ASIAN FOODS

Asian foods derive from the cultures of Asian countries. For the purposes of RIRDC's program, Asian foods include fresh, semi-processed and processed foods relating to Asian cultures.

The market for Asian vegetables in many Asian countries is large. In 1988, Japan imported $120 million of fresh Asian vegetables. Imports to Asia of frozen, salted, canned Asian vegetables and seed total almost $2,000 million annually. Foods other than vegetables, particularly processed foods, are popular and include dried meat and fish as well as noodles and rice crackers. Japanese consumption of pickles is approximately 1.2 million tonnes per annum and worth about $5 billion at the manufacturing level. Domestically, with increases in the Asian-Australian population, Asian tourists in Australia and changes in eating habits of Australians, interest in Asian foods is high. The markets for Asian foods in other parts of the world are also expanding.

This program has been developed in close consultation with Australian producers and processors, the Asian community in Australia and following review of the Asian foods market for Australia. Background papers are available from the Corporation.

RIRDC priorities should be seen in the light of Australia's competitive advantage for export. Australia has extensive land resources; mechanisation to reduce unit costs; produces amongst the most biologically and chemically clean foods in the world; is geographically located favourably to temperate north east Asian markets, favouring high value out-of-season supply from Australia; and multicultural diversity can be considered a business asset for product knowledge, production and marketing of Asian foods.

RIRDC achievements in this program include the commissioning and launching of four very popular Asian food reports over the last 18 months to help producers of Australian made Asian foods gain access to market information never before collated.
1. MARKET DEVELOPMENT POTENTIAL FOR HOT CHILLI PEPPERS

Objectives
The aim of this project was to assess the market potential for Australian hot chilli pepper industry by determining if chillies could be grown, processed and marketed to satisfy demands and compete economically with imports on both price and non-price factors. Furthermore, the possibility of expanding into an export market was also assessed.

Background
Australians are responding to Asiatic and Spanish-American influences by consuming greater quantities of hot and spicy foods. This has manifested itself in many forms such as: hot and spicy Kentucky Fried Chicken, Mexican pizza and hamburgers, chilli and sate flavoured peanuts, and tex-mex flavoured chips. Consequently, in the last four years, imports of dried chillies have almost doubled to $2.2 million.

Although this level of import replacement may not be considered large nationally, it could be considered lucrative to a regional community. Furthermore, if Australia was to follow USA trends, the total chilli industry could grow to A$30 million.

Research
The report was conducted in two parts, the Australian chilli market and the overseas chilli market. In both cases extensive desktop study was undertaken to determine market parameters.

Outcomes
This report concludes that Australia may be able to compete with imported chilli if harvesting costs can be reduced. Harvesting costs are high due to the labour intensity of harvesting chillies. Consequently, a form of mechanical harvesting needs to be developed and this may be achieved by using a modified bean harvester.

Implications
There is potential to reduce costs of supplying chilli domestically by lowering harvesting costs, but this will depend on associated yield losses. Further research is needed to investigate this relationship.

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2. ASIAN FOOD: MARKET TRENDS AND PROSPECTS

The paper is to examine on-shore and off-shore movements to determine key countries, markets and foods and likely movements over the longer term (three years).

It is also expected to include: trends in trade and consumption as GDP changes, and associated Asian food flows in selected Asian countries; and trends in imports, domestic production and consumption of Asian foods in Australia. Based on the above research, predictions will be made for key export and domestic opportunities for Asian foods for Australia over the next 510 years.

Background
There are a number of factors favouring the expansion of Asian food production and processing in Australia: Asia has the fastest growing economies in the World; its disposable incomes are increasing significantly; its potential consumer base is enormous; there is a large growth in per capita food

Objective
To prepare a paper on prospects for an Australian based Asian foods industry and the research and development needed to realise its potential.
consumption; there is an increase in the number of two-income families; and there is a high proportion of youth in most Asian countries. Also important are improved Australian trade linkages with countries of the region and the growth of the Asian population in Australia.

**Research**
Data from *World Development Indicators* were used to establish a number of basic economic, demographic and agriculture-food standards. Three basic data areas were examined: population; income and wealth; and agriculture and food.

Asian foods were grouped into: oriental vegetables; seaweed; grain-derived products such as noodles, tofu and *tempeh*; and snack foods. Emphasis was placed on fresh and lightly processed products. Wholesale data rather than retail process, and three criteria were used to study the potential for export of oriental vegetables to Asia. The three criteria applied were: annual average price must be greater than $4.00/kg; the vegetable should be relatively production–resource hungry; and there should also be a high degree of labour intensiveness in production (and hence opportunities to compete through mechanisation).

**Outcomes**
Recommendations include further research on:
possibilities for using Australia’s idle waterways for water-based vegetables;
possible mechanisation for the production and/or harvesting of those vegetable that are labour intensive;
cultivation and marketing of hornwort, water chestnut, bamboo, broad bean, mushrooms and *wasabi*;
Australia’s potential for producing seaweed;
Australia’s potential to supply herbs and spices, soluble fibre, textured vegetable protein, vitamins, deer velvet and bird’s nests to the functional foods market;
the production of fermented foods and sodium-reduced pickles; and
vitamin enhancement of instant noodles.

**Implications**
This study clarifies market prospects Australia’s Asian food market, provides background information for industry participants in this market and provides a basis for RIRDC’s priorities for research in this program.

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### 3. ASIAN FOOD DISTRIBUTION IN CHINA AND HONG KONG

**Objectives**
To identify the existing distribution system of Asian Foods within China and Hong Kong. Specifically, the key items addressed included:
market distribution structure for unprocessed Asian Foods;
market distribution structure of processed Asian Foods;
government regulations on imported Asian Foods;
recommendations on commercial and trading methods relevant to the success of Australian Asian-type food interests marketing and distributing their produce in Asia; and
Corporate detail listing of significant import distributors of Asian Foods.
Background
One of the priority areas identified in RIRDC’s Asian Foods Strategic Workshop in July 1993, was the lack of commercial marketing knowledge of key target markets. The project was an endeavour to facilitate the understanding and direct contact by Australian Asian food interests in approaching the China and Hong Kong markets. With SIRA providing 40 percent of expenses, the project was viewed as both timely and cost-effective for RIRDC.

Research
The project was undertaken as field market research exercise utilising existing SIRA staff in China, Hong Kong and Australia. This involved numerous face-to-face and telephone discussions amongst food importers, distributors, retailers, processors and manufacturers as well as industry associations and Government authorities.

Outcome
The project resulted in the production of a 194 page book detailing the structure and major statistical significance of the Chinese and Hong Kong food distribution system. The book also provided contact details for almost 400 food importers and distributors.

All objectives were achieved in the project with the published report well received by the industry and media. In addition, future projects seeking funding from RIRDC and other related bodies should find the research results of the SIRA project to be highly beneficial.

Implications
The project provides a good information base for the knowledge area concerned. It also provides some indications for future market research and focus by Australian exporters of Asian foods:
indications of competitive market data for potential processed Asian foods in these markets;
provision of a ranking of priorities for prospective Asian vegetable exports to these markets.

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4. USING AUSTRALIA’S ASIAN FOOD RESOURCES TO MAXIMISE AGRI-FOOD EXPORTS AND IMPORTS

Objectives
To identify and quantify the full extent of resources for Asian food products that already exist within Australia’s culturally diverse population—thus maximising the nation’s agri-food export and import replacement opportunities;
To build more effective trade and investment links with Asia in this sector.

Background
Increasing numbers of people from Asia live in or visit Australia, and the spread of Asian tastes within the general community has created a burgeoning demand for food processed according to Asian traditions. Most domestic manufacturers are small family businesses and have made little headway against the tide of imports, except in a few areas where a degree of natural protection exists.
Mainstream Australian domestic food manufacturers have not generally seen the substantial local market for processed Asian foods as a priority business opportunity, or as a base on which to develop export markets.

Research
Demand for Asian foods in Australia was estimated by: summing imports and domestic production; counting people in Australia with Asian tastes and making surveys of their consumption patterns; close
study of import statistics; asking importers, distributors, retailers and manufacturers of their estimates of total demand; and by a literature survey. Estimates of an increase in demand were made by: projecting recent rates of increase in imports; examining demographic statistics to make projections of the rate of increase of people in Australia with Asian tastes; and seeking the views of industry.

**Outcome**
Since 1970, demographic changes and the spread of Asian tastes throughout the wider community have created a rapidly increasing demand in Australia for food processed in the Asian tradition. Demand grew at an annual rate of about 10–15% throughout most of the seventies and eighties. At the retail level, the total size of the market may now be as high as $1 billion. This is about 3% of the total consumption of processed food.

Only about 20% of processed Asian food consumed in Australia is manufactured in Australia. Of Australia’s total imports of processed food, about one quarter comes from Asia. Projections about the ethnic composition and tastes of Australia’s population lead us to conclude that the rate of growth of demand for processed Asian foods will remain strong.

By the end of the decade, the market is likely to grow by at least 60%, to $1.6 billion. Small-scale domestic manufacturers of Asian food cannot be expected to replace many of the imports. In general, they produce low volume, semi-perishable goods that enjoy a degree of natural protection.

**Implications**
the Department of Industry, Science and Technology (DIST) and AUSTRADE should consider programs to assist the processed Asian food industry and encourage exports; mainstream Australian food processors and their industry associations should be encouraged to look for business alliances with the stronger domestic Asian food processors; domestic manufacturers of processed Asian foods should be invited to join advisory bodies such as the Agri-Food Council; the Federal Government should consider the establishment of an Asian Foods Council;

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CASHEWS

Cashews are native to Brazil but are also widely grown in India, east Africa and Mozambique. They are a premium nut on the world confectionery market.

Initial plantings were made in northern Australia during the 1950s, but it has been only since 1984 that larger scale plantings supported by renewed research effort have achieved significant progress towards an Australian industry. Cashews were exported commercially for the first time in late 1993.

The Corporation works closely with the emerging industry and with research agencies (CSIRO, the state and NT departments, and universities) to identify research needs, priorities and development opportunities and to co-operatively fund those projects which will achieve highest aggregate return, earliest adoption and best strategic advantage for the industry. Industry information and support systems will be systematically developed as part of an integrated and phased approach to this potential new industry.

RIRDC achievements in this program include aiding the industry to export its first commercial shipment of cashews in 1994 and to release its first home-grown cashews onto the Australian domestic market.
5. NPK NUTRITION OF CASHEW ON KUNUNURRA CLAY IN WA

**Objectives**

- to identify optimal NPK fertiliser requirements to maximise yield of cashew grown on the Kununurra clay soil type; and
- to determine suitable leaf and tissue sampling techniques and show whether leaf mineral levels can be used as a tool for evaluating field fertiliser treatments.

**Background**

The development of a cashew industry in Australia depends on high returns and hence the crop requires intensive management including optimum nutrition. Cashews are almost exclusively grown on light sandy soils around the world and not on clay soils. Kununurra clay is low in phosphorus and nitrogen and also shows zinc and copper deficiencies. To maximise yield, fertilisers are essential, especially ones containing the major elements N, P and K.

**Research**

The effects of five levels of nitrogen as Urea (0, 50, 100, 200 and 400 b/tree/year) four levels of phosphorous as Double Super (0, 165, 500, 800 g/tree/year) and four levels of potassium as Sulphate of Potash (0.60, 305, 610 g/tree/year) were studied. The fertilisers were applied in a randomised complete block design with N as main plot factor and P and K as sub plots. The cashew varieties used were: 9.14 (experimental) and 10.8 (pollinator) at 7 x 4 m spacing. Growth and early yield were assessed along with monitoring of leaf nutrient levels.

**Outcome**

Young cashew trees (2–3 years old) grown on the Kununurra clay soil showed a marginal response in terminal growth and nut yield at medium N and P levels; there was no response to added K. Of the two varieties in the trial, selection 10.8 used as pollinator/buffer gave significantly higher m²-yield but reduced nut size at medium N levels of 92 to 185 g/year/tree; the main variety 9.14 showed no significant increase in yield. Early yields of <100 kg/ha obtained in this trial are low compared to the yields obtained in the Northern Territory. Whole leaf sampling proved adequate in assessing nutrient status. However wide variation was found in trace element uptake. Leaf tissue monitoring showed most elements to be low with the exception of P. Leaf N status increased with increased levels of nitrogen application.

**Implications**

The trial was terminated when the trees were very young and therefore these results are preliminary and should be viewed with caution. Leaf analysis can be used as diagnostic tool in managing NPK nutrition of cashews. Phenological studies and litter recycling indicate July and December are suitable times for leaf nutrient sampling, because of restricted growth on clay soils, and that high density planting of selected superior clones would maximise yields.

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The Australian deer industry has grown rapidly over the past decade from a very small base to an estimated 160,000 deer on some 1,500 farms in 1993. The Australian industry, however, remains small by New Zealand standards which has an estimated one million farmed deer. Australia has the advantage of four species of deer - red, fallow, rusa and chital - and a sizeable domestic market. High value products such as venison, deer leather and velvet are produced from deer.

In 1991, RIRDC initiated a co-operative program of research with the Deer Farmers' Federation of Australia aimed at addressing key market development and production problems. Industry supported the new program through a voluntary levy and a statutory levy was introduced in July 1992.

The initial strategy for this co-operative program is to focus on the development of improved market support systems for both velvet and venison to ensure the efficient handling and distribution of quality products from farm through to end use consumer and to provide objective feedback of market information to producers. Production research will not be overlooked but, of necessity, will be allocated a smaller proportion of the program funds in the initial years.

RIRDC achievements in this program include:

A doubling of national venison slaughter levels and increased overseas exports and domestic consumption of Australian venison, largely due to the RIRDC-coordinated venison market development project.

Development of an AUSMEAT language and specification system in November 1992 to improve the quality assurance of venison. The project resulted in a range of publications for use by processors.

Development of velvet grading charts for fallow and rusa to establish standards for the industry. Three Australians were trained overseas in grading techniques acceptable to international traders. These skills and services were previously unavailable in Australia.
Objectives
to stimulate demand and
fully develop the market
for Australian venison;
to identify specific
market segments and
their respective

6. VENISON MARKET DEVELOPMENT PROGRAM

requirements;
to develop an awareness of venison’s positive attributes, and educate the trade and consumers to dispel
myths and misconceptions;
to develop an industry cooperative approach to particular challenges and opportunities.

Background
The deer industry has matured rapidly from a heavy dependence on breeding stock sales to where
venison and velvet provide most income. As is usual with small developing industries of this nature, lack
of knowledge or skills in the market development area was identified as the major constraint to progress.

Research
In 1991 a report by AACM to RIRDC entitled ‘Deer Production & Marketing Study’ identified the need
for a Market Development Program. A second project in 1992 by Food Consultants International
produced the Venison Market Development Plan. The general thrust of the plan was used as the basis
for this project although it was anticipated that directions would need to be made as information was
gained.

Outcome
Results have come from a strong communications program, an active public relations strategy to
educate, raise awareness and stimulate demand initially by Food Service and then by consumers, and
strategies to improve export market access. The critical need for resources was addressed with the
following publications:
venison AUS-MEAT language;
venison AUS-MEAT Specification (for cuts);
cuts charts;
leaflets for food service professionals;
information and recipe feature leaflet for ‘Foodie’ consumers.

A seminar program for food professionals and media that uses the services of high profile, innovative
chefs in each state to develop signature venison recipes has resulted in an improved image for
Australian venison. Presentation of resource lists to TAFE and other training establishments has
improved their access to industry suppliers.

Implications
The further development of the venison market depend on a number of issues of product quality.
Educating producers of customer needs and encouraging processors and boners to correctly specify and
describe venison cuts is vital. After further market research, it is likely that close attention will need to
be given to packaging and presentation of venison for the target market.

The major constraint for the industry continues to be a lack of suitable abattoirs and boning rooms to
process deer for specific export markets.

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7. DOMESTIC MARKETING OF DEER BY-PRODUCTS IN AUSTRALIA
Objectives
Improve marketing planning by increasing product and market knowledge of velvet and deer by-products.

Background
A more targeted and methodical approach towards harvesting and marketing deer by-products to the domestic Asian sectors in Sydney and Melbourne should increase profitability of the industry. As well as better knowledge of deer by-products and their application in traditional Chinese medicine, customer profiles and product perceptions are also required.

Research
A survey was conducted of 41 Asian retail outlets. Trade information was analysed against a literature survey of pharmacopoeia, demographic and industrial sources. Also, informal discussions were held with suppliers and producers in New Zealand, Melbourne, Sydney and Seoul.

Outcome
Apart from velvet, the only items of deer by-products regularly consumed by Han-Chinese are sinews, pizzles and tails, while Korean demand only velvet and horns. Only dried forms are generally bought by Asians but recently Australasian green velvet has been marketed. During the surveyed period, the Asian retail markets of Sydney and Melbourne were well supplied with dried velvet, dried tails and deer horns. However, dried sinews and pizzles were in acute shortage in both Sydney and Melbourne. The industry perception that Asians are the major consumers of deer by-products has been confirmed. Australasian deer products are generally well accepted except by some upper socio-economic consumers who still rely on overseas supplies.

Country of origin, size and quality of finish, and the credibility of the retail outlet and branding are major factors in determining the retail price structure for deer by-products. New Zealand was found to have lower wholesale prices and a better knowledge of frozen deer by-products than Australia. Australia must improve the quality and quantity of co-products to take advantage of the sellers market for by-products. In contrast with New Zealand by-products sold in Australia are not labelled with an import permit number. This deficiency restricts severely the appeal of processed by-products to tourists.

Implications
The future of the by-product industry depends on value-adding and the willingness of producers and processors to appoint a professional marketer dedicated to the promotion of the products to the Asian markets at home and overseas. The present practice of direct marketing by producers to Asian retailers precludes coordinated marketing programs for the Industry.

If continuity of supply of green products can be assured, the industry should consider funding a public relations and advertising campaign to create local demand for green products. Successful registration with the Australian Register of Therapeutic Goods would enable access to the mainstream markets in addition to the traditional Asian users.

