53)	14.70	10.56	7
	Titanic	9.12 (47)	9.70 (49)	10.14 (51)	5.45 (53)	2.04	1.87	7
Medina								
February	Marksman	20.47 (42)	13.82 (44)	16.27 (46)	27.20 (49)	19.81 (51)	3.58	10
	Silverado	14.92 (42)	4.02	2.61				1
March	Marksman	27.46	37.53 (42)	35.53 (43)	24.57	31.52	12.59	2
	Silverado	18.14	28.34	38.35 (43)	32.70 (44)	33.12 (45)	22.71	3
April	LE 169	0.00	19.12 (53)	20.49 (55)	24.91 (57)	26.77 (60)	24.61 (62)	10
	Oxley	0.87	4.81	4.89	7.24	16.86 (67)	10.14 (69)	3
May	LE 169	17.77 (53)	25.92 (55)	31.85 (57)	14.58	28.93 (64)	34.77 (67)	15
	Oxley	11.40	5.38	6.42	4.29	10.08	19.07 (67)	1?
June	LE 169	18.51	21.94	28.85 (73)	33.18 (76)	32.59 (78)	27.00	6
	Oxley	18.04	24.80 (80)	15.33	9.84	9.71	3.79	1?
July	LE 169	2.36	20.16	26.66	39.70 (71)	28.67	20.19	1?
	Oxley	1.12	15.70 (67)	12.32 (69)	12.14 (71)	4.26	5.92	5
August	Marksman	31.46 (63)	30.49 (64)	21.64	11.91	6.44	2.31	2
	Silverado	10.71	23.48 (66)	24.67 (68)	24.49 (70)	20.40 (71)	15.88 (72)	7
September	Casino	15.90 (52)	10.70 (53)	9.37 (54)	19.93 (55)	0.00	0.00	7
	Magnum	28.72 (52)	14.93	13.98	9.13	6.58	1.95	1
October	Casino	19.53 (45)	18.74 (47)	4.25	3.67	0.00	1.57	3
	Magnum	29.28 (45)	12.24	11.66	2.49	1.91	2.65	1?
November	Magnum	2.83 (38)	5.56 (39)	3.19 (40)	5.29 (41)	2.09 (42)	1.76 (44)	7
	Sheeba	14.94 (40)	18.87 (41)	21.69 (42)	6.05	6.20	2.63	3

? – harvests were >1 days apart so can't tell if should have been one day or two.

HEAD VARIABILITY

Some lettuce varieties seemed to be inherently variable. Table 8.7 summarises the recovery rates for the lettuce varieties we used as a function of site x planting month x variety. The data uses results from the best harvest out of the six (i.e. the one where the highest proportion of marketable lettuce was harvested - theoretically the optimum harvest time). The first column shows the percentage of lettuce in the density categories 3-5 out of the total number planted. The last set of columns shows breakdown of any crop losses. The balance of that is the percentage of lettuce harvested that fell outside the densities acceptable to the processor. Ideally this column should be zero. If a variety is highly variable then this figure can be high due to the range of maturities in the crop. This can occur if a variety is grown out of its ideal timeslot but in some cases the variety itself is inherently variable (e.g. Oxley for which the recovery rate never exceeded 71 per cent). This may not be such an issue for the fresh market but is unacceptable for anyone growing for the processing market where consistency is critical.

Table 8.7. Summary of lettuce recovery rates. Data taken from harvest with largest numbers of lettuce in grades 3 to 5

Site	Month of planting	Variety	% harvested out of number planted (n=72) in grades 3-5	% lettuce harvested outside grades 3-5	Misses	< 300 g	Disease	Malformed
Manjimup	November	Casino	90.3	6.9	2	0	0	0
Medina	September	Casino	54.2	41.7	1	2	0	0
Medina	October	Casino	66.7	26.4	3	2	0	0
Medina	April	LE16	77.8	9.7	3	3	1	2
Medina	May	LE16	100.0	0.0	0	0	0	0
Medina	June	LE16	88.9	6.9	2	1	0	0
Medina	July	LE16	93.1	6.9	0	0	0	0
Manjimup	November	Magnum	72.2	19.4	2	4	0	0
Medina	September	Magnum	95.8	2.8	0	1	0	0
Medina	October	Magnum	72.2	20.8	0	5	0	0
Medina	November	Magnum	86.1	5.6	2	1	3	0
Manjimup	February	Marksman	94.4	4.2	1	0	0	0
Medina	February*	Marksman	52.8	13.9	24	0	0	0
Medina	March	Marksman	91.7	4.2	0	3	0	0
Medina	August	Marksman	75.0	9.7	0	6	1	4
Medina	April	Oxley	58.3	4.2	0	0	4	23
Medina	May	Oxley	59.7	9.7	8	6	0	8
Medina	June	Oxley	70.8	16.7	1	8	0	0
Medina	July	Oxley	45.8	15.3	1	0	25	2
Medina	November	Sheeba	87.5	6.9	2	2	0	0
Medina	February*	Silverado	52.8	1.4	10	23	0	0
Medina	March	Silverado	90.3	5.6	1	1	0	1
Medina	August	Silverado	59.7	37.5	0	2	0	0
Manjimup	February	Titanic	81.9	9.7	4	2	0	0

* There was some residual tomato spotted wilt virus infection in this crop which killed some plants at a very early stage and is also believed to have stunted crop growth.

Materials and methods - variability

This issue of variability was investigated further by comparing data collected from trials on grower's properties with that collected from our work at both research stations. The analyses compared variance in head weights and looked at whether there was any effect of month of planting, variety or harvest. The effect of fertiliser programs on crop variability was also examined by analysing data collected from those trials which involved a series of trials where our evolving mineral fertiliser program was compared with the growers own program. It was hoped that, over time, our program might not only produce a better crop but also a more uniform crop.

Average head weight, standard deviation (SD) between heads and SD as a percentage of the mean was calculated for each variety by harvest from experiments and grower trials. Relationships between mean and SD or %SD were examined.

A linear mixed model was fitted to %SD data from the Manjimup and Medina trials. Since only a smooth trend over time (which might be either an effect of season or experience) was of interest, month effects were initially modelled as a linear effect plus a smooth spline effect. However since neither the linear or spline effects of month were significant but there were significant effects of month not explained by these smooth effects, month was finally included in the model as a factor. Harvest effect within month and location were modelled as random effects. Average head weight and the percentage of heads rated between 3 and 5 were also included in the model but removed when found to be non significant. The final model fitted for testing fixed effects was:

Fixed terms: Location + Variety + Month + interactions

Random term: Harvest.Month.Location + Harvest.Month.Location.Variety

Non significant fixed effects were removed prior to estimating means. Plots of residuals were examined to confirm that the data was reasonably well behaved with respect to the assumptions required for linear mixed models.

Preliminary analysis of the yield and head weight data from all trials suggested that Standard Deviation increased with increasing head weight. However no relationship appeared to exist between mean head weight and %Standard Deviation at most sites and, as a result, this was chosen as the dependent variable for linear mixed modelling comparing times of year and varieties.

Results - variability

Analysis of the results of harvests from commercial crops as outlined in Chapter 6 showed that the Standard Deviation (SD) of head weight at harvest was consistently between 10 and 25 percent of the mean for the four growers tested (Figure 8.13). There was a trend to greater uniformity of head weight (lower %SD) for September to December harvests.

The results from fertiliser trials conducted on one grower's property over an 18 month period showed a range in %SD from 10 per cent to 45 per cent. Lowest SD’s were again recorded in the October to November period (Figure 8.14). The results presented in Figure 8.14 suggest that crops became more uniform with increasing mean head weight in the ‘Grower’ fertiliser trials. However low %SD at high head weights can also be explained by lower %SD in two trials in November and December 2001when head weights were high.

The graph for trials conducted at Medina RS for each month (Figure 8.15) shows that %SD for most trials ranged between 10 per cent and 30 per cent. There was a trend for lower %SD from September to March compared to the period April to August. However there was considerable variation in %SD values within each month for different dates of harvest.

No obvious differences in %SD could be demonstrated between varieties in the Medina trials (Figure 8.17).

The data for Manjimup (Figure 8.16) again showed a spread of %SD from 10 per cent to 30 per cent with no obvious trend by time of planting.

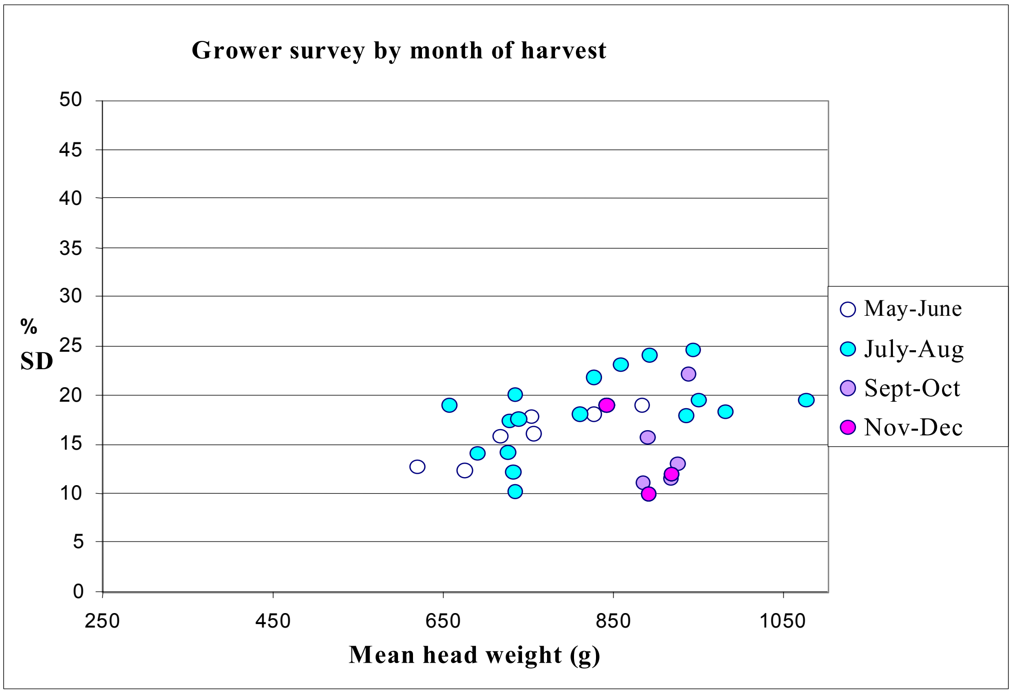


Figure 8.13. **Relationship between percent Standard Deviation of head weight (%SD) and mean head weight for the combined data from four commercial growers by month of harvest (see Chapter 6).**

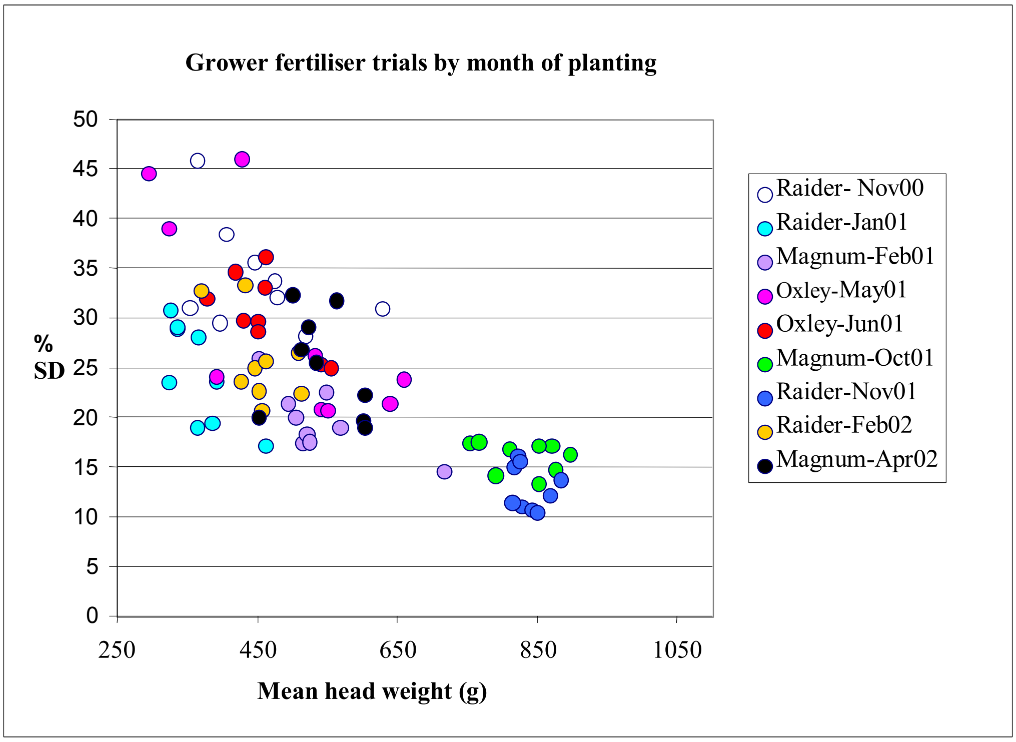


Figure 8.14. **Relationship between percent Standard Deviation of head weight (%SD) and mean head weight for the combined data from nine fertiliser trials on the property of a commercial grower by month of planting (see Chapter 7.1).**

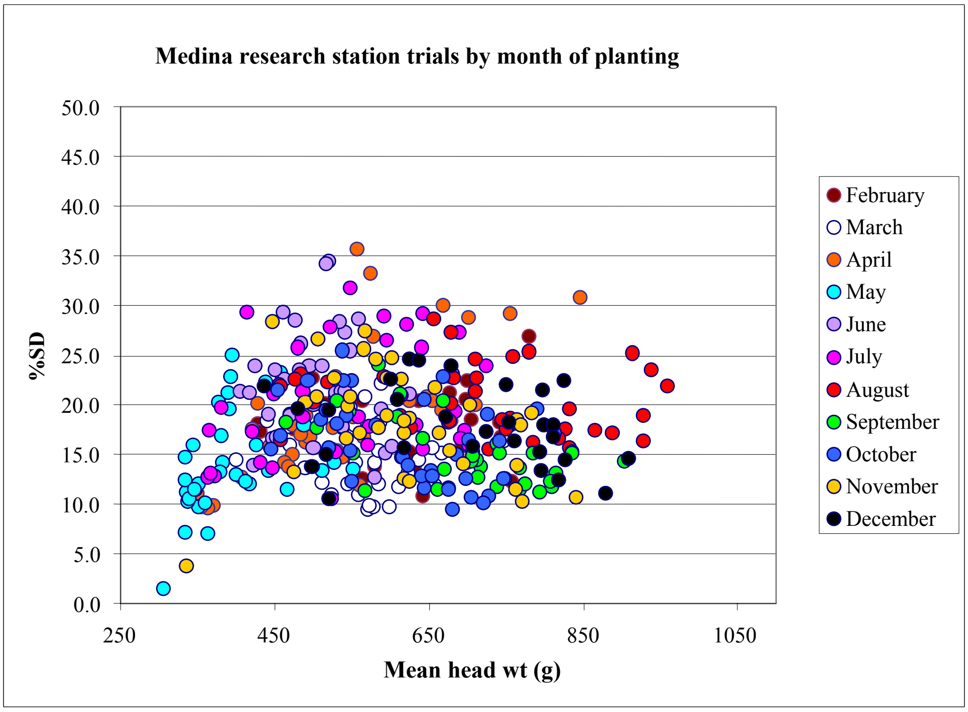


Figure 8.15. **Relationship between percent Standard Deviation of head weight (%SD) and mean head weight for the combined data from nine trials at Medina Research Station by month of planting.**

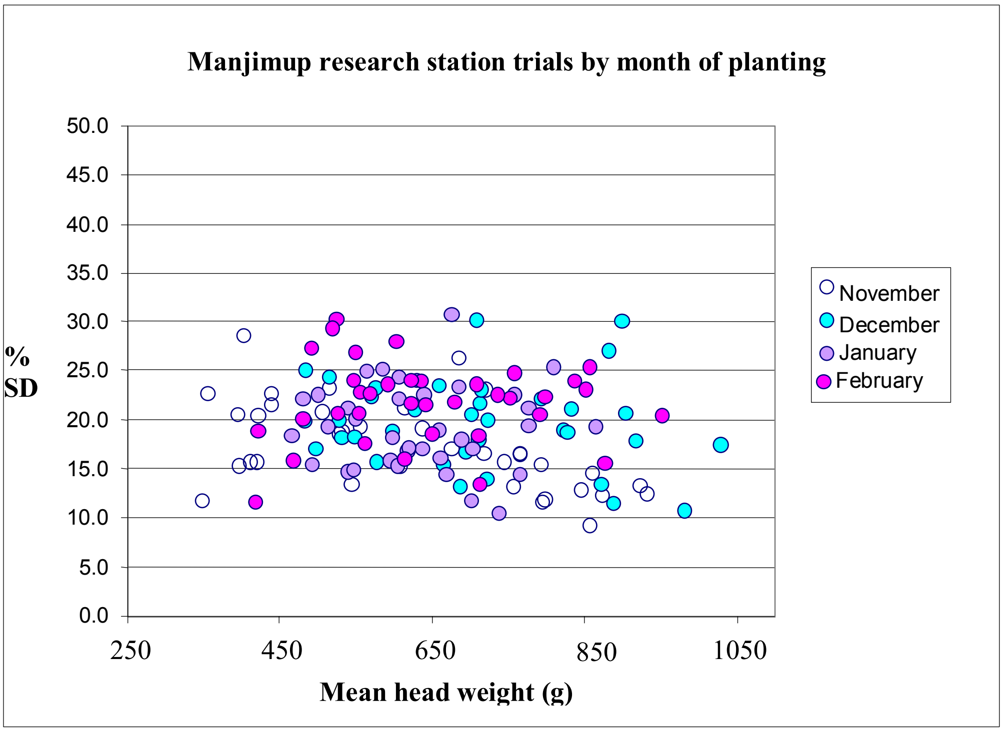


Figure 8.16. **Relationship between percent Standard Deviation of head weight (%SD) and mean head weight for the combined data from nine trials at Manjimup Research Station by month of planting.**

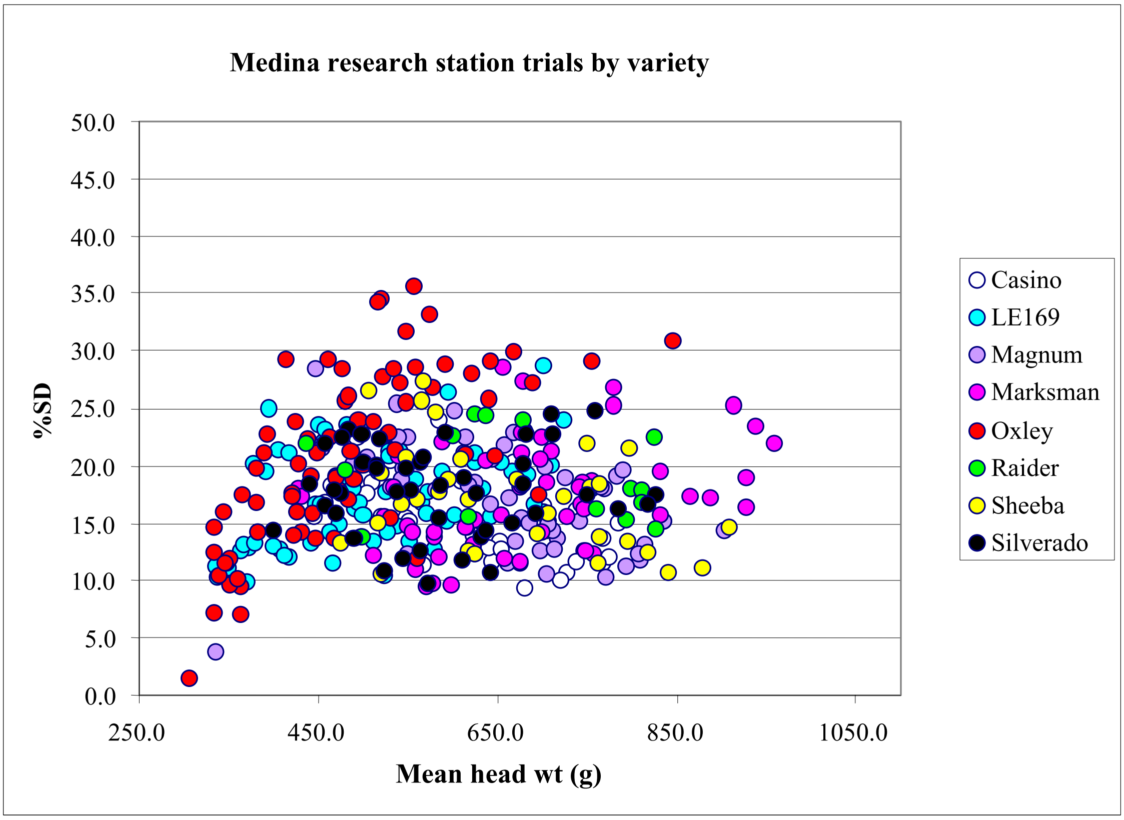


Figure 8.17. Relationship between percent Standard Deviation of head weight (%SD) and mean head weight for the combined data from nine trials at Manjimup Research Station by variety.

Statistical analysis of all the data was conducted as described and showed the following significant effects:

Wald tests for fixed effects

Fixed term	Wald statistic	d.f.	Wald/d.f.	Chi-sq prob.
Month	75.93	11	6.90	< 0.001
Location	2.71	1	2.71	0.100
Variety	32.19	6	5.36	< 0.001
Month.Location	2.72	2	1.36	0.256
Month.Variety	46.04	8	5.76	< 0.001
Location.Variety	0.33	1	0.33	0.565
Month.Location.Variety	0.00	0	*	*

All location effects were not significant and removed from the model prior to estimating Month by Variety %SD means and standard errors (SE's) shown in table 8.8 below. None of the varieties were consistently uniform over the times of planting tested, but uniformity may improve in the optimum time slot for each variety.

The data in Table 8.8 shows the average %SD over all dates of harvest for each variety. For each time of planting, there were up to six harvests spanning the range from too early (immature heads) to too late (over-mature).

Figure 8.18 shows the relationship between %SD (head uniformity) at the harvest dates that maximised marketable yield, i.e. the dates where the percentage of heads in maturity categories 3-5 inclusive were maximised. High marketable yields with low variability of head weight (low %SD) were achieved from LE169 planted in May, Magnum in September, Marksman in March, Silverado in March and Casino in November (Manjimup) as can be seen from those clustered at the lower right-hand corner of Figure 8.18.

Table 8.8. Percentage standard deviation (%SD) of lettuce varieties at each of the times planted at Medina RS and Manjimup RS over a 12 month period. Standard errors of difference (SE) of %SD are shown in brackets

Month	Casino	LE169	Magnum	Marksman	Oxley	Raider	Sheeba	Silverado	Titanic
January						17.18	21.45		
						(1.23)	*(1.23)*		
February				19.6				17.3	22.65
				(0.87)				*(1.69)*	*(1.21)*
March				13.28				15.81	
				(1.23)				*(1.23)*	
April		16.99			21.54				
		(1.23)			*(1.23)*				
May		15.98			13.23				
		(1.23)			*(1.23)*				
June		19.29			25.01				
		(1.23)			*(1.23)*				
July		17.36			23.16				
		(1.23)			*(1.23)*				
August				20.46				20.56	
				(1.23)				*(1.23)*	
September	16.37		14.49						
	(1.28)		*(1.23)*						
October	14.28		18.41						
	(1.23)		*(1.23)*						
November	15.61		19.11				17.75		
	(1.21)		*(0.87)*				*(1.21)*		
December						19.87	17.92		
						(0.92)	*(0.92)*		

Varieties in Table 8.8 can be compared in different months using a 5%LSD = $2 * \sqrt{(SE_1^2 + SE_2^2)}$ where SE_1 and SE_2 are standard errors for the two means being compared. For example, when comparing Casino and Magnum in the October planting at Medina, the 5%LSD is $2 * \sqrt{(1.23)^2 + (1.23)^2} = 3.48$. Casino was significantly more uniform (5% level) than Magnum in this trial.

The rest of the results shown in Figure 8.18 need to be tempered somewhat in light of other factors. For example the results for the February planting at Medina (Marksman and Silverado) are less than satisfactory due to a Tomato Spotted Wilt Virus infection which killed some young plants and lowered head weights of others. Other varieties performed poorly and seemed to be out of their ideal timeslot, such as Casino in September at Medina and both Casino and Magnum, in October. Silverado also performed poorly in two of the three plantings and seemed to be out of its ideal planting time.

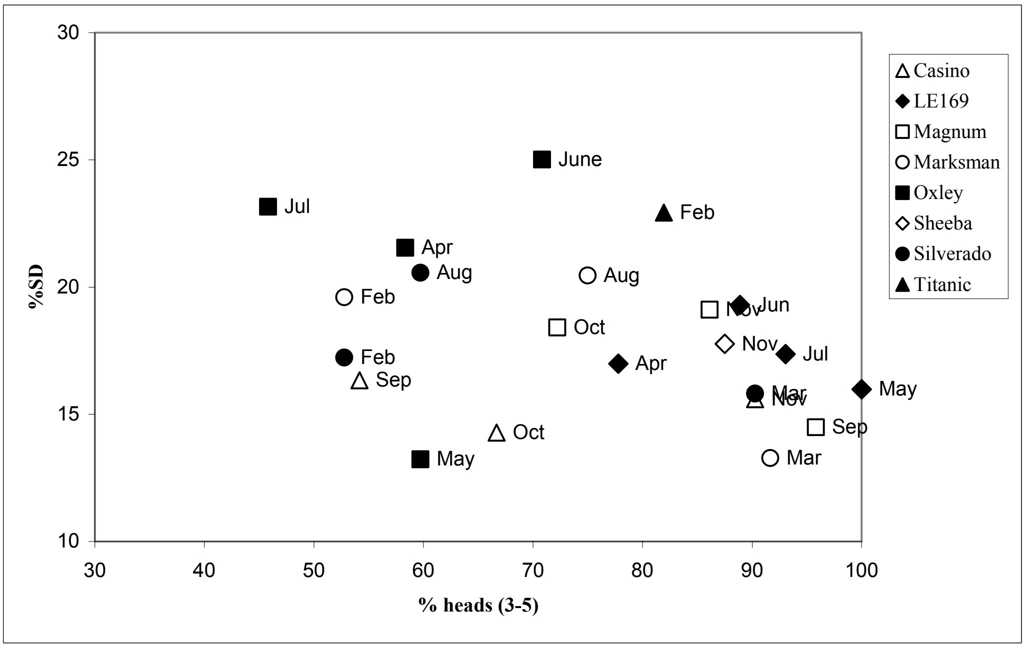


Figure 8.18. Percent SD and percent of heads in grades 3 to 5 inclusive (plant number =72) at the best time of harvest for each variety. The month of planting for each variety is shown in the legend.

Discussion

The research described here demonstrates that iceberg lettuce varieties are very sensitive to time of planting and climatic difference. It also shows that high yield of processing quality lettuce is critically dependent on accurate prediction of harvest date assuming the right variety is planted in its best time slot. Failure to correctly estimate the optimum time of harvest by as little as two days in summer could be the difference between a healthy profit and a loss because head weights and head density increase so rapidly near maturity.

Attempts to devise a simple objective measure of optimum head density for processing lettuce proved unsuccessful and were not well correlated with subjective measures. The method of calculating head density by assuming lettuce head volume can be calculated from the formula for volume of a sphere proved to be not well enough correlated with subjective assessment by eye to be reliable. The need to rely on subjective measures will continue to make it difficult for growers to accurately estimate the optimum time to harvest crops which will maximise their profit as well as maximising processing yield.

A common feature of lettuce across a range of varieties, in controlled experiments and in commercial crops was a high level of non uniformity of heads at harvest. This variability was commonly reflected in the standard deviation of head weight as a percentage of the mean of the order of 10 to 30 per cent. Our research showed that this measure of uniformity was no worse in relative terms for high yielding crops than for low yielding ones but it tended to be minimised when varieties were grown in their 'best' time slot and harvested at the optimum date. It was also less in spring and summer crops for the varieties adapted to these times of planting.

This lack of uniformity presents a great opportunity for improving marketable yields at a 'single pass harvest' if the reasons for it can be isolated and uniformity can be improved.

Recommendations

The research proved that for growers to maximise marketable yield and profit, they need to pay particular attention to estimation of the correct time to harvest the crop. At some times of year, this optimum window for harvesting can be as short as two days and may increase head weight 200 grams per head and profit by as much as $6000 per hectare compared to harvesting two days too early. It is recommended that growers conduct sample harvests of 20-50 heads per time in the days leading up to harvest to map the 'bulk up rate' of heads, in order to correctly predict when to harvest the whole crop. This exercise will more than pay for itself in increased yield and profit.

Growers will need to be trained in estimating the optimum time for harvesting crops for processing using subjective methods until a reliable objective test can be developed.

Variability of lettuce heads at harvest is a characteristic of all varieties tested which limits marketable yield. Further research needs to be done to elucidate the causes and find solutions in the quest to increase marketable yields. This observation suggests that there is considerable room for improvement of marketable yields in this crop.

At Medina (32° South Latitude), LE 169 planted in May and July, Marksman in March, Magnum in September and Silverado in March are high yielding and relatively uniform compared to other times of year. The same applies for Casino at Manjimup (34° South Latitude) in November. These varieties are recommended for planting at these times and locations until further work can be done.

9. BULK SHIPPING

9.1 BULK BIN AND PRE COOLING DEVELOPMENT

Introduction

As discussed in Chapter 4, one of the first tasks that the Lettuce Export Working Group set itself at their first meeting was to investigate the potential for reducing export freight costs.

The Working Group recognised from its inception that improving our export competitiveness would require efficiency gains beyond the farm as well as reduced production costs 'on-farm'. A very significant cost is incurred in sea or air-freight to the market. Air-freight to Singapore and Malaysia is particularly expensive, adding around $1/kg to the cost of the product. Sea-freight in cartons in a 20' reefer adds about 45 cents/kg while the cost is around 30 cents/kg in a 40' reefer.

It was clear that while our industry is restricted to 'spot marketing' using air-freight or shipping 'mixed sea container loads', we would be even less competitive than we could be if we could ship fully loaded 40' containers of lettuce.

One objective of our export plan was to reduce the costs of exporting. There were, and still are, several areas in which efficiencies could be gained. Lettuce is currently exported in cartons, which hold about 14 kg each. These have to be individually packed and handled, including manual stacking into reefers.

The Working Group included two processors with experience in shredding lettuce for supply to 'quick service' restaurants in Australia. Through their industry contacts, they identified market opportunities to supply their counterparts in South East Asia and the Middle East with the raw product. With current packing and handling techniques, WA grown lettuce was not often price competitive with product sourced from the USA in these markets.

The group set itself the task of finding a bulk container into which lettuce could be packed directly in the field as a way to reduce the landed price in these markets. This container needed to be palletised and so moved easily for pre-cooling, refrigeration and shipping without having to further handle the lettuce itself. The container also needed to be robust enough for field use and forklift handling yet comparable in cost to cardboard cartons as well as suitable for use on both harvest platforms and tractor forks. Other design constraints were:

- it should have dimensions which would utilise the space inside a reefer container optimally, both 20' and 40' reefers;
- not too deep so as to crush that lettuce in the bottom of the bin;
- it would afford protection of the product from contaminants such as dirt and wood splinters during harvest and handling;
- able to be cooled by forced air, or vacuum cooling; and
- it would minimise dehydration of outside leaves in the harvest, cooling and shipping process.

The search began with an investigation of returnable bin options, for hire and collapsible returnables. A range of non-returnable containers is also made by several companies in Australia. We canvassed the cardboard packaging industry to determine if there was anything currently available that would be suitable.

Although a number of cardboard and returnable packages showed potential, they suffered from one of a small number of fundamental flaws. Most cardboard non returnable packages were designed to fit the dimensions of the 'Australian Standard Pallet' and as such would not fit two wide across the internal space in refrigerated reefers used in Australia. Returnables either suffered from this flaw or cost too much. Other problems included the need for quarantine inspection on return to Australia and a certified 'closed loop supply' arrangement with the export buyer and no back-loading options from the destinations where markets had been identified.

The working group soon came to the conclusion that a custom made non-returnable bin was the most practical option to meet all the criteria we set, and a potential supplier showed a willingness to assist with design and supply of prototypes.

Table 9.1.1 details our list of contacts and the products of possible interest to us that were available 'off the shelf', plus options for a custom made product. The investigation of some cardboard products remained inconclusive because manufacturers or suppliers did not respond to requests for further information.

Table 9.1.1. Summary of bulk harvest and handling options

Manufacturer/supplier	Product	Dimensions	Material	Container fit	Features	Comments
Chep	Unicon	1170 mm x 1100 mm x 1073 mm	HDPP plastic panels, steel base and frame	2 wide, European standard	Stackable 5 high	Cost too high, no backloading to target markets.
Chep	Wire cage	Australian pallet	Wire, galvanised pipe	Don't fit	Stackable	No backload.
Carton Traders	Pallet Box	1165 mm x 1165 mm x 1000 mm(high)	Cardboard	Standard pallet size	Stackable	Clean 2nd hand, not used for produce before. Too wide for reefer.
Visy	Citrus King Pak	600 mm, 900 mm and 1800 mm high Also have one 610 mm high to stack 3 high.	Cardboard	Octagonal, fits two wide on Australian pallet only. Won't fit two wide in a reefer.	Octagonal, stackable with nailed pallet	No base, not robust enough to stack. Would need extra air vents.
Visy	Macadamia bin	1010 mm x 1010 mm x 960 mm high.	Cardboard	Fits European pallet - may be internal dimension	Stacks two high, has solid sides	Est $50 plus pallet. May not use reefer space optimally. Needs further investigation.
AMCOR	Carton manufacturers	COVPAK ISO	1093 mm x 1093 mm x 1074 mm with pallet, actual volume 1.04 m^3	Fits reefer		Would make to fit pallet size required. Price too high and lack of feedback from manufacturer.
Activ Industries	Bin maker	1165 mm x 1165 mm x 600 mm high	Wooden	Make to Australian pallet size		Prepared to make to order. Price favourable.
Pinetec	Pallet makers	Pallets for sea containers suggested 1120 mm x 1120 mm				Can make up a ply box. Requires further investigation.

Once the decision had been made to build prototypes of a non-returnable wooden bin, design considerations to minimise cost and maximise the utilisation of space in reefers became important. Discussions with shipping lines using Fremantle as a port of disembarkation for fresh produce revealed a wide variation of internal dimensions for reefers of 20' and 40' configuration. Heights to the load line inside 20' reefers typically ranged from 2000 mm to 2520 mm, widths from 2236 mm to 2304 mm and lengths from 5365 mm to 5549 mm. We could not design a single bin which would be compatible with reefers from all shipping lines.

Later in the project, the shipping agent used by one of our processors was Pacific Asia Express Pty Ltd and their shipping line, Pacific International Lines (PIL), were using 20' reefers with the following internal dimensions and bins were designed to fit these.

Height:	2520 mm	(load line)
Width:	2304 mm	
Length:	5506 mm	

For optimum use of space and lowest shipping cost per kg of lettuce we decided that 20 bins per container was optimal (two high, two wide and five long). The bulk bin we designed and have since used for the most recent export shipments (20' reefer) had the following dimensions:

Height:	1225 mm
Width:	1115 mm
Length:	1050 mm

After some 'land based' trial and error we decided on the following bin tolerances per container because it was not possible for all bins to be identical using pinewood construction:

Height:	70 mm	(35 mm bin)
Width:	74 mm	(37 mm bin)
Length:	255 mm	(51 mm bin)

Another lettuce processor and potential exporter used a Maersk Maxicube which is a 40' container. Its dimensions are:

Height:	2410 mm
Width:	2275 mm
Length:	11550 mm

A custom made bin for this container could be:

Height:	1200 mm	(load line)
Width:	1100 mm	
Length:	1130 mm	

with tolerances of:

Height:	10 mm	(5 mm/bin)
Width:	75 mm	(37.5 mm/bin)
Length:	500 mm	(50 mm/bin)

Eventually we decided to commission a bin to be made by Activ Industries (see Figure 9.1.3).

Pre-cooling and bulk storage - Trial 1: March 2002

This trial was conducted on a growers property in Wanneroo. We utilised lettuces from a pre-existing trial which were surplus to requirements. We picked and filled half a bin and this was placed in his coolroom for pre-cooling. This first run used room cooling only, no forced air cooling. We placed loggers throughout the bin and recorded temperature from the time the bins were placed in the coolroom until the next morning.

Results - Trial 1

The growers coolroom was not as cold as we had hoped (approx 7°C). From the initial core temperature of between 26.3 and 29.9°C, the lettuces took about 14 hours to cool down to the temperature of the coolroom (see Figure 9.1).

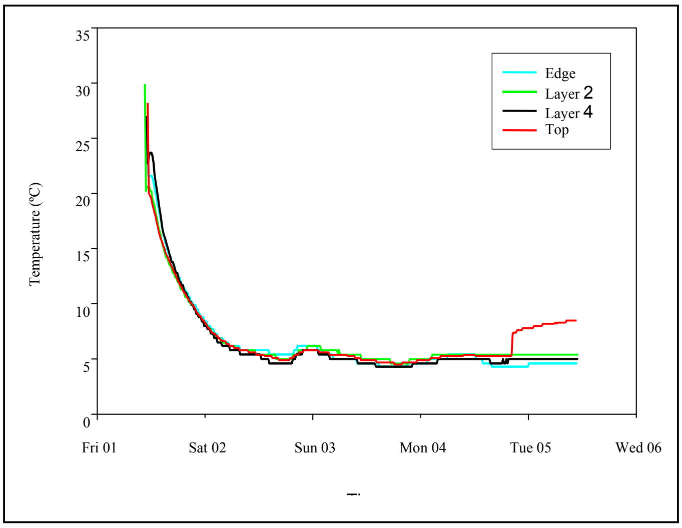


Figure 9.1.1. Cooling curves of loggers in four positions in a lettuce bin during room cooling.

Pre-cooling and bulk storage - Trial 2: April 2002

A series of prototypes with different dimensions and side rails were built before arriving at the final dimensions shown above. Our first prototype (1070 mm x1170 mm x1000 mm), first used in March 2002 aimed to test its cooling characteristics and cooling efficiency. This bin had three side rails equally spaced in the vertical direction, leaving gaps between rails of approximately 300 mm (Figure 9.1.2a).

Surplus lettuces (cv Raider) were harvested direct into two prototype bins from a trial at Medina Research Station. Tipburn was evident on the lower outer head leaves but the lettuces were internally sound. The bins held 400 and 425 heads of lettuce at a net weight of 330 kg and 360.6 kg respectively. The bins were transported to a growers premises at Wanneroo where they were subjected to forced air cooling in a 'state of the art' forced air cooler (Figure 9.1.2c).

The test compared one bin wrapped in open weave net wrap against the other which was wrapped in plain 20 micron polythene 'pallet wrap' (each wrapped at least three times around). These wraps had the effect of containing the contents of the bin within each of the 300 mm gaps between side rails on the bins. In addition each bin had a cardboard floor with 32 x 60 mm holes punched in for vertical airflow (Figure 9.1.2b). Initially we had had some concerns regarding the durability of the cardboard floor, however the test with the half filled bin in early March showed that the cardboard bin floor absorbed little moisture and should stay intact throughout storage and transport.

The open net wrap allowed airflow through the sides of the bins (Figure 9.1.2d) during forced air cooling but the pallet wrap did not.

After cessation of pre-cooling (15 hours), both bins were stored in the same cool room with the forced air fans turned off for 21 days and lettuce examined for deterioration at 7 day intervals. The net wrapped bin was covered with a polyethylene pallet bag during this period whilst the polythene wrap bin was left open at the top.

Figure 9.1.2a. Early prototype of bin with three rails.

Figure 9.1.2b. Underside of bin showing floor ventilation.

Figure 9.1.2c. Conventional forced air cooling of prototype bins.

Figure 9.1.2d. Net wrapped bin.

Results: Trial 2

We found both wraps extremely clumsy and time consuming to apply. Both bins bulged beyond the rail width in the 300 mm gaps between rails at harvest, suggesting that more support may be required in these zones, and the bins may need to be modified. The cheapest way to do this would be to put two pallet straps in each of these gaps.

To our surprise, there was negligible difference in the rate of pre-cooling between the two wraps and both bins reached 0.7°C from an initial core temperature at the completion of harvest of 14ºC, within 15 hours (Figure 9.1.3). Cooling within both of the bins was uniform, with lettuce in the centre of bins cooling as fast or faster than those exposed on the surface. This suggests that either floor ventilation in the plastic wrapped bin was adequate, or that conduction was more important than convection in cooling these dense packages of produce. Net wrapping was therefore discarded as an option because it would probably require a pallet bag to reduce dehydration during storage.

Given the success of the fully poly wrapped bin we felt a poly bin liner may work equally well. This would offset food safety concerns about contact between lettuce and wood in the bin. This is particularly so if conduction is the major factor in heat loss from the produce. The cardboard floor would complement the pallet bag to define the internal space in the bin for field harvesting operations.

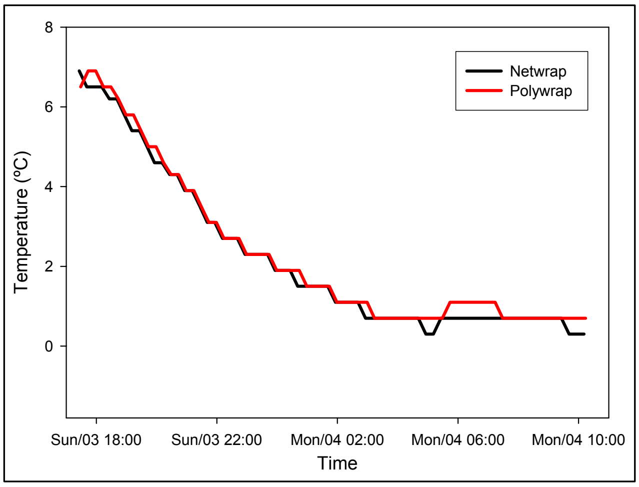


Figure 9.1.3. Comparison of cooling rates of net-wrapped bin versus poly-wrapped bin.

Pre-cooling and bulk storage - Trial 3: April 2002

The next step was to evaluate bins of different depths for handling in the field (Figure 9.1.4). We needed to determine whether there were problems in: (a) filling the bins; and (b) damage to the product at the bottom of the bin. Four bins of lettuce of depth 800 mm, 1000 mm 1100 mm, and 1200 mm were compared by filling them direct in the field at a grower's property. The tallest bin was 1200 mm high. This was the most efficient height for packing two high in a shipping container but was difficult to fill in the field. At the start of filling, lettuce could not be placed in the bin, but had to be dropped. To try and overcome some of the bruising that resulted from this practice we used a large piece of hardboard as a sled so that initially, the lettuce could be placed at the top of this board and it would then slide down to the bottom. This could be removed later as the bins progressively filled and the lettuce could be placed more gently in the bin (Figure 9.1.5).

Figure 9.1.4. The four bins side by side.

Figure 9.1.5. Sled in use while picking in the field.

The shipping line MAERSK were kind enough to loan one of the processor members of the Working Group a refrigerated CA container for a 21 day test to evaluate the post-harvest performance of the lettuce over a period of time equivalent to a sea journey to Kuwait. Two days later on 24 April, we used two of these bins of lettuce , 800 mm and 1000 mm (Figure 9.1.6) in a trial static shipment. The bins were both lined with a 50µ polythene bin liner and the pre-cooling was not forced air assisted. These bins were strategically placed within the container together with a number of standard plastic bins to make up the load (Figure 9.1.7). Temperature, humidity, CO_2 and O_2 were monitored over a 21 day period. At the end of the trial the lettuce was removed and processed by shredding at a processor in Munster. It was assessed for quality at the time of processing and after seven days in a vacuum pack.

Figure 9.1.6. **View of the two bin sizes (1200 mm and 800 mm high) used in the simulated shipping trials.**

Figure 9.1.7. View of shipping container packed with bins for the simulated shipment.

The other two bins from the four harvested were sent to another processor for processing (shredding) after eight days of conventional cooling and storage in the grower's coolroom.

Results - Trial 3

Despite the core temperature of the lettuce not being as low as we had wanted when the container was loaded (7°C rather than 1°C), the lettuce (cv. Casino) out-turned well at the end of the 21 day period. The sea container, in fact managed to pull the core temperature down to 0.3° within 48 hours of loading (see Figure 9.1.8).