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ESSENTIAL OILS

There is growing interest in essential oils as a new industry in Australia. The current value of production (excluding tea tree oil but including the refining of imported eucalyptus oils) is about $20 million retail a year. The eucalypt and tea tree oil segments aside, the principal focus for essential oil development is in Tasmania and Victoria with some interest also in South Australia and southern Queensland.

The Australian industry produces essential oils and fractions thereof based on black current bud (cassis), boronia, citrus, clary sage, dill, Eucalyptus, fennel, lavender, lemon grass, parsley, peppermint, spearmint and tea tree. These products are largely used in the food flavouring and fragrance industries.

The success of the pyrethrem, poppy, and hop industries, with a combined farmgate production value of around $27 million, suggests that there are significant opportunities for producing natural plant extracts in Australia, involving both native and exotic spices.

Australia has a comparative advantage as a reliable supplier of clean, good quality, unique essential oils and plant extracts based on the use of high technology in both production and extraction. The increasing use of essential oils in aroma therapy and other healthcare areas offers new opportunities for the industry.

RIRDC’s achievements in this program include the establishment of the Essential Oil Producers Association of Australia, which brought together key players in the industry for the first time to address product development, and national/international standards and issues.
8. IDENTIFICATION OF ESSENTIAL OIL CROPS FOR THE EMERALD REGION OF CENTRAL QUEENSLAND

Objectives
To make a preliminary examination of essential oil crops to assess their suitability for production in Central Queensland.

Background
The Emerald region in Central Queensland hosts an emergent horticultural industry based on citrus, table grape and vegetable production. The region has a reliable water supply from the Fairbairn Dam irrigation scheme, and an ideal climate for plant growth. This offers the opportunity to extend the product range to high value products which are not plagued by transport problems associated with many of the horticultural (fresh produce) crops that have been considered for the area.

Research
The project concentrated on identifying existing essential oil crops in regions with a similar climate to that of Central Queensland. Library data-based searches were conducted for information on the identified species. Consideration was given to the growth and yield characteristics of the selected crops which determine their potential for mechanisation to reduce labour inputs during production. Public and private domain sources were used to identify price and quantity data for the selected crops in the wholesale market.

Outcome
A number of essential oil producing species considered worthy of testing for growth in Central Queensland have been identified. These include vetiver grass (*Vetiveria zizanoides* Stafp.), which is currently being tested in Queensland as a vegetative hedge to control soil erosion. The crop lends itself to mechanisation, with the possibility of mechanised planting of vegetative propagules (after labour intensive division of parent plants) and harvesting of roots. Light sandy soils would be required for ease of harvesting. The commercialisation of vetiver could be advantaged by its use as a dual purpose crop, producing vegetative material for landcare projects and root material for essential oil distillation.

An essential oils industry in Central Queensland may be able to steam-distil sandalwood oil (*Santalum album*, *S. spicatum*, *S. lanceolatum*, *Eremophila michelli*) from timber purchased from local landholders or trough tender from the Department of Primary Industries Forest Service. Plantation culture of *S. lanceolatum* and *E. mitchelli* may be possible as both coppice easily, but research into oil yield and quality is needed before commercialisation can be considered.

A number of grass and herb crops have potential as essential oil crops in Central Queensland. These are lemongrass, palmarosa, sage, basil, coriander and chamomile.

Implications
The nature of the essential oils industry makes it difficult to assess the feasibility of the new essential oils enterprises without trialing the selected crop species for yield and oil quality.

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9. POTENTIAL FOR AN EXPANDED ESSENTIAL OILS INDUSTRY IN SA
Objectives

to collate existing information on the production and marketing of essential oils;
to identify opportunities for developing an expanded essential oils industry in Australia;
to establish a network of interested people and to facilitate the orderly development of an essential oils industry in Australia;
to set future directions and R&D objectives for an expanded essential oils industry in Australia.

Background

Essential oils are fragrant compounds, such as lavender and eucalyptus, distilled from plants and used extensively in the food and beverage, cosmetic, and pharmaceutical industries. They have been obtained from more than 1500 plant species and about 150 are in common use. World trade in essential oils is well established and is currently estimated at around US$1 billion dollars annually. Imports of essential oils into Australia in 1990 were valued at about $13 million.

Furthermore, a United States Department of Agriculture report has indicated that the essential oil market is expected to grow by ten percent per year. It appears likely Japanese and European markets will grow at a similar rate. Recently there has been a rapid expansion of the essential oil industry in Australia but there is a lack of readily available information particularly on markets. There is also a need to define research and development needs on a national basis.

Research

Through consultation with industry, speakers were chosen to cover such topics as world markets, trends and opportunities and technological requirements for essential oil production. In selecting speakers an emphasis was placed on marketing opportunities. The conference was publicised through the national rural press and by contacting existing organisations in the essential oils industry.

Outcome

The Australian Essential Oils Industry Seminar was held in Adelaide in conjunction with the Australian Institute of Food Science and Technology 26th Convention. The seminar was attended by more than 100 people including producers, processors, marketers, researchers, and potential industry participants. Topics covered included world markets and trade, industry development, research, and the role of government. Papers presented were published as a booklet.

Implications

The papers presented and subsequently published provide an insight into the developmental steps required of an emerging industry, and the current industry status in Australia.

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10. THE BIOLOGY AND CONTROL OF THRIPS IN FENNEL

to determine methods of assessing thrips populations and their effects;
to locate origins of infestations;
to relate thrips numbers to crop losses;
to obtain sufficient efficacy, residue and bee toxicity to data to enable recommendation and registration of an insecticide from thrips, aphid and potato bug control;
to disseminate information on project progress via Essential Oils of Tasmania field staff and ultimately provide an advisory leaflet on the control of thrips, aphids and potato bugs.
ESSENTIAL OILS

Background
Around 600 ha of fennel is grown in Tasmania for its essential oil. It is a fully exported product with high value and low volume, worth more than $1 million (FGV). Insect pests, particularly thrips, can result in severe yield reduction in fennel. Control is difficult because of: (i) lack of registered insecticides (ii) presence of bees for crop pollination during an extended flowering period of 12 weeks. Seed production is the major determinant of yield. To achieve increased yields an economic bee-safe insect control method needs to be developed for fennel.

Research
The research consisted of three integrated areas: (1) the biology of insect pests infesting fennel; (2) the efficacy of insecticides for controlling thrips and aphids in fennel; and (3) a study to follow the path of insecticide residues in the herb and oil.

Outcomes
The main pests of fennel were onion thrips, carrot aphid and green peach aphid. Onion thrips overwinter in crops and pasture and breed on various vegetation. The lifecycle of onion thrips may be up to 30 days in midsummer.

The four insecticides tested in this study included two industry standards: Pirimor (pirimicarb) and Rogor (dimethoate); and two potential bee safe alternatives: Ekatin (thiometon) and Mavrik (fluvalinate). Research using the more accurate washed samples showed that adult and juvenile thrip numbers were significantly reduced by Mavrik and Rogor, whilst numbers of wingless aphids were also reduced by Pirimor. Oil yield correlated strongly with onion thrip numbers (~0.95) but less so with aphid numbers (~0.76). Insecticide treatment with Mavrik and Rogor significantly increased yield.

Residue analysis showed a decline in level of insecticide in the herb from the time of spraying to harvest, 28 days after spray application. There were no detectable residues of dimethoate or fluvalinate in the oil at the recommended rate of application. Pirimicarb was detected in oil from one site at 0.5 mg/kg whilst thiometon was present at levels above recommended maximum residue level. A program for monitoring and control of pests in fennel will be published shortly as a manual for field advisers and growers.

Implications
Yield of fennel oil can be improved by correct management of insect pests, particularly onion thrips. The insecticides recommended to be used in the management program will include Rogor (dimethoate) pre-flowering and Mavrik (fluvalinate) post-flowering to protect fennel pollinators. The use and with holding period for Pirimor will be reviewed whilst Ekatin will not be recommended for use. There is potential to investigate more cost effective synthetic pyrethroids for use in fennel during the flowering period. The program developed will ensure residue free oil, higher oil yields and protection of the honey bee pollination service.

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11. THE DEVELOPMENT OF ALTERNATIVE FUNGICIDES FROM ESSENTIAL OILS

Objectives
- to screen the efficacy of essential oils obtained from commercial sources and from Australian native plants against the major post-harvest pathogens of fruit crops;
- to compare their fungicidal efficacy with synthetic fungicides currently used for the control of major pathogens in the fruit industries;
to identify and test the efficacy of the active components in the essential oils found to be fungicidal;
to comment on the commercial potential for producing fungicides from essential oil crops grown in
Australia.

**Background**
Australian horticultural industries rely heavily on the use of pesticides, especially fungicides. The
predominant post-harvest pathogens of fruit are: *Monillia* (brown rot), *Botrytis* (grey mould), *Rhizopus*
(transit rot), *Mucor* and *Penicillium* spp. (blue and green mould). There is an urgent need to develop
non-toxic and non-residual alternative post-harvest treatments that are acceptable to consumers.

**Research**
Potentially fungicidal essential oils were identified by literature review. Fungicidal properties were
assessed as single oils or as mixes to investigate possible synergistic effects. All oils were screened *in vitro*
to determine their inhibitory activity against five major post-harvest pathogens of fruit crops (*Mucor
piriformis, Botrytis cinerea, Rhizopus stolonifer, Monillia fructicola and Penicillium digitatum*).

Two screening methods were used: the paper disc technique to establish post-infection fungistatic and
fungicidal properties of the essential oils; and thin layer chromatography (TLC) to separate the
components of the most promising essential oils. All components separated by TLC were identified by
gas chromatography. Identified fungicidal components were purchased in refined forms and tested *in vitro*
to ascertain the presence of the ‘active ingredient’ in the raw essential oils.

**Outcomes**
Twenty-four oils exhibited anti-fungal activity of varying degree against some or all tested fungi.
Hinokitiol, a natural substance from the Japanese cypress was the most effective. The oils of *Cassia*
and *Origanum* both displayed anti-fungal activity against all but one of the test fungi (*Rhizopus*).
Lemon grass (A), almond bitter and bay leaf each exhibited anti-fungal activity against *Monillia, Botrytis*
and *Mucor*. Other essential oils that inhibited three test fungi were: thyme wild (*Monillia, Rhizopus*
and *Mucor*), lemon eucalyptus(A) and garlic (*Monillia, Botrytis and Penicillium*).

The other essential oils tested were less fungicidal. *Monillia* was highly sensitive to most essential oils
tested. Although some oils in mixes showed synergistic activity by lowering the effective inhibitory
concentration of the mix, there was no broadening of the spectrum of efficacy.

**Implications**
The efficacious essential oils reported here originate from only a small fraction of the plants likely to
contain such compounds. The further development of post-harvest fungicides from essential oils will
depend on the following:
*in vivo* testing to demonstrate commercial efficacy on horticultural products;
elucidation of the mode of action of potential essential oils and their components to maximise their
usage;
determination of the average daily ingestion of essential oils through eating treated produce;
the marketing of a fungicidal essential oil will require local production and continuity of supply of the
raw material in commercial quantities;
the prospect of adoption of essential oils as alternative fungicides in the horticultural industry will
depend upon assured uniformity of the raw materials through local production and processing.

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PUBLICATIONS:
Oct.3)
30)
and varieties of basil that would be suitable for the production of high quality oil under south eastern Australian conditions.

**Background**
The genus *Ocimum* is an important source of many essential oils and aroma chemicals used in the perfume and cosmetic industries. Basil Oil, extracted from the leaves and flowers, contains camphor, citral, geraniol, linalyl acetate, methyl chavicol, eugenol and thymol. At present, an essential oil industry is expanding in north eastern Victoria based on peppermint. The future viability of this industry would be greatly enhanced, if other essential oil crops were introduced to utilise expensive surplus distillation capacity.

**Research**
Species and varieties of *Ocimum* were sourced worldwide and evaluated under local growing conditions. Oil was extracted using steam distillation and yields and chemical compositions were determined for each line tested. The potential markets, both domestic and export, and the likely demand levels and price ranges were evaluated.

**Outcome**
Wide differences in the presence of absence of major and minor essential oils were observed in the various lines tested. Furthermore, the ratio of oil components present in each line varied according to the plant growth stage, emphasising the critical importance of determining optimum harvest time. Unfortunately, the results of these tests were not available at the time this Report was submitted.

**Implications**
The study provides sound preliminary information on which to base further work. The results indicate that commercial should not be attempted until a direct seeding method and a suitable weed control program have been developed. Information on the final market prices and type of oil required by industry will also be essential.

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**ESSENTIAL OIL FROM CORIANDER SEED**

market value.

**Background**
During recent years the School of Chemical Technology has gained considerable experience in the application of LCO2 technology to food processing, particularly for the recovery of flavours and aromas. As part of this work a process is being developed for the commercial extraction of coriander seed.

Coriander seed can be extracted with liquid carbon dioxide to recover its oil. Process development has reached the stage where 'large' quantities of extract for market evaluation are needed. In addition, better control of extract quality was required.

**Research**
A pilot scale extractor with a capacity of at least 5 L was designed, constructed and commissioned. Chromatographic procedures for the analysis and identification of major components in the extracts were developed and refined.
ESSENTIAL OILS

Outcomes
A pilot scale extraction/refining plant has been built with an extractor working capacity of 20 litres (8 kg crushed coriander seed) and recirculation of carbon dioxide. The extraction plant is equipped with separators for 2-stage refining of oil extracts. Facilities exist for large scale processing of seed. The best conditions for maximum oil yield were 0°C and 10°C or above. The extraction rate was mainly limited by the solvent's solubility. A seed bed of 50 mm was found to be adequate. Any greater depth reduced the yield.

The LCO₂ extracts were refined at supercritical conditions to produce a vegetable oil fraction (12–15% of original seed mass) containing 75–88% C₁₈:₁ triglycerides. Optimum conditions for the refining of the extract in a single stage were 45–60°C, 8–10 MPa. Analytical procedures were developed and refined for analysis of extracts using capillary gas chromatography. All major peaks have been identified.

A budget feasibility study was made of a plant designed to process a range of spice oil seeds totalling 4000 t/year. It was found that a combined extraction-refining operation was necessary to obtain a high yield of an essential oil low in fatty oil components. The combination of initial LCO₂ extraction of the seed at 0° to 10°C temperature followed by supercritical refining of the extract is thought to be novel and patentable.

Implications
market development: The industry needs to interact with essential oil buying houses and enlist industry support for a proper evaluation of the product. It was noted that there seems to be resistance in some areas of the market place to accept a new product, despite verbal assurances that the carbon dioxide extracts are of a high quality. The blending of LCO₂ extracts with conventional steam distilled material may be necessary during a ‘phasing in’ period while the newer product gains acceptance;

technical development: Processing of pilot-scale batches (approximately 10 kg lots) of selected seed, for both essential oil and by-products should continue. This should use facilities now available to gain experience with other seed types and operational experience with high pressure extraction equipment, as well as providing material for market evaluation. In addition there is much scope for basic research on the relative solubilities of essential oil components in carbon dioxide, and interaction effects.

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GOAT FIBRES

The established animal industries that produce rare natural fibres comprise angora and cashmere goats, which produce mohair and cashmere, respectively. Other rare natural fibres, from animals such as alpaca and camels, also could have commercial potential for Australia.

Renewed interest in the goat fibre industry has resulted from the turnaround in the economic recession in Australia. As the economy has recovered, so has the world demand for rare fibres. Many graziers with an interest in goats are rebuilding their flocks to take advantage of the price increases. At the same time, the introduction of Texan and South African mohair breeding lines has led to major genetic improvements to mohair goats which will underpin stable industry development.

An industry study commissioned by RIRDC to review the goat industry's status, potential, and research needs was completed in June 1993. A key recommendation of the report identified the need to foster and facilitate the linkages between the various sectors of the industry, from the production of Australian goat fibre through to the processing and marketing of distinct products, and ultimately through to the fashion and garment retail industry. A Market Development Officer, Mr John McIntosh, has been contracted to RIRDC for a two year period to implement the recommendations. Mr McIntosh is now working closely with industry to promote value adding in Australia and to increase the demand for Australian goat fibre.
Objective
To develop and validate the OFDA (optical fibre diameter analyser) to measure the mean fibre diameter of cashmere down and yield of cashmere fibre and the mean fibre diameter and degree of medullation in mohair.

Background
The high costs of objectively testing both cashmere ($A24) and mohair fibre ($A19) is recognised as one of the most important factors limiting the development of the goat fibre industry in Australia. Therefore most goat producers rely on visual assessment to select their breeding does rather than using current objective measurement. However, this restricts the potential rate of genetic improvement that can be achieved in a flock. In 1991, the OFDA was developed to measure the fibre diameter distribution of wool.

Research
The ability of the OFDA to measure cashmere yield and mean fibre diameter was investigated using known standards and compared with current methods using fleece sub-samples; and compared with the current test method for predicting the proportion and type of medullated fibres in mohair.

Outcomes
A technique was developed to analyse the fibre diameter distribution of 2 mm snippets by the OFDA and so calculate the cashmere yield of a goat fleece without dehairing. By calculating the total volume of fibres below and above 35 μm from the diameter distribution of the OFDA, the cashmere yield of 30 standards ranging from 10 to 60% yield could be predicted (r²=0.968). The Shirley Analyser and Fibre Diameter Analyser (FDA) were compared with the OFDA for measuring cashmere yield (r²=0.594) and cashmere mean fibre diameter (r²=0.942) of 110 goat fleeces.

Differences in results from the Shirley Analyser and OFDA predictions of cashmere yield for fleeces probably resulted from variations in dehairing abilities between individual fleeces. Calculation of cashmere yield and down mean fibre diameter by the OFDA has been shown to be accurate for standards and as precise as the Shirley Analyser making it a potential low cost alternative for ranking individual goat fleeces.

The OFDA has been shown to discriminate medullated fibres from non-medullated fibres on the basis of fibre opacity. However some kemp fibres can not be distinguished from non-medullated fibres on the basis of opacity. It is suggested that these undesirable fibres can be eliminated by breeding animals with a finer and narrower fibre diameter distribution. The OFDA has been shown to agree with existing test methods of determining medullated fibres (ex. kemp, r²=0.58).