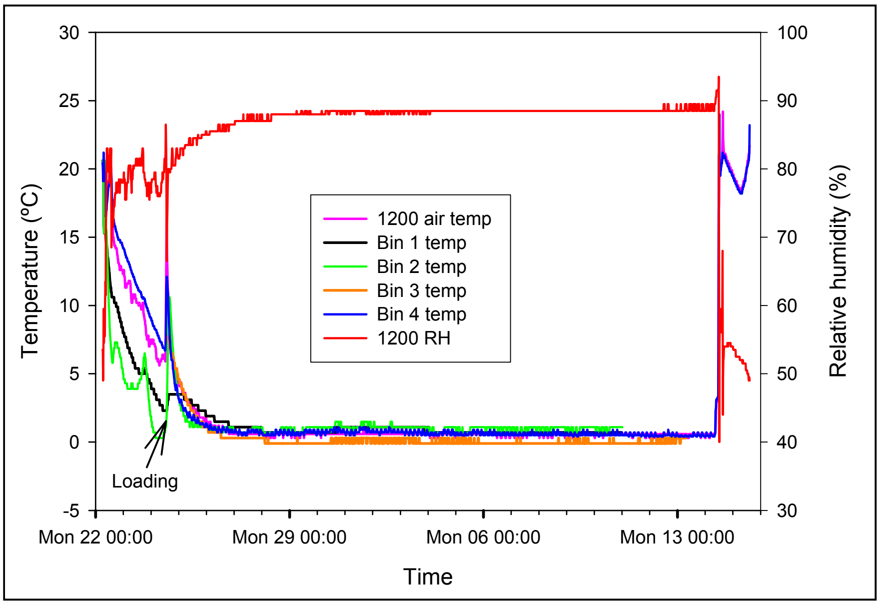


Figure 9.1.8. Cooling and humidity curves for simulated shipment to Kuwait on 24 April.

Processing was satisfactory and the product had acceptable shelf life.

The other two bins which were kept in the grower's coolroom and processed after eight days (to simulate a sea voyage to Malaysia) took 72 hours for the lettuce core temperature to fall from 15°C to 4°C. This time was undesirable for product quality and shelf life and illustrated the importance of an efficient method of pre-cooling compatible with these bins. The processing yield from the two bins was 60 per cent compared to the desired level of 68-70 per cent.

Microbiological and sensory tests were conducted by the processor at receival and after processing and the results of these tests are presented in the following tables.

Table 9.1.2. Raw product microbiological tests

Test date	SPC	Coliform	*E. coli*
30/04/02	27600	10	0

Table 9.1.3. Post shredding microbiological tests

Production date	Age of product	SPC	Coliform	*E. coli*
1/05/02	Production day (P)	22500	50	0
1/05/02	P+5	174000	410	0
1/05/02	P+7	1,300,000	120	0
3/05/02	P+5	19,100	7100	0
3/05/02	P+10	740,000	7800	0

Table 9.1.4. Sensory evaluation after shredding 0-9 hedonic scale 9 = maximum

Production date	Age of product	Odour	Appearance	Texture	Score
1/05/02	P+5	3.0	2.5	2.5	8.0
1/05/02	P+6	3.0	2.5	2.5	8.0
1/05/02	P+7	3.0	2.5	2.5	8.0
1/05/02	P+8	2.5	2.5	2.5	7.5*
1/05/02	P+9	2.5	2.5	2.5	7.5
1/05/02	P+12	2.5	2.5	2.5	7.5
1/05/02	P+13	2.5	2.0	2.5	7.0
1/05/02	P+14	2.5	2.0	2.5	7.0
1/05/02	P+15	2.5	1.5	2.5	6.5
3/05/02	P+5	2.5	2.5	2.5	7.5
3/05/02	P+6	2.5	2.5	2.5	7.5
3/05/02	P+7	2.5	2.5	2.5	7.5
3/05/02	P+10	2.5	2.5	2.5	7.5
3/05/02	P+11	2.5	2.5	2.5	7.5
3/05/02	P+12	2.5	2.0	2.5	7.0
3/05/02	P+13	2.5	2.0	2.5	7.0
3/05/02	P+14	2.5	2.0	2.5	7.0

* An aggregate score of 7.5 is considered adequate for sale.

Vacuum cooling in bins immediately after harvest is considered the ultimate post harvest treatment but the capital cost of around $400,000 is prohibitive for many growers. Therefore the next phase of the project was aimed at developing a low cost, effective handling and cooling protocol compatible with our disposable bulk bin configuration. We needed to test how much tolerance the product and the market has to pre-cooling method and identify the lowest cost most practical cooling and handling strategy which would allow us to ship to the target markets with confidence.

Forced air cooling - Trial 1: July 2002

A portable forced air cooling device which had previously been used for cooling experimental quantities of fruit was modified to enable vertical airflow through the bins of lettuce rather than the conventional horizontal flow.

The device consisted of a rectangular box made of sheet metal of dimensions 1.35 m high x 1.2 m wide x 0.4 m deep with a variable speed aerofoil exhaust fan, 24 cm in diameter and rated at 190 watts and 2700 RPM mounted on top. A slot matching the dimensions of the space formed by the bearers on the base of a bin (1035 mm wide x 100 mm high) was cut in one face of the box and fitted with a rubber gasket as shown in the accompanying photographs.

When the exhaust fan on this device was turned on and the inlet air slot was secured to the fork lift gap between a pair of bins stacked one on top of the other, air was drawn up through the floor of the lower bin, and down through the open top of the upper bin. This forced draught, created inside a working coolroom, rapidly cooled the lettuce contained within both bins at a uniform rate.

The airflow characteristics of the fan were measured using a handheld anemometer and pitot tube and found to be 543 litres/second at 43 km/hour under zero load. When attached to a two bin stack the flow rate dropped to 7-13 km/hour and 9-15 km/hour on a four bin stack. Under load, the airflow volume fell to 420 litres/second.

The desired air flow rate for optimal cooling of lettuce was 1 litre/second/kilogram of produce (Watkins 1985). With a two bin stack of around 800 kg total, the airflow rate was about half that recommended for cooling lettuce and the predicted 'seven eighths' cool down time was 550 minutes.

The first test of this cooling method was on 9 July 2002 at a growers property in Neerabup.

Figure 9.1.9a. Side view of the experimental forced air cooling assembly.

Figure 9.1.9b. Overview of same.

Three wooden bins (1100 mm x 1130 mm x 1200 mm) of lettuce heads cut for export/processing were placed in the growers coolstore at approximately 10.00 am. Two bins, one placed on top of the other, were 'forced air cooled' (see Figures 9.1.9a, b). Each bin contained temperature loggers which recorded core temperature using an external probe. Each logger had two probes, the left probe was placed in the core of a lettuce near the middle of the bin and the right probe placed in the core of a lettuce at the top of the bin. The bins were identified as either top bin or bottom bin.

The third bin (control) was not forced air cooled (FAC) but also had a temperature logger in place with two probes; left trace (middle of bin) and right trace (top of bin). Two further loggers (combined temperature/humidity) were placed, one on top of the control bin and the other on top of a forced air cooled bin.

The initial core temperature was observed to be 14.6°C measured using a hand held probe. The forced air cooler was switched on at about 10 am. The grower reported that by 3.00 pm of that day the loggers in the FAC bins were reading core temps of between 3 and 4°C. At 3.45 pm the top bin logger read left (middle of bin) 3.4°C and right (top of bin), 1.7°C. This was confirmed with hand held probe readings taken at various positions in the bin, of around 2.6°C. The control bin (not FAC) at the same time had core temps of about 7°C at the top of bin and about 12-13°C in the middle of the bin (hand held probe readings only). The forced air cooler was turned off at 3.50 pm.

The following day the three bins of lettuce were transported to the processor at Canning Vale for processing. The loggers were retrieved and the lettuce inspected prior to processing. The product looked in good condition and processed successfully.

Forced air cooling - Trial 2: August 2002

The principles established with the experimental fan outlined in the first trial were taken further by building a larger 48 cm diameter portable fan mounted on a trolley. This fan had the capacity to pre cool a multiple stack of bins, sufficient to prepare a full sea container for a trial shipment.

This fan moved five times the air volume compared to the experimental fan at 2700 litres/ minute under zero load at an airspeed of 54 km/hour. Under load, the volume dropped to 2030 litres/minute. At the recommended flow rate for lettuce of 1 litre/second/kilogram, this fan was predicted to operating optimally on a stack of between four and six bins.

This new fan was tested on 10 August at the same growers property at Neerabup. Four bins were loaded with lettuce and hooked up to the new fan.

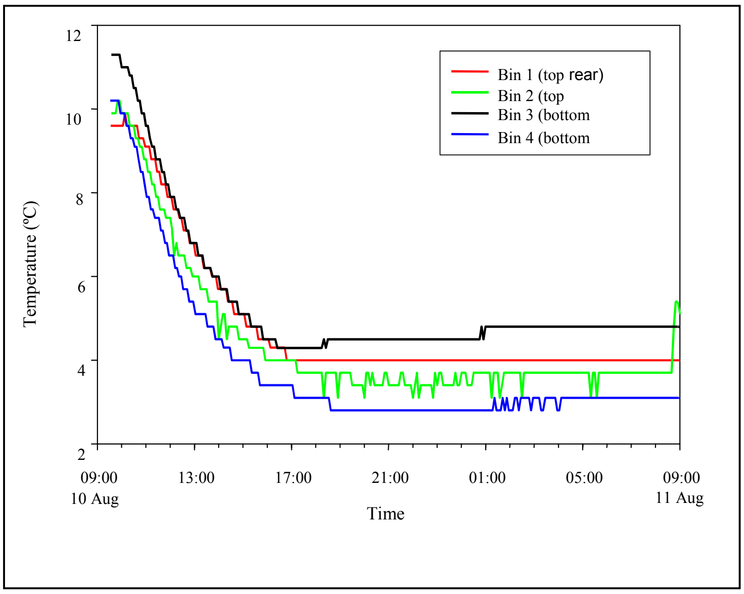


Figure 9.1.10. Cooling curves of four loggers placed in cores of lettuces in bins.

The cooling curves shown in Figure 9.1.10 show that the rate of cooling was slightly faster for the two bins closest to the fan (Bin 4 and Bin 2), with the lower bin (Bin 14), cooling fastest overall and reaching the absolute lowest temperature. The order of cooling was reversed for the two bins furthest from the fan (Bin 1 and Bin 3). This suggests an uneven temperature distribution in the coolroom.

Discussion

This series of trials demonstrated that it was possible to harvest and handle lettuce in bulk bins as deep as 1100 mm and holding up to 400 kg of lettuce each without unacceptable levels of damage to the product. Minor issues with dehydration of the outer leaves could be easily remedied by harvesting with an extra leaf on which can later be removed at the processors.

Traditional wisdom dictates that lettuce for long distance transport should be rapidly pre-cooled using vacuum cooling immediately after harvest. This cooling method is in widespread use by our export competitor, California. Vacuum cooling is efficient but also highly capital intensive, with a starting cost for a basic unit around $250,000. It is also expensive to run and typically results in around 5 per cent water (and weight) loss from the product in the cooling process.

The capital cost of vacuum cooling can only be justified by very large farming operations or shipping companies with access to a large production base. We did not have the luxury of allowing vacuum cooling to be a pre-requisite to exporting lettuce to SE Asia and needed to develop a simpler, cheaper method that was compatible with our smaller scale producers and existing infrastructure.

We developed and proved a modified form of 'forced air' cooling that was compatible with our bulk bin design. Development work showed that this method was quick and effective and simulated shipments showed clearly that storage periods of up to 21 days are tolerated well by lettuce after pre-cooling by this method.

Recommendations

The success of this series of trials gave us the confidence to proceed to the next stage of shipping lettuce to Malaysia using our protocol (see Section 9.3).

9.2 PLANNING SUMMER SUPPLY - BULK PLANTINGS AT MANJIMUP 2002

Introduction

Major yield and quality limitations include tip burn and bolting in summer grown crops and diseases such as big vein virus and sclerotinia in winter. Current production in Western Australia comes mainly from districts from Gingin to Baldivis 32°S latitude but Manjimup/Pemberton 34°S latitude is considered to be a better location for summer production due to its milder climate. WA based processors are increasingly sourcing their summer supplies from this area. Locations around Perth are preferred for spring and autumn production, and satisfactory for winter production in the immediate future.

At the time of writing, there were only three growers in this district growing lettuce for fresh or processing markets and all of them were struggling to make a profit from the crop due to low yields.

The aim of this part of the project was to demonstrate the principles and practices of growing lettuce profitably in Manjimup and at the same time producing quantities sufficient for two trial export shipments to Malaysia to further quantify the economics of bulk shipping of lettuce for processing overseas.

Materials and methods

Two plantings (16,000 plants each) were established, one month apart (10 December 2002 and 15 January 2002) at the Manjimup Horticultural Research Institute. The plantings of all but the variety Jefferson were seeded in trays at a commercial nursery in Perth on 13-14 November and 18, 19 December respectively. Jefferson was grown by a commercial seedling nursery in Manjimup and seeded 30 October and 2 December 2002 for respective plantings. The same mix of varieties was used for each planting (Sheeba - 10,000, Casino - 2,000, Saboteur - 2,000, Silverado - 1,000 and Jefferson - 1,000).

Sheeba was chosen as the bulk of the planting because it had performed well in small plot trials in the summer of 2001/02, Saboteur was a variety commonly grown by growers in Manjimup and Jefferson was nominated by the seed producer as its successor. Casino had performed well in a November 2002 planted small plot trial at the Research Institute and Silverado had given good results in the second trial shipment to Malaysia.

Other cultural and management practices were extrapolated from those used in previous small plot trials at Manjimup and nutrition studies conducted in Perth over the preceding two years.

Site preparation - Double superphosphate 2500 kg/ha and 200 kg/ha Keiserite, together with 1000 kg/ha Superspud was broadcast in strips over the site prior to planting. Metham sodium @ 500 L/ha was applied 14 days prior to transplanting on November 19 but was not used for the second planting in January. Nemacur 400® was applied at 24 L/ha seven days prior to planting. Five days before transplanting Stomp® was applied at 3 L/ha and followed with 12 mm of irrigation.

Seedling trays were drenched with 40 g/litre potassium nitrate at 500 mL/tray (100 cells) within one hour of planting. The seedlings were transplanted to give four rows under the tractor @ 300 mm between rows and 350 mm between plants. Immediately after transplanting Kerb was applied at 4.5 kg/ha (December planting only). Plots were irrigated one to three times a day for three days to a total of 9 mm per day depending on the weather. Fertiliser treatments (see Tables 9.2.1, 9.2.2) were started on the day after planting. There were some slight differences between these for the two plantings.

Table 9.2.1. Fertiliser regime for the December bulk planting demonstration

Week number	Date	Fertiliser	Rate	Comments
1	11 December	Urea	22.5 kg/ha	Sprayed but not washed in
		Potassium nitrate	20 kg/ha	Sprayed but not washed in
		Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	13 December	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
2	16December	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
	19 December	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
	20 December	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
3	23 December	Ammonium nitrate	200 kg/ha	Sprayed and washed in
	27 December	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
4	30 December	Ammonium nitrate	200 kg/ha	Sprayed and washed in
	31 December	Dominex®	400 mL/ha	Applied at night time
	3 January	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
5	6 January	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	9 January	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	10 January	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	

Table 9.2.3. Fertiliser regime for the January bulk planting demonstration

Week number	Date	Chemical	Rate	Comments
1	16 January	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
		Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	20 January	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
2	23 January	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
	24 January	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	28 January	Urea	22.5 kg/ha	Sprayed and washed in
		Potassium nitrate	20 kg/ha	Sprayed and washed in
3	30 January	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	31 January	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	3 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
4	6 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	7 February	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	10 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
5	13 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	14 February	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	17 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
6	20 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in
	21 February	Ambush®	15 mL/100 L	
		Mancozeb®	2 kg/ha	
		Pirimor®	0.75 kg/ha	
	24 February	Ammonium nitrate	100 kg/ha	Sprayed and washed in

Sample harvests were taken as each crop approached maturity (Tables 9.2.3 and 9.2.4).

Table 9.2.3. Head weights and maturity of lettuce from sample harvests from the first planting

Sample date	Variety	Mean head weight (g)	Comments
16 January	Sheeba	531.80	Immature
(37 days after planting)	Silverado	442.10	Very immature
	Jefferson	368 22	Very immature
20 January	Sheeba	660.40	Borderline immature
	Silverado	596.60	Immature
	Jefferson	490.78	Borderline immature
22 January	Sheeba	732.50	Ready
	Silverado	706.00	Still 50% immature
	Jefferson	475.40	Ready
	Saboteur	571.10	Mostly ready
	Casino	391.75	Immature
28 January	Sheeba	1089.73	Mostly too dense
	Casino	565.22	Ready

Table 9.2.4. Head weights and maturity of lettuce from sample harvests from the second planting

Sample date	Variety	Mean head weight (g)	Comments
26 February	Sheeba (advanced)	429.45	Ready
(42 days after planting)	Sheeba (immature)	< 300	Very immature
	Jefferson	472.50	Mostly ready
28 February	Sheeba	483.00	Ready
	Saboteur	454.36	Ready
	Silverado	534.80	About 50% still immature
	Casino	470.18	Mostly immature
4 March	Sheeba	552.77	Mostly ready, some over dense
5 March	Sheeba	712.00	About 50% over mature
	Silverado	650.92	Ready
	Casino	705.42	Ready

Harvesting of the December planting commenced on 22 January with Sheeba and concluded with Casino on 28 January. The first bay of Sheeba harvested had a very high rate of doubles which may have been due to the sudden change in temperature in the days after transplanting (see Tables 9.2.5 and 9.2.6).

Table 9.2.5. Maximum and minimum temperatures for the days immediately after transplanting the first lettuce crop

Date	Max temp (ºC)	Min temp (ºC)
10 December	24.2	9.7
11 December	28.4	12.7
12 December	34.6	16.5
13 December	38.5	13.9
14 December	24.3	12.3
15 December	21.2	11.2
16 December	24.1	13.4
17 December	26.2	14.6
18 December	27.9	13.1
19 December	32.2	13
20 December	28.7	13.1

Table 9.2.6. Maximum and minimum temperatures for the days immediately after transplanting the second lettuce crop

Date	Max temp (ºC)	Min temp (ºC)
3 January	16.9	6.5
4 January	17.1	5
5 January	23.6	7.8
6 January	27.8	12.3
7 January	30.5	12.8
8 January	20.2	8.2
9 January	19.7	9
10 January	24.2	9.7
11 January	28.4	12.7
12 January	34.6	16.5
13 January	38.5	13.9
14 January	24.3	12.3
15 January	21.2	11.2
16 January	24.1	13.4
17 January	26.2	14.6

Harvesting of the January planting commenced on 28 February and finished on 5 March. Jefferson bolted in the second planting, most likely due to the fact that the seedlings were sown 16 days before the other varieties by the nursery but all varieties were transplanted in the field at the same time.

Results

Marketable yields from the bulk plantings were, in some cases, substantially less than for the small plots. The first harvest (22-28 January) produced an exportable yield of 7803 kg from 16,000 plants.

A summary of the harvest is provided in Table 9.2.7. No counts were taken in this harvest. ‘g’ denotes a green plastic bin and ‘w’, a prototype wooden bin.

Table 9.2.7. Summary data from first bulk harvest at Manjimup

Variety	Mean bin net weight (kg)	Yield	Yield (kg/ha) based on 78,000 plants per hectare
Casino	173 g	692 kg from 2000 plants	26,988[a]
Sheeba	379 w/214 g	1989 kg w/2782 kg from 10,000 plants	15,514[b]
Silverado	284 w/166 g	450+ kg from 1000 plants	35,100[+]
Jefferson	283 w/177 g	Not enough data	
Saboteur	324 w	648+ kg from 2000 plants	25,272[+]

[a] These plants were harvested late so the yield estimate is not believed accurate.
[b] For this variety, the wooden bins contained export quality heads, the green bins were second grade. The yield estimate is based on export quality only.
[+] denotes a part bin filled and so no head weight available.

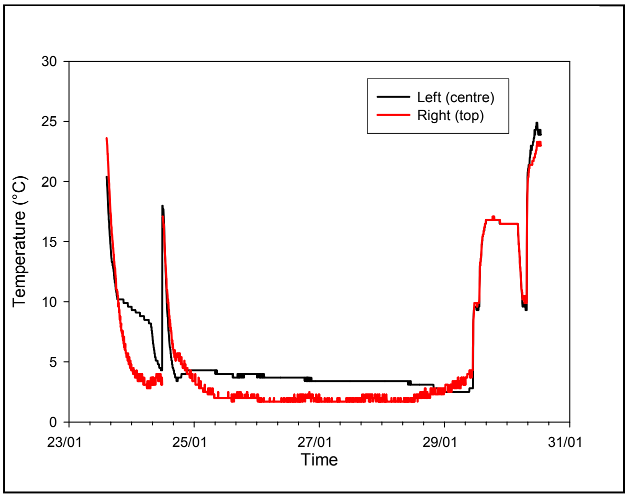


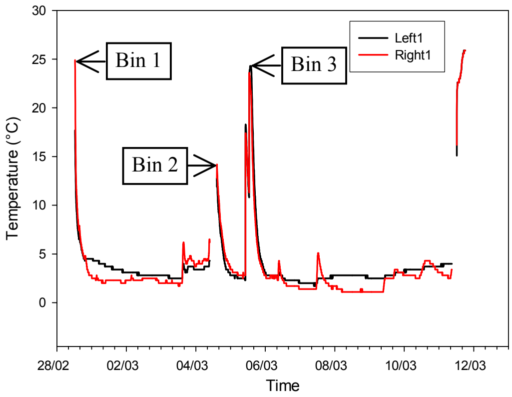
Figure 9.2.1. Logger tracings from selected lettuce cores in bins of first harvest at Manjimup.

The second harvest (28 February and 4 and 5 March) produced an exportable yield of 7083 kg from 16,000 plants. A summary of the harvest is provided in Table 9.2.8. 'g' denotes a green bin, 'm', our modular bin and 'b', our bulk bin.

Table 9.2.8. Summary data from second bulk harvest at Manjimup

Variety	Mean bin net weight (kg)	Head weights (g)	Yield	Heads/bin	Yield (kg/ha) based on 78,000 plants per hectare
Casino	321 m/183 g	554 - 736	1,189 kg for 2,000 plants	454 (placed), 554 (rolled)	46,371
Sheeba	347 b/354 m	553	4,342 kg for 10,000 plants	658 (placed), 646 (rolled)	33,868
Silverado	312 m	609	623 kg for 1,000 plants	489 (placed), 534 (rolled)	48,594
Jefferson[a]	260 b		Unable to be estimated		
Saboteur[a]	272 b		Unable to be estimated		

[a] Only one complete bin of each of these was harvested and no counts were taken.



Figures 9.2.2. Cooling curves for three bins from the second Manjimup harvest.

Discussion

The bulk plantings at Manjimup were a useful exercise. They highlighted the problems that can be encountered when making the transition from small plot work to work on a more commercial scale. Even though we felt we were very conservative in our estimates of crop recovery, the yields from the first harvest were well below expectations and consequently the planned shipment had to be abandoned. A significant part of the reason for that was the poor performance and hence recovery rate of Sheeba in the first planting believed due to the unseasonally hot weather just after planting, though the second planting also did not perform well in terms of total recovery. In theory, from 16,000 plants, even at 75 per cent recovery and an average head weight of 750 g we should have realised a harvest of about 9,000 kg, which would have been sufficient for an export shipment.

The exercise allowed us to observe the performance of five varieties in quantities sufficient to fill at least one bulk bin each. Two of these varieties, Silverado and Casino showed promise for this district and soil type and highlighted the need to do more variety research in this district where there is little commercial experience with the crop.