Implications
The costs of testing cashmere yield and MFD will be reduced by at least a quarter of present prices ($A3–$A5) using the OFDA. This will allow a greater number of producers to test their breeding animals. The estimated cost of testing one fleece for fibre diameter distribution and medullated fibre content will be $2.00. This is a tenth of current testing costs and will easily make fibre testing more accessible to producers.

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**Objectives**

to design and manufacture knitted and woven goods containing high proportions of Australian mohair and cashmere;
to observe and, where appropriate, overcome any processing problems arising from the use of processing machinery designed for wool;
to compare these fabrics, including wear trials.

**Background**

Annual Australian production of mohair is about 600 tonnes and cashmere/cashgora about 20 tonnes (fleece) giving about 5 tonnes of down after dehauling. This is much less than annual wool production (about 600,000 tonnes). These specialty fibres have much in common with wool. They are appropriately tested by wool-testing apparatus, and processed in woollen and worsted systems. Some distinctive features are:

*Mohair* has less-prominent scales, especially in comparison with Australian merino wool. Because of this less impurity accumulates on the fleece; the fibres are slick and must be processed with several precautions before spinning; and felting shrinkage is lower.

*Cashmere* contains an intimate mixture of guard hair and down; only the latter is of commercial significance in apparel. Cashmere feels slicker than wool of the same fineness, but has generally lower diameter uniformity, shorter length and difficult processing characteristics.

**Research**

The researchers obtained supplies of mohair, cashmere and other suitable fibres from many institutions and manufacturers. These were spun into heavy two-ply yarns of pure mohair, mohair/wool and mohair/polyester; and into fine yarns of pure cashmere (in a trial quantity), cashmere/wool and cashmere/microfibre. These were knitted into a range of attractive garments designed to enhance the best characteristics of the goat fibres. In the woven part, the fibres were spun into wool-rich blends containing up to 35% of specialty fibre of each kind in warp, weft, or both.

**Outcome**

Most of the original objectives have been achieved, despite the absence of expected student assistance. Self-twist spinning makes fine yarns with cashmere blends. Commercial feasibility under Australian conditions of all processes was demonstrated, except for the pre-spinning of pure cashmere. The addition of polyester greatly improved dry processing, but made level dyeing difficult. Knitted garments of all the fibre combinations have been made, and are being trialled successfully. Further work on the woven fabrics passed to RIRDC’s marketing arm in mid-1994.

**Implications**

With the availability of used, slow, but inexpensive, worsted machinery, there is scope for processing these fibres on the worsted system in Australia, but processors must be prepared for trial and error, waste, and slow processing. If yarns can be produced and the correct shades dyed, the designer’s imagination may help achieve consumer acceptance in strong competition with imported mohair-blend garments.
16. DEHAIRING AND OBJECTIVE MEASUREMENT OF AUSTRALIAN GOAT FIBRES

Objectives

to assess current dehairing practices and to examine possibilities for improving dehairing;
to set up a dehairing room with appropriate atmospheric conditions and perform trials on surface finishes and humidity;
to measure cashmere and mohair properties on modern wool apparatus where possible and to make modifications, with reference to fineness, length, tensile properties, medullation and yield;
to determine the extent to which high-volume cotton testing instruments can be applied to cashmere.

Background

Goat fibres provide some unique characteristics which, with favourable management and markets, could lead to expansion in Australian production. This research focuses on some of the ways in which these fibres differ from wool, especially the need of cashmere, as well as llama hair, bactrian camel hair and yak hair, for dehairing, a process of separating the fleece into hair and down.

There is little published information about dehairing, but it is known to have three chief features; high humidity, centrifugal action, and repetition. At the fibre state, mohair and cashmere are often classed by ephemeral characteristics like style and character, which largely disappear when carding begins. But objective measurements like fineness, length and tenacity can be traced to the final product. Commercial laboratories have been known to provide yield results varying by a factor of two on the same cashmere. Dehairing (as distinct from scouring) yield must be measured mechanically; there are no materials for calibrating yield instruments, and there are formidable obstacles to preparing them.

Research

By constructing a temperature and humidity controlled plastic tent, realistic dehairing trials on cashmere fleeces were carried out using a range of surface active agents. The researchers examined the objective measurement of almost every property and submitted some scoured cashmere fibre to HVI testing.

Outcomes

Cashmere dehairing was improved by the addition of commercial lubricant and antistat, but impaired by household detergent and softener. As a criterion of this ‘improvement’ the researchers are developing the concept of determining the proportion and mass of fibre coarser than 30 μm at each stage of dehairing.

This deals well with guard hair, but poorly with cashgora, mohair-type fibre of intermediate coarseness that raises the diameter variation of Australian cashmere above that of wool. The airflow meter was recalibrated to enable it to read directly the fineness of any cashmere, by determining the relationship between sample mass and reading.

Trials with a cotton line found that cashmere was too extensible and crimped for successful tensile testing but provided results for length distribution and, with adjustment for density, for fineness. A roundtrial of dehairing yield found all four labs in the range 30–36%.

Implications

Cashmere can be dehaired in Australia if pains are taken to provide good equipment, good humidity control and some patience, especially with cashgora. With the correct modifications, all relevant properties can be reliably measured.

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17. SURFACE STRUCTURE/PROPERTY RELATIONSHIPS OF AUSTRALIAN MOHAIR AND CASHMERE FIBRES

Objective
To enhance processing performance and retain/enhance aesthetic properties of mohair and cashmere through a study of surface structure and surface treatments.

Background
The attraction of mohair and cashmere as textile fibres is based on their lustre, their softness and their natural origins. The smooth surface of mohair compared with that of wool leads to the high lustre. This smoothness is probably a factor in causing processing difficulties such as poor sliver cohesion (leading to breaks in the sliver during gilling and combing) and a strong tendency to electrostatic charging.

It has been shown for wool that the lipids at the fibre surface can be altered by various scouring procedures and by specific chemical modifications. The more practical of such modifications can be considered for us on mohair and cashmere to try to alleviate processing difficulties. It is of prime concern that any pretreatment does not adversely affect the desirable lustre and softness of the fibres.

Research
Mohair, cashmere and wool samples have been scoured and treated with various agents known to affect the surface lipids of wool fibres and assessed for surface tension (wettability) and fibre/fibre friction. Assessments of gilling performance, sliver cohesion and static charging propensity (SCP) have been made on mohair and wool top samples. An improved instrument for SCP measurement has been constructed, and measurements made of fibres treated with commercial lubricants, surface modifying chemical treatments, and novel treatments based on combined anionic/cationic surfactant mixtures.

A laser goniophotometer system for studying the lustre of treated and untreated fibres has been constructed. Results demonstrate the extreme complexity of the light emissions from natural fibres. Light intensity varies by a factor of 2 or 3 at angular intervals of about 0.1° throughout a wide range of the specular emission. Alterations are being made to the detector system to allow for these peak shapes.

Outcomes
Mild chlorination caused the surface tension of both mohair and cashmere to become more like that of wool. Cationic surfactant treatments were somewhat less effective. The fibre/fibre friction of mohair and cashmere were only slightly affected by any of the treatments.

Sliver cohesion was increased by several of the treatments used, but not to the same extent as obtained with proprietary anti-stat additives. The SCP of clean mohair was found to be very similar to that of wool. The more serious problems in mohair processing are due to the poorer sliver cohesion which allows fibres to escape from the charged sliver. The SCP of mohair slivers was markedly reduced by chlorination and by cationic surfactant treatments. For chlorination this was reflected in improved gilling performance. Scouring of mohair with anionic surfactant prior to cationic surfactant treatments was found to be a very effective means of reducing the SCP of mohair. Spray treatments with mixtures of cationic and anionic surfactants were also effective.

While no change in subjectively assess lustre was observed due to chlorination or cationic surfactant treatments, a decrease in whiteness and a harsher handle were encountered at higher levels of chlorine treatment, and a slight dulling of the fibre colour was observed on cationic surfactant treatment.
18. MOHAIR & CASHMERE PRODUCTION - STUDY TOUR REPORT

Objective
To assist in the printing and distribution of a report on recent developments in the speciality fibre processing, and product development industries in Britain and the USA.

Background
A study tour was made of the UK and USA to further Australian knowledge of recent trends in product development, marketing and processing of mohair and cashmere. Effective dissemination of the results of the tour required the printing of a report that could circulated to RIRDC, industry associations, interested processors and fibre producers.

Outcome
One hundred copies or the report were printed and distributed. Copies were lodged with state and national libraries.

Implications
The availability of the report and its recommendations should assist RIRDC with its current review of this area.

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HORSES

There are some 1.2 million horses in Australia used for racing, equestrian sports, recreation and meat products. The thoroughbred racing sector alone has an annual turnover of $15 billion per annum. The Equestrian Federation has 500 registered clubs, 13,800 members and 28,500 registered horses. 60,000 young Australians are members of pony clubs. Over one million horses are kept on Australian farms and those in metropolitan areas provide a major demand for livestock feed. The statistics indicate the significance of industry and community involvement.

Despite the size of the domestic horse industry, the export sector remains small, there is a trade imbalance to Australia’s detriment, the industry is almost unsupported by research and development, industry problems are not being resolved and developmental opportunities are not being taken up. To a significant degree horses have been everyone's interest but no-one's responsibility.

The Corporation intends to work closely with the diverse interests in this industry to clarify both research needs and opportunities, to arrange research programs to meet those needs, and to manage collaborative funding support for research.

RIRDC’s achievements in this new program include:

the publication of a comprehensive study of horses as a significant Australian primary industry (jointly with the Bureau of Resource sciences); and

the establishment of a Research Advisory Committee and a RIRDC-funded research program coordinator to facilitate the management of this new research program and to guide its future direction (launched in January 1995).
19. PREVENTION OF DIET INDUCED LAMINITIS IN HORSES

Objectives
to reduce the risk and losses associated with laminitis in horses.

to simplify and improve the nutritional management of horses fed grain or lush pasture.

Background
Laminitis can result from acidic conditions in the gut which are caused by the rapid fermentation of starch or soluble carbohydrate in the caecum and colon. The most common diets containing high levels of fermentable carbohydrates are those based on lush green pastures during spring and supplements of cereal grain. Laminitis results in the separation of the hoof from the pedal bone and can leave the horse permanently lame or with a greatly reduced capacity to perform. The product Founderguard helps to prevent the development of acidic conditions in the gut and offers the potential of safer nutritional management of horses at pasture or when fed grain supplements.

Research
Three areas of investigation were undertaken:
- improving the understanding of the biological pathway leading to laminitis and to determining whether laminitis could be prevented by treating animals with Founderguard after they had consumed excessive amounts of grain;
- examining how pasture causes laminitis;
- investigating the consequences of high concentrations of grain (or lush pasture) in the diet once the threat of laminitis has been overcome. Since Founderguard helps to make it safer to feed high levels of grain, we therefore investigated effects of high energy diets on behavioural changes and on exercise performance.

Outcome
The studies so far indicate that, while Founderguard can be used to prevent laminitis if it is given before horses consume high levels of grain, it is not effective if used as a treatment immediately after a horse has consumed too much grain.

The pasture conditions leading to acidic conditions in the gut are characterised by high levels of soluble carbohydrate. No horses in our studies developed laminitis but Founderguard was effective in reducing the acidity in the gut when grazing lush pastures. This pattern of activity suggests that it may be useful in managing horses at pasture.

By preventing acidity in the gut associated with high levels of grain in the diet Founderguard reduces the adverse behaviour normally associated with feeding grain such as chewing wood and eating bedding. We are in the process of completing studies on the effect of Founderguard and high grain diets on the animal’s exercise performance.

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20. ROAD TRANSPORT OF HORSES FOR SLAUGHTER

Objectives
to assess physical injuries, physiological and biochemical changes associated with transport;
to compare the merits of single and double-deck semitrailers for long distance horse transport.

with transport;
Background
More than 40,000 horses are transported each year for distances up to 3000 km to be slaughtered at export abattoirs for overseas sales of meat for human consumption. Many of the horses transported are feral horses and there are welfare concerns related to transport, as well as substantial losses associated with bruising to the meat.

Research
Five loads of double-deck and five loads of single-deck transported horses were assessed, using pre- and post-transport blood samples to indicate signs of stress and markers of electrolyte loss and muscle damage. Furthermore, note was made of cuts and abrasions suffered by horses as a result of transport and subsequently the carcasses were assessed on the slaughter floor for indications of bruising.

Outcome
The key findings from the study were that:
there are substantial blood biochemical changes, associated with mustering of feral horses before transport. In most cases, these changes are more significant than those occurring during transport; single and double deck transport produces similar disturbances to blood biochemistry and a similar number of injuries; injuries do not appear to be related to the length of the journey but seem to be dependent on social behaviour and interaction between groups of horses; observing behaviour of horses and drafting them into compatible groups before loading may assist in reducing aggressive behaviour and hence injuries; head injuries are common in transported horses and these injuries may be reduced by padding overhead structures and introducing a false ceiling; access to both food and water after transport is important to restore electrolyte and water imbalances.

Implications
This research has provided valuable information on the effects of transport on horses and suggested ways to reduce some of these effects.

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21. SURVEY OF AGRONOMIC PRACTICES ON THOROUGHBRED HORSE STUD FARMS

Objectives
identify, by means of a survey, current agronomic practices on thoroughbred horse-stud farms in eastern Australia and analyse how they influence profitability and sustainability of production, and horse health;
disseminate findings to industry and communicate priorities for future research to appropriate bodies.

Background
RIRDC has declared the intention to work closely with the diverse interests in the horse industry to identify both research needs and opportunities. This project addresses this intention by capturing and analysing data relevant to the RIRDC program areas concerned with pasture mixes and management regimes for horses; developing sustainable land use practices; and improving extension and training for pasture management.
Research
Sixty thoroughbred horse-stud properties were visited and a detailed interview conducted with the owner/manager. Inspections were made of paddocks representative of predetermined categories. Twelve properties were visited between January and April 1994 in each of the five regions: Darling Downs (Qld), Hunter Valley (NSW), Outer Sydney (NSW), Riverina SW Slopes (NSW), Euroa district (Vic.).

Outcome
The average regional property size ranged from 133 ha (Outer Sydney) to 1034 ha (Hunter Valley) and this was reflected in horse numbers (e.g. foals ranged from 30–158 respectively). Annual supplementary feed-use per property in the Euroa region (455 t) was similar to that in the Hunter Valley (459 t). Properties in Euroa carried far fewer horses but at higher stocking rates than those in the Hunter Valley.

Native pastures were found on twenty five properties and semi-improved pastures on only seven. Fully improved pastures were the most common category, being absent on only nine properties. Dominant pasture species in fully improved pastures included kikuyu, paspalum, lucerne, couch, cocksfoot, phalaris and perennial ryegrass. Soil pH was highest in the Darling Downs (6.5) and lowest in Euroa where some readings were below 5.0.

Reported levels of developmental orthopaedic disease (DOD) in foals were significantly higher in Euroa (18.9%) and lower in Outer Sydney (4.5%). Bare ground and erosion were recorded along fencelines and around trees in all regions but was most severe around feeders.

Implications
Reliance on supplementary feed varied markedly between regions and this indicates considerable potential to reduce feed costs. For properties on which pasture improvement had been undertaken, an average of nine percent of the property budget was reportedly dedicated to pasture management. Research to identify optimal pasture species is clearly needed. Though expertise in pasture management from other industries was used, the majority of decision makers lacked formal training. Therefore, extension of information on best practice and improved opportunities for education would be valuable.

Acid-soil management is an aspect requiring such attention. Relatively high levels of DOD in the Euroa region may be influenced by supplementary feed practice, low soil pH as well as other aspects of pasture management. More generally, scope exists for reducing incidence of bare ground and erosion by movement of feeders.

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PASTURE SEEDS

Australia produces around 28,000 tonnes of pasture seed annually, principally for domestic use. This also includes about 1000 tonnes for export. Approximately 5,000 tonnes of pasture seed are imported annually, mainly from New Zealand. The estimated gross value of production is $67 million pa.

The industry has three principal components: temperate legumes, temperate grasses and tropical grasses and legumes. It comprises seed growers, seed cleaners, merchants, retailers, exporters, certification authorities, and a small but active research support infrastructure.

The temperate legume component of the program is funded in part by industry levies. Other segments of the program are funded from government appropriations and direct industry contributions.

The Corporation consults with the Seeds Committee of the Grains Council of Australia in program development and reports regularly to that Committee.
22. STRATEGIES TO SUCCESSFULLY ESTABLISH AND MANAGE A PRODUCTIVE DRYLAND LUCERNE STAND

Objectives

to improve the success rate of dryland lucerne establishment by demonstrating in large scale plots sound and proven technology for lucerne seedling survival;
to examine alternative technology aimed at further improving the success rate of dryland lucerne establishment;
to disseminate known technology for dryland lucerne establishment and management through the production of a high quality publication, field days and the use of media.

Background

Dryland lucerne stands throughout Australia suffered severely from the pasture aphid invasion in the late 1970s. In southern Australia, almost 2 million hectares of non-productive lucerne country have the potential to be resown to lucerne. Surveys conducted as early as 1970 have illustrated the difficulty of re-establishing aphid resistant lucernes on the sands of the upper south-east of South Australia. The success rate by farmers attempting to re-establish dryland lucerne stands was only 50%. The survey also revealed that the percentage of the technology presently developed and not being used (or poorly implemented) is as much as 42%.

Research

Large scale field demonstration sites were established successfully on non-wetting sand each year since 1991. Alternative technology tested to further improve the success rate of dryland lucerne establishment showed no statistical differences.

Outcome

By applying the seven steps listed below, it was demonstrated that the first attempt at establishment will be a success.

1. Weed control in the year(s) prior to establishment.
2. Soil pH checked and lime used if below 6.5.
3. Inoculate seed with lucerne inoculants.
4. Shallow sowing of seed into a damp compact seedbed.
5. Monitor pests regularly and control if necessary.
6. If a cover crop has been sown remove it in early spring.
7. No grazing of seedling lucerne in its first summer.

A loose leaf manual was produced in May 1994. It covers all aspects of establishing and managing a lucerne stand, with more than 80 pages of information and full colour illustrations.