Growing two bulk crops under research conditions allowed us to capture more data on bin weights, cooling time (Figures 9.2.1 and 9.2.2) and moisture loss during cooling than was possible in a commercial environment and this data helped to improve the quality of the economic opportunity model. As an example of the extra data obtained, water loss during pre-cooling was measured for the first time at 0.7 per cent average for 10 bins of four varieties. This showed that the ‘forced air’ pre cooling method had the potential to deliver a more turgid crisper product to the market than traditional vacuum cooling, with up to 4 per cent saving in weight loss.

Recommendations

Overall, the experience gave us confidence that the Manjimup district is suitable for summer lettuce production for export to ensure continuity of supply year round. Further trials are needed at Manjimup to determine the best varieties for the region. In addition, our fertiliser regime needs fine-tuning for the local conditions to try and improve on marketable yields and reduce within-crop variability.

9.3 TRIAL SHIPMENTS TO MALAYSIA

Introduction

First shipment - August 2002

Our first trial shipment of lettuce for processing sailed from Fremantle for Malaysia on August 22 2002. It was consigned by a Western Australian based processor, GSF Australia to a processor in Malaysia supplying the same chain of 'quick service restaurants'.

The consignment was sent by sea in a 20' reefer container owned by the shipping line PIL using our new technology for fresh product shipping. The lettuce was packed in 20 wooden bins with plastic liners and ventilated cardboard floors. The lettuce (cv. Oxley) was harvested direct into these bins in the field on 20 and 21 August, pre-cooled on the farm and loaded by forklift into the sea container on-farm on August 21 (Figures 9.3.1a,b).

The shipment also provided PIL with an opportunity to test new reefer technologies, including a modified atmosphere container equipped with a satellite monitoring system known as Klaxon. This was the first container of its type shipped from Fremantle.

Representatives from PIL based in WA and Adelaide and Klaxon in Sydney flew to Western Australia to supervise the loading of the reefer on 21 August. Representatives from PIL in Malaysia and Singapore were on hand to inspect the outturn at the processor in Malaysia.

Fig 9.3.1a,b. Lettuce bulk shipment - PIL 20' container loading 21 August 2002.

Temperature and humidity logging equipment was placed in the reefer by the project team as well as the shipping agent. The Klaxon satellite monitoring equipment was also placed by the shipping agent as shown in the diagram on the following page (Figure 9.3.2).

Front of container (refrigeration unit end)	
T20 (CLA) B19 (NL)	T18 (CLA) B17 (NL)
T16 (CLV No. 2) B15 (NL and KLAX)	T14 (NL) B13 (NL and CPIL No. 7786160)
T11 (NL) B12 (CL No. 6)	T10 (CL No. 6 and CLH) B9 (NL)
T8 (CL No. 5) B7 (NL and CPIL No. 7786161 and KLAX)	T6 (CLV No. 1) B5 (NL and KLAX)
T1 (NL) B2 (CL No. 3)	T4 (CL No.4) B3 (NL)
Container rear (doors end)	

Codes:

T	=	Top layer of bins.
B	=	Bottom layer of bins.
Number	=	number written on bin.
CL	=	Cox logger Department of Agriculture with dual external probes measuring core temps top and mid bin.
CLV	=	Cox logger Department of Agriculture with dual external probes and VDU measuring core temps top and mid bin.
CLA	=	Cox logger Department of Agriculture measuring air temperature only.
CLAH	=	Cox logger Department of Agriculture measuring air temperature and relative humidity on top of bin.
CLPIL	=	Cox logger PIL on top of bin measuring core temperature.
KLAX	=	Klaxon's in cores on top of nominated bins, also recording supply air, return air and door air temperatures.
NL	=	No Department of Agriculture logger.

Figure 9.3.2. Schematic representation of logger layout in shipping container. (To be read in conjunction with figures 9.3.3a-h.)

Outturn report on Malaysia shipment

Periodic Klaxon reports on product and container temperatures and gas composition were supplied by PIL during the eight days after dispatch from Fremantle. These all showed that storage parameters were excellent, with product temperatures between 0°C and 1°C, temperatures of return air around 1.7°C and O_2 around 20 per cent (G. Grimm, pers. comm.).

The reefer was opened at the Malaysian processing factory at 16:15 on 30 August and unloading was completed by 17:00. Temperature monitoring equipment was removed from all the bins and they were weighed to determine weight loss in transit before being removed to cool rooms on the premises. The unloading was very professionally handled onto a temperature controlled loading dock (10ºC). A number of bins were emptied manually for immediate processing before unloading was completed.

The gross weight of the consignment on dispatch (21/08/02) was 7651 kg and the net weight of lettuce was 6568 kg. At outturn, the net weight had fallen to 6475 kg, a loss of 93 kg or 1.4 per cent during the nine days since loading. The quality of lettuce was very good overall and rated in the top 10 per cent compared to regular consignments from other suppliers (Queensland and the US). Minor dehydration of outside leaves on lettuce on top of bins was evident but not so below the top layer. A small percentage of quality disorders were evident as bins were emptied. These included some early development of sclerotinia and occasional petiole spotting similar to 'Varnish Spot'. Both of these diseases were present in the crop in the field at harvest and it came as no surprise that there was some development of these in transit. Some heads were distorted by up to 50 per cent of their diameter in the bottom layer of the bin (1100 mm depth) but few could be described as crushed or unprocessable.

Temperature profiles

Ten Cox® temperature loggers were retrieved from the bins and downloaded. The loggers monitored core temperature at various points within the load as well as return air temperature and humidity. Core temperatures were measured in pairs in selected bins, with one probe in a lettuce on top of the bin (right probe) and its twin in a lettuce in the centre of the bin (left probe).

These recordings showed that loading temperatures were mostly good but a few were as high as 7ºC due to insufficient time spent pre-cooling, e.g. Bin 8, Figure 9.3.3f. However the vertical airflow design of the bins took advantage of the airflow in the reefer to bring these down to the optimum range within 24 hours of loading. This can be seen in all figures 9.3.3a-h where core temperatures were measured, by the steep cooling gradients before Thursday 22 followed by the relatively shallow 'stepped gradients after Thursday 22. The former reflect active forced air cooling using fans and the latter is the result of the forced air draft in the reefer. The core temperature of lettuce in the centre of the bins fell to a lower level than those on top and was stable throughout the journey, proving the effectiveness of the air flow characteristics of the bins and their design.

Temperature profiles from these loggers are shown in the accompanying figures 9.3.3a-h, together with a plan of the logger distribution in the container.

The shipment was a success with all technical aspects including bin cooling, ventilation in the container and container performance exceeding expectations. The pre-cooling fans worked well and pre-cooled the consignment uniformly. However, attention will need to be paid in future to the time fans are left on the bins when core temperatures of lettuce from the field are high. Nine hours of pre-cooling was not enough when the entry core temperature exceeded 20ºC (Figure 9.3.3.h). Fortunately the sea container was able to take the residual heat out of those bins in the 24 hours after loading, albeit at a much slower rate than the pre-cooling fans. There is a need in future consignments to use loggers with visual displays to confirm that pre-cooling has finished before fans are turned off. Forced air cooling beyond this point is likely to only cause unnecessary dehydration.

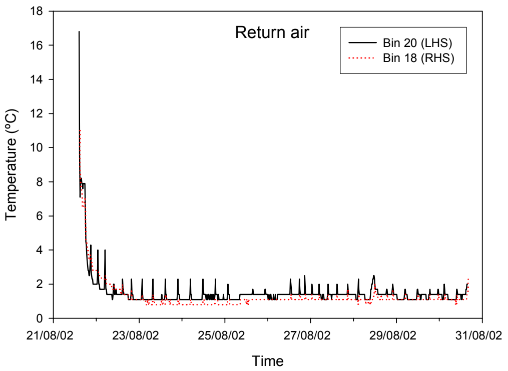


Figure 9.3.3a.

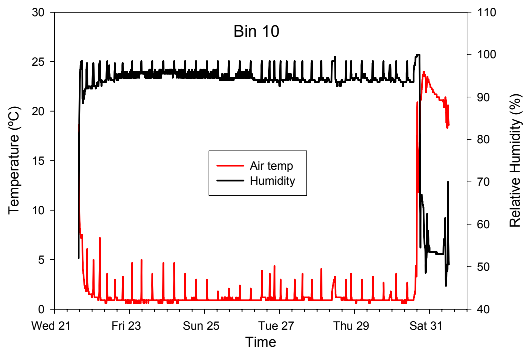


Figure 9.3.3b.

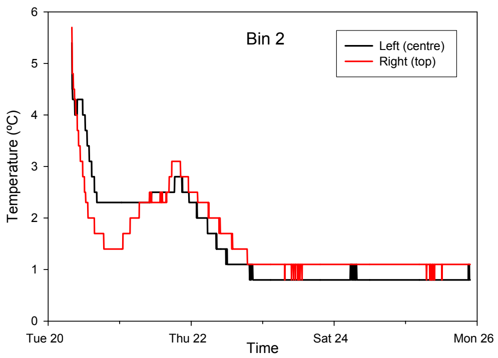


Figure 9.3.3c.

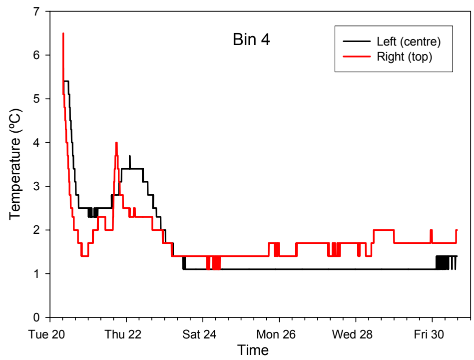


Figure 9.3.3d.

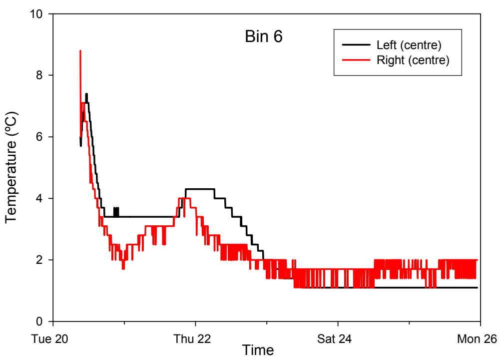


Figure 9.3.3e.

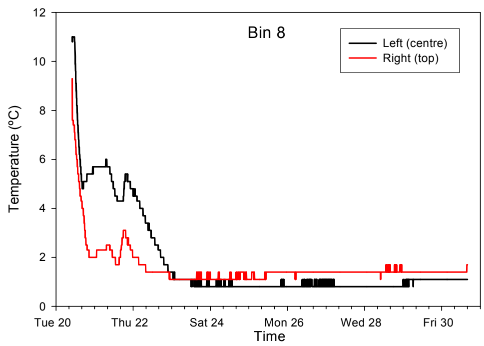


Figure 9.3.3f.

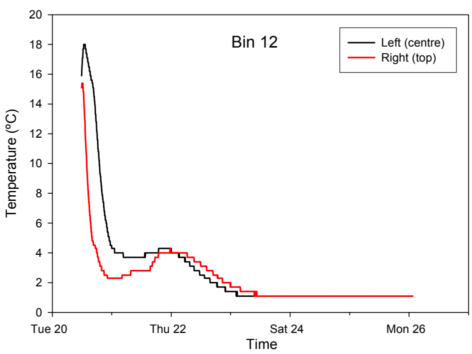


Figure 9.3.3g.

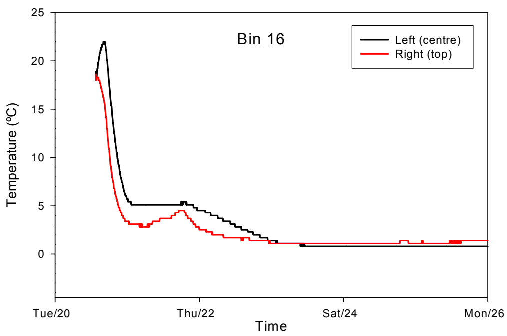


Figure 9.3.3h.

Figures 9.3.3a-h. **Cooling curves for selected bins in trial lettuce shipment on 21 August.**

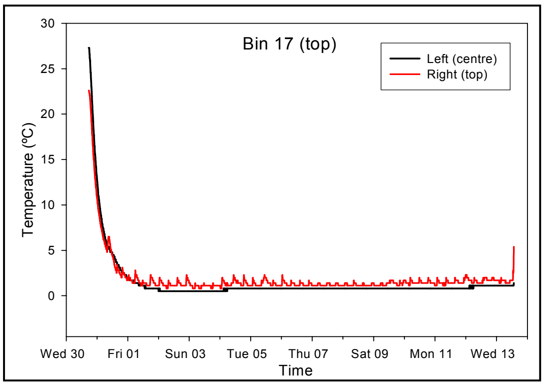
Weight loss overall from loading to outturn was 1.4 per cent. In this consignment, we were not able to get an estimate of weight loss during the pre-cooling step of the process. Figures 9.3.4a-f show the product arriving in Malaysia, its inspection and processing in the factory.

Figures 9.3.4a-f. Unloading, product inspection and processing of trial shipment in Malaysia.

The main concern that the Malaysian processor had after processing the consignment was the level of mechanical damage to outside leaves of most heads, which reduced processing recovery rates. These were down to around 60 per cent compared to the same crop processed in Perth at around 68 per cent. Our challenge should be to get yields up to 65 per cent cost effectively. Other concerns were with the depth of the bins and difficulties emptying them. The processor was also surprised at the relatively low density of heads compared to what they are used to from the US.

Second trial shipment - October/November 2002

A second shipment of lettuce (cv. Silverado) was harvested by the same grower as the first shipment on 29 and 30 October 2002. The reefer (PIL) was loaded on the farm on 31 October, sailed from Fremantle on 3 November and out-turned in Malaysia on 13 November. Figures 9.3.5a,b below show the cooling curves for the shipment.



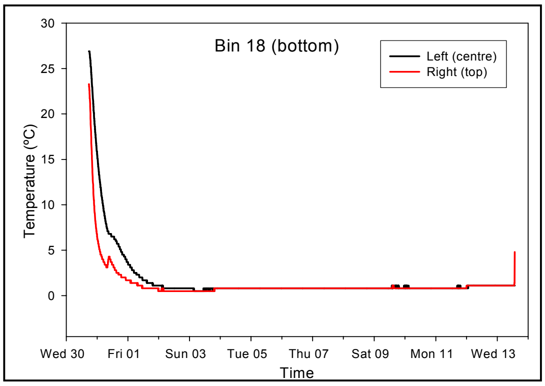


Figure 9.3.5a, b. Cooling curves from two bins in the second trial shipment to Malaysia.

The shipment tested conventional bins against two with a suspended 'mezzanine floor' to share the weight load in the bottom of the bins, and two 'modular' bins of 'two piece' construction.

Results

This second consignment was a technical success and gave us encouragement to continue developing the method, but we were not able to get much feedback from the Malaysian processor on the new bin modifications we made. Container weights were almost 1 tonne more than the first consignment at 7742 kg.

The modular and mezzanine bin modifications tested in this shipment are shown in the accompanying photographs (Figures 9.3.6a,b).

Figures 9.3.6a. The two halves of the modular bin being fitted together.

Figure 9.3.6b. Assembling the bin.

Discussion

The two export shipments to Malaysia were a success proving that:

- Head lettuce could be shipped in bulk in refrigerated sea containers for journey times as long as 16 days with minimal loss in weight or quality.
- The bulk bin design was highly compatible with the vertical air flow in reefer containers and this allowed the storage temperatures and relative humidity in the containers to approximate optimum for lettuce throughout the trip.
- Cool chain integrity could be maintained from farm to processor by attention to basic principles of pre-cooling and storage.
- Shipping by sea in non returnable bulk bins allowed Australian lettuce to be landed in Malaysia at a price which was competitive with the US.
- A multi disciplinary team approach to developing a new innovation like this can work for the benefit of all parties if there is goodwill between the partners, as there was in this case.
- Modular bins made in two pieces that can be separated in the field make loading and unloading easier and should form the basis of future design.

On the negative side, we were unable to maintain a continuity of supply to this buyer because both grower and buyer were conservative in their outlook to developing the opportunity, and a firming Australian dollar made Australian lettuce less competitive in 20' reefers compared to the US.

Recommendations

Further work needs to be done to find markets for lettuce shipped in bulk and both grower and buyer need better information on the profit potential and technical feasibility of the process. In Western Australia, time needs to be spent developing a reliable summer production base in the Lower South West of the state to allow continuity of supply and in re-educating existing growers further north on how to grow processing lettuce for profit.

References

Watkins, J.B. (1985). Forced - Air Cooling Queensland Department of Primary Industries Information Series Q185022 49 pp. Queensland Dept of Primary Industries.

10. MARKET OPPORTUNITY ANALYSIS

Peter Gartrell

Introduction

The lettuce industry in Western Australia is largely oriented toward the domestic fresh market, for iceberg or head lettuce as well as gourmet leafy types. The export market for head lettuce has declined over time with increasing competition and declining prices. A significant trade in these traditional export markets does however still exist. This market is in two main forms, the fresh and processing markets.

After the survey of the current lettuce industry, a 'best bet' economic model was developed to examine the economic competitiveness of production in Western Australia (Chapter 5.3). The model was developed for a chain of supply regions that have apparent timing of supply advantages. This was then coupled with a post harvest model to examine the whole cost chain for export (Chapter 5.5). A specific opportunity for the supply of lettuce for processing in bulk created the export market target.

Materials and methods

Two sets of data were used in the analyses, from Chapter 5, to calculate on-farm costs of production. These were the WA grower survey data, which was extrapolated to simulate crops grown for export, and a model crop based on a combination of inferred best production practices and 'best bet' estimates of realistically achievable long term average yields. These two sets of data were used to predict likely crop profitability using the economic models as a basis for prediction. With the examination of the costs of production two key areas of performance were examined. The first was the ability to increase yield and the second to reduce product handling costs.

An export or processing crop needs to be managed in a different way to that of the domestic wholesale product. Price signals are based on volume for domestic produce whilst the others are weight based. The fundamentals for weight are planting density and unit weight. This coupled with plant survival is critical in establishing crop yield performance. The survey indicated that head weights were an average 778 grams per head and had a field recovery rate of 94.6 per cent. The 'best bet' model assumed much lower head weights and survival percentage (Table 10.1) which netted a reduction factor of 61 per cent. The average survey yield was 38.6 tonnes per hectare compared to the 'best bet' yield of 32.4 tonnes per hectare. This is approximately 13 per cent higher yield from an average 50,000 plants per hectare, versus the 72,000 used in the 'best bet' model.

Table 10.1. Yield assumptions for the 'best bet' scenario

Item	Percentage	Plant number	Average head weight	Kilograms per hectare
Total yield	100	72,000	0.60 kg	43,200
Saleable yield	75	72,000	0.60 kg	32,400
Process/export	75	72,000	0.60 kg	32,400
Waste/losses	25	72,000	0.60 kg	10,800

The 75 per cent recovery and 600 gram head weights are an achievable target over time. This will vary between crops. The recovery percentage accounts for the range of nil to major losses expected across the year. The head weights are variable within and between crops and seasons. The estimate used in the model is conservative by comparison to producers in other States and countries. Plant numbers or planting density compensates to some degree but adds to the cost of establishment.

Results

Costs of production using the data collected from the WA grower survey were compared to costs derived using more conservative assumptions in the 'best bet' model (Table 10.2).

Table 10.2. Cost of production outline by stage of production for survey data versus 'best bet'

Costs	Survey data		'Best bet'	
	$ per kilogram	**$ per hectare**	**$ per kilogram**	**$ per hectare**
Preparation and establishment	0.135	4,935	0.240	7,773
Crop management	0.034	1,226	0.036	1,180
Harvest	0.069	2,510	0.159	5,138
Post-harvest	0.169	6,157	0.036	1,181
Overhead allocation	0.068	2,493	0.097	3,155
Total costs	**0.475**	**17,320**	**0.569**	**18,427**

The 'best bet' crop appeared more expensive per unit. Furthermore the survey data includes agent's commission costs of 6.9 cents per kilogram. Production cost excluding commission is approximately 41 cents per kilogram. The 'best bet' model is based on conservative assumptions of yield and estimates of production cost compared to the grower survey. If the 'best bet' yield assumptions were applied to the survey data then the cost would rise to 77 cents per kilogram or 66 cents per kilogram before agents' fees. The big differences in the two methods of calculating cost of production lie in assumptions about labour for harvesting and transport/ marketing costs (post-harvest).

Table 10.3 shows some of the detail used to derive the costs by category in Table 10.2. The cost of chemical and fertiliser increased with a more conservative program, as did the estimate of man-hours to harvest and handle. This reflects more realistic harvest logistics. Irrigation is reduced marginally. Machinery operating increases with more chemical and fertiliser applications and harvest operation time. Higher plant numbers increase the crop establishment cost. Other costs are primarily overheads resulting from a decrease in assumed scale for the operation. The addition of cooling charges increase this cost.

By introducing the bulk handling system to the 'best bet' model, transport and bin hire are eliminated from the farm costs. Field picking and packing into bins removes the costs incurred by bin hire. Transport is included in container freight to port from farm gate. By not marketing through the domestic wholesale market the agent fees are also removed.

Table 10.3. Cost of production by item input

Costs	Survey data		'Best bet'	
	$ per kilogram	**$ per hectare**	**$ per kilogram**	**$ per hectare**
Chemical	0.024	859	0.050	1,616
Fertiliser	0.035	1,277	0.066	2,145
Labour	0.106	3,870	0.197	6,389
Irrigation	0.008	292	0.007	240
Transport	0.053	1,940	0.000	0
Agents fees	0.069	2,503	0.000	0
Machinery operating	0.009	317	0.021	670
Bin Hire	0.043	1,579	0.000	0
Seedlings	0.060	2,190	0.100	3,240
Other	0.068	2,493	0.127	4,127
Total	**0.475**	**17,320**	**0.569**	**18,427**

Sensitivity analysis of head weight and planting density effects on costs

Opportunities to improve the production-based economics primarily lie with yield. Table 10.4 outlines the sensitivity of production costs with changes to head weight and planting density assuming the 'best bet' production costs. It shows that cost of production is more sensitive to head weight than planting density. By increasing head weight with better harvest scheduling, giving 10 per cent heavier heads, the cost of production will change by 5 to 6 cents per kilogram. Commonly, a planting density of 55,000 plants per hectare is adopted. At the same head weight the cost of this compared to the 'best bet' program at 72,000 plants per hectare would add 13 cents per kilogram in costs. Whilst these changes may be achievable the complexities and risk need to be better understood.