Implications

Benefits are expected to flow through to the grazing industry and the small seed industry, with a positive impact on the environment, in southern Australia.

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Stanley, Mark, ‘Success with Dryland Lucerne’.
23. DEVELOPMENT OF EXPORT MARKETS FOR COLD-TOLERANT ANNUAL MEDICS

**Objectives**
To develop export markets for cold-tolerant annual medics by:
- further demonstrating that cold-tolerant cultivars with export potential can be economically grown in Australia;
- consolidating and servicing an established overseas network of collaborators who are testing the adaptation of cold-tolerant medics in target countries;
- supporting product development and encouraging evaluation of farming systems for using medics in target countries; and
- developing those procedures which will achieve further product improvement.

**Background**
Annual medics were developed in southern Australia for use in pastures and in ley farming systems in conjunction with cereal crops. Since the 1970s, this practice has also been advocated in the Mediterranean and Western Asian regions of the Old World and, as a result, significant quantities of Australian medic seed has been exported to these regions.

Most Australian medic cultivars have been developed from naturalised introductions or by screening accessions from overseas, and all have been developed in the Mediterranean type environment of southern Australia. In export destinations, except for certain areas, the lowest extremes of winter temperatures are generally lower than in southern Australia. In these areas having colder winters Australian cultivars often failed because they were killed or severely damaged by frost. Consequently, in the early 1980s the export of Australia cultivators contracted as customers found that they were poorly adapted to frost-prone areas.

The redevelopment of the export industry therefore required the identification of genotypes of annual medics which were adapted to the frost regimes which would be expected in target areas, and which also would have seed yielding capability so that they could be produced economically for export.

**Research**
In Australia sites were established at Mallala and Yongala in SA, to determine levels of seed production and the grazing tolerance of the various cultivators and lines selected for evaluation. Mallala is a centre for medic seed production, and Yongala is a potential centre but is sometimes subject to severe frosts.

From 1991 to 1993 various lines and check cultivators were also evaluated at La Fage in southern France, and at Tulake in northern California, USA. Attempts to evaluate material in north Africa were frustrated by drought (morocco), and civil unrest (muslim fundamentalism, in Algeria).

**Outcome**
As a result of testing both in Australia and overseas, a short list of thirteen genotypes from five species of *Medicago* have been chosen for further commercial assessment by the commercial partner, Seedco. Three of the species have not previously been advanced for commercial consideration in Australia.

**Implications**
There is strong commercial interest in this project from around the world. It is difficult to predict what the demand for seed will be, but a realistic estimate is 1000 tonnes per annum for markets not currently supplied with Australian cultivators.

One of the strong features of this project has been the close involvement of the commercial partner, Seedco who bring considerable experience in developing export markets.
24. SURVEY TO DETERMINE DEMAND FACTORS IN PASTURE LEGUME SEED USAGE IN AUSTRALIA

Objectives
To develop a survey that would assist in developing a marketing strategy to increase the use of pasture legume seeds. The main objectives were to determine:
- major roles of permanent and ley pastures;
- farmer practices with respect to pasture species use, source of seed and resowing of pastures;
- future intentions regarding the use of pastures on the farm and sources of seed;
- farmer opinion on improvements thought desirable in the management of their pastures;
- needs for improvements in pasture legume cultivars; and
- sources of information used for decisions on pastures.

Background
At the Seed Industry Research Workshop in October 1990 it was agreed that the slow growth in sales of pasture legume seed in Australia was poorly understood.

Furthermore, there is little feedback from seed users on the characteristics they require in pasture legume cultivars or the information they need to assist in pasture establishment and management. It was agreed that there is a need for the seeds industry to be more ‘market-led’ and less ‘producer-driven’.

Research
A questionnaire was distributed in all areas where annual medics, subterranean clovers or lucerne are sown, in rotation with crops (ley pastures). Such areas, in total, correspond closely to the Australian cereal belt as far north as southern Queensland.

Because some parts of farms may be permanently under pasture due to soil type or topography, questions on both permanent and ley pastures were included in the questionnaire.

Outcome
It was found that about 90% of respondents had more that 10 years experience in growing cereal grain; and that about 26% of respondents used private consultants to obtain further information about pastures.

The overall impression was that pastures are an important part of most cereal grower’s farm systems. The survey predicts that the great majority will continue to grow legume pastures to feed livestock and improve soil nitrogen.

Implications
There are differences between states which should be taken into account when planning future surveys and regional surveys may be necessary due to the low number of replies from each region.

Information needed to develop a program for pasture improvement and a strategy for seed marketing includes:
- the current state of pastures, and use and value of pasture species,
- most important roles of pasture on farms;
- future intentions on resowing of pastures;
- changes in pasture area and sources of seed;
- the need for improved management practices and cultivars; and,
- the major sources of information on pastures.
All these matters have been addressed by the survey.

The generally high status of state departments of agriculture needs to be taken into account regarding information, as well as the tendency for farmers to use various other sources of information (e.g. private consultants).
Objectives

to examine first hand how seed certification schemes implemented in USA and Europe differ from existing schemes in Australia;
to determine how procedures and methods implemented overseas have contributed to these low or lower cost schemes;
to identify which procedures can be implemented in Australia to make our schemes more cost efficient and effective whilst maintaining eligibility and status with the OECD certification scheme.

Background

Seed certification costs contribute significantly to the cost of certified seed. For example, in South Australia, certification costs are on average estimated to be greater than $65.00 per metric tonne for pasture seeds and $53.00 per metric tonne for field-crop seeds. High certification costs are also becoming a barrier to securing valuable overseas multiplication contracts of field-crop varieties since these costs can be greater than 15% of production costs.

Because these costs are encouraging farmers to produce uncertified seeds, more seed must be absorbed by the local market and this depresses values. Furthermore, any increase in seed without a base standard of quality will depress farm production.

Research

The project required the appointment of consultants with wide experience in the seed industry to visit seed certification authorities, seed companies, seed producers and seed trade organisations in the USA, Canada and Europe. The consultants investigated: procedures used in overseas schemes; the extent, use and training of outside contracted personnel by certification authorities; the degree of self-assessment encouraged or permitted by the authorities; funding arrangements of certification services; and auditing and regulatory procedures that have been implemented to ensure compliance with OECD certification rules.

Outcome

The Australian seed industry and certification schemes were found to differ significantly from ones observed overseas in the following ways:
industry in Australia is relatively small and serviced by individual certification authorities;
most certification authorities are unable to maximise efficiency by dealing with a relatively small number of companies that contract with large numbers of growers;
there is a relatively high proportion of public varieties;
certification authorities are responsible for maintaining public varieties and producing and allocating early generation seed of public varieties;
there is a heavy reliance on full-time government employees in most States for all certification procedures; and
Australia has a relatively low level of delegation of responsibility for certification procedures to growers, cleaners and seed companies.

Implications

Recommendations to overcome the deficiencies noted included: establishing a single industry-based association to progressively assume responsibility for all certification services; certification authorities develop training and audit procedures to facilitate use of cleaning plant personnel to submit seed
samples and part-time non-government inspectors to inspect and monitor seed cleaning plants; that the
post-control testing program for temperate species be at one site;

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26. DEVELOPMENT OF RAPID BIOCHEMICAL METHODS FOR THE
IDENTIFICATION OF MEDIC CULTIVARS

Objectives
To develop electrophoretic ‘finger-prints’ capable of differentiating between ‘look-a-like’ cultivars of
annual medics.

Background
Some of the newer and superior cultivars of annual medics are morphologically indistinguishable from
older, agronomically different cultivars. If the benefits conferred to pastoral industries through
development of these elite cultivars are to be exploited and sustained, then methods need to be
developed for distinguishing between these ‘look-a-likes’

The aim of this research has been to develop electrophoretic ‘finger-prints’ to distinguish between
cultivars. The procedure should be rapid, inexpensive, and lend themselves to automation. The
technology should benefit the producer, and ultimately, the pastoralist end user of the seed, by the ease
and cost effectiveness with which the ‘finger-prints’ might be generated. The maxim caveat emptor will
always be with us, but seed certification and the ability, when necessary, to quickly identify seed will
afford considerable protection to the buyer.

Research
Electrophoretic tests were developed for a range of cultivars of annual medics.

Outcome
Successful tests were developed for a distinguishing cultivars of annual medics in eight different
mixtures, each containing two cultivars. An illustrated manual outlining the procedures for
electrophoretic identification of these major cultivars has been produced.

Implications
Those concerned with the need to identify morphologically indistinguishable cultivars of annual medics,
now have a reliable, established technique for doing so biochemically. A manual describing the
procedures is available for their use. Application of this technology in seed certification procedures will
extend the useful number of years paddock may be used in the production of certified medic seed.

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PUBLICATIONS:
Woodward, J. Electrophoresis Manual to assist in Annual Medic Mebalds, M.I (Medicago sp.) Seed
Identification (1993) Department of Agriculture Victoria

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## 27. DEVELOPING EFFECTIVE RHIZOBIAL INOCULANTS FOR LUCERNE IN WA

### Objectives

to increase the area sown to lucerne by effective nodulation with strains of *Rhizobium meliloti* to give more persistent, dense and productive stands;
to increase animal, and subsequent crop production and increase grower confidence in the crop.

### Background

Results are showing that lucerne can grow in areas receiving only 350 mm of annual rainfall, provided certain soil and management conditions are met. Thus the soil pH should be above 4.7, there should be no waterlogging and only intermittent grazing allowed. Growing lucerne would give a more even feed distribution pattern than annual pastures, and therefore improve wool quality. Out of season rainfall can be exploited to provide quality forage when annual pastures deteriorate because of false breaks, complementing the broadly used pasture species. Other benefits are easy weed control and good nitrogen fixation before crop phases.

### Research

Trials were established at Esperance, Katanning, Jerramungup and Broomehill, Western Australia. A range of lucerne varieties and inoculum strains were used and parameters measured included dry matter production, persistence and nodule numbers and weights in relation to individual plant weight.

### Outcome

In a typical experiment (at Esperance) lucerne plants inoculated with an efficient rhizobial strain produced and persisted four times better than uninoculated controls, and twice as much as those plants inoculated with what was then the commercially available strain.

Efficient rhizobial strains identified were U45, WSM826 and WSM922. Of these, the strain WSM826 was recommended and adopted by the industry and is now available commercially in Australia. Across all experimental sites, the smallest improvement in production, over one year, of WSM826 over the previously available commercial strain was 30%. Near Katanning, the increase in production with the new strain was 78%.

The development of the new strain, together with a lucerne variety evaluation program at several sites, has increased interest in lucerne as a forage plant to such an extent that brokers report an increase in seed sales of 500% in the last year.

### Implications

The use of the new strains will be worth $0.5 million annually in out of season forage for every 10,000 ha sown to lucerne, over and above that produced with the old strain. If 60,000 ha are sown to lucerne in the near future, this will be worth $20 million per annum to the industry from reduced hand feeding of sheep.

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Objectives
to determine the distribution and economic significance of burr rot;
to develop methods for controlling Rhizoctonia burr rot in subterranean clover seed crops.

Background
Production of seed of subterranean clover (predominantly under irrigation), has become a significant industry in south eastern SA. In 1990–91 nearly half Australia’s production of subterranean clover seed came from this region. Yields, however, are variable, and frequently poor, particularly in cultivar (cv) Clare (>70% of the national production of seed of this cultivar comes from this area).

Investigation of crops of cv Clare revealed rotted burrs which produced few or shrivelled seed, and Rhizoctonia was implicated as the causal organism. Yield losses are estimated by growers to be 375–500 kg/ha, representing 75% of potential yield in some crops. Total losses in cv Clare are estimated to be worth $250,000.

Research
Various aspects of the ecology and distribution of Rhizoctonia burr rot were studied, including:
the identification of symptoms in diseased plants;
estimations of yield loss in a range of cultivars;
characterisation of the strains of the fungus associated with diseased plants;
the geographical distribution and epidemiology of diseased crops;
the host range of the strains of the fungus involved;
an examination of the resistance status of a range of cultivars; and
an evaluation of possible chemical control options.

Outcome
Rhizoctonia burr rot is caused by several strains of R. solani, none of which is specific to subterranean clover. The disease occurs in dryland crops but is most active under irrigation. Seed infection is low and unlikely to be a major source of inoculum for uninfected crops.

The disease occurs in all major subterranean clover-producing areas of south-eastern Australia, but is most common in the south-east of SA and in western Victoria. Yield losses of 50% for cv Clare, and 40% for cv Karridale have been confirmed in the field.

Equivalent losses in other cultivars have been recorded in pot trials. The diversity of the pathogen and its wide host range make control by crop rotation extremely difficult, but cereal break crops before subterranean clover should reduce the risk of burr rot. Susceptible hosts will increase the risk of burr rot in subsequent clover crops and, conversely, could be affected by disease after a subterranean clover crop.

All cultivars of subterranean clover examined so far, are susceptible to the isolates of the fungus virulent on cv Clare, and there are no obvious opportunities to control the disease using resistance.

Economic control of the disease can be achieved with routine applications of the fungicide tebuconazole (Tradename Folicur). This fungicide is not currently registered for use on subterranean clover, but is expected to be commercially available soon.

Implications
This research has shown that, despite the serious losses caused by the disease, a better understanding of the pathogen and its host range, can be used to develop control strategies and reduce losses. The economic benefit to growers will be substantial, once appropriate fungicide treatments have been registered.

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29. DEVELOPMENT OF FOUR FODDER LEGUME SEED SPECIES FOR EXPORT

Objectives
To develop suitable varieties of fodder legumes so that seed can be produced in Australia for export as sowing-seed.

Background
Farmers in Europe sow annual legumes for green manure or as fodder crops. Much of the high quality, certified sowing-seed required is imported. The tall-growing crop legumes used have not been grown extensively in Australia, where the emphasis has been on low-growing legumes, resistant to grazing.

In this program, varieties of species important in Europe have been modified so that high yields of quality seed can be produced by Australian seed-growers with minimal use of chemical sprays. The disease-resistant varieties that have been developed can also be used by Australian farmers interested in exporting quality hay to Asian markets.

Research
The four species of fodder crops are: *Trifolium alexandrinum* (berseem clover), *T. resupinatum* (Persian clover), *Vicia villosa* (woolly-pod vetch) and *V. sativa* (common vetch). The research approach varied with species, but involved hybridisation, various forms of selection and progeny testing, and evaluation. Much of the research was conducted on commercial seed farms to ensure that the varieties produced are well adapted to the seed-growing environment.

Outcome
For Persian clover, two varieties, ‘Laser’ and ‘Leeton’, from this program are in commercial production. They have high yields of seed and are rust-resistant so that fungicides are not required. For the other three species, seeds have been sown for increase so that varieties will be released for commercial use in 1995 and 1996.

Implications
There are excellent, though competitive markets for sowing-seed of these species in Europe. In addition, since these species are recognised as useful for producing excellent hay in many parts of the world, Australian farmers will now have more flexibility in the production of legume hay under dryland conditions. This should allow greater on-farm diversity and increased returns.

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FODDER CROPS

Australia produces an estimated 1.2 million tonnes of hay and a considerable quantity of silage and other fodder crops for on-farm use, domestic trade and export. In 1992, fodder production in excess of 9.9 million tonnes was cut from 5 million hectares and had a farmgate value in excess of $1 billion.

The production of fodder is a multi-industry activity often falling between the prime interest of the major livestock industries but having implications for provision of drought relief. A $US 10 billion market for animal feeds in East Asia is largely untapped by the Australian industry. However, there has been limited success in some areas, notably oaten hay exports to Japan, which reached 130 000 tonnes last year.

The research and development supported by RIRDC aims to complement the considerable assistance already provided by other R&D corporations to this important industry. In this sense, RIRDC support is essentially limited to sectors of industry committed to developing stable markets for fodder and fodder products, based on the wide range of crop and pasture species grown, that can be harvested and lightly processed to facilitate off-farm trade, particularly export.

RIRDC’s achievements in this program include the funding of the Kondinin report *Cut and Dried*, which provides information on innovative methods of handling fodder and presents case studies of the most efficient methods and systems being used throughout Australia. The book sold over 1,100 copies in its first month of release (November 1994).
Objectives

to investigate the technology of alternative packing and shipping methods for the export of oaten hay and cereal straw;
to investigate the fumigation requirements arising from these alternatives;
to investigate the economics of all stages in the marketing chain from farm gate to Japan;
to assess the market acceptance of the product in Japan.

Background

From 1990 to 1993 Western Australia exported, per year, about 40,000 tonnes of fodder valued at approximately $10 million —around half of the total exported by Australia. It is conservatively estimated that this amount could be increased more than five times through improved packing and shipping. Alternative methods to be studied are: higher density compression and use of 20’ (TEU) containers; and break bulk packing of fodder in units for shipping on conventional cargo vessels.

Before new packing technologies can be introduced, the economics of all stages of the marketing chain from farm gate to Japan, and acceptance of the changes by the Japanese market, need to be assessed. Also insect fumigation requirements arising from changes in packing and shipping will need to be investigated.

Research

Trials of high density compression of hay were carried out using facilities of Independent Wool Dumpers Pty Ltd at Fremantle capable of a maximum compression force of 250 tonnes. It was shown that 21.6 tonnes of fodder could be packed into a TEU container. There was some concern that moisture would be released from hay but after 30 days in plastic there was no evidence of condensation or mould formation. Moisture condensation was measured and instruments for analysing it surveyed. Feeding trials demonstrated suitability of the compressed fodder as cattle food. In a trial shipment of 13 tonnes to Japan there were no quarantine problems.

Data on insect species infesting oaten hay were gathered. Enough species were found to justify fumigant concentrations used. Gas concentrations and gas-tightness were also measured. An economic analysis of on-farm prices, before-processing costs, after-processing costs, export prices and margins was made.

Outcome

Analysis confirms that shipping costs pose a serious threat to the viability of WA’s export-hay industry. While the study shows that it is possible to obtain high densities of fodder in 20’ containers, changing to the smaller containers may only result in a minor export increase because the Japanese market appears to prefer 40’ (FEU) containers.

Implications

This study has indicated that a significant increase in exports of WA oaten hay would come only from developing break bulk shipping, but it is noted that support for this has, so far, been extremely disappointing.

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30. DEVELOPMENT OF EXPORTS OF OATEN HAY TO JAPAN - ALTERNATIVE SHIPPING METHODS
Objective
To collect and disseminate information to Australian farmers to assist with fodder exports by:
conducting a reliability and performance survey of fodder handling equipment currently in use; and
collating information on innovative methods of handling fodder and presenting case studies of the most
efficient methods and systems in Australia.

Background
There are currently 46,000 properties producing fodder in Australia. The export fodder industry is
centred around Western and South Australia and has a huge growth potential for markets in the Asian
and Pacific area. Machinery problems are known to be costly in time and to cause a decline in
nutritional value of conserved fodder.

Research
Methodology consisted of:
developing and distributing a questionnaire;
analysing data and writing reports;
making field visits and collating farm information including machinery modifications, equipment
servicing and case studies of innovative fodder producers; and
publishing a manual.

More than 450 fodder producers were contacted for information for the manual and considerable
information obtained from machinery manufacturers.

Outcome
A comprehensive manual based on the information gained from the research has been published. The
manual titled Cut and Dried: the Complete Guide to Hay & Silage Management provides information on
the total fodder production system for farmers across Australia with emphasis on “who is doing what
and how they are achieving it”.

Implications
Many farmers should significantly improve the quality of hay bound for export by taking advantage of
equipment modifications and advice contained in Cut and Dried.

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Group, WA. 424 pp.
RICE

The Australian rice industry is now based entirely in the Murrumbidgee and Murray Valleys of southern NSW, where some 2,200 family farms produce about 1.1 million tonnes of paddy a year. It is one of the most productive and efficient rice industries in the world, with yields averaging 8.53 t/ha in the 1990-93 period. The production system is fully irrigated and is unusual in that an extended rotation system is used that favours high productivity and sustainability in contrast to the monoculture-based systems elsewhere.

The industry is both organised and vertically integrated. It generates an annual gross revenue of around $400 million, of which more than $300 million is earned from export sales (mostly of value-added rice in small branded packs) to more than 50 destinations.

The Rice R&D Committee’s draft five-year R&D plan recognises three key issues facing the industry: understanding consumers and markets; market access, regulatory environments and subsidy regimes; and profitability and sustainability (the main focus of the Corporation’s rice research program).
**Objectives**

to develop simple and reliable screening techniques for identifying tolerance to needle nematode (*Paralongidorus australis*) and,
to incorporate tolerance, good grain quality, high yielding ability and lodging resistance into rice cultivars adapted to tropical Australia.

**Background**
The needle nematode (*P. australis* Stirling and McCulloch) is indigenous to the lower Burdekin region in northern Queensland. This nematode occupies a unique ecological niche. It is active for 3–4 months in flooded rice fields and survives the rest of the year in dry soil. It is the only needle nematode species reported to damage rice and feeds on roots of rice seedlings, causing stunting, yellowing and plant death. Reductions in yield of more than 50% have been observed in severely affected crops.

Identification of resistance or tolerance in rice appeared to be the only practical, long-term solution to the problem.

**Research**
Identification of tolerance was adopted as the focus in this project since the long life cycle and low multiplication rate of nematode was likely to make it difficult to find resistance. Concurrent breeding and selection for improved grain quality (i.e. for good grain appearance, high whole grain millout intermediate amylose and gelatinisation temperature), high grain yield, short stature and lodging resistance, and resistance to brown plant hopper and bacterial leaf blight.

**Outcome**

Glasshouse experiments to develop suitable screening techniques proved frustrating. Effective screening for nematode tolerance could only be satisfactorily carried out in the field because of the nematode’s susceptibility to mechanical damage when soil is moved and its low multiplication rate.

Severity of nematode damage to rice roots was the most useful measure of tolerance/susceptibility. However, large numbers had to be assessed and clay soil had to be carefully washed from the roots. It may be simpler to compare yields in the presence and absence of nematodes.

Breeding lines that have shown some tolerance in the field are being used in the crossing program to incorporate tolerance into advanced breeding material. Advanced lines adapted to the north Queensland environment, and improved yield and/or grain quality characteristics have been identified.

Further regional testing is required before any cultivars can be recommended for release for commercial production, and a new phase of research work will need to be conducted to combine these characteristics with needle nematode tolerance, and to improve the levels of tolerance in improved varieties.

**Implications**
Since nematicides are unlikely to be used to eliminate *P. australis*, it is important that tolerance be incorporated into breeding lines. A number of more tolerant parents have been identified and used in the breeding program to produce several adapted long grain breeding lines which show enormous potential for commercial production. However, continued field tests will be needed to determine whether this level of tolerance is commercially useful, or whether it will eventually be overwhelmed by increased nematode populations.
Objective
To enhance the productivity of rice by developing a means of inducing root nodules containing nitrogen-fixing bacteria. More specifically, to establish nitrate-excreting mutant *Azospirillum brasilense* endophytically inside artificially induced root-tumours on rice.

Background
High yields of rice require the use of expensive nitrogenous fertilisers or the use of green manures. Both of these sources of nitrogen have undesirable side effects as well as direct costs. One alternative means of supplying nitrogen would be to enable the rice plant to fix nitrogen via nitrogen-fixing bacteria within artificially induced nodules on its roots.

Research
The bacterium used was a mutant strain of *A. brasilense*. Introduced bacteria were traced within roots by a marker gene and an enzymatic staining technique.

Outcome
Auxin treatment produced nodule-like tumours in roots and the nitrogen-fixing bacterium was successfully established within such tumours.

Implications
Further work is needed to show whether the bacteria within root nodules actually express an active nitrogen system as has been found in similar situations on maize and wheat.

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34. IMPROVED PRODUCTION SYSTEMS FOR RICE IN NSW

of water depth and rate of nitrogen application in relation to environmental effects and variety for optimising the growth, development and quality of rice;
to develop a computer-based rice model to simulate crop growth and development;
to include the results of the crop-growth model in a decision support system to aid decision making with respect to cold damage and fertiliser application.

Background
The existing decision support system for the rice industry is the paper based RICECHECK system. This specifies target levels for seven key management factors to raise yields from 6–8 t/ha to 10 t/ha.
However, flexible systems are required to manage climate risk in rice production to lift average yields and stability of production.

Research
Detailed experiments on rice were carried out to produce the raw data for model development and testing. In both years, the nitrogen (N) response of standard New South Wales varieties depended on planting date and water depth at early pollen microspore (EPM). In the first experiment grain yields ranged from 0 to 13 t/ha.

From this data, a simplified rice crop model was developed that was responsive to management factors such as planting date, fertiliser application and water depth, and environment factors such as temperature and radiation. The rice model was further tested on paddocks, with the error of grain-yield-prediction, slightly larger than the error of measurement.

Outcome
maNage rice, a computer-based, decision-support system was developed. This allows climate risk analysis, yield expectation and what-if scenarios for Amaroo rice crops at the panicle initiation (PI) stage. Users input PI shoot number, nitrogen content and expected microspore water depth into a single screen interface. maNage rice returns a yield-response curve for a particular year, average-response for a range of years or best-and-worst scenario. Financial information such as gross margin and marginal dollar return are also calculated.

Implications
Further development of decision support systems for new and current rice varieties is warranted, especially in the area of pre-flood nitrogen management and harvesting for quality.

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35. CHEMISTRY OF FRAGRANT RICE FLAVOUR VOLATILES

Objectives
To identify chemical entities responsible for fragrant rice aroma;
To examine changes in fragrant rice aroma during storage;
To determine the stage when flavour volatiles develop in the rice plant;
To conduct early generation tests for fragrant rice character in breeding programs.

Background
Fragrant rices are an important commodity worldwide and command a premium price over non-fragrant varieties. Comparatively recently, Australian fragrant rice varieties have been developed and the cultivar Goolarah, presently being marketed by Sun Rice Australia, has enabled import replacement and export of Australian fragrant rices.
**Research**

The project involved development of extraction, separation and identification of rice volatiles, their correlation with sensory attributes, investigation of volatile compounds in the plant, and investigation of changes to volatiles during storage of fragrant rice.

**Outcome**

Fragrant rices of the Basmati and Jasmine type and the Australian Goolarah and YRF9 varieties, and the non-fragrant Pelde variety, were examined during this program. Several hundred rice volatile components were extracted and separated by gas/liquid chromatography. Over seventy were identified including several not previously reported in rice.

The major differences in volatile components between rices were that Pelde contained more of some aldehydes, furans and phenols than the fragrant types. On the other hand, Jasmine and Goolarah had more indole, Goolarah and YRF9 has more 2-acetyl-1-pyrroline and Basmati more 2-phenylethanol, compared to Pelde.

The differences in sensory properties between the rice types reflected differences in relative proportions of the compounds mentioned above between the rices. Most volatile components in rice grain were present in the plant at levels which changed as the plant matured. 2-Acetyl-1-pyrroline was detected in the straw and stems of the fragrant Goolarah and YRF9 varieties, but not in the non-fragrant Pelde.

Changes to volatiles during storage were less under vacuum than at atmospheric pressure and increased in the order paddy < brown < white rice. The results strongly implicated oxidation as the major cause of volatile changes during storage.

**Implications**

The results of this research highlight the fact that differences in odour between rices is a consequence of quantitative, rather than qualitative, chemical variations. Fragrant rice stored as paddy retains its aroma constituents better than white or brown rice and changes to rice volatiles during storage are largely due to oxidative processes. Early generation testing for fragrance could be based on determination of 2-acetyl-1-pyrroline and, perhaps, indole in the developing plants.

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**36. PRODUCING RICE VARIETIES WITH SUPERIOR, INHERENT STABLE WHITENESS**

**Objectives**

to develop a routine procedure for evaluating rice lines with superior inherent stable whiteness using reflectance spectrophotometry;  
to develop a routine procedure for determining the level of gloss it is possible to impart to a rice sample under standard conditions and from this derive a gloss index for selection;  
utilise these systems within all segments of the breeding program;  
evaluate lines from crossbreds that have been made with elite, stable, white parents to attempt to estimate the heritability of these characters.

**Background**

The whiteness and gloss of milled rice is a major price determinate in all world markets. Other rice exporting nations, particularly Thailand, have improved the whiteness and gloss of their products in recent years. To be able to provide rice varieties to the Australian rice industry that will maintain their traditional appearance advantages, a routine mechanism for increasing the emphasis and selection pressure for whiteness is required by the breeding program.
Research
A wide range of genetic material was stored at a range of temperatures and water activities, and then assessed for colour on a reflectance spectrophotometer. Yellowness was measured using the ASTM D1925 yellowness index. A range of varieties with superior colour were identified.

Outcome
A storage technique at elevated temperature (50°C) and a constant water activity (Aw 46) has been developed that can determine the inherent yellowness and inherent rate of yellowing of rice varieties. The technique has been used to evaluate the new low amylose, long grain variety, Langi, which has low yellowness and lower rates of yellowing than Pelde, the current standard variety in this class. The procedures have now been simplified so that six readings taken over a six month aging trial is sufficient for variety classification and selection.

Implications
At a given degree of milling, rice grain whiteness is one of the major determinants of market acceptability. Rices that are white, and stay white during storage, have an inherent advantage.

The testing procedure developed as a result of this research project will allow the Australian rice breeding program to test all advanced material before release. It will also allow the selection of inherently superior lines at the early generation stage.

Objectives
- to assess the distribution of warehouse beetle;
- to determine the daily and seasonal flight activity periods;
- to investigate the diapause mechanism of warehouse beetle;
- to assess chemical control methods;
- to assess non-chemical control methods.

Background
The warehouse beetle (Trogoderma variabile) was first discovered in Griffith, New South Wales in 1978. Attempts to eradicate it were not successful. In New South Wales, a Ministerial Order under Section 5A of the Plant Diseases Act requires the owner or occupier of land or premises harbouring the pest to undertake specific treatments to control the pest. Furthermore, Western Australia has gazetted very stringent and expensive treatment for all rice products crossing the Nullarbor to prevent spread of this pest.

Research
A series of laboratory and field experiments were conducted from 1990 to 1993 on many aspects of the warehouse beetle’s biology and control in the rice producing region of New South Wales.

Outcome
An Australia-wide survey for the presence of warehouse beetle confirmed that it had spread to all mainland grain-growing states, but was still most prevalent in New South Wales.

Studies of the seasonal activity patterns showed that in the Murrumbidgee Irrigation Area, warehouse beetle adults start to fly in November, reach peak flight activity in December and continue to fly at a lower level until May. The beetles overwinter as diapausing larvae. The adults have a distinct daily flight period of about 8 hours duration, peaking 4 hours after sunrise. Initiation of diapause was shown to be influenced by photoperiod, density of larvae and volume of food.
Both admixture and structural chemical treatments were tested to find the most effective registered materials for each purpose. A number of non-chemical control techniques were investigated. Dryacide®, an inert dust, was found to control adults but not larvae. The heat doses required for control in a bake-out type control approach were determined. A microsporidian pathogen (*Nosema* sp.) was intensively studied, and while it will not give the control expected from a microbial insecticide, it may have the ability to slow the rate of population growth through its chronic effects. Hygiene and cleaning protocols were developed in collaboration with the cleaning crews from the Ricegrowers’ Cooperative.

**Implications**

The wide distribution of warehouse beetle (shown by this project) and the futility of maintaining extraordinary measures to prevent its spread have been recognised by New South Wales Agriculture, which is proposing to delete warehouse beetle from Section 5A of the Plant Diseases Act.

A suite of effective non-chemical and chemical control measures have been identified and are being adopted by the rice and other grain industries. The biology of the insect in Australia is now much better understood and a number of novel non-chemical control techniques show promise for the future.

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**38. MINIMISING DEEP PERCOLATION FROM RICE CULTURE**

**Objective**

To develop practical methods of soil preparation for rice cropping that minimise recharge of the watertable.

**Background**

Rice growing is a major contributor to the rapid development of high watertables in the irrigation areas and districts of southern New South Wales. To restrict recharge of the watertable (deep percolation), recent policy aimed to restrict rice growing to paddocks where rice paddock water use is 716 ML/ha (16 mm), in an average season.

Strict implementation of the 16 ML/ha policy would create severe economic hardship for significant numbers of rice growers in some areas. However, research and experience overseas have shown that soil modification by puddling, smearing and compacting can reduce deep percolation by up to 3 orders of magnitude.
Research
A technique of puddling to reduce deep percolation from rice was developed for the rice cultural system in Southern New South Wales.

Outcomes
Puddling can dramatically reduce water use in high water use rice paddocks, but is not always as effective as required. Further refinement of the technique is needed to ensure the desired result. The few data available also suggest that puddling has the potential to further reduce deep percolation in paddocks using around the 16 ML/ha target.

Rice establishment, growth and yield can be equally good with puddling as with conventional cultivation — provided a couple of well-defined traps are avoided. The main agronomic constraint is turbidity. This problem can be minimised by careful water management at the time of puddling.

There is no evidence to date that the growth and yield of crops (wheat, canola) sown immediately after rice are impaired by puddling for rice. These results are from crops direct drilled shortly after rice harvest, in replicated treatments that have had 0, 1, or 2 consecutive years of puddling.

One of the constraints against adoption of puddling is the large amount of time (person, tractor) it takes to puddle a paddock. However, one-pass seedbed preparation is possible with puddling, compared with three to four passes for conventional cultivation.

Considerable effort has gone into demonstration and promotion of puddling. In 1993/94, twelve growers tested puddling on significant areas. The relatively low adoption rate implies that it is not an attractive option to rice growers.

Implications
Puddling is now sufficiently well proven that farmers should test it in a couple of bays, and monitor its effect on water use. Puddling has the potential to significantly reduce recharge of the watertable from rice culture.

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Humphreys et al., 1995, Minimising deep percolation from rice. RIRDC Final Report.

39. ON-FARM DEVELOPMENT OF A TROPICAL IRRIGATED RICE-SOYBEAN CROPPING SYSTEM

Objectives
To develop a productive and sustainable two-crops-per-year system incorporating rice grown in rotation with soybean;
To trial research concepts of saturated soil culture, organic sources of nitrogen, controlled traffic lanes, permanent beds, reduced tillage and improved management of soybean in tropical environments using commercial management practices;
To identify limitations to production with emphasis on varietal adaptation, nitrogen use, weed control and machinery design.
**Background**

The tropical environment of North Queensland is well suited to year-round crop production. Rice was an important crop in North Queensland for a number of years, but it was difficult to grow other crops in contiguous rotation with rice because of the difficulties in changing from a paddy system to a furrow-irrigated, row-cropping system.

This project developed a system for growing rice based on a number of individual research components:

- growing rice on permanent beds using saturated soil culture;
- use of controlled traffic lanes to improve trafficability and timeliness;
- use of organic sources of nitrogen to supply the rice crop;
- improved management of soybeans using new varieties and saturated soil culture.

**Research**

A three hectare site was established in the Burdekin River Irrigation Area on a co-operator’s farm. Raised beds were prepared with permanent wheel tracks and laser levelled furrows of 300 metres in length. A crop of lablab was planted to stabilise the beds and to provide an organic source of nitrogen to the following rice crop. The rice was sown as a winter crop and planted both onto the beds and into the furrows. The rice was harvested with a small plot mobile harvester. Soybeans were planted as a summer crop into the rice stubble on the beds only and water was recirculated.

**Outcome**

The new system was a success with excellent crops of rice and soybeans being grown. Rice yields of 8 tonnes per hectare from the bed and 6 tonnes per hectare from the furrows were obtained from hand-harvested samples. From the entire area, the machine harvested yields were greater than six tonnes per hectare.

**Implications**

The system worked well and produced yields as good as or better than yields produced for these crops under conventional production systems. The major benefits were that rice and soybeans could be grown reliably together in a two-crop-per-year cropping system. This enables growers to get a better return over a system that only produces one crop per year. Water was able to be recirculated and there are excellent opportunities to reduce the amount of water needed to produce a crop of rice.

This system has enormous potential not only in tropical areas of Australia but also in other tropical cropping areas of the world. Already other rice producing areas including Thailand and Laos have expressed interest in this cropping system.