Table 10.4. Cost of production ($/kg) - head weight by planting density

		Head weights - kg				
		0.49	0.54	0.60	0.66	0.73
Plant numbers - 1000's per hectare	45	1.00	0.90	0.82	0.74	0.68
	55	0.85	0.77	0.70	0.64	0.58
	65	0.75	0.68	0.61	0.56	0.51
	72	0.70	0.63	0.57	0.52	0.48
	80	0.64	0.58	0.53	0.48	0.44

Other input costs

The role of all other activities must not be ignored. Input unit cost, such as best price fertiliser sources for example, should be evaluated.

Chemical and fertiliser programs are essential in maximising yield potential. The practice of using these products in excess, as yield 'insurance', must be reduced for economic and environmental reasons. These represent 20 per cent of production inputs. Better understanding of crop nutrition and Integrated Pest Management for production regions and seasons will greatly enhance the ability to reduce these inputs with out increasing crop risk.

The cost of seedlings at 18 per cent of production costs is significant. Gains in nursery performance by new technologies and/or scale may improve unit price.

Sensitivity analysis of harvest mechanisation on costs

Labour is the most significant single cost of production. With Australia's relatively high labour cost this needs to be understood and addressed. Labour efficiency at planting and harvest could be improved through introduction or improvement of mechanised operations.

Mechanical harvesting is an obvious solution to reducing labour costs. While not common place, there are some mechanical lettuce harvesters in use in Australia. The level of labour reduction and the additional capital requirement need examination to ensure cost effectiveness. Typically, specialised machinery such as this requires a significant planted area to dilute the cost of ownership.

To examine the concept, a mechanical harvesting model was developed. Many of the inputs are at best assumptions. The case study was for a 3-row harvester on a 30-hectare lettuce producing property. The machine was assumed to cost $140,000. Ownership costs include an annualised replacement provision, finance, repairs, maintenance and insurance. The harvest operation requires nine people with operating costs to cover fuel and oil. At a harvest speed of 0.5 kilometres per hour, or 8.3 metres per minute, the work rate would be 2,988 heads per hr, 49 heads per minute or eight heads per operator per minute. This is based on six operators along with one driver and two people doing bin handling. This equates to 18.1 machine hours per hectare or 163 man-hours per hectare. Model yield assumptions are used.

Compared to the 'best bet' crop with hand harvesting (18 cents per kilogram), the predicted machine harvest cost would be 13.4 cents per kilogram. This is 4.7 cents per kilogram or $1511 per hectare cheaper for machine harvesting.

Table 10.5. Machine harvest cost sensitivity - capital cost and scale (cents per kilogram)

		Area - hectares				
		16.9	22.5	30.0	37.5	46.9
Purchase price - $	90,000	13.8	13.0	12.4	12.0	11.7
	112,000	14.6	13.6	12.8	12.4	12.0
	140,000	15.6	14.3	13.4	12.8	12.4
	168,000	16.6	15.1	14.0	13.3	12.7
	202,000	17.9	16.0	14.7	13.8	13.2
	242,000	19.3	17.1	15.5	14.5	13.7

Table 10.5 shows that the harvest model is slightly more sensitive to scale of area than the capital cost of the machine employed. Table 10.6 shows that the effect of plant spacing (translates to plant density) on cost is marginally more sensitive than the operating speed or work rate. It is important to note a relationship between these two would exist but the figures presented here are 'a best guess' and would need to be determined for a 'real time' operation with a particular mechanical harvester.

Table 10.6. Machine harvest cost sensitivity - plant spacing and operating speed(cents per kilogram)

		Operating speed - km per hour				
		0.28	0.38	0.50	0.63	0.78
Plant spacing - metres	0.28	20.1	15.8	12.5	10.5	9.0
	0.30	21.6	16.9	13.4	11.3	9.6
	0.32	23.0	18.0	14.3	12.0	10.2
	0.34	24.4	19.1	15.2	12.8	10.9
	0.36	25.9	20.3	16.1	13.6	11.5
	0.38	27.3	21.4	17.0	14.3	12.2

There is a significant possibility that machine harvesting may offer minimal cost savings depending on machine parameters and crop management. An unknown factor in this analysis is the effect of improved worker comfort associated with mechanised harvest on labour productivity and reliability. There still may be a substantial case for mechanical harvesting even if it did not reduce costs significantly. The relative attractiveness to employees of this type of work is important in securing and retaining labour. If the work is attractive to employees, workforce stability and choice of employees should lead to harvest efficiencies and potential for expansion of scale of the operation to meet future market demands.

Economies of scale will provide cost improvement. These account for about 20 per cent of production costs. Increased throughput volumes will dilute fixed and semi fixed costs such as insurance, management, administration, professional services, machinery utilisation and general facility costs. Increased business spending can also improve purchasing power. Increases in scale must be carefully balanced with market, management and risk.

Bulk handling and freight efficiencies

A bulk handling system was examined and introduced to reduce post harvest costs. More importantly there are significant post-production gains to be realised with this system. Comparisons of transport efficiencies from using bulk handling compared to cartons are presented in Table 10.7.

Table 10.7. Handling and freight costs - export to Malaysia via air pallet and 40' sea container (reefer)

	Carton air pallet	Carton 40'	Bulk 40'
Handling cost $/kg	**0.475**	**0.513**	**0.260**
Cooling and storage	0.020	0.020	on farm
Packaging	0.200	0.200	0.194
Packing	0.214	0.214	0.000
Quarantine/admin/customs	0.012	0.024	0.020
Container freight to port	0.029	0.055	0.046
Export freight cost	**Air**	**Sea**	**Sea**
Weight per unit	2,800	11,200	13,392
Cost per unit	2,560	3,600	3,600
$ per kilogram	0.914	0.321	0.269
Total cost $/kg	**1.389**	**0.835**	**0.529**

Current harvesting and handling practices employed by some growers and exporters use small returnable bins on pallets to transport produce to a central packing facility to be repackaged for export. This is highly inefficient. Field picking and packing is an essential element to improving the cost of handling produce. Packaging and freight are also significant elements of the CIF product cost. Table 10.7 outlines the range of costs for different export modes. Airfreight is increasing in cost and is better suited to high value and/or high perishable produce. Airfreight availability can also be limiting. To compare bulk bins and cartons in 40-foot sea containers, a cost reduction of approximately 30 cents per kilogram can be achieved. This is primarily due to field packing eliminating the need for double handling. The bulk packing density is also significant in diluting all post production costs.

The bulk container is equal to approximately 24 cartons. This can range from a 22 to 27 carton equivalent. This can vary the packaging costs but more significantly dilute or improve the freight container weight capacity. This is essentially related to head weights and density. It is important to establish the point where head density can be maximised without compromising product quality or increasing production risk.

Table 10.8. Malaysia CIF cost ($/kg) for sea freight lettuce - sensitivity to freight rate and head weight

		Head weights - kg				
		0.49	0.54	0.60	0.66	0.73
Sea freight cost - $/40' container	2,916	1.28	1.16	1.05	0.96	0.87
	3,240	1.31	1.19	1.07	0.98	0.89
	3,600	1.34	1.22	1.10	1.00	0.91
	3,960	1.37	1.25	1.13	1.03	0.93
	4,356	1.41	1.28	1.16	1.05	0.96

Exporters traditionally have little control over production parameters. The exporter maintains vigilance over factors that are directly within their control. Freight rate and price signals are key tools in this endeavour. Table 10.8 shows that whilst significant changes to freight rates may occur this is far less significant to cost performance than is head weight and conformation. The exporter has difficulty in providing measurable price incentives under the current system for such produce. In response the exporter would justly react by passing on this risk through a lower producer price. Table 10.9 further demonstrates the CIF cost sensitivity to production practice performance.

Table 10.9. Malaysia CIF cost ($/kg) for sea freight lettuce - sensitivity to plant density and head weight

Plant numbers - 1000's per hectare		Head weights - kg				
		0.49	0.54	0.60	0.66	0.73
	45	1.66	1.49	1.35	1.23	1.12
	55	1.51	1.36	1.23	1.12	1.02
	65	1.41	1.27	1.15	1.04	0.95
	72	1.35	1.22	1.10	1.00	0.92
	80	1.30	1.17	1.06	0.97	0.88

On examination of the market opportunities for lettuce in South East Asia, it appears that a CIF price of A$1.35 to A$1.60 should be relatively easy to achieve using 40' reefers for bulk export. When examining the 'best bet' production costs and associated post harvest costs for bulk shipping in a 40-foot sea container, the CIF cost is approximately A$1.10 per kilogram. This would realise a return of between 25 and 50 cents per kilogram (Table 10.10). This level of return would appear to be sufficient for participation in this market.

Table 10.10. Hypothetical CIF price scenarios for production and handling costs

Price range	Low	Moderate	High
CIF price ($A/kg)	1.35	1.45	1.60
CIF cost ($A/kg)	1.10	1.10	1.10
Surplus ($)	0.25	0.35	0.50
Exporter			
Exporter margin ($)	0.124	0.133	0.146
Container margin ($per 40')	1,659	1,779	1,960
Producer			
Farm price ($)	0.694	0.785	0.921
Farm margin (c/kg)	0.125	0.216	0.353
Gross margin ($/ha)	7,209	10,157	14,579
Margin ($/ha)	4,054	7,002	11,424

Discussion

To effectively assess the opportunity that has been identified for bulk handling of lettuce, it is imperative that potential export markets for lettuce presented in this form be identified and quantified. The obvious target is for the increasing processed product market with increasing convenience and fast food demand and the corresponding increase in lettuce demand. This is a closed market system that does not require wholesale market handling. The traditional markets, in the main, are not equipped to handle the product in bulk. It would also be beneficial to examine the potential for supermarket chain distribution centres in various destination countries to handle such product.

In order to capitalise on the potential of this market there are many areas that should be addressed with more rigour. These areas include:

- Identify key parameters to increase head weights.
- Identify best practice agronomic packages.
- Establish product quality and freight efficiency relationships.

- Test potential of mechanical harvesting.
- Outline other market opportunities.

Head weights and plant numbers per hectare hold the key to cost minimisation. Special attention is needed to devise a program to identify varieties, time of sowing, nutritional requirements and time of harvest. This should be done by region with special attention to production risk. Processing product specifications should be identified and used to govern assessment. Optimal head weight will be derived by maximising weight without excessive production risk, problematic processing qualities (tip burn, head density) or making concessions on eating or aesthetic qualities.

An agronomic package that aims to minimise the inputs without increasing risk or compromising yield is essential. This package should address the complete supply calendar. This will be evolutionary and require medium term research and development support.

There needs to be investigation into the optimal head conformation. Head conformation can deliver freight cost advantage with or without actually increasing head weight. The variance in bulk container weights is testimony to this. An awareness of this factor in head weight maximising and produce appraisal is important. Factors affecting the level of processing wastage should also be identified.

The potential to mechanically harvest will impact on the ability to integrate this enterprise into large-scale operations such as carrot, potato and onion production. Whilst it could potentially lower unit costs of production it could more importantly deliver the ability to service larger areas without an excessive labour requirement. Lettuce presents itself as a good short rotational disease break crop. The cost and performance of such engineering advances should be examined.

If the lettuce industry has the capacity to produce cost competitive, bulk supplies of produce, then it is imperative to understand and quantify the potential market. The sizes of markets appear to be substantial enough to accommodate short-term capacity. If the production capacity is increased other markets may need to be identified. Alternative markets are also a good hedging option. With recent changes to sea freight services to the Middle East, this could be worth further investigation.

In conclusion, there are many production and post harvest improvements to be extended and developed for the lettuce industry. Many of these are intertwined from the nursery right through to the processor or export market place.

Recommendations

A focussed approach to product needs and processes through the production and handling chain have assisted in the identification of opportunities. This focus should be maintained and applied to all market opportunities. With this specialised attention, the potential for industry growth is significant. Many lessons learnt from the analysis presented here could be adapted to other horticultural export industries.

11. EXTENSION AND TECHNOLOGY TRANSFER

EXTENSION ACTIVITIES

Newsletters

A quarterly newsletter entitled ‘Leafy crops newsletter’ was produced for the term of the project. The first newsletter was produced in Spring 2000, the final in December 2002. Copies of each edition are attached in Appendix 1a-g.

The first edition was mailed out to 115 growers, horticultural business and interstate researchers in mid September 2002. By the last edition this had grown to 160 recipients which included local and interstate growers, researchers and allied industry personnel.

The newsletters covered the activities of the project as well as other topical information relevant to the industry sector. In at least one instance, it was known to result in adoption of fertiliser programs developed by the project and bulk shipping technology by a grower in South Australia.

Conferences

In June 2000, Dennis Phillips, Linda Teasdale and Bill Piasini (WA grower) attended Australia’s first national lettuce conference in Hay, NSW. The two day event included a program of the research underway supported by the Aus Veg levy and HRDC, during which Dennis and Linda presented four papers - two on aspects of the terminating project VG97083 and two outlining the work planned for this project VG99014. These two papers were entitled ‘Improving Export Opportunities’ and ‘Quality Assurance and Food Safety - Implications for the lettuce industry’. Copies of these two papers from the Conference Proceedings are included in Appendices 2 and 3. The conference was attended by a wide cross section of the lettuce industry with more than 150 delegates and our contribution to the success of the conference is acknowledged in a letter from the organisers.

Subsequently one of these papers has been reproduced in ‘Good Fruit and Vegetables’ magazine (Appendix 4) and the other was published in Practical Hydroponics and Greenhouses magazine (January/February 2001, 26-30) (Appendix 5).

Dennis Phillips also attended the second national lettuce industry conference held at the University of Queensland at Gatton from in May 5-8 2002. The conference was jointly organised by the Queensland Department of Primary Industries at Gatton and the NSW Agriculture vegetables group from Yanco in NSW.

Over 160 delegates from all States of Australia and New Zealand attended the conference, including Andrew Tedesco from Western Australia who was invited by the organising committee to give a report on the Western Australian industry to the delegates. Dennis’ presentation was entitled “A strategy to increase Australian lettuce exports”. A copy of this presentation is in Appendix 6.

Field days/seminars/workshops

A field day was held for WA growers on 22 September 2000 at the Wanneroo Recreation Centre. Presentations were given on the terminating project VG97083 as well as two presentations introducing the new project, VG99014. The field day was attended by 15 people including growers, a processor and the Vegetable Industry IDO. Contacts were established for the crop loss study and cost of production activities planned for a later stage of this project.

An interim results seminar for industry was abandoned because the newsletter has proven a better method of disseminating information. A ban on the use of poultry manure for vegetable growing proved to be a distraction from other events such as this seminar and it was considered prudent to choose a time when growers had less meetings to attend.

Results of the nutrition studies were incorporated into two ‘Factsheets’ which were mailed to all growers on the Swan Coastal Plain providing options for cropping lettuce without poultry manure.

A field walk planned for September 2001 to view fertiliser trials showing new methods of growing the crop without fowl manure had to be abandoned because the grower whose property the trial was sited on had a high level of sclerotinia in some of his crops, which would have distracted some from the results we wanted to show.

A display was mounted at the Karragullen Field Day in September 2002 showing our prototype forced air cooling system.

Two field days were held at Manjimup Research Centre (Figures 11.1, 11.2 and 11.3). The first, on 18 December 2002 allowed growers to inspect the progress of our first bulk planting and brought them up to date with the trial work. The second was held in conjunction with the harvest of our bulk planting on 23 January 2003 and enabled us to present details of our cultivation methods. The processor was also present to explain their requirements for processing lettuce.

Figure 11.1. Field day for growers at Manjimup Research Institute, January 2003.

Figure 11.2. Demonstrating bulk bin design to growers at Manjimup, January 2003.

Figure 11.3. Demonstration crop for bulk shipping at Manjimup, January 2003.

Miscellaneous articles

February 2001. Two articles (HRDC lettuce project successfully completed in WA and another in the Regional Round Ups) were published in 'Lettuce Leaf' Issue No. 3 - the newsletter of the IPM project VG98048 at Yanco in NSW.

June 2002. Dennis Phillips contributed an article to 'Lettuce Leaf' in Regional Round Ups summarising the lettuce season and progress on the project.

August 2002. In the Countryman magazine, 29 August, page 28, two articles on the lettuce project were published - ‘Crate helps WA growers seal Asian lettuce deal’ and ‘First bulk shipment crunch time.’

September 2002. Media press release for bulk shipment to Malaysia (Appendix 8).

October 2002. Good Fruit and Vegetables magazine story “Australian first - bulk lettuce bound for Asia”.

November 2002. An article on the first shipment to Malaysia in the Countryman.

February 2003. An article on the bulk planting at Manjimup.

February 2003. Dennis Phillips contributed an article to ‘Lettuce Leaf’ in Regional Round Ups summarising the lettuce season and progress on the project.

APPENDIX 1a

APPENDIX 1b

APPENDIX 1c

Leafy Crops Newsletter

Vol 1. No. 3
Winter 2001

Lettuce Cropwatch

Management Program for Sustainable Lettuce Production

APPENDIX 1d

APPENDIX 1e

APPENDIX 1f

APPENDIX 1g

APPENDIX 2

IMPROVING EXPORT OPPORTUNITIES

Dennis Phillips Agriculture Western Australia, Midland WA
Peter Gartrell Agriculture Western Australia, Manjimup WA

(Paper presented at the 1st National Lettuce Industry Conference
June 2000, Hay, New South Wales)

The lettuce industry in Australia is typical of many other sectors of the industry in that its primary focus is the domestic market. This characteristic leads to an opportunistic approach to export marketing resulting in lost opportunities. Export markets in our region are highly price sensitive due to the presence of low cost US grown product. The impact of this presence is less apparent in Singapore and Malaysia than Hong Kong, presenting opportunities for suppliers in different states of Australia.

An HRDC funded project commencing in WA will investigate possibilities and methods for Australian producers to become more cost competitive by focusing on yield improvement and cost control through use of budgeting techniques.

BACKGROUND

Lettuce is grown in all States and Territories of Australia. Queensland and Victoria are the largest producers approximately 40,000 tonnes each and NSW and WA follow with around 10,000–12,000 tonnes annually (Source ABS). The gross and farm-gate values of production rose steadily during the 1990's reaching a peaks of $76.8 million and $51.5 million respectively in 1995-96. Values fell away by more than $15 million in 1997, the last year for which official statistics are available.

Exports of lettuce from Australia have traditionally been a small but important part of the overall picture. Export tonnages in the 1990's have fluctuated in the range of 3,000 to 4,000 tonnes per annum with head lettuce (iceberg) about double the volume of gourmet out of a national total of around 100,000 tonnes. Values have ranged between $6 million and $8 million annually (fob) - (source AGWEST T&D).

Overall, Australia's export volumes of iceberg lettuce have remained static or fallen slightly albeit with a large seasonal variation in volumes and values. For example, 1997/98 was a relatively good year with national volumes approaching 3000 tonnes while 1995/96 was poor with the total slipping below 2000 tonnes.

Export performance by state has also been patchy with WA dropping from 43% of the national volume in 1993 to a low of 10% by 1996, followed by a turnaround to 30% in 1997/98. New South Wales has experienced steady growth over the last 5 years (state of shipment) while Victoria, and Queensland have remained overall static, with a larger seasonal variation from Queensland. Volumes from South Australia have fallen.

The reasons for this difference in performance by state is partly explained by Western Australian exporters traditionally having a greater presence in the Singapore and Malaysia markets and the rest of Australia linked more to the fortunes of the Hong Kong market.

It is widely acknowledged within the industry, that the overriding factor limiting growth of Australian exports into South East and North Asian markets is the influence of the US in these markets. Hong Kong is particularly difficult with Australia accounting for only 4-5% of total imports. The size and scale of US production and its large domestic production base has made markets in our region highly price sensitive and we only compete when prices are high in the US due to supply shortages.

The challenge for Australian producers is to become more price competitive with the US so that we can compete effectively in these markets more often than we do now. This challenge led to the establishment of an HRDC project funded from the national vegetable levy which commenced this year. The project (VG99014-'A model for lettuce industry development') seeks to use the WA industry as a test case to identify strategies and methods that could be employed nationally to improve cost competitiveness of production.

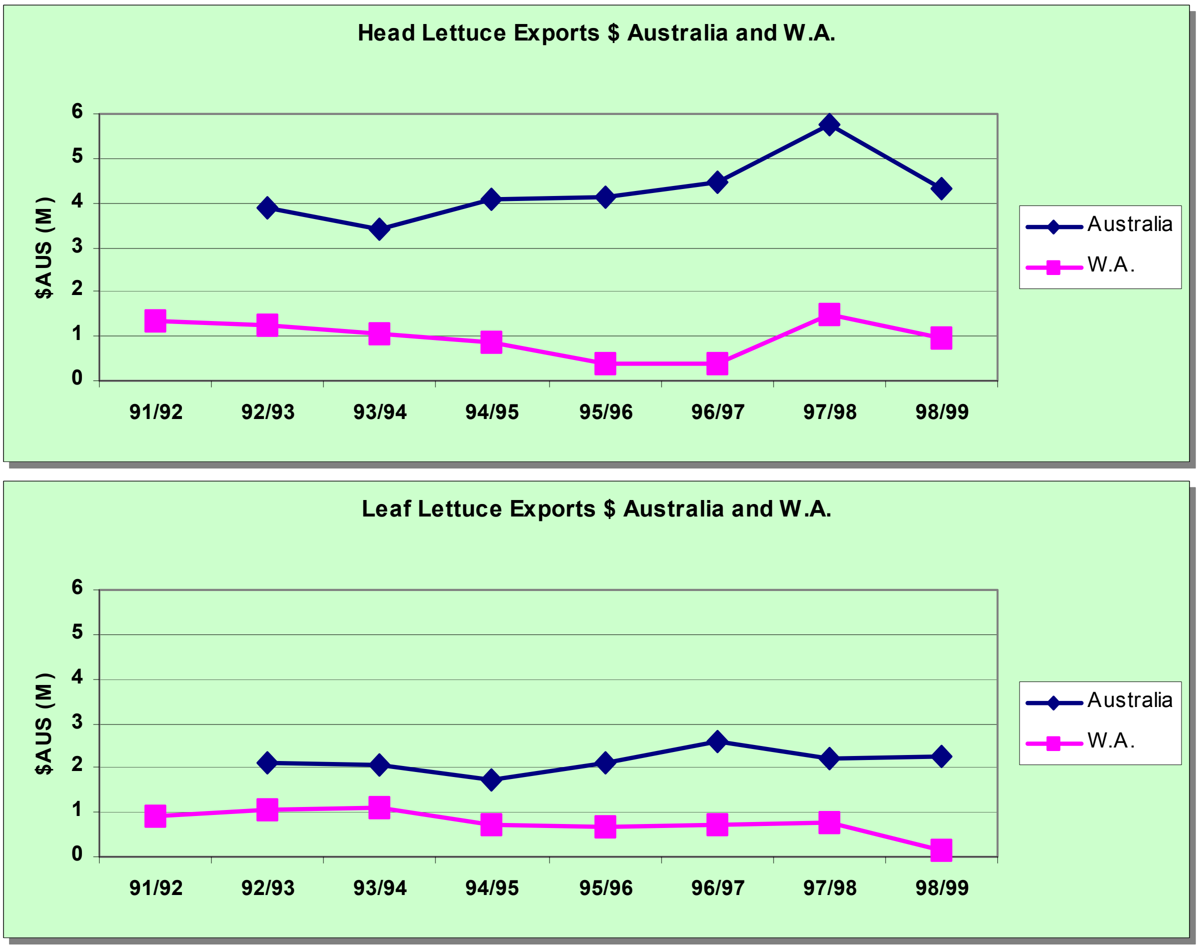


Figure 1. **Lettuce exports from Australia and WA in $Australian. Source: AGWEST T&D**

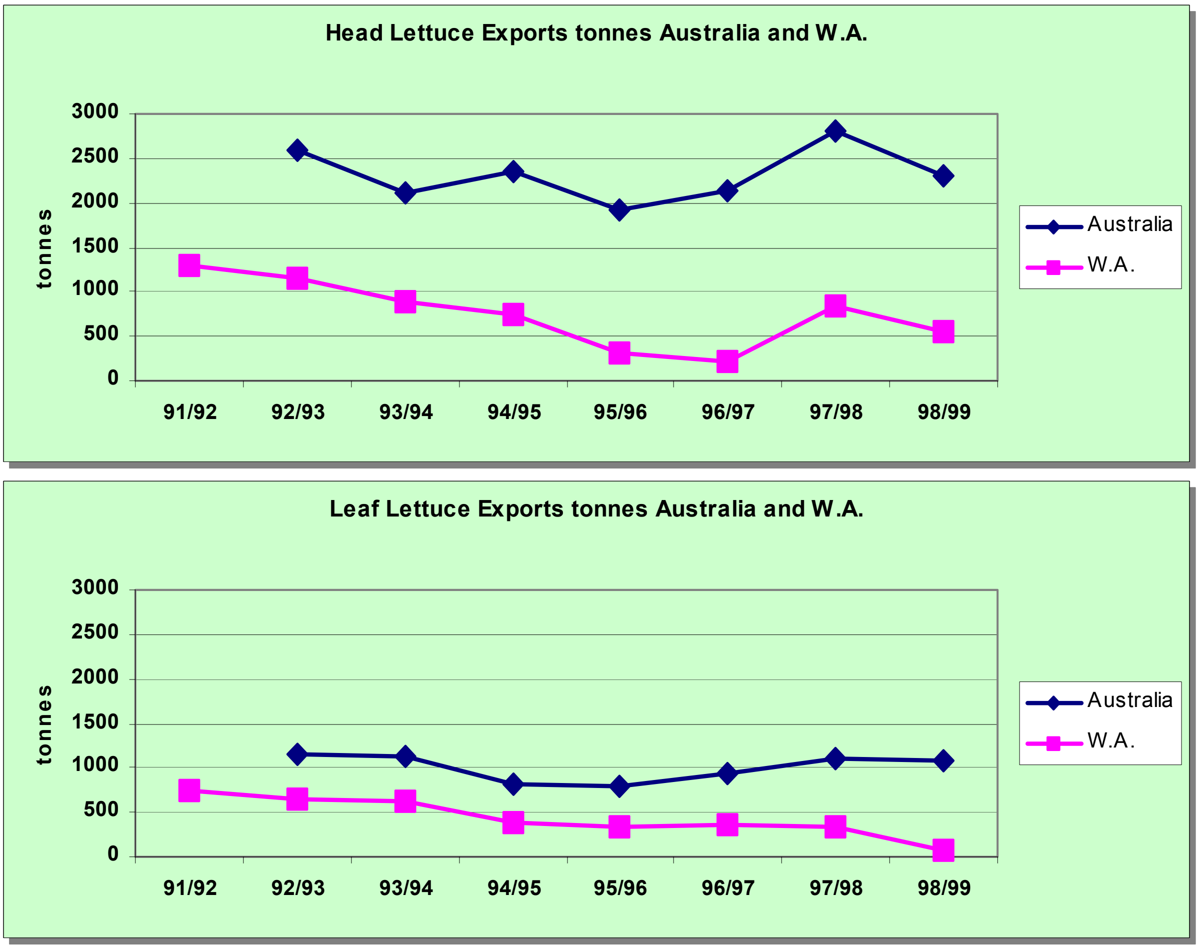


Figure 2. Lettuce Exports from Australia and WA in tonnes. Source: AGWEST T&D.

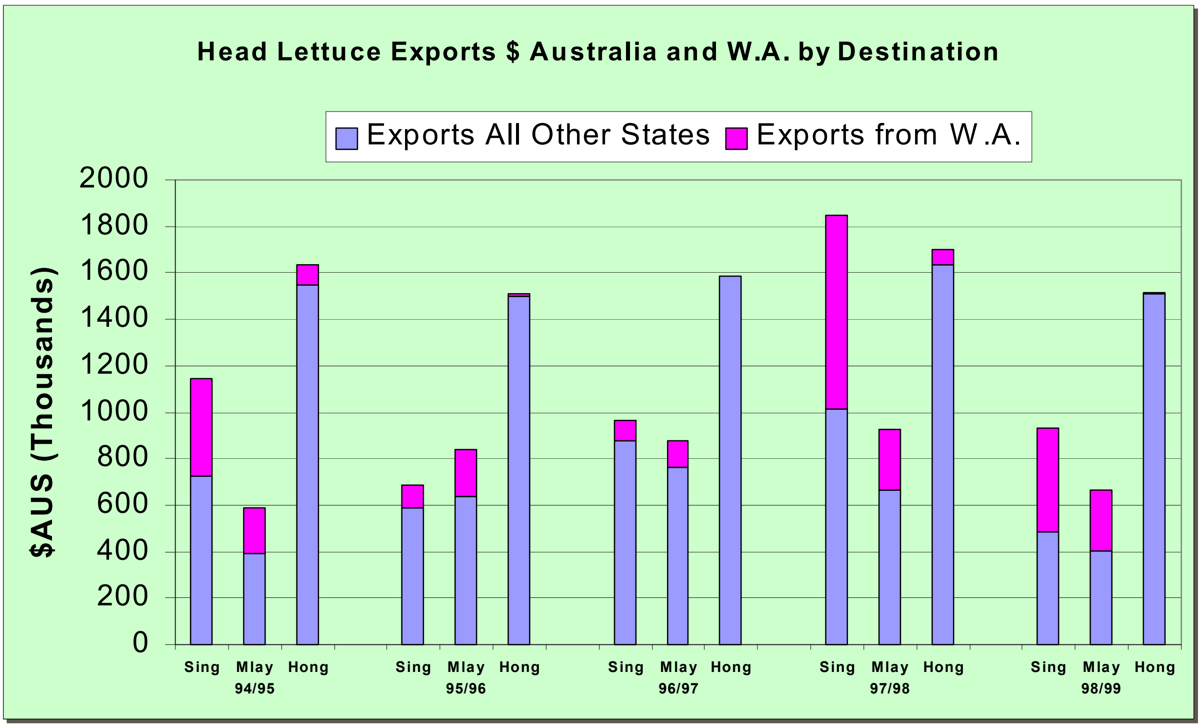


Figure 3. Head Lettuce Exports from Australia and WA to Singapore, Malaysia and Hong Kong in $Australian. Source: AGWEST T&D

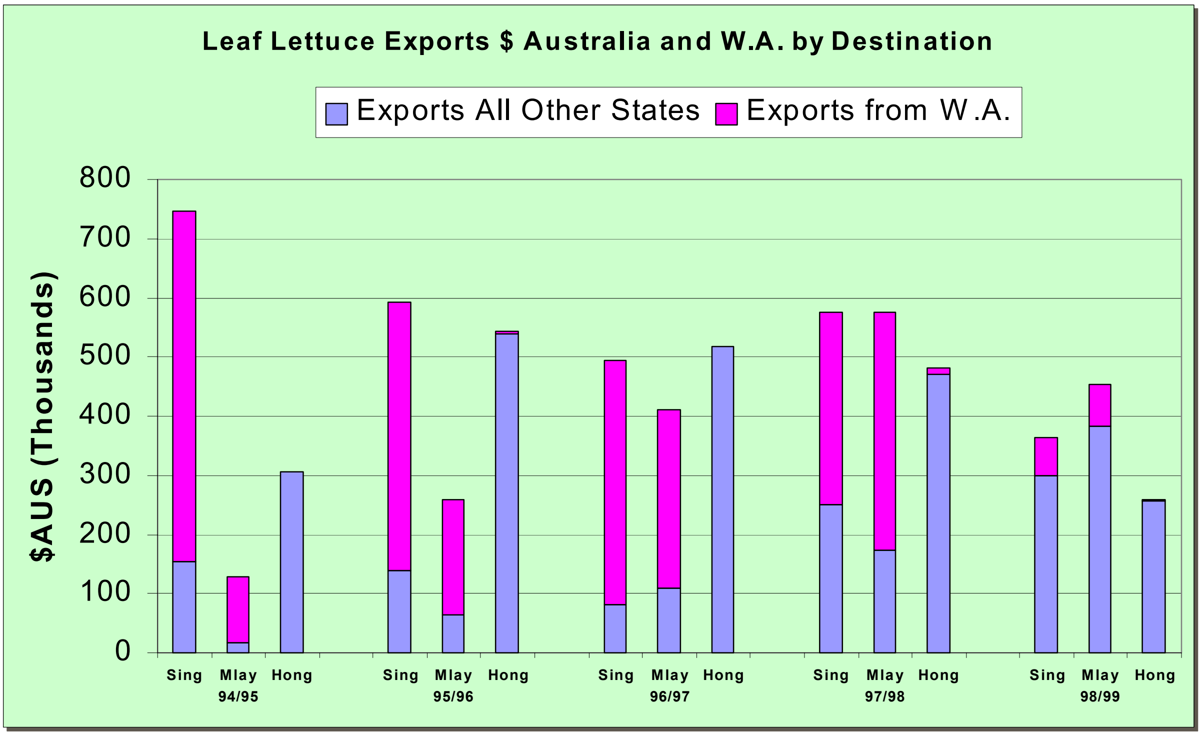


Figure 4. Leaf Lettuce Exports from Australia and WA to Singapore, Malaysia and Hong Kong in $Australian. Source: AGWEST T&D

EXPORTS TO SELECTED MARKETS FROM AUSTRALIA AND COMPETITORS, 1997 TONNES						
Importing Country	Australia	USA	China	Netherlands	Other	Total
Hong Kong	1176	21230	1497	221	158	24282
Malaysia	1416	2190	128	52	98	3884
Japan	11	3381	0	83	708	4183
Singapore	1337	4519	19	203	1420	7498

Figure 5. Export Competitors 1997. Source: AHC 2000.

CHARACTERISTICS OF THE AUSTRALIAN LETTUCE EXPORT SECTOR

The price sensitive nature of our export markets and perishability of the product has led to the Australian lettuce industry and export sector having the following characteristics:

- Domestic market first.
- Opportunistic export supply - spot marketing.
- 80% air freight.
- Weight specifications often not met - 24 heads weights 10-18kg (Aus); 22kg (US).
- Diversion of domestic product in unsuitable cartons without cool chain.
- Few if any dedicated suppliers.
- A profile typical of many other Australian Horticultural industries.

HRDC PROJECT ISSUES

The HRDC project within which the export market performance of the industry will be studied is entitled ‘A model for lettuce industry development’ and has four main components.

These include:

1. The declining export performance and opportunistic supply exemplified by the WA industry.
2. Meeting specifications for the growing processing sector.
3. A uniform approach to QA and HACCP.
4. The relative profitability of the sectors and how to choose between them.

The overriding aim of the project is to explore methods of tackling industry wide problems and capturing opportunities in a working partnership with growers and marketeers. The principles established should be applicable to the wider national industry.

METHODOLOGY

The approach to be taken to addressing issues identified above is to establish a working partnership with marketeers and processors and with their support, work through the attitudinal issues associated with producing the crop for each of the sectors with their grower suppliers.

A study of the reasons for crop loss and potential for yield improvement and cost control will be undertaken with growers with an emphasis on identifying the changes to management practices which make significant changes to bottom line cost and profit.

Field experiments will be conducted to identify techniques which increase yields and meet market sector specifications better than currently. New techniques will be demonstrated to growers on farm and specific training will be supplied in budgeting techniques and cost control.

Estimates will be made of the magnitude of change in unit cost required to become more cost competitive with US exports and the increased export market share that may open up for Australian producers.

EXAMPLE OF THE IMPACT OF CHANGED PRACTICES ON PRICE COMPETITIVENESS OF AUSTRALIAN GROWN LETTUCE FOR EXPORT

The following example shows the effects on bottom line profit from changes in crop management changes which do not add to costs compared to cost cutting by reducing inputs.

The current position shows a typical budget for producing lettuce on sandy soils of the Swan Coastal Plain and a projected Gross Margin profit of $5607 per ah for an export yield of 30.8 t/ah (2200 cartons @ 14kg/carton packed).

Introducing a new management technique such as better nutrition management which raises yields 15% with no increase in fertiliser cost doubles bottom line profit and significantly reduces cost per tonne. Such a result could be achieved by increasing average head and carton weights from 14kg to 16kg.

With full adoption of this technique across the industry in 5 years would result in a $1.4 million pay-off for the whole industry.

Comparing the yield increase method of reducing unit costs to direct action to reduce inputs or use cheaper products shows that the latter methods are likely to have minimal effects on unit costs by comparison. The magnitude of direct changes in input costs would have to be very large to have comparable effects on bottom line profit to yield increase.

Table 1. Current position of the Western Australian Lettuce Export Industry

Western Australian Lettuce Export Industry			
CURRENT POSITION			
	t/ha	$/ha	$/t
Paddock Yield	30.8		
Total Income		**$30,800**	**$1,000**
		$/ha	$/t
Planting		2400	77.92
Fertiliser		1585	51.46
Pest Control		1233	40.03
Machinery Operation		833	27.05
Irrigation		770	25.00
Labour		5062	164.35
Packing		8800	285.71
Cartons		2200	71.43
Cartage		2310	75.00
Total Direct Cost		**$25,193**	**$818**
Gross Margin		**$5,607**	**$182**

Table 2. Target management change

Change of Yield Through Better Management - Increased head and carton weights			
		t/ha	Change
Target Yield Increase	15%	35.40	4.60
Total Income		**$35,400**	**$4,600**
		$/ha	$/t
Planting		2400	-$10
Fertiliser		1585	-$7
Pest Control		1233	-$5
Machinery Operation		833	-$4
Irrigation		770	-$3
Labour		5062	-$21
Packing		8800	-$37
Cartons		2200	-$9
Cartage		2310	-$10
Total Direct Cost		**$25,193**	**-$106**
Gross Margin		**$10,207/ha**	**$4600/ha**

Table 3. Industry size

Industry Position

Current Industry Size	5 Year Forecast no change (5% pa) (No Yield Increase)	5 Year Forecast with change (5% pa) (15% Yield Increase)
325 ha	415 ha	415 ha
10000 t	12763 t	14677 t
$7.4 mill.	$9.4 mill.	$10.8 mill.

Efficiency Value	
Income Change	$1.4 mill.
Cost Change	$0
Profit Change	$1.4 mill.

Table 4. Target change

Target Change	Level of change	Change			Probability
		Cost $/t	Gross margin $/ha	Industry profit	
Yield increase through better management.	15%	-$106.00	$4,600	$1.4 mill.	70%
Reduce fertiliser cost through monitoring.	-15%	-$7.72	$238	$60,690	70%
Reduce irrigation through scheduling.	-10%	-$2.50	$77	$19,635	50%
Reduce packing cost through mechanisation	-10%	-$28.57	$880	$224,400	50%

APPENDIX 3

QUALITY ASSURANCE AND FOOD SAFETY - IMPLICATIONS FOR THE LETTUCE INDUSTRY

Dennis Phillips, Agriculture Western Australia, Midland WA

(Paper presented at the 1st National Lettuce Industry Conference June 2000, Hay, New South Wales)

Quality assurance schemes for horticultural producers are rapidly becoming a reality under market pressure from Australian supermarkets. This paper examines the factors that underlie the push by supermarkets to source produce from QA accredited suppliers. The role of the Australia New Zealand Food Authority (ANZFA) is examined together with implications for growers.

BACKGROUND

There would be few people in Australian Horticultural Industries who have not heard of Quality Assurance but even less who could predict the consequences it will have for the industry over the next decade.

Consumers have long been suspicious of the pest and disease control practices employed by the horticulture industry and the implications residues may have for their health and wellbeing. Prior to 1994, this was the major focus of community concern and Government regulation relating to horticultural crops. Since that time, there have been a number high profile food contamination incidents both nationally and internationally which have focussed public attention on the risks presented by micro-organisms and agricultural practices. The most notable of these was the BSE or 'mad cow disease outbreak in the UK which did irreparable damage to the beef industry in that country and resulted in the slaughter of 4 million cattle. Closer to home we had Garibaldi sausage, Kraft peanut paste and Nippy's orange juice at disturbingly regular intervals since.

These incidents have shaken public confidence to the point that the primary focus of food safety legislation in Australia has now shifted from pesticides to microbiological contamination and food poisoning.

Governments around the world have been moving away from 'end point inspection' as the means of dealing with these problems towards preventive measures. The preferred process to achieve this is known as HACCP.

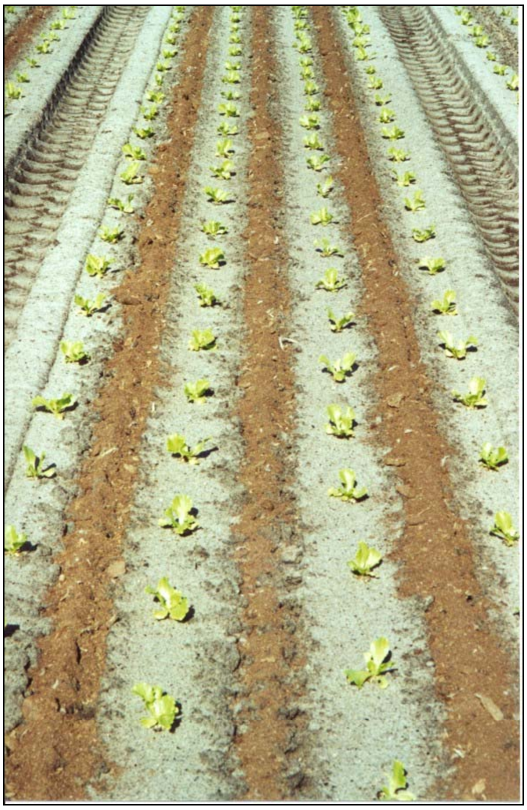
IMPLICATIONS FOR HORTICULTURAL INDUSTRIES

We constantly hear the cry from the Horticulture industry, 'Why should we be caught up in this? – Our product is safe!' On the contrary, Health Authorities estimate that there are 4.2 million cases of food poisoning in Australia every year at a cost to the nation of $2.7 billion. Authorities in the US claim that fruits and vegetables are the most frequent vehicles associated with food borne illness with an estimated annual death toll from food borne illness of 9000.

Lettuce has not been immune from blame with reported cases of poisoning from the deadly *E. coli* 0157 linked with lettuce overseas. Pre packaged leaf lettuces and fresh mixes are generally considered to present a greater risk than intact head lettuce.

Food safety regulators have identified five areas of food safety concern with regard to agricultural production:

- Contaminated water
- Raw manure
- Employee sanitation
- Transport and handling
- Product trace back



Deep litter poultry manure banded on a lettuce crop.

WHO IS DRIVING THIS PROCESS IN AUSTRALIA?

To date, many of the larger livestock industries in Australia have sought to address the demands of their customers and improve product quality in the market place through adoption of industry wide programs on a voluntary basis. These include initiatives such as Cattle Care and, Flock Care for cattle and lamb.

Horticulture industries in Australia have had no such programs and the push to Quality Assurance has largely been imposed on the industry by the big three supermarkets. Supermarket chains in Australia wield enormous power, accounting for 85% of the fresh produce trade. They have been acting to allay the fears of their customers about food safety, to avoid litigation and to be ready to meet new food safety standards being drafted by the Government regulatory body ANZFA.

ANZFA stands for Australia New Zealand Food Authority. This body has for the past 2 years been developing a joint food standards code for the two countries. They recently released a draft code for public comment. The closing date for comment was May 17. Details of this draft code can be found at www.anzfa.gov.au. They have outlined a timetable for gazetting and implementation of the code as follows:

November 2000	New code gazetted
Nov 2000 - May 2002	New and old codes run in parallel
May 2002	New code stands alone

Under the new code, all food businesses in Australia will be required to implement a food safety program based on 'Hazard Analysis and Critical Control Point'(HACCP) principles. The program will need to be implemented and reviewed by the food business and be subject to periodic auditing by a qualified food safety auditor.

Foodstuffs will be categorised according to perceived risk as high, medium and low. Primary producers may not have to comply with these regulations if their product is considered to be a low risk. As a general rule, horticultural industries are considered to be a problem area. Implementation is expected to take about 2 years for high risk industries and up to 6 years for low risk.

QUALITY SYSTEMS AND HACCP

A food safety program for a food business as described above must:

- Systematically identify hazards that may be expected to occur in all food handling operations of the business.
- Identify where, in a food handling operation, each hazard can be controlled and the means of control.
- Provide for the systematic monitoring of those controls.
- Provide an appropriate corrective action when a hazard is found to be not under control.
- Provide a regular review of the program by the food business to ensure its adequacy.
- Provide for appropriate records to be made and kept by the food business demonstrating action taken and compliance with the food safety program.

HACCP is a system that identifies, evaluates and controls hazards that are significant for food safety. These hazards are biological (e.g. bacteria), chemical (e.g. pesticides), physical (e.g. glass) and some schemes also identify quality hazards (e.g. bruising).

Various schemes are available for implementation by horticultural businesses which are based on HACCP principles. The most widely known are SQF 2000 and Freshcare (Approved Supplier Program). Woolworths has its own scheme known as Vendor Quality Management. Which of these schemes will ultimately become the industry standard in Australia is still sorting itself out.

It has already become clear that primary producers cannot bear the burden of running different schemes for different crops and markets on the same property with different audit standards. A national committee representing various affected industries and regulators has been set up to establish the equivalence of these various schemes. The issue is also being tackled by a reference group funded by the AusHort group which is a fund within HRDC set up to deal with 'across industry' issues. Funds from the vegetable levy support this group.

QA AND VEGETABLE INDUSTRIES

The acceptance and implementation of HACCP based QA schemes in the vegetable industry has already proven to be difficult and where it has been done, it is mostly by individual producers with little uniformity between growers. Marketers and consumers need to have confidence that when they buy product from a grower who has accreditation with one scheme or other that it is compatible with other growers' programs who have the same or similar accreditation.