**Objectives**

- to confirm the influence of LONDAX application rates and timing on of *Alisma lanceolatum*;
- to identify optimum timing and nitrogen management for salvage control of *Echinochloa crus galli* using PUMAS (fenoxaprop);
- to demonstrate the efficacy, crop safety and reliability of the SCWIIRT (Soluble Chemical Water Injection In Rice Technique) system.

**Background**

*Alisma lanceolatum* is a breadleaf aquatic weed that has often escaped attempts to control it in recent seasons. Previous experiments highlighted the importance of LONDAX application rates and timing in the control of *A. lanceolatum*.

PUMAS is a grass selective herbicide with potential to salvage crops where *E. crus galli* has escaped previous control attempts.
SCWIRT is a system for applying rice herbicides directly to floodwater thus avoiding the potential for off-target drift.

**Research**

A series of seven replicated field experiments were conducted at four sites. Commercial demonstrations of the SCWIRT system were conducted on seventeen properties in order to evaluate this method of chemical application.

**Outcome**

*Alisma lanceolatum* control
responses to increased LONDAX rates were confirmed on both seedling and corn plants;
later timings improved control of both corn and seedling plants;
foliar contact of LONDAX plus ORDRAM improved corn *Alisma* control;
early LONDAX timings (Days 0 and 4) injured rice excessively.

Salvage control of *Echinochloa crus galli* with PUMAS.
best applied 30–40 days post seeding;
urea ought not be applied prior to spraying with PUMAS;
long grain rice varieties appear less tolerant than medium grain varieties to PUMAS;
PUMAS is incompatible with MCFA amine, but compatible with LONDAX.

**SCWIRT application of rice chemicals**
ORDRAM, LONDAX and LORSBAN were all successfully applied using the SCWIRT system;
full submergence of crop and weeds was essential to ensure adequate spreading of the chemicals;
advantages perceived by ricegrowers included the absence of spray drift, flexibility to treat as and where required and the low operating costs of the equipment;
perceived disadvantages included the requirement to handle chemical concentrates, the risk of stalling or toppling a machine when crossing banks, the necessity to clean the machine between paddocks and another operation to be performed at a busy time of the year.

**Implications**

*Alisma* control can now be practised with confidence. Foliar treatment using LONDAX plus ORDRAM mixtures and delaying treatment poses some dilemmas that may warrant further investigation if and when resources permit.

PUMAS salvage control of grass weeds could now be managed with confidence, however the lack of a ‘Maximum Residue Limit’ (MRL) for rice prevents application of PUMAS to rice under New South Wales law. This is despite the registration of fenoxaprop (the active ingredient) in rice in most of the countries that we compete with for rice exports.

PUMAS cannot be considered as a serious alternative to early season intervention with molinate or thiobencarb, however it could prove of immense value to individual growers who have failed to manage their grass weeds effectively.

Results from the SCWIRT program present many advantages to individual ricegrowers and to the industry in general. The absence of spray drift and the flexibility to use our major chemicals as and where we wish is of immediate benefit

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**41. IMPROVED MANAGEMENT STRATEGIES FOR BLOODWORMS AND AQUATIC SNAILS IN RICE**
Objectives

to evaluate the toxicity and residual effectiveness of currently used and potential bloodworm treatments;
to investigate the biology of bloodworms in establishing rice crops to determine whether more than one species is responsible for crop damage, how long crop protection is required, and whether novel treatments such as perimeter spraying may be effective in delaying re-infestation;
to evaluate alternative molluscicides to copper sulphate for their laboratory and field efficacy;
to examine the biology of aquatic snails to determine the role of short rotations in stimulating snail outbreaks and the susceptibility of snails to cultural rather than chemical control.

Background

Between 100,000 and 125,000 hectares of rice are grown in New South Wales each year, and New South Wales has the highest yield of any rice-growing area in the world, partly because most of the pests that affect tropical rice are either not present in Australia, or cannot tolerate the low winter temperatures experienced in south western New South Wales.

Bloodworms and snails are the most serious pests of the New South Wales rice crop. Eliminating copper sulphate from snail control programs is of particular importance, since its use leads to environmentally unacceptable levels of soil contamination.

Research

Bloodworm ecology was studied using emergence traps, and developmental studies were conducted in the laboratory. Current and potential new bloodworm and snail control treatments were evaluated in the laboratory and field. Snail dormancy was studied in the field.

Outcome

Chironomus tepperi Skuse was the dominant bloodworm species affecting rice during the study, and had only a single generation in each crop studied. The species colonises with particularly rapid development, and shows a high level of susceptibility to most organophosphorus and all pyrethroid insecticides, as well as to some growth regulators. Pelletised formations of temephos and choryphyrifos have the potential to provide extended residual control of all bloodworm species for 30 days from a single drift-free application.

Most serious infestations of the snail Isidorella newcombi are due to repeat cropping, and can be eliminated by improved rotation practices. Isidorella newcombi is highly tolerant to thiodicarb, emthidathion, ethoprophos and thiobencarb, but is susceptible to the molluscicides in trietyl morpholine and niclosamide.

Implications

The results of this study present further opportunities for bloodworm research. If C. tepperi has only a single generation in establishing rice, then the malathion treatment applied to aerially-sown seed should eliminate the initial infestation and further treatments should not be necessary. Rice growers consistently report, however, that considerable crop damage occurs if follow up treatments are not applied. Reasons for this anomaly (including the possibility that malathion may be ineffective as a seed treatment) need to be evaluated. Control of snail infestations through crop rotations and spot-treatment rather than wide-area copper application needs to be promoted throughout the rice industry.
**Objectives**

to measure the range of minerals important for the growth of rice plants;
to formulate rice management strategies which could improve rice yield through better fertiliser recommendations;
to reduce environmental pollution by reducing the application of excess or inappropriate fertiliser.

**Background**
The yields of rice in Australia are amongst the highest in the world (up to 15 tonne/ha in research plots) and the rate of removal of nutrients is very high. Soils not given large inputs of nutrients, and soils of growers who consistently achieve high yields, are now low in several plant-essential elements (nitrogen, phosphorus, sulphur and possibly other nutrients).

Yields are being reduced where these deficiencies remain undetected. The research was undertaken to examine the extent of these deficiencies as the first step to improving yields and reducing pollution caused by applications of excessive or inappropriate fertilisers.

**Research**
Rice shoot samples were collected and dried by rice growers and analysed for plant-essential elements using the ICP technique (inductively-couple plasma emission spectroscopy). The nutrient levels were then:
mapped to assess distribution patterns;
compared to yield and growth data to establish critical nutrient levels for rice;
used to test the hypothesis that there is an optimum nitrogen:starch ratio for rice; and
used to determine which minerals would be amenable to analysis by the NIR technique.

Some samples were also collected from mature crops and analysed for a range of elements to determine the rate of removal of plant-essential elements form the soil in the grain and straw.

**Outcome**
The concept of starch:nitrogen ratio in whole rice shoots was demonstrated to be an effective indicator of plant nutrient deficiencies in that abnormal ratios show that there may be a deficiency in a nutrient other than nitrogen. This finding has been incorporate in RICECHECK.

The nutrient profile of rice grains, bulbs and straw were determined as basis for calculating the several rates of hay nutrients. The several means of P and S give cause for concern.

A reliable calibration for S was incorporated into the NIR tissue test. Progress was made in the development of a calibration for phosphorus.

The composition of rice at the panicle initiation stage was used to map areas of nutrient deficiency.

**Implications**
It was indicated that initially the benefits per rice crop could be as high as $400/ha and the overall benefit to the rice industry could be in excess of $1,000,000 per year. Considering that the proportion of crops with an abnormal starch:nitrogen ratio recorded in this study was approximately 15%, these estimates are still regarded as realistic.

The study of plant essential elements in crops should be regarded as an ongoing check on the mineral balance of the rice crop and the cropping sequence. Further study of plant minerals is required to assess the effects on the quality of rice grain. Some minerals, especially nitrogen, affect the appearance of rice grains (colour) and, according to some workers in Japan, influence the physical properties of the grain (texture).
The process of mapping the latitude and longitudes of each rice farm should continue, to update the map database so it is useful for not only mapping crop nutrient variation, but also other data of interest to the rice industry.

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43. GYPSUM AND GROUNDWATER USE IN RICE ROTATIONS

Objectives
To provide information which will improve water use efficiency at the field and farm scale by reducing deep drainage from rice and by reusing groundwater for irrigation. More specifically:
- to determine the effects of gypsum, applied at commercial rates, on groundwater recharge under rice; and
- To determine the potential to use high salinity groundwater for the irrigation of the non-rice phases of a wheat–subterranean clover pasture–rice rotation, using rice, irrigated with low salinity channel water, as a leaching crop.

Background
The irrigation districts of southern New South Wales face major waterlogging and salinisation problems due to the development of shallow watertables. There is a need to control shallow watertables by increasing the efficiency of water use at all levels of operation e.g. plant, bay, field, farm and district.

Research
Gypsum rate experiments were conducted at five sites on the Riverine Plain, New South Wales. Sites were selected to include both grey clays and red brown earths and deep and shallow watertable conditions. Deep drainage was estimated from changes in the soil water chloride concentration sampled before and after rice.

A long term rice rotation experiment was established to evaluate the potential to use saline-sodic groundwater for irrigation and control watertables.

Outcome
Gypsum increased deep drainage at four of the five sites. Results indicated that rice should not be grown in gypsum-treated soil until soil tests indicate that gypsum has been completely leached from the surface soil.

Early results indicate that there is considerable potential to use waters with salinities greater that EC 3 dS/m. Deep drainage during the rice phase has the potential to provide adequate leaching for the designated rotation. The effects of variation in seasonal conditions on salt loads and leaching rates will be evaluated as the experiment progresses. Because exchangeable sodium changes slowly compared to salinity, the effects of increased soil sodicity on soil structure and infiltration cannot be evaluated at this stage of the experiment.

Implications
The benefits of gypsum for reducing water logging and assisting crop establishment come at a cost of increased deep drainage. The use of very low gypsum rates (less than 1 t/ha) in attempts to clear muddy water is unlikely to affect deep drainage. It is recommended that gypsum use on rice soils be avoided, particularly within the 12 month prior to rice growing.

It is not yet possible to make firm recommendations on water salinities that can be used within rice rotation. However it is clear that there is considerable potential to use water with a salinity greater
than EC 3 dS/m. The amount of salt leaching that occurs at even low deep-drainage rates from rice (e.g. 100 mm) is sufficient to reduce rootzone salinities to acceptable levels for most annual pastures and crops.

Further data need to be collected to evaluate the effects of crack flow on leaching efficiency so that leaching requirement models for clay soils can be improved.

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Objectives
To establish the levels of non-starch polysaccharides (NSP; fibre), starch, resistant starch (RS) in Australian rice products, how those carbohydrates are modified by industrial and domestic processing, and their effects on colonic fermentation in experimental animals.

Background
Dietary plant fibre is not hydrolysed by human gut enzymes and so increases faecal bulk which helps to explain the relief of constipation seen with increased fibre intake. Both fibre and starch (resistant starch, RS) which escapes small intestinal digestion are fermented by large bowel bacteria. The resulting short chain fatty acids (SCFA) are though to protect against degenerative large bowel disease (e.g. colitis, cancer) and to promote large bowel health.

Previous work at the Division Human Nutrition, CSIRO showed that rice Fibre (as rice bran) raised colonic digesta and SCFA in pigs. However it was also shown that if rice was fed, digesta and SCFA rose disproportionately. This effect was thought to be due to RS and suggested extra health benefits from brown rice consumption.

Research
The major Australian rice cultivars (Dongara, Waxy and Calrose) and their products were analysed for NSP, starch and RS. Effects of domestic cooking in a rice cooker or microwave followed by cold storage were also examined.

Outcome
As expected, starch was higher in white rice and NSP higher in brown rice. Parboiling increased the fibre and starch levels of brown rice (probably by inhibiting endogenous enzymic degradation) and also changed the sugar composition of NSP. Both of these effects varied with cultivar. Parboiling also increased the relative content of polyunsaturated fatty acids, which enhance their nutritional value.

Commercial rice products (extruded rice flour, rice cakes etc) had significantly higher fibre levels than the corresponding raw materials. Cooking in a microwave or rice cooker raised the starch content of white rice (presumably by increasing its susceptibility to enzymic attack), an effect which depended on cultivar. Similar changes were seen with brown rice except for waxy (starch content fell). Although freezing increased the RS content of cooked rice, levels remained very low with all of the procedures examined and neither cooking nor storage could explain the high levels seen in animals.

It was suggested that the in vivo data might reflect the particle size of the rice (as pigs do not chew). This was examined in pigs with caecal cannula and it was found that considerably more starch escaped into the large bowel of animals fed coarse rice compared with finely ground rice. In these animals, caecal VFA concentrations were unaffected by the type of rice fed or its particle size.

44. VOLATILE FATTY ACID PRODUCTION THROUGH THE LARGE BOWEL FERMENTATION OF RICE STARCH
Implications
parboiling enhances the retention of nutrients, especially in brown rice. However, the interaction with cultivar type deserves further investigation as it does for effects of processing on NSP sugar composition;

chewing of rice grains may enhance digestibility. This has implications for stock feed as well as for human nutrition in that finely milled flours may be more digestible than coarse ones. The distribution of SCFA along the colon may be influenced by digesta flow.
SPICES, HERBS, TEA & COFFEE

Australia imports about 6,000 tonnes of herbs and spices each year at a cost of about $16 million. About 6,000 tonnes are exported (mainly coriander and ginger) with a value of around $11 million. Australia imports 17,000 tonnes of tea valued at $57 million pa.

Most of the world’s supply of herbs and spices is produced in developing countries where the cost of harvesting and cleaning is very low by Australian standards. Therefore, while Australia has growing conditions from north Queensland to southern Tasmania which are suitable for nearly all herbs and spices, we can only expect to compete with crops that can be mechanically harvested and cleaned or which are superior in quality to those produced elsewhere.

Herbs and spices are used extensively in food processing and are repackaged for supermarket sale. The Australian market for packaged herbs, spices and seasons is estimated at $80 million retail.

An additional and crowning market is the domestic herbal teas and medicinal herb segment which currently takes about 80 tonnes of product annually.

Only about three per cent of the black tea consumed in Australia is grown locally and hence there is a significant import substitution opportunity. Good markets also exist in Japan for green tea.

Coffee has been grown in north Queensland and northern NSW since the 1920s and the Corporation has supported work in this industry since 1988. Following a review in 1993, the research and development program being managed by the Queensland Department of Primary Industries will be supported only until the end of 1994-95.

RIRDC achievements in this program include:

- Establishment of a reliable spice seed industry in southern Australia. Particularly good progress has been made in commercialising coriander, dill fenugreek an mustard, with more than 5,000 tonnes of these spices already having been exported.
- Development of a national strategy for the future direction of the Australian herb industry.
- Development of a new green tea industry worth $10-$20 million per annum. Results to date are very promising with six thousand plants now established in Tasmania. Through this project, Tasmania could become an important source of fresh premium quality tea for the large markets in Japan and south-east Asia during the northern hemisphere off-season.
- Commercialisation of a coffee processing system by the Queensland Department of Primary Industries and an agreement with Austoft Industries Ltd of Bundaberg to manufacture and sell coffee processing equipment.
45. HERBICIDES FOR USE IN FENNEL AND PEPPERMINT

Objectives
- to establish maximum residue limits (MRLs) for herbicides presently used in both crops;
- to establish herbicide efficacy in both crops;
- to obtain registration of herbicides for use on these crops.

Background
Fennel and peppermint are high-return crops attracting increasing interest among growers, particularly those wishing to diversify their enterprises. However, the future of these crops depends on good weed control and at present there are no herbicides registered for commercial use. Herbicides currently used have been approved on a trial basis only. Data on efficacy and MRLs are required for herbicide registration to allow the continued growth of this potentially high valued industry and the acceptance of residue-free oil on domestic and overseas markets.

Research
An extensive range of pre- and post-emergent herbicides were tested on both crops over a three year period. Efficacy against a range of weeds and phytotoxicity against the test crops were evaluated from planting to harvest. Crop production of treated areas was compared against hand weeded controls. Herbicide residue levels were measured in plant samples throughout the season and also in oil extracts after harvest.

Outcome
A range of pre- and post-emergent herbicides were found to be effective against all weed species encountered in the trials. At the effective rates, plant samples had either no detectable residues or residues at levels of existing MRLs in vegetable crops. No residues herbicides tested were detected in either fennel or peppermint oil.

Implications
The efficacy of a range of herbicides has been demonstrated conclusively for fennel and peppermint. The basic data required for registration purposes is now available to chemical companies to proceed and have their products registered for this purpose. While the crops have no value for human consumption, the plant residue after oil distillation could be used for stock feed. Australian producers of essential oils from fennel and peppermint can confidently market residue free products domestically and overseas.

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46. COMMERCIALISATION AND DEVELOPMENT OF JAPANESE GREEN TEA

Objective
To investigate the feasibility of commercial green tea production in Tasmania for supply to the Japanese export market.

Background
Japanese Green Tea is produced from the leaves of Camelia sinensis. While the essential difference between green tea and black tea is one of post harvest processing techniques, varietal and climatic influences are also of major importance.
In Japan, tea production reached 100,000 tonnes in 1975 but has steadily declined since that time to 90,000 tonnes in 1990. This was due to the progressive contraction of traditional production sites in Japan caused by pollution, urbanisation and the ageing nature of the traditional grower base. The market demand, however, has not decreased. As a consequence local marketers and manufacturers have been seeking alternative sources of supply, particularly in southern hemisphere areas.

Visits to New Zealand and Japan in 1991 by Mr S D Martin confirmed the potential for green tea production in Tasmania. It is believed by New Zealand and Japanese interest that the potential demand for green tea could support both the New Zealand and Tasmanian industries. A Tasmanian industry with a production area of 100 - 200 ha worth $10-20 million could develop within 5-10 years. This would represent less than 0.03% of the current Japanese demand. New Zealand and Japanese agribusiness have indicated an interest in developing a co-operative venture with Tasmanian producers.