Some sectors within the Australian horticulture industry, particularly fruit industries with strong national bodies, are making a concerted effort to ensure conformity and uniformity of schemes by developing plans on a 'whole of industry basis'. This cannot be said of any sector of the vegetable industry nationally but it is happening for some on a local or regional basis.

There is an urgent need for vegetable industries to develop uniform templates for QA schemes which form the core of schemes for individual businesses. HRDC projects funded from the national vegetable levy have a role to play in developing these templates and assisting with implementation across the industry.

The absence of formal QA programs in the lettuce industry in WA and the gourmet sector in particular and the widespread use of raw poultry manure in the production process led to this aspect being addressed by an HRDC which commenced this year. The project (VG99014-'A model for lettuce industry development') seeks to use the WA industry as a test case for introduction of a uniform HACCP based QA scheme applicable to producers of gourmet lettuce.

The project has four main components.

These include:

1. The declining export performance and opportunistic supply exemplified by the WA industry.
2. Meeting specifications for the growing processing sector.
3. A uniform approach to QA and HACCP.
4. The relative profitability of the sectors and how to choose between them.

The overriding aim of the project is to explore methods of tackling industry wide problems and capturing opportunities in a working partnership with growers and marketers. The principles established should be applicable to the wider national industry.

MARKING THE REPORT CARD ON QA

The jury is still out on whether the push towards uniform QA will be a good or a bad thing for horticultural industries. The result will depend on the actions of many players within the industry and government and the wider community. These are some observations on its apparent positives and negatives.

POSITIVE

- Improved business management practices and more professionalism in the industry.
- A common purpose for growers to make it uniform - more teamwork.
- A better image for the industry with consumers.
- Access to overseas markets we currently have difficulties with, especially in the Northern Hemisphere.
- Grower protection from litigation.
- Reduced risk of food poisoning in the community.

NEGATIVE

- Who will bear the added cost?
- Will supermarkets uphold their end of the bargain and only buy QA product?
- Significantly greater office time requirement of growers and some won't be able to cope
- Greater capital investment required by growers to comply
- Who will audit the auditors and QA consultants?

Pesticide registrations are inadequate and will have to be reviewed. Who will do it and at what cost? (see: www.dpie.gov.au/nra/ for details of minor use permits and Crop Protection Approvals Ltd (Office of Minor Use for priority for registration in the vegetable industry) - peterat@tsac.com.au).

APPENDIX 4

Good Fruit and Vegetables, September 2000

VEGETABLES LETTUCE EXPORT

Improving Australia's lettuce export opportunities

This presentation, made at the recent national Lettuce Industry conference at Hay, NSW, explains that the lettuce industry in Australia is typical of many other sectors of the horticultural industry in that its primary focus is the domestic market. This characteristic leads to an opportunistic approach to export marketing, resulting in lost opportunities. Export markets in the Australiasian region are highly price sensitive due to the presence of low cost product from the United States. The impact of this product is less apparent in Singapore and Malaysia than in Hong Kong. Consequently there are opportunities for suppliers in different states of Australia.

By DENNIS PHILLIPS

Lettuce is grown in all states and territories of Australia. Australian Bureau of Statistics (ABS) figures show that Queensland and Victoria are the largest producers with just over 40000 tonnes each followed by NSW and Western Australia with around 10000-12000 tonnes annually. The gross and farm-gate values of production rose steadily during the 1990s reaching a peak of $76.8 million and $51.5 million respectively in 1995-96. Values fell away by more than $15 million in 1997, the last year for which official statistics are available.

Exports of lettuce from Australia have traditionally been a small but important part of the overall picture. Export tonnages in the 1990s fluctuated in the range of 3,000 to 4,000 tonnes per annum (Figure 1) with head lettuce (iceberg) about double the volume of leaf lettuce out of a national total of around 100,000 tonnes. Export values ranged between $6 million and $8 million fob annually (fob – free on board).

Overall, Australia's export volumes of iceberg lettuce have remained static or fallen slightly albeit with a large seasonal variation in volumes and values. For example, 1997/98 was a relatively good year with national volumes approaching 3000 tonnes while 1995/96 was poor with the total slipping below 2000 tonnes.

Export performance by state has also been patchy with WA dropping from 43% of the national volume in 1993 to a low of 10% by 1996, followed by a turnaround to 30% in 1997/98. NSW has experienced steady growth over the last five years but the figures are confusing since they include some product not grown in the state but which was exported out of Sydney. Victoria and Queensland have remained static overall, with a larger seasonal variation from Queensland. Export volumes from South Australia have fallen.

The reason for this difference in performance by state is partly explained by WA exporters traditionally having a greater presence in the Singapore and Malaysia markets while the rest of Australia has been linked more to the fortunes of the Hong Kong market (Figure 2).

It is widely acknowledged within the industry, that the overriding factor limiting growth of Australian exports into south-east and north Asian markets is the influence of the US in these markets. Hong Kong is particularly difficult with Australia accounting for only 4-5% of total imports. This contrasts with Singapore and Malaysia where Australia, while still secondary to the US, provided 18% and 36% respectively of imports in 1997 (Table 1). The size and scale of US production and its large domestic production base has made markets in our region highly price sensitive and we only compete when prices are high in the US due to supply shortages.

The price sensitive nature of the export markets and perishability of the product has led to the Australian lettuce industry and export sector having a number of clearly identified characteristics.

The industry is primarily concerned with supplying Australian domestic markets, either fresh or processing, and exports are often opportunistic rather than dedicated.

This can result in product being sourced from domestic markets. The cartons are likely to be unsuitable for export and re-packing may be needed. Cool chain handling procedures, in line with export requirements, are unlikely to have been followed.

Eighty percent of lettuce exports are transported by air and there are few dedicated suppliers.

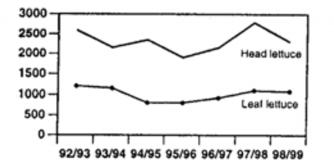
Cartons of Australian lettuce often fail to meet the weight specifications of importers. For instance, it is not unusual for 24 heads of Australian lettuce to weigh 10-18kg when US product weighs 22kg.

The challenge for Australian producers is to become more price competitive with the US so that we can compete effectively in these markets more often than we do now. This challenge led to the establishment of a project funded from the national vegetable levy with support from the Horticultural Research and Development Corporation which commenced this year. The project seeks to use the WA industry as a test case to identify strategies and methods that could be employed nationally to improve the cost competitiveness of production.

The over-riding aim of the project is to explore methods of tackling industry-wide problems and capturing opportunities in working partnerships between growers, marketers and retailers.

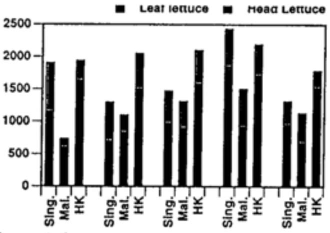
Dennis Phillips is a senior horticulturist with Agriculture WA based at Midland.

Figure 1: Australian exports of head and leaf lettuce (tonnes)



Source: *Agriculture Western Australia*

Figure 2: Australian lettuce exports by destination (Aust $)



Source: *Agriculture Western Australia*

Don Smith, of Don Smith Horticulture P/L, with leaf lettuce from the Lotus Red company in the Hong Kong wholesale market.

Table 1: Exports to selected markets by Australia and competitors (tonnes in 1997)

Importing Country	Australia	USA	China	Netherlands	Other	Total
Hong Kong	1176	21,230	1497	221	158	24,282
Malaysia	1416	2190	128	52	98	3884
Japan	11	3381	0	83	708	4183
Singapore	1337	4519	19	203	1420	7498

Source: *Australian Horticultural Corporation*

APPENDIX 5

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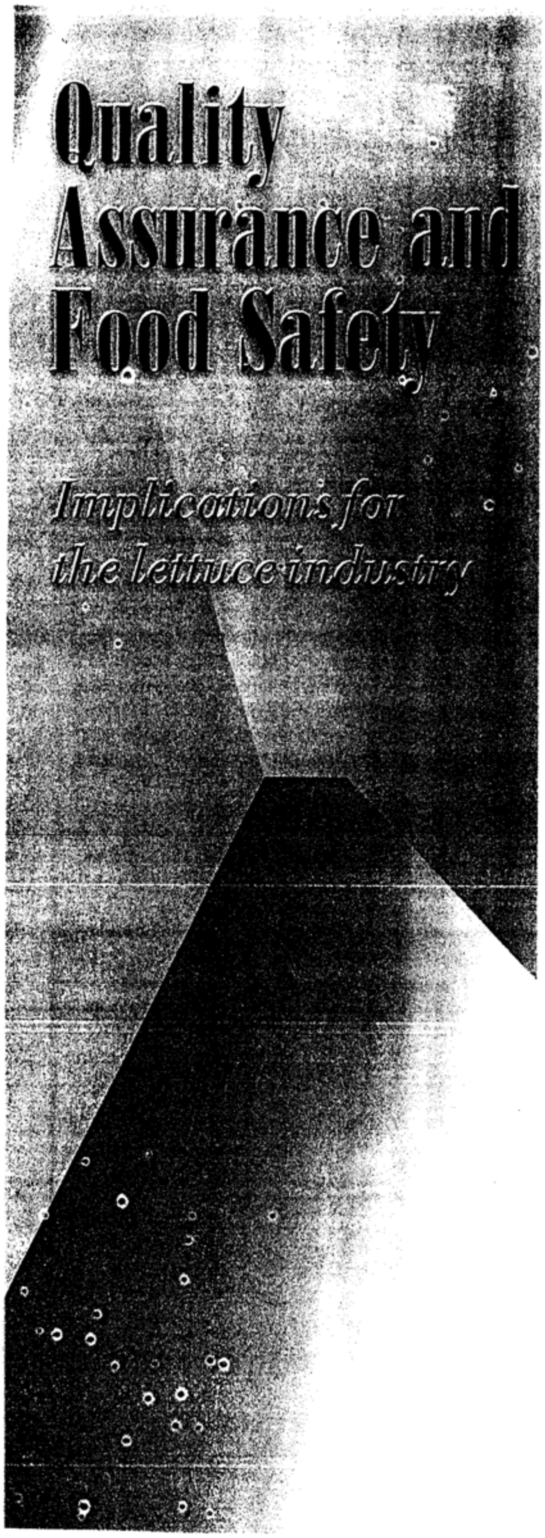

Quality assurance schemes for horticultural producers are rapidly becoming a reality under market pressure from Australian supermarkets. DENNIS PHILLIPS examines the factors that underlie the push by supermarkets to only buy produce from QA accredited suppliers. The role of the Australia New Zealand Food Authority (ANZFA) is examined together with implications for growers.

Background

There would be few people in Australian horticultural industries who have not heard of "Quality Assurance", but even less who could predict the consequences it will have for the industry over the next decade.

Consumers have long been suspicious of the pest and disease control practices employed by the horticulture industry and the implications residues may have for their health and wellbeing. Prior to 1994, this was the major focus of community concern and Government regulation relating to horticultural crops. Since that time, there have been a number of high profile food contamination incidents both nationally and internationally which have focused public attention on the risks presented by micro-organisms and agricultural practices. The most notable of these was the BSE or 'mad cow disease' outbreak in the UK which did irreparable damage to the beef industry in that country and resulted in the slaughter of 4 million cattle. Closer to home we have had Garibaldi sausage, Kraft peanut paste and Nippy's orange juice at disturbingly regular intervals since.

Practical Hydroponics and Greenhouses, January/February 2001

These incidents have shaken public confidence to the point that the primary focus of food safety legislation in Australia has now shifted from pesticides to microbiological contamination and food poisoning.

Governments around the world have been moving away from 'end point inspection' as the means of dealing with these problems towards preventative measures. The preferred process to achieve this is known as HACCP.

Implications for Horticultural Industries

We constantly hear the cry from the horticulture industry: 'Why should we be caught up in this? Our product is safe!' On the contrary, health authorities estimate that there are 4.2 million cases of food poisoning in Australia every year at a cost to the nation of $2.7 billion. Authorities in the US claim that fruits and vegetables are the most frequent vehicles associated with food borne illness with an estimated annual death toll from food borne illness of 9000.

Lettuce has not been immune from blame with reported cases of poisoning from the deadly E coli 0157 linked with lettuce overseas. Pre-packaged leaf lettuce and fresh mixes are generally considered to present a greater risk than intact head lettuce.

Food safety regulators have identified five areas of food safety concern with regard to agricultural production:

- Contaminated water
- Raw manure
- Employee sanitation
- Transport and handling
- Product trace back

Who is driving this process in Australia?

To date, many of the larger livestock industries in Australia have sought to address the demands of their customers and improve product quality in the market place through adoption of industry wide programs on a voluntary basis. These include initiatives such as Cattle Care, and Flock Care for cattle and lamb.

Horticulture industries in Australia have had no such programs and the push to Quality Assurance has largely been imposed on the industry by the big three supermarkets. Supermarket chains in Australia wield enormous power, accounting for 85% of the fresh produce trade. They have been acting to allay the fears of their customers about food safety, to avoid litigation and to be ready to meet new food safety standards being drafted by the Government regulatory body ANZFA.

ANZFA stands for Australia New Zealand Food Authority. This body has for the past two years been developing a joint food standards code for the two countries. They recently released a draft code for public comment. The closing date for comment was 17 May 2000. Details of this draft code can be found at www.anzfa.gov.au They have outlined a timetable for gazetting and implementation of the code as follows:

November 2000	*New code gazetted*
Nov 2000 - May 2002	*New and old codes run in parallel*
May 2002	*New code stands alone*

Under the new code, all food businesses in Australia will be required to implement a food safety program based on 'Hazard Analysis and Critical Control Point' (HACCP) principles. The program will need to be implemented and reviewed by the food business and be subject to periodic auditing by a qualified food safety auditor.

Foodstuffs will be categorised according to perceived risk as high, medium and low. Primary producers may not have to comply with these regulations if their product is considered to be a low risk. As a general rule, horticultural industries are considered to be a problem area. Implementation is expected to take about two years for high risk industries and up to six years for low risk.

Quality Systems and HACCP

A food safety program for a food business as described earlier must:

- Systematically identify hazards that may be expected to occur in all food handling operations of the business.
- Identify where in a food handling operation each hazard can be controlled and the means of control.
- Provide for the systematic monitoring of those controls.
- Provide an appropriate corrective action when a hazard is found to be not under control.
- Provide a regular review of the program by the food business to ensure its adequacy.
- Provide for appropriate records to be made and kept by the food business demonstrating action taken and compliance with the food safety program.

HACCP is a system that identifies, evaluates and controls hazards that are significant for food safety. These hazards are biological (eg bacteria), chemical (eg pesticides), physical (eg glass) and some schemes also identify quality hazards (eg bruising).

Various schemes are available for implementation by horticultural businesses which are based on HACCP principles. The most widely known are SQF 2000 and Freshcare (Approved Supplier Program). Woolworths has its own scheme known as Vendor Quality Management. The schemes which will ultimately become the industry standard in Australia is still being sorted.

It has become clear that primary producers cannot bear the burden of running different schemes for different crops and markets on the same property with different

Practical Hydroponics and Greenhouses, January/February 2001

audit standards. A national committee representing various affected industries and regulators has been set up to establish the equivalence of these various schemes. The Australian horticulture industry does not appear to be directly represented on this committee.

QA and vegetable industries

The acceptance and implementation of HACCP-based QA schemes in the vegetable industry have already proven to be difficult and where it has taken place, it is mostly by individual producers with little uniformity between growers. Marketers and consumers need to have confidence that when they buy product from a grower who has accreditation with one scheme or other, that it is compatible with other growers' programs who have the same or similar accreditation.

Some sectors within the Australian horticulture industry, particularly fruit industries with strong national bodies, are making a concerted effort to ensure conformity and uniformity of schemes by developing plans on a 'whole of industry basis'. This cannot be said of any sector of the vegetable industry nationally but it is happening for some on a local or regional basis.

There is an urgent need for vegetable industries to develop uniform templates for QA schemes which form the core of schemes for individual businesses. The Horticultural Research and Development Corporation (HRDC) projects funded from the national vegetable levy have a role to play in developing these templates and assisting with implementation across the industry.

The absence of formal QA programs in the lettuce industry in Western Australia, the gourmet sector in particular, and the widespread use of raw poultry manure in the production process led to this aspect being addressed by the HRDC, which commenced in 2000. The project (VG99014-'A model for lettuce industry development') seeks to use the WA industry as a test case for introduction of a uniform HACCP-based QA scheme applicable to producers of gourmet lettuce.

The project has four main components. These include:

- The declining export performance and opportunistic supply exemplified by the WA industry.
- Meeting specifications for the growing processing sector.
- A uniform approach to AQ and HACCP.
- The relative profitability of the sectors and how to choose between them.

The overriding aim of the project is to explore methods of tackling industry-wide problems and capturing opportunities in a working partnership with growers and marketers. The principles established should be applicable to the wider national industry.

Marketing the report card on QA

The jury is still out on whether the push towards uniform QA will be a good or a bad thing for horticultural industries. The result will depend on the actions of many players within the industry and government, and the wider community. These are some observations on its apparent positives and negatives.

Positive

- Improved business management practices and more professionalism in the industry.
- A common purpose for growers to make it uniform - more teamwork.
- A better image for the industry with consumers.
- Access to overseas markets we currently have difficulties with, especially in the northern hemisphere.
- Grower protection from litigation.
- Reduced risk of food poisoning in the community.

Negative

- Who will bear the added cost?
- Will supermarkets uphold their end of the bargain and only buy QA product?
- Significantly greater office time requirement of growers and some won't be able to cope.
- Greater capital investment required by growers to comply.
- Who will audit the auditors and QA consultants?
- Pesticide registrations are inadequate and will have to be reviewed. Who will do it and at what cost? (see www.dpie.gov.au/nra/ for details of minor use permits, and Crop Protection Approvals Ltd (Office of Minor Use for priority for registration in the vegetable industry) - peterat@tsac.com.au.

About the author

Dennis Phillips is a Development Officer with Agriculture Western Australia. His paper on 'Quality Assurance and Food Safety' was presented at the Australian Lettuce Industry Conference, June 2000.
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APPENDIX 6

A STRATEGY TO INCREASE AUSTRALIAN LETTUCE EXPORTS

Dennis Phillips, David Gatter, Aileen Reid, Peter Gartrell and Linda Teasdale
Department of Agriculture Western Australia

(Paper presented at the 2nd National Lettuce Industry Conference
May 2002, Gotton, Queensland)

Background

Australian exports of head lettuce have remained static for the last decade at around 2000 - 2500 tonnes per annum. Australia's traditional markets have been South East Asia, Hong Kong and the Philippines. Australia's main competitor in these markets has been the United States and in more recent times China.

The Australian industry is relatively small and fragmented compared to the massive industry in California, which supplies 70% of US production alone. This market power has brought with it economies of scale which have made it difficult for any other country to compete with the US on price in export markets. This is particularly so in markets with shorter sailing times from California such as Japan and Hong Kong.

A lack of price competitiveness with the US throughout the 1980's has led to an erosion of Australia's export infrastructure. The result has been that our traditional markets, which were serviced by dedicated export growers with 'forward orders' have been replaced by a culture of 'spot marketing' when the price is right. This trend has been no more evident than in Western Australia where the Singapore and Malaysian markets for lettuce and other vegetables were taken for granted in the 1970's, but are no longer. This occurred against a backdrop of favourable sea freight sailing times to these markets and a mostly favourable exchange rate.

A HRDC (Horticulture Australia) project was initiated in 2000 to investigate the causes of our declining export performance and propose solutions and a strategy to regain lost market share. The project was named 'Á model for export market development' because it sought to demonstrate how an industry in decline could turn around its fortunes by adopting a systematic planned approach supported by the industry.

Aims

The primary aim of the project was to develop and test a plan to increase lettuce exports from Western Australia as a model that could be followed elsewhere in Australia if successful.

Methods

The initial phase of the project was to talk to existing exporters, growers and processors about the causes of declining exports. These discussions reinforced the following assumptions that were made when the project application was written.

- Lettuce exports had declined because we had become uncompetitive on price in traditional markets.
- Export opportunities for lettuce were growing due to an increase in demand from the 'food service sector', especially for shredded iceberg lettuce.
- Future demand for lettuce would increasingly be in minimally processed form.
- Future markets would be increasingly concerned about 'Food Safety', particularly microbiological.
- Our cost competitiveness could be improved by increasing marketable yields, reducing losses in the field and reducing production and export costs.
- Reliable data on costs of production and export were not readily available.

The export development plan sought to address these issues through the following strategies and actions:

1. **Discussions** with existing exporters, growers and processors to develop a plan of action.
2. Commissioning a **study of key markets** to assess trends in head and leaf lettuce prices and volumes to identify opportunities.

3. **Benchmarking** our production costs with those of competitors to identify areas for improvement. This was done by collecting 'on farm' cost of production data from the published literature.
4. Developing a **cost chain model** for traditional production and export methods. This was done by interviewing growers and exporters in WA.
5. Conducting a study in commercial crops, which included independent estimates of **yield and crop loss** throughout the year to validate key assumptions of the 'cost chain model'.
6. Using the ‘cost chain model’ to estimate the effect on our **export competitiveness** of significant changes to production, handling and export methods. To propose changes to current practices in the light of these findings.
7. Developing **fertiliser schedules** to produce head and leaf lettuce which maximise exportable yield (by weight) with minimum risk of microbiological contamination in the field. The intention was to reduce the unit cost of production as well as minimising the ‘food safety hazard’ associated with growing the crop with raw poultry manure. This was done by conducting a series of experiments in commercial crops over a 2-year period.
8. Developing a **harvest index** to allow growers to predict when to harvest their crops to maximise head weight yield without exceeding the head density specifications of processors (for shredding). This is important because mean head weight can double in one week when harvest maturity is reached. An error in estimating harvest date by three days could mean the difference between profit and loss.

As the project unfolded, industry circumstances have changed and new opportunities have presented themselves. New activities were added to the plan in response to these changes as follows:

9. An opportunity arose to supply lettuce processors (shredders) with raw and finished product in Malaysia and the Middle East. Economic analysis had shown that we would not be competitive using traditional export methods (cartons) but **bulk handling** could reduce costs sufficiently. In response to this opportunity, we set out to develop and test a ‘non returnable’ bulk bin that would meet the needs of these buyers and test market in collaboration with ‘non traditional’ exporters.

Results

Discussions

Discussions with traditional exporters and growers revealed that they were despondent about the future of lettuce exports because our costs were too high. Consequently it was difficult to engender enthusiasm for the project and it proved impossible to involve them in a working group to develop the project.

Processors proved to be more positive about the prospects for export, especially raw product to associated food service companies in SE Asia and the Middle East but the cost of our product was still a problem. I dialogue has remained open throughout the project's life and a working group has been recently established to test bulk handling for export.