**Research**

The research includes:
- multiplication of introduced tea plants for expansion of trial sites;
- agronomic assessment of the tea located around Tasmania;
- trial processing and marketing of product;
- continued establishment of commercial links with overseas/local production and marketing interests;
- assessment of commercial viability.

**Outcome**

Successful propagation of tea from tip cuttings has been achieved with over 90% strike rate. However, for commercial purposes, it is believed that timing of tip cutting removal will be critical for producing an economical plant for industry. It has been observed that rooting of cuttings occurs more rapidly when taken in spring/summer rather than in autumn. This method was used to establish the first clonal speeding plantation of tea in Tasmania.

Agronomic assessment of the tea plantings has included growth measurements and ontogeny records. An analysis of this data will provide information on the suitability of the three different tea cultivators to Tasmanian conditions and indicate the preferred location for tea production.

Varied success has been encountered with green tea growth and productivity throughout Tasmania. Factors including out of season frosts, root spiralling due to extended life in pots during quarantine and salt accumulation causing tip necrosis have been recorded. No serious diseases have been identified.

A mini-tea processing plant was imported to Tasmania in early January. This is currently being commissioned with the first harvest anticipated in November/December 1995. Trial marketing of green tea produced in Tasmania will be possible after this date.

The establishment of commercial links with both overseas and local production and marketing interests has been achieved through visits to New Zealand, Japan and India. This has stimulated a great deal of commercial interest in Tasmanian green tea production with visits to Tasmania by Japanese tea growers, processing companies and financiers.

**Implications**

A decision as to the commercial viability of green tea production in Tasmania is yet to be fully assessed. This will require sufficient green tea production to allow yield and quality assessment and subsequent test marketing of the processed tea.
47. SPICE PRODUCTION FOR IMPORT REPLACEMENT AND EXPORT

Objective
To establish a viable spice seed industry in Australia by:
- identifying spice crops most suited to dryland and irrigation areas;
- evaluating adaptability, productivity and disease resistance of the most promising selections;
- identifying areas with potential for seed production; and
- identifying major agronomic constraints to seed production.

Background
Market research confirmed significant potential for import replacement and export of a wide range of spices. Initial production and marketing of coriander and to a lesser extent fenugreek, confirmed the potential for Australian production. Suitability for mechanical harvesting, ability for growth on a wide range of soil types and similarities between climates in some parts of Australia and those of major spice producing regions around the world suggest that a commercially viable spice industry could be established in Australia.

Research
Following on from ASSRF project UA-10A, SEEDCO has continued to collect and evaluate a wide range of spice germplasm from around the world. Agronomic trials were done at sites selected to provide soil, climate and crop rotations representative of extensive agricultural production areas throughout South Australia. The trials incorporated screening for disease resistance and tolerance to fungicides and herbicides. Where appropriate, trials were done on a scale to approximate commercial conditions.

Outcomes
A range of suitably adapted spice seed accessions were identified for commercial cultivation under the Mediterranean climatic conditions that occur in South Australia. A total of eight species were investigated, including aniseed, caraway, coriander, cumin, dill, fennel, fenugreek and mustards. For each of these species, suitable accessions and suitable production areas were identified in South Australia.

Agronomic management programs for all species have been developed and yield increases are likely to be achieved by further work. A total of sixteen accessions of four different spices have now been released to industry for commercial production. Diseases, and to a lesser extent weeds, remain the major factors limiting successful spice production in South Australia.

Implications
The results of this and previously related projects, provide a basic technical package for the development of a successful spice industry in South Australia that should also apply to other parts of Australia. More detailed research and development will be required for individual spice species in the future.

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48. ASSEMBLY AND PRELIMINARY EVALUATION OF IMPORTED TEA CLONES
Objectives
To assemble a range of clones with potential for significant yield improvement over seedling material, and to test their adaptation to the local environment.

Background
The tea industry in Australia is an infant industry, which has significant potential for import replacement. Current production of 750 tonnes per annum supplies only 3% of Australia’s current consumption. It has been shown that there is ample suitable land for Australia to be self-sufficient in tea production.

Current Australian production is based on seedling material, which was introduced to this country in the 1930s. Experience in the major tea growing countries has shown that the use of selected high yielding clones can increase yield by 100%, and improve quality.

This substantial yield increase would have particular importance in Australia, where tea production is highly mechanised, as most costs are fixed rather than variable. The benefits accruing from this level of yield increase would be $3000 per hectare per annum at current prices. This could represent a benefit of $6 million per annum from 2000 hectares of clonal tea.

There is no other current work being done in Australia on evaluation of black tea clonal material. Major programs of clonal selection and breeding are carried out in the major tea growing areas of the world, particularly Malawi, Kenya, Sri Lanka and India. Communication is maintained with the Tea Research Foundation of Central Africa, Malawi which carries out the best organised improvement program in the world.

Research
A number of clones have been imported from Africa and propagated and grown at South Johnstone Research Station. These are being evaluated for adaptation and preliminary assessment of yield potential in comparison with locally selected material.

Outcome
The collection of clonal material at South Johnstone provides the basis for a clonal improvement program for the future. Well adapted clones that have produced high yields and good tea making quality are available for further evaluation in Australia.

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49. AUSTRALIAN HERB INDUSTRY — A FUTURE DIRECTION

Objectives
To identify problems and opportunities facing the industry then develop a strategy to solve these problems.

Background
The herb industry in Australia is a growth industry but the majority of herbs used in Australia, apart from those sold as fresh-cut culinary herbs, are imported from overseas. There are a number of entrepreneurial herb enterprises in each state, and many small growers attempting to establish markets on an individual or cooperative basis. These, however, are catering to only a small portion of the potential market.

Considerable research is being directed at the industry but it is largely uncoordinated. There is duplication of effort in some areas but insufficient research in others.
Research
Thirty people were invited to attend a workshop which was held over the weekend October 1–3 at the Australian Emergency Management Institute, Mt Macedon, Victoria. Those attending represented growers of fresh-cut and dried culinary and medicinal herbs, marketers, manufacturers, processors, researchers and representatives from state departments of agriculture.

Outcomes
The workshop agreed that:
the Australian herb industry is not maximising its full potential in the marketplace;
the fragmentation existing within the industry, and the lack of integrations between growers, processors, manufacturers and retailers are the main reasons the herb industry is not maximising it full potential in the marketplace;
there is a need to establish a formal networking system as a positive step towards on-going and open communication within the industry; and
a national umbrella body for the herb industry, while desirable in the long term, is not feasible at this stage of industry development

Implications
The workshop recommended that:
an active network system be established:
to promote information exchange;
to strengthen mutual understanding and develop a sense of cohesion and cooperation within the industry; and
to give the industry a capacity to unite and more effectively respond to the challenges and opportunities currently existing and likely to arise in the future

Further to these recommendations a steering committee was appointed comprising Howard Rubin (Herb Farms Australia), John Penninger (Fancy Foods Freelance), Rodney Brennan (Blackmores), and Kim Fletcher (Focus on Herbs Consultancy).

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50. DEMONSTRATION AND EVALUATION OF MECHANICAL HARVESTING IN NSW

Objectives
To validate recent developments to the Austoft shaker system, aimed at improving selectivity and performance under difficult harvesting conditions;
to provide a further demonstration and evaluation of mechanical harvesting to the New South Wales Coffee Industry.
Background
The coffee industry in Northern New South Wales has been undergoing a revival based on the region’s ability to produce premium coffee, and the prospect of machine harvesting to reduce labour costs. Initial machine harvesting trials in 1989, using Brazilian technology, were unsuccessful. The unusual strength of the attachments of the cherry to the laterals, and lack of understanding of the limitations of machine harvesting, were causative factors. Machine harvesting trials conducted in 1990 with the Queensland Department of Primary Industry-developed harvester demonstrated that potential existed for machine harvesting of coffee in Northern New South Wales.

Trials in 1992 with the newly developed Austoft harvester, based on the Queensland Department of Primary Industry machine developed in 1990 demonstrated commercial commitment to the development of an internationally competitive coffee harvester. Research in North Queensland demonstrated potential for improvements in the shaker systems to enhance performance, particularly under difficult harvesting conditions.

Research
Trials were conducted in Northern New South Wales to assess the impact on performance of the changes to the shaker system. A field day and demonstrations were conducted for the local industry to see the latest developments to the machine and harvesting and processing being conducted. Further trials were conducted in Northern Queensland to verify the results, and high speed cinematography was used to further investigate the processes of fruit removal.

Outcome
The result of the trials has been validation of the value of increasing the number of fingers on the hands of the shaker system in the Austoft harvester. This modification has now been incorporated on the latest machines, including the machine recently sent to Brazil for demonstration.

Implications
Trials and results signal further development of the Australian developed ‘second Generation’ coffee harvester, now marketed world-wide by Austoft. A consortium of Northern New South Wales growers are now negotiating to purchase a harvester, and expansion of the industry is occurring.

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51. COMMERCIALISATION OF THE WALKAMIN COFFEE PROCESSING SYSTEM

Objectives
To finalise the research program on the processing of machine-harvested coffee by developing a system designed for commercialisation, in conjunction with a commercial partner. This is to include: developing key components of the coffee processing system identified as requiring further R&D prior to commercialisation; and liaising with the licensee, Austoft, on the design of a ‘turn-key’ coffee processing system, and testing components of the system as they are developed.

Background
Mechanically harvested coffee cherry can include significant proportions of immature and/or overripe cherry. Commercially available processing equipment is designed for use with hand-picked feedstock, and can only accept very small proportions of immature cherry before the quality of the final product is severely compromised. A major problem for the North Queensland industry has been the reputation it has gained for poor product quality; because appropriate processing equipment has not been available.
The RIRDC funded project ‘The development of processing systems for machine harvested coffee’ demonstrated a system with the ability to produce a line of prime wet processed coffee, almost irrespective of the composition of the feedstock. This was achieved by the use of novel separation techniques, including the development of the patented ‘tyre-pulper’ which is central to the system. A number of further developments were required to achieve a commercially viable throughput.

**Research**
Design (in association with Austoft staff) of components for the system, to allow the processing of 6t/hr of cherry, based on the current system with a capacity of 1.5–2t/hr. The upgrading of the capacity of the tyre pulper was of concern;
Development of alternative components to simplify the processing system e.g. the cherry separator and hydrocyclone, first to proof-of-concept stage then to a commercial sized units;
proof-of-concept components were designed and built to be trialed in Northern New South Wales at the end of the 1993 season. This allowed the design of full sized components for the 1994 Northern Queensland season.

**Outcome**
The full-size, pre-production prototypes of all critical components were developed and trialed during the 1994 Northern Queensland season, with considerable success. This has allowed Austoft to design and build a complete ‘turn-key’ system for trialing in Northern Queensland during the 1995 harvest.

**Implications**
International interest in the system is very promising, both from organisations contemplating machine harvesting of coffee and established plantations. For example, considerable interest has come from New Guinea, where processing systems that allow handpickers to be less selective, yet maintain product quality, will reduce production costs.

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**Objectives**
to review prospects for an economically viable and sustainable coffee industry in Australia;
to review the nature and outcomes of the current R&D program;

**Background**
The RIRDC Coffee R&D Program was last reviewed in February 1991 at which time it was concluded that ‘the development of this production, harvesting and processing package can be achieved within the original 5-year program’. The review also recommended that funding after 1992–93 be subject to a final review of the 5-year program under terms of reference shown as objectives above.

**Outcomes**
Although world coffee production has decreased in recent years, high levels of stocks have maintained supplies but world prices are likely to increase sometime in the next two years as stocks decline.

It is also concluded that world consumption is unlikely to grow by more than one percent per year and, without a marketing edge, Australia will find it hard to compete with overseas suppliers. Premium prices are needed by the Australian producers and obtaining these will require sound marketing and integrated processing. Profits currently exist, generally at higher levels in New South Wales than in Queensland. However, some Queensland growers roast and grind coffee to increase profitability.
Farm-gate value of the industry is currently about $0.5 million with production in Queensland averaging about 120 tonne and New South Wales about 10 tonne per year. The industry could achieve a gross value of $5 million in 6–10 years if there was significant new investment in coffee over the next few years. This was thought unlikely unless there is a world price increase that pushes up the price of Australian coffee. On the other hand, smart marketing and promotional support should warrant investment at present to take advantage of existing price premiums.

**Research**

Areas under Subprogram A—development, yield and quality that contain uncertainties include: pruning for regrowth and manipulation of fruit maturity in Queensland; and over-bearing die-back at several Qld sites.

In Subprogram B—harvesting and processing, most objectives have been achieved. These include greatly reduced harvesting costs and successful liquoring trials, commercialisation and sale of the QDPI based-harvester by AUSTOFT and interest of companies in refining and commercialising the processing equipment.

In other studies, researchers have successfully contributed to the development of coffee quality standards and quality assurance schemes (Subprogram C—marketing) and it was concluded that studies under Subprogram D—program coordination, monitoring and evaluation have been of a high standard.

The program overall was judged to be highly effective in that it has provided high quality research results, has been well managed and used resources efficiently. However, it was noted that the current lack of a newsletter was preventing transfer of findings to growers an adequate written record of the program’s outcomes is urgently needed.

**Implications**

In considering the future of the R&D program, it was noted that the Australian coffee industry was expected to remain a modestly sized one because, when output exceeds local needs, prices will then move down towards the international prices. Nevertheless, growth is expected especially in view of increasing mechanisation and as well resourced growers move into the industry. Also, government may support a move from declining industries such as tobacco. Thus it was concluded that it is economically rational for RIRDC to commit further resources to coffee R&D, albeit at a modest level.

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TEA TREE OIL

Tea tree (*Melaleuca alternifolia*) is native to the north coast of New South Wales where it has been harvested by bush cutters and distilled in the field since early this century. Over the years it has gained widespread therapeutic use for fungal and microbial infections but is not yet registered for use by the medical profession. Its status as a 'natural product' has been valuable for marketing purposes.

The current annual production of tea tree oil in Australia is estimated to be 150 tonnes, having a farmgate value of around $8 million and a value-added worth of around $15 million. Recent plantings in northern NSW and the increasing interest in tea tree amongst North Queensland tobacco growers seeking an alternative crop mean that production is likely to rise sharply within the coming five years.

In NSW, production is expected to reach 450-500 t/pa within five years. Queensland growers could eventually add as much as 720 t/pa if all apparently suitable lands were to be planted. It is likely that such increases in supply will exceed market demands, at least in the short-term, and hence depress prices.

Currently, hopes for continued and increased market demand are based on greater acceptance of tea tree oil by the US Food and Drug Authority Monograph system as an over-the-counter medicine for first aid and health care.
Objective
Investigate possible links between environmental parameters and the yield of tea tree oil.

Background
The oil concentration in tea tree varies widely with the most pronounced trend being for the concentration to increase from late winter to summer. In addition, however, the concentration, the rate of change in concentration, and short-term fluctuations all differ, both between plantations and between years in the same plantation. These variable trends have made it difficult to identify what controls the oil concentration and to decide when the oil concentration is at the best level to harvest.

Research
Designed experiments were set up in tea tree plantations to test whether:
- stomatal functioning was impaired by cold winter temperatures, leading to less controlled water loss and low oil concentrations;
- cavitation in the xylem vessels induced water stress; or
- the plants were poorly adapted to handle a high evaporative demand.

Outcome
Average oil concentrations were highest in summer/autumn when most of the leaves on a tree had developed during the warmer months. The tea trees were water stressed even when they were irrigated. Stomatal movements were sluggish, leading to a generally low leaf water potential, especially in mature leaves.

However, there was no relation between water potential and oil concentration in leaves. Whilst water stress persisted throughout most of the dry season (September-December), the oil concentration generally increased over this period and more than doubled in one experiment.

Overwintering did not impair plant functions or give a lower oil concentration in subsequent growth. Shading did not ameliorate the evaporative demand effects, and irrigation only gave a 10% increase in oil yield.

Defoliation just before or after winter never increased the subsequent growth rate of plants and, in some cases, it severely reduced growth.

Implications
No one cultural practice or local environment appeared to be able to reduce the water stress which is endemic in tea trees grown in plantations. Warm to hot temperatures are required to obtain high growth rates, but can also induce more water stress. Whilst winter frosts as experienced on the north coast of New South Wales reduced growth rates, they did not cause long term damage.

From a production perspective, harvesting should be delayed until the crop canopy is fully developed.

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Objectives
- to identify the components of tea tree oil;
- to search for means to provide tea tree oil with enhanced antimicrobial activity;
TEA TREE OIL

to establish the relative antimicrobial activity of tea tree oil;
to identify the components of tea tree oil that are active against the microorganisms that cause thrush, acne, dandruff and tinea;
to develop a test method suitable for the determination of the antimicrobial activity of tea tree oil.

Background
Increases in local and overseas sales have created a need for more information about the properties, composition and quality of tea tree oil and how these factors should be related to price. This will become more important as the use of tea tree oil as a ‘medicine chest in a bottle’ is superseded by cosmetic and pharmaceutical companies using the oil in formulations having specific medicinal applications. For these applications, quality is most likely to be related to antimicrobial activity.

Research
The antimicrobial activity of a large number of commercial oils was examined. The relative contribution of cineole and terpinen-4-ol to the activity was then studied.

Outcome
Results demonstrated the importance of terpinen-4-ol for activity against microbes including those causing acne, tinea, dandruff. The powerful antimicrobial activity of p-cymene, a minor component of tea tree oil, was confirmed. Some microorganisms are highly susceptible to a combination of terpinen-4-ol and p-cymene.

Implications
As a result of information from these studies, several industrial groups have requested detailed discussions on tea tree oil.

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55. GENETIC VARIATION IN OIL PRODUCTION AND QUALITY IN TEA TREE

Objective
To establish the basis for a breeding program in tea tree by defining the degree of genetic variation within the species used for oil production.

Background
Expansion of the tea tree oil industry requires the use of plantations of high genetic quality.

Research
Seed and leaf material was collected from trees at fifteen seed sources of M. alternifolia and six of M. linarifolia. This was used in five complementary studies to define the degree of variation within the species, the degree of genetic control and the possible effects of breeding.

Oil in the leaves of each tree was analysed to define which geographic locations contained useful oil. Isozymes and chloroplast DNA were used to evaluate patterns of genetic variation.