A study of key markets

A ‘desk top’ study of readily accessible import statistics for Malaysia and Singapore was conducted by AGWEST Trade and Market Development in April 2001. The study identified the following trends:

- Between 1997 and 2000, 'head lettuce' has declined from 54% of all lettuce imported to 6%, while Malaysian imports and exports to Singapore have increased.
- The US has taken over as the largest supplier of head lettuce to Malaysia and Australia's share has declined.
- Head lettuce import prices in Malaysia (cif) have risen steadily from 1997 to 2000, while there has been a general trend for export prices from WA (fob) to fall.
- The average import (cif) price for leaf (other) lettuce in Singapore declined from S$1.80 to S$1.60 from 1997 to 2000.
- Landed prices for leaf lettuce from the US have averaged S$1.57 since July 1998 while prices for product from the Netherlands are more than double this.
- The US became the largest supplier of leaf lettuce to Malaysia in 2000.

Benchmarking

Indicative costs of production for lettuce from within Australia and overseas show that Western Australian surveyed producers are relatively competitive. Figure 1 shows an outline of the relative costs of production. Post harvest costs for Queensland and NSW are significantly higher than WA, for lettuce sold in Australia largely due to more expensive packaging (cartons vs returnable crates) and transport (more distant markets). Seedlings, fertiliser and fumigants make WA establishment costs higher. The US cost of production is competitive on a dollar for dollar basis but exchange rates increase their relative cost. The US domestic price tends to offer lower margins per unit than Australian markets. The resultant profit margins per unit are reduced. Relevant data was not available to make these comparisons for export lettuce.

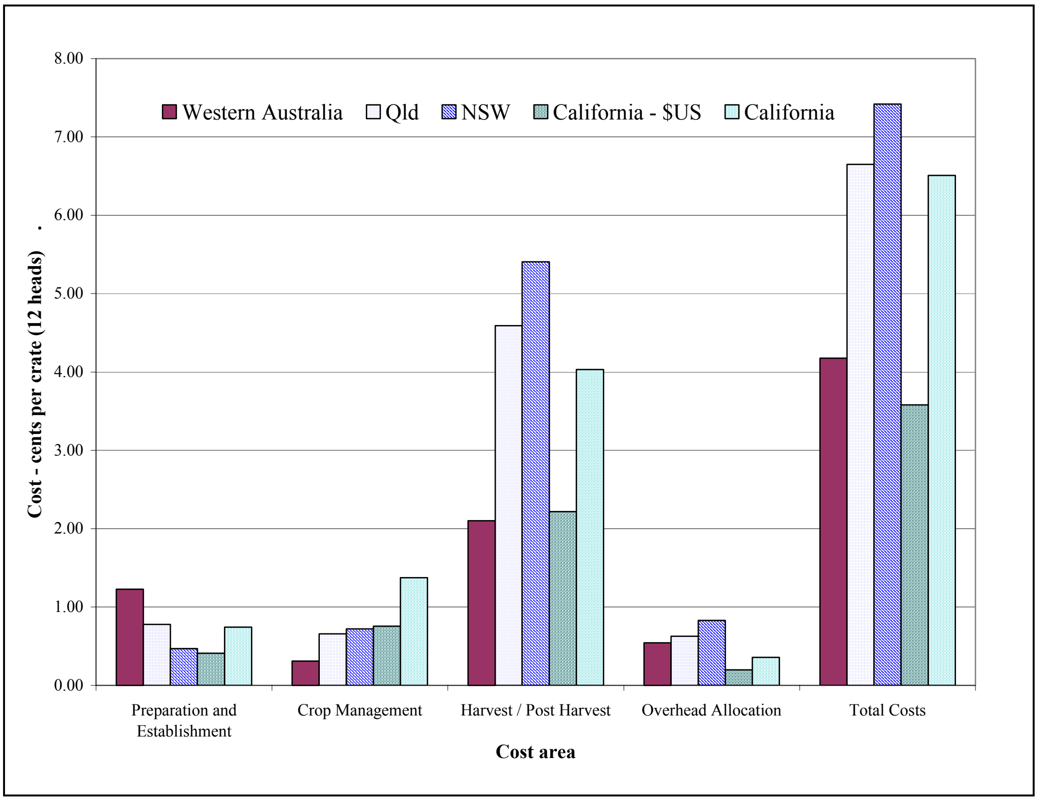


Figure 1: Cost of lettuce production for various production areas.

Cost chain model and cost competitiveness

A consequence of WA's lack of cost competitiveness and the 'spot market' approach to export has been an increasing dependence on airfreight, which is expensive. A comparison of typical costs for lettuce airfreighted in cartons (A/V) to Malaysia and dedicated supply in bulk bins by sea (hypothetical) is as follows:

By air in A/V	Cost (c/kg)	By sea in bulk bins	Cost (c/kg)
Growing cost	42-54	Growing cost	37-47
Packing	18-25	Bin preparation	2
Packaging	18-21	Bins	17
Agent fee	9-11	Agent fee	0
Exporter margin	10-12	Exporter margin	5
Internal freight	6-10	Internal freight	3
A/V freight	100	20' reefer	39-45
Total	**203-233**	**Total**	**103-117**

Given that the CIF price of head lettuce from competing suppliers is in the order of $1.50/kg, this analysis shows the reasons for our current lack of competitiveness. Sea freight in bulk offers the potential to make us competitive in the supply of lettuce for processing.

Yield and crop loss

Between January 2001 and November 2001, 141 individual lettuce plantings on five grower properties were monitored and assessed for causes of crop loss.

The results from the survey showed that the main contributing factors which resulted in crop loss were Lettuce Big Vein Virus, Sclerotinia Lettuce Drop, Tomato Spotted Wilt virus and other physiological factors, for example, stunted and misshapen heads and plants. Preliminary results of the survey are shown in Table 1.

Table 1. Major causes of crop loss over all five properties

Cause	Loss (mean per crop)
Lettuce Big Vein *	6%
Sclerotinia Lettuce Drop	7%
Tomato Spotted Wilt Virus	3%
Other (physiological factors)	5%

* The figures for Big Vein are presence of symptoms. Most of these affected heads could have been sold but were of a lower weight and quality due to the presence of the virus.

Selected crops were harvested to determine head weights (hearts) at harvest. Over the course of the season, 71 plantings on the 5 grower properties were harvested to get an independent assessment of head weight yield at the time the grower(s) chose for harvest. The results are encouraging in that, they verify that high head weight yields can be repeatedly obtained in commercial crops with relatively low levels of loss. The data will be used to estimate the real seasonal profitability if the crops had been sold for export and processing.

Fertiliser schedules

Lettuce processors of both leaf and head types are not well disposed to the risk presented by the product being grown with raw animal manures for reasons of microbial contamination. For most growers, poultry manure is an integral part of the production process and they are reluctant to abandon it for reasons of cost and familiarity. During the second year of this project, the use of raw poultry manure on vegetable crops was banned for all but 4 months in winter in most production districts.

In response to these factors, we set out to develop fertiliser programs based on chemical fertilisers only. A production system has been developed after a sequence of eight trials with iceberg lettuce which increased marketable yield and crop uniformity while reducing cost by as much as 60 per cent compared to traditional programs based on animal manure.

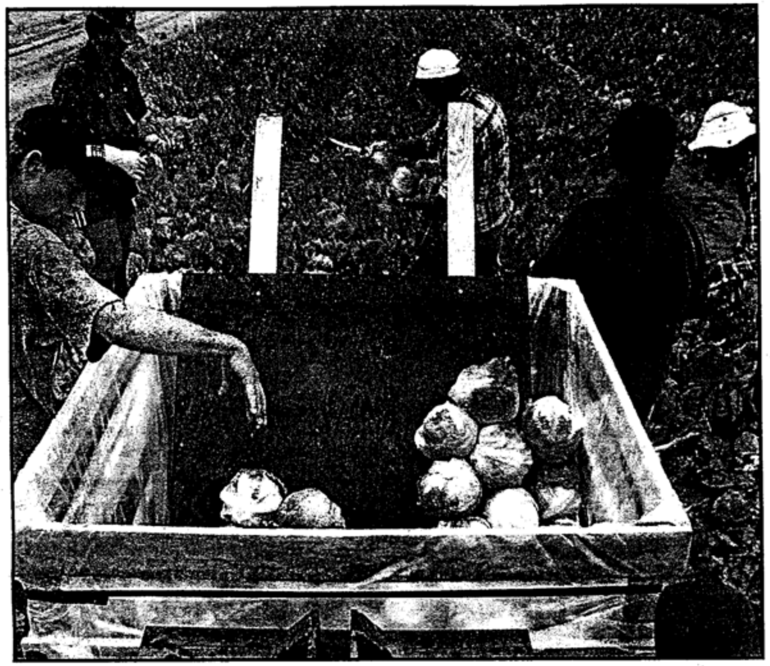
A low cost program which did not require poultry manure was also developed for leaf lettuces, cos, raddichio and endive after a sequence of 4 trials on a grower property.

Harvest index

A series of 15 research station experiments are currently underway to identify the optimum time to harvest for processing in districts near Perth and at Manjimup (300km south of Perth). The work consists of planting 2 varieties each month and harvesting over 6 dates, each approximately 2 days apart and measuring the change in head size and weight. It is hoped that a test can be developed that will help growers decide when to harvest to maximise yield in the optimum head density range.

APPENDIX 7

Countryman Horticulture, August 29, 2000



Harvesting lettuce for the first bulk exports to the Malaysian market directly into specially designed crates.

First bulk shipment crunch time

SPEARWOOD cauliflower and lettuce grower Troy Cukrov believes the potential for lettuce to the international fast-food industry is huge.

Japan goes through a whopping 3000 tonnes a week and that's without touching the market in China, Taiwan, Singapore, Malaysia and the Middle East.

"The Japanese market is supplied mostly by the US but if we could tap into 10 per cent of that market that would be 500,000 head of lettuce a week," Troy said.

The first trial of Troy's bulk lettuce to Malaysia was due to arrive in Kuala Lumpur yesterday.

If the lettuce arrived in the condition it left Fremantle Port, Troy feels confident he will be in Malaysia within weeks talking to the McDonald's subsidiary company about his growing programs.

"There is every indication this shipment will work," he said.

Lettuce is an ideal rotation crop for Troy's expanding cauliflower-growing business.

Lettuce grower Troy Cukrov: market potential huge.

In the past year he and his father, Danny, have taken on another 32 hectares of land in Wanneroo and Spearwood to add to their initial 10ha.

They have used the extra land to hike their export cauliflower production by 50 per cent. The father and son team now grows 30,000 cauli a week.

Troy concedes there is potential for other WA growers to get involved in the food service industry he is spearheading.

"I'll bring other growers into this if I need to," he said.

"I'm sure there will be plenty of people interested if this works."

Crate helps WA growers seal Asian lettuce deal

By MIGNON SHARDLOW

A NEW pine crate and a dose of dedication was all it took to prise open a potentially large export opportunity for WA growers from Wanneroo down to Pemberton.

The crate has lowered labour costs enough to crack the price-competitive fast food lettuce market in Malaysia.

The first bulk shipment of lettuce from Fremantle was sent to Malaysia last week.

The shipment represents 2½ years work by the Department of Agriculture on a project funded by Horticulture Australia.

Department senior development officer Dennis Phillips said the shipment project was still only halfway on its journey to full-scale commercial success.

"The first shipment has to work — it has to identified by industry as successful and then adopted by growers," Mr Phillips said.

He said the project was designed to arrest the decline in WA's lettuce exports over the past decade.

"A lack of price competitiveness with the United States throughout the 1980s led to erosion of Australia's export infrastructure for lettuce," Mr Phillips said.

"The result was traditional markets, which were serviced by dedicated export growers with forward orders, were replaced by a culture of spot purchasing, when the price was right."

Mr Phillips said discussions with processors who supplied the food service sector in WA with "ready to use" shredded lettuce had identified untapped market opportunities in South-East Asia and the Middle East.

"I've seen the figures for how much lettuce goes into the fast food sector in Singapore and Japan," he said.

"The quantities are massive."

A working group was established between two processors, a grower — Troy Cukrov — and department staff to develop a strategy to capture these markets.

Key issues for WA have been lack of price competitiveness and the high cost of packing and freight, especially airfreight, into these markets.

The fast food market did not need lettuce individually wrapped and packed in cardboard cartons as was traditional practice, so the working group developed packaging options which could reduce handling and freight costs.

"A series of pinewood prototypes were built with the assistance of the ACTIV foundation in Bentley, until a design was arrived at which maximises the internal space in a sea container at minimum cost and with minimum damage to lettuce hearts," Mr Phillips said.

"The bin was robust enough to be bulk loaded in the field and loaded by fork lift direct into a sea container on the farm.

"A specially designed fan and floor pan in the bins allowed cold air to be drawn vertically through the bins.

"This eliminated the whole process of wrapping, packing in cardboard cartons and manual loading of sea containers carton by carton which is current industry practice."

The bulk bin could be mechanically unloaded at the delivery end, further reducing labour costs.

Mr Phillips hopes the bins will have an economic value after unloading at their destination such as being reusable for transporting local products in South-East Asia or for low cost furniture making.

The department is now seeking a complementary grower in the south.

APPENDIX 8

Department of Agriculture
Government of Western Australia

MEDIA STATEMENT

3 Baron-Hay Court, South Perth, Western Australia 6151
Tel: (08) 9368 3641 Fax: (08) 9474 2018
www.agric.wa.gov.au

26 September 2002

BULK EXPORT LETTUCE SHIPMENT A SUCCESS

In an Australian first, a sea container of Western Australian grown head lettuce was exported to Malaysia in bulk crates in late August.

The consignment was shredded by a processing company in Malaysia which in turn supplied the finished product to the McDonalds restaurant chain in that country.

The shipment was arranged between the Australian supplier of shredded lettuce to McDonalds, GSF Australia and their Malaysian counterpart, MacFood through a strategic alliance.

WA Manager for GSF Phillip Van Den Einden was given the challenge by his management to support his Malaysian counterpart with WA grown lettuce late last year. Traditionally, WA had been a high cost supplier of lettuce to this market and unable to compete with the US on price grounds alone, but our quality was highly regarded by the market.

Dennis Phillips from the Department of Agriculture WA had been leading a project funded by Horticulture Australia at the time, which had the aim of reviving lettuce exports from Australia. GSF was in contact with the project and joined forces to establish an export working group, which included an interested grower (Troy Cukrov) and another processor with an interest in export. Members of the working group soon found that they had common objectives and set about the task of coming up with a strategy to meet the requirements of overseas lettuce processors.

Traditional practice is for lettuce to be shipped or flown into these markets in cardboard cartons, often individually wrapped, from the US, Australia and other countries. The working group quickly recognised that the processing sector did not need to receive it this way and that the high cost of packing and loading cartons made WA uncompetitive. The idea of bulk handling and mechanical loading was born and the group set out to explore options.

Department of Agriculture officers, Dennis Phillips and David Gatter designed a non returnable wooden crate for the purpose, with the help of their private sector partners. The crate had to match the internal dimensions of a sea container, be cost competitive with cartons, able to be field loaded and pre cooled on-farm while also giving the product protection from contamination.

After a period of trial and error, the development team came up with a unique crate design and pre cooling system, which was cheap and effective. The crate design also took advantage of the air flow characteristics of sea containers to ensure that any heat generated by the lettuce during shipment was continually removed from the product.

Dennis Phillips and Phillip Van Den Einden followed the trial shipment to Malaysia and inspected its outturn at MacFood. The shipment arrived in excellent condition after the six-day voyage to Malaysia.

Mr Phillips said that an array of on-board temperature, air and humidity monitoring equipment in the container and regular updates by satellite during the voyage gave them the confidence to predict that the shipment would be successful, and it was.

"The air flow design of the crates kept temperatures uniform and close to optimum for lettuce storage throughout the voyage," he said.

"Taking the time to inspect the outturn of this first shipment was crucial to the success of the project and future trade with the food service sector in the region," Mr Phillips said.

"Being present at outturn allowed us to identify areas that needed improvement in future shipments, it established a personal relationship with the buyers and it encouraged MacFood to appreciate the R&D aspects of the work and the role they can play in developing the bulk shipment concept. They are now keen to help us develop the concept further."

Mr Phillips said the shipment demonstrated that there were significant untapped markets in the food service sectors in both Malaysia and Singapore for lettuce and other vegetables shipped in this form.

"These markets are more sensitive to quality than price, in contrast to the traditional wholesaler network in these countries, Mr Phillips said.

"We were able to show a benefit to them in both categories as well as developing a true ‘supply chain alliance’ from grower to end user. In this chain, ‘cool chain integrity’ was maintained throughout, in contrast to the traditional supply chain through importers and wholesalers used by our competitors," he said.

Media contact

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APPENDIX 9

Good Fruit and Vegetables, October 2002

Australian first - bulk lettuce bound for Asia

The first bulk shipment of lettuce from Australia was sent to the Malaysia in August.

The bulk shipment of lettuce is the culmination of two and a half years work by the WA Department of Agriculture on a project funded by Horticulture Australia

Department senior development officer, Dennis Phillips, said the project was designed to arrest the decline in Western Australia's lettuce exports during the last decade.

"A lack of price competitiveness with the United States throughout the 1980s led to erosion of Australia's export infrastructure for lettuce," Mr Phillips said.

"The result was traditional markets, which were serviced by dedicated export growers with forward orders were replaced by a culture of spot purchasing, when the price was right."

Mr Phillips said discussions with processors, who supplied the food service sector in WA with ready to use shredded lettuce, identified untapped market opportunities in South East Asia and the Middle East.

A working group was established between two processors, a grower and department staff to develop, a strategy to capture these markets.

He said key issues for WA have been lack of price competitiveness and the high cost of packing and freight, especially airfreight for lettuce into these markets.

The food service market did not need lettuce individually, wrapped and packed in cardboard cartons as is the traditional practice, so the working group developed packaging options which could reduce handling and freight costs.

"A series of pinewood prototypes were built, with the assistance of the Activ foundation in Bentley, until a design was arrived at which maximised the internal space in a sea container at minimum cost and with minimum damage to lettuce hearts," Mr Phillips said.

"The bin was robust enough to be bulk loaded in the field and loaded by fork lift direct into a sea container on the farm. A specially designed fan and floor plan in the bins, allowed cold air to be drawn vertically through the bins," he said.

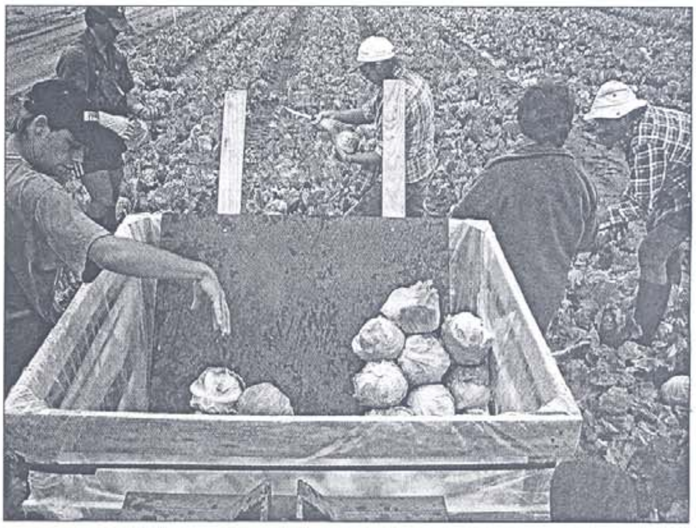
"This eliminated the whole process of wrapping, packing in cardboard cartons and manual loading of sea containers carton by carton which is current industry practice."

The bulk bin could be mechanically unloaded at the delivery end, further reducing labour costs. It was hoped that these bins would also have an economic value after unloading at their destination, such as reuse for transporting local products in SE Asia or for low cost furniture making.

The unconventional method of forced air cooling was devised so a plastic liner could be used inside the bins to give the product added protection from contamination and to minimise dehydration of the lettuces.

GSF Australia, which received and processed trial consignments, was impressed with the quality of product cooled by this method. Mr Phillips said it was relatively cheap and easy to do, compared with alternative methods commonly used in Eastern Australia and overseas. GSF Australia is sponsoring the trial shipment to supply its affiliate in Malaysia with high quality product, as part of the McDonald's global product sourcing network.

The shipment was made through Pacific International Lines (PIL) and they will utilise a modified atmosphere unit, which is permanently built into the sea container, together with an independent satellite daily temperature monitoring system, which is new for world wide shipping.



Lettuce being packed in the field.

APPENDIX 10

Countryman Horticulture, February 2003

Good results with lettuce

POSITIVE results from a new lettuce crop trial in Manjimup could see a year-round supply of lettuce secured from WA producers to Asian fast food outlets.

The Department of Agriculture trial involves five varieties, some of which were found to be suitable to the South West climate in summer, a time when heat usually affects Perth crops.

The trial follows similar work in Perth in August and November last year.

Horticultural project manager Dennis Phillips said that because of a hole in the market caused by disease in Perth crops at present, the experiment was able to test the market by selling what it produced on a big scale.

He said this was a veritable first for the Government department.

"At this time of the year Perth is suffering quality problems because of the heat affecting crops," Mr Phillips said.

And because this is about the coolest part of the State that has the horticultural infrastructure and good soil and water, we saw that it had potential to make up the difference in that market.

Department horticultural development officer Aileen Reid said the trial was of a huge scale, with the researchers growing 16,000 plants compared with 400 in previous studies.

"We hope growers see we are fairly serious about this and how important the results could be for them," she said.

"It will be a matter of taking our results to them and convincing them this has potential, without them having to take the risks and do the guesswork."

The pair also tested a new method of storing the lettuces in high bulk cartons.

He travelled to the UK and Europe in [illegible] with his wife Jan, to inspect seed lines and spotted the Nadine, which had recently reached the UK market.

"It had all the attributes we were looking for," Mr Eldridge said.

"It was PCN resistant, good wash packing variety, good skin colour, high yielding and tough skin suitable for harvesting."

He secured the rights to Nadine variety in Australia, through the UK's Caithness Potato Breeders and introduced it to Australia under PBR protection.

One of the earliest varieties to go through the PBR system, Nadine became the only suitable wash packing potato in WA which was also PCN resistant.

Nadine is now a market leader in WA and is in demand in South Australia with NSW and Queensland markets set to follow.

Since then Mr Eldridge has brought seven more varieties into Australia of which five have been successful at a market level.

Successful breeds include Kestrel, Red Gem and blight resistant and salt tolerant Harmony.

With the cost of obtaining PBR for a variety at up to $12,000, along with sourcing the product from overseas, quarantine, two years of trial work and bulking up of the variety through tissue culture, the process of introducing a new variety into the market is a long and expensive one.

Mr Eldridge's primary source of income is from his 50 acre potato crop with seven lines.

His aim in introducing new lines is to give both consumers and producers more options, which they now have with up to 12 varieties on the WA market.