Outcomes
Oil quality.
Previously three different oil types had been described. In *Melaleuca alternifolia* the ‘type’ variety is useful with cineole levels in different populations ranging from 0.8% to 8% and terpinen 4-ol levels from 38–42%. The others are not valuable as they have high cineole and low terpinen 4-ol. Two more types were recorded in this species — both have high terpinolene levels, are confined to the Queensland populations and are of no commercial value.

‘Type’ oil was almost the only oil found in *M. alternifolia* in four locations in the Bungawalbin area. Grafton and Whiporle did not generally have ‘type’ oil and were of no commercial value.

Trees at Tabulam, mid way between Casino and Armidale, Barcoongere on the coast south of Grafton and at Port Macquarie all had ‘type’ oil.

The oil produced by *M. linarifolia* from both Queensland (Talro) and New South Wales (Bulahdelah) conforms to the Australian standards and the species can be used in plantations.

*Other characteristics.*

Within the species there are differences between trees in growth rate and biomass production, in oil production and quality, and coppicing ability. Some seed sources exhibited a reduced coppicing ability but, for all characteristics, variation between trees was greater and more important than that between seed sources.

A negative correlation between leaf oil yield and vigour suggests that if trees were bred for high leaf production there would be a reduction in the quantity of oil per weight of leaf.

*Genetic studies.*

The isozyme and DNA studies confirmed the Queensland populations of *M. alternifolia* as distinct and suggested the Port Macquarie population was hybrid between *M. alternifolia* and *M. linarifolia* was genetically distinct from the south (Bulahdelah).

*Gains from breeding.*

A 17% gain in oil yield from breeding could be expected in the first generation using a selection intensity of 1 in 10, combining selection for oil yield and coppice production and holding dry weight production constant.

*Implications*

Breeding programs should select for several characteristics and include coppicing ability as well as biomass and oil production and oil quality. Care will be needed to combat any negative relationship between biomass and oil yield.

Although the use of *M. alternifolia* is a sound procedure in the Casino/Lismore region of New South Wales the material used need not be confined to trees from Bungawalbin and *M. linarifolia* with good characteristics could also be used.

If tea trees are to be introduced to new areas it would be desirable to test *M. alternifolia* from all areas shown to produce useful oil and to include *M. linarifolia* sources also.
Western Australia, the home of the industry, accounts for about half of Australia’s wildflower production of some $25.3 million a year (farmgate equivalent). However, wildflowers are now cultivated in all states, on about 2,600 hectares. The relative importance of the bushpicked flowers on which the industry was founded is declining, even in WA, and now represents only about 16% (ie. $4.1 million a year) of the farmgate value of wildflower production.

Between 1980-81 and 1992-93, exports of wildflowers and native plants have grown from around $2 million to about $22 million a year. More than 300 species are exported, largely by air freight, but the key commercial wildflowers are Geraldton wax, kangaroo paw, Thryptomene, and species of Banksia, Leucadendron and Protea. The major markets are Japan, the USA, Germany and the Netherlands.

In 1992-93, exports of fresh flowers (69% by value) greatly outweighed exports of dried flowers (23%), foliage (4%) and orchids (4%). Estimates of the domestic market for fresh wildflowers for the same year range from $10 to $13 million farmgate value. The total value of dried wildflowers for both domestic (wholesale) and export was some $8 million in 1992-93.

The Corporation’s draft five-year R&D plan for wildflowers and native plants will be discussed with the industry and the research community during late-1994 and early 1995 with the goal of having an agreed plan in place by March/April 1995. In the meantime the strategies indicated below should be used as a guide to the Corporation’s intentions.

RIRDC’s achievements in this program include:

- Completion of the most comprehensive baseline study of the Australian wildflower industry yet produced, which provides much needed data on the industry.
- Development of riceflowers as commercially acceptable cutflowers. Plant variety rights protection is being sought for two of the best lines arising from this project.
## 56. DEVELOPMENT OF BAECKEA BEHRI SPECIES AS CUT FLOWERS FOR THE EXPORT AND LOCAL MARKETS

### Objectives

to develop cultivars of Baeckea behrii, other members of the genus Baeckea, and the genus Scholtzia for cut flower production;
to develop production and post-harvest protocols for these cultivars;
to provide the flower industry with cultivars and information to ensure that protocols are taken up.

### Background

A number of species of Baeckea and related genera of Myrtaceae have good potential as floral fillers. In particular B. behrii produces an attractive floral display of small Myrtaceous flowers. As this species flowers naturally from October to December, it will complement the market for Geraldton wax and thryptomene by expanding the time that Australian filler flowers from the Myrtaceae are available to export markets.

### Research

A large number of plants were surveyed in natural populations to select plants with suitable characters for development as cut flowers. Cutting material was collected from superior plants, for propagation and cultivation at Knoxfield. In total 118 species and clones were collected for further assessment, which included 60 clones of B. behrii. All the clones were assessed on their ease of propagation, cultivation, and the floral display of plants in cultivation. Field plots were also established on flower farms throughout Victoria.

A range of postharvest solutions and pulses were tested to determine the best vase solution to extend vase life. A vase solution containing 10 g/L sucrose with 100 mg/L chlorine delayed the onset of senescence the longest. Postharvest vase life varied dramatically between clones of B. behrii, and the clones selected on physical characters were also assessed for vase life. From the clones suitable for assessment, nine had an acceptable vase life of greater than seven days.

### Outcome

From the large number of plants surveyed in natural populations, only eight clones of B. behrii are being released for commercial evaluation. These clones will be evaluated by members of the wildflower industry and will be covered by a testing agreement.

### Implications

A network of growers around Australia will be established to provide information on variations in flowering time, growth rates and yield in different geographic regions of Australia. These growers will be the first to commercially trial the new clones, and will provide information to assist other growers and future exporters of this product.

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57. DEVELOPMENT OF NUTRIENT MANAGEMENT TECHNOLOGY FOR AUSTRALIAN WAXFLOWERS

Objectives

to determine the nutritional status of Australian waxflower and protea plants associated with high yield and premium quality;

to develop nutrient management technology (e.g. plant and soil tests) to ensure that crops achieve the nutrient status required for high yield and premium quality;

to determine the effect of rate, source and timing of nitrogen and potassium fertiliser and trace elements (in particular, copper, zinc, manganese and iron) on yield, quality and postharvest life;

to develop maintenance fertiliser strategies;

to develop a computer based user package to facilitate transfer of the technology developed.

Background

Australian waxflowers (Chamelaucium species and hybrids) are the major export flower crop developed in Australia.

Problems, such as vegetative growth above flowers before harvest, leaf yellowing, and premature leaf and flower abscission, may be affected by the nutrient management of the crop and lead to poor quality flowers being exported.

Research

Commercial planting's of waxflowers, proteas and leucadendrons in South Australia were monitored for growth, flowering and nutrient status.

Outcome

On siliceous sands, the application of nitrogen increased shoot growth, tip-growth, total biomass, yield and length of stems, vase life of the cv. Alba and soil acidity, and decreased the incidence of yellow, poorly coloured foliage. The effect of nitrogen on harvest index, dry matter content of stems and solution usage by flowering stems was inconsistent between sites and years. The application of nitrogen did not affect soil salinity. In the third year, the application of potassium, up to 20g K/plant/year, increased the yield and length of stems at 1 of the 3 sites. Vase-life and soil acidity or salinity were not affected. The application of P, at 7.5 g/plant/year, decreased the yield and length of stems of the cv. Alba at one site.

Protea and Leucadendron spp. The application of N, calcium and potassium to Protea 'Pink Ice' and leucadendron cvv. 'Silvan Red' and 'Safari Sunset' did not significantly affect productivity and stem length at any site. For King proteas, the application of N, at 25 or 50 g/plant/year, increased the number of stems harvested in 1992 and 1993.

Plant Testing Procedures. Based on a consideration of sampling error, variation in nutrient composition with leaf position, seasonal trends in nutrient composition and cultivar and species differences, plant testing procedures and interpretation standards have been suggested.

Maintenance Fertiliser Strategies. Nutrient removal data are useful to develop maintenance fertiliser strategies and to make decisions on the nutrient composition of fertilisers recommended. For irrigated protea and leucadendron crops, annual applications of nitrogen and Ca up to 20–30 g/plant and Mg and k to 10–15 g/plant should be considered on siliceous sands.

Implications

It is concluded that significant improvements in productivity, quality and postharvest life can be achieved for waxflowers, and certain Protea spp., by adopting improved nutrient management strategies. For the future, it is suggested that there is need to:

study the effect of N, P and K on productivity, quality and postharvest life of new cultivars (for example, Mullinb Brook, Microwax 63 series, Early Bird, Eric John, Eclipse and Lady Stephanie);

determine the effect of irrigation x nutrition (N and K) on productivity, stem length and postharvest life;
identify appropriate soil nitrogen application and foliar nitrogen spray strategies to minimise tip growth of mid to late season cultivars;
to ensure systems are sustainable in the long term, determine the effect of improved nutrition management strategies on soil acidification and salinisation of the root zone;
monitor the nutrient status of commercial plantings to validate and refine the interpretation standards developed in this study.

RIRDC Project No:DAS-35A

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58. VISIT TO ASIAN FLOWER MARKETS AND JAPANESE HORTICULTURAL CONGRESS

Objectives

to gain first-hand knowledge of flower and vegetable markets in Hong Kong, Taiwan and Japan;
to participate in the International Horticultural Congress Floricultural Symposium.

Research

Between 6-20 August 1994, Professor Considine visited flower and vegetable markets in Hong Kong, Japan and Taiwan. The International Horticultural Congress Floricultural Symposium was attended.

Outcome

The major impressions gained were:

Vegetables. Fresh vegetables are being promoted in Asia to improve public health. Local production of vegetables is likely to decrease as young people leave the country and the farm population ages. Also it is difficult to produce high quality summer vegetables because many of the areas have wet tropical and sub-tropical climates. Opportunities exist now for production of high quality fresh fruits and vegetables to meet shortfalls caused by climate disasters and seasonal effects.

These opportunities will expand further as Asian economies develop. Much produce is sold locally rather than through supermarkets because of lack of refrigeration. Bulk products are unacceptable in Japan and the market demands a high standard of preparation and packaging. Internal transport is a problem for all of Asia and storage facilities are limited. Market share for Australian produce should be increased by direct marketing to regional centres; and breeding and packaging/treating for extended shelf life in high temperatures.

Asian markets are becoming more open: Korea will open its markets in 1995 and Japan has doubled its imports of vegetables during the past five years. Extensive work has been done to collect vegetable genetic resources in Taiwan and mainland China and this is a top priority in Chinese five-year plans. There was little evidence of a capacity for postharvest research and it was indicated that postharvest expertise would be sought through collaboration with Australia.

Floriculture. Australia will host the 1996 New Floricultural Crops Symposium in Perth. It was notable that South Africa is encouraging bush-pickers of wild flowers to farm improved varieties. This would help conserve biodiversity since bush-picking has led to spread of diseases. In the USA and Europe the market trend is towards potted rather than cutflowers. Floriculture has been in recession in Europe but is now improving. Geraldton wax is the largest single floricultural crop in Israel. In Japan, floriculture is much less important than fish and vegetables.

The evaluation of new genetic resources is regarded as an important element in the maintenance of vigour of the flower industries of Europe, South Africa and Asia. In contrast, the USA appears to be
highly conservative. The Europeans are evaluating two hundred new species and it is suggested that Australia should collaborate with them.

**Implications**
There is clearly a need for a reliable supply of fresh produce from a region with a more equitable climate during the Asian summer and this need will grow as regional economies develop. Additionally, there is a clear need to develop technologies and products that will hold their quality in stressful environments, high temperature and high humidity.

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**59. IMPROVED LONGEVITY OF SELECTED AUSTRALIAN NATIVE CUT FLOWERS**

**Objectives**
to use ultrasonic acoustic emission (UAE) detectors to investigate rapid desiccation in selected native cut flowers and to isolate physical and physiological causes;  
to study the effect of vase solution additives on cavitations and wilting;  
to design appropriate postharvest treatments to extend longevity.

**Background**
Many woody-stemmed Australian species, notably *Acacia*, *Eucalyptus* and *Grevillea* have commercial potential as cut flowers and foliage but possess very short vase lives (1 to 3 days).

**Research**
Cut stems were clamped to UAE detectors and the pattern of UAE emissions was recorded while stems were held dry and compared to vase life of species in water. In addition, the relationship between UAE events and hydraulic conductance was investigated by studying the effect of various vase solutions on *Backhousia citriodora* stems.

**Outcomes**
UAE detectors were found to be not suitable for rapid determination of vase life, as peaks in UAE events recorded in stems held dry did not correlate with vase life in water and peaks in stems held in water occurred close to the time of visible wilting. The detectors appeared to record the formation of emboli within xylem vessels, and the number of emboli formed increased with a decline in solution uptake in stems.

Wilting was at least partially determined by the speed of emboli formation at harvest and during dry storage, and the ability of the vase solutions to remove these emboli. Nonionic detergents, such as Teric N8 were more effective than distilled water of citric acid in removing emboli formed at harvest, and preventing formation of further emboli while stems were in vase solution.

**Implications**
More work is needed to further determine the role of emboli in wilting but this study indicates that the species that wilt quickly after harvest develop a large number of emboli (detected as UAE events) within two hours of harvest.

Increases in the number of visible emboli roughly correlated with peaks in UAE events but research is needed to establish a more quantitative correlation between UAE events and emboli. The study has also helped elucidate the mode of action of non-ionic detergent solutions.

These results have important implications for the design of postharvest holding solutions used for Australian native flowers. It is therefore recommended that further research be undertaken to
ascertain the optimal non-ionic detergent and its best concentration to extend the vase life of a wide range of Australian flowers.

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60. FIELD AND POSTHARVEST CONTROL OF INSECTS ON NATIVE AUSTRALIAN CUT FLOWERS

Objectives
To develop an integrated system, for eradicating insects from export native Australian cut flowers by:
- defining insect population dynamics on flowers in field plantations and developing effective methods to control these insects in the field; and
- developing a postharvest insect-disinfestation system able to kill insects remaining on flowers after field treatment yet preserve flower quality.

Background
Successful eradication of insects from flowers is a major limitation to fully exploiting high-value markets in Japan and the USA. Failure to meet quarantine requirements results in fumigation of flowers which is costly, damages flowers, delays orders and reduces consumer confidence.

With the increased cultivation of native cut flowers, the need for better field and postharvest controls is apparent. However, little is known of the insect populations infesting native flowers grown in plantations.

Research
Insect populations in flowers were surveyed to determine the nature and extent of insect infestations on native flower plantations. Field insecticide spray treatments and postharvest disinfestation procedures were designed and tested for use on Geraldton wax.

Outcomes
A large number of arthropods from nine orders were found on Geraldton wax flowers. Their numbers were effectively monitored using sticky traps. Later, flowering, white varieties were more at risk from insects. The insects found most often were native thrips, flower bugs (Notobrachyplerus spp), nectar feeding scarab beetles (Phyllotocus ustulatus) and various sucking bugs.

A spraying protocol was developed according to insect numbers over a season and the necessary level of postharvest treatment to kill insects in flowers. The insecticide formulations Mavrik® and Dominex® were found to be effective for field spray control.

A postharvest procedure was developed for dipping flowers, using the formulation Cislin 10®, was found to be highly successful for Geraldton wax as it removed and killed insects while not damaging flowers. Best results were obtained when postharvest procedures were used in conjunction with a timed field spray program.

Implications
A field and postharvest protocol has been presented to control insects, ensure flowers arrive at export destinations free of insects and reduce the number of rejections of Australian cut flowers. This protocol has been applied by cut flower industries across Australia.
Such a system has been used to produce an insect-free quality product not only for the high value export markets in Japan and USA but also for other never expanding markets in South East Asia. Similar protocols based on that for Geraldton wax as a model could be developed for other cut flower exports.

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### 61. DEVELOPMENT OF *HELICHRYSUM DIOSMIFOLIUM* AS A CUT FLOWER CROP

**Objectives**

To improve productivity, product quality and stability of rice flower production in Australia by identifying superior cut flower genotypes and determining the most appropriate cultural practices and postharvest handling measures.

**Background**

*Helichrysum diosmifolium* syn. *Ozyothamnus diosmifolius* (rice flower) is a spring flowering, perennial, woody shrub occurring naturally in the eastern mainland states of Australia and has colour forms ranging from white to dark pink. Rice flower has considerable potential for development as a cut flower crop as it is in demand for Australian and overseas markets in both fresh and dried form. Until recently, this flower was cut exclusively from natural stands. Better information on the selection and use of superior cut flower forms, the most appropriate cultural requirements and postharvest treatment is required.

**Research**

A wide range of rice flower genotypes was collected and assessed for their potential for cut flower production viz. ease of propagation, crop agronomy, disease tolerance, flowering season and postharvest performance. Close collaboration was maintained with growers and other factions of industry on the domestic and export markets.

**Outcome**

Superior lines of riceflower were identified that were productive, disease tolerant, provided extended production (up to 6–8 weeks) and had acceptable vase life. Plant Variety Rights(PVRR) is currently being sought on QDPI selection 44.7 now named Redlands Sandra PVR pending no. 94/184. Major diseases and pests of rice flower for example *Phytophthora* root rot and nematodes have been identified and disease tolerant rice flower lines determined.

Additional work is required to further extend production season by acquisition of additional genotypes and by improving understanding of the influence of location. Collection of germplasm may include other closely related species in Asteraceae which can still be marketed as rice flower. There is a need to improve control of nematodes by identifying resistant genotypes.

A production and marketing advisory brochure including recommended agronomic practices is also a high priority as an information base for this new cut flower industry.
Implications
An extended and stable production season provided from tested and recommended lines will enhance marketability of rice flower. Improved control of pests and disease from use of resistant and tolerant genotypes will occur.

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Objectives
To provide an opportunity for researchers and industry representatives to discuss the problem of disinfesting cut flowers and native plants in light of:
- the likely withdrawal of the 'standard' fumigant methyl bromide;
- the advent of a new fumigant carbonyl sulphide; and
- the arrival in Australia of the western flower thrip.

Background
The workshop was held at the Institute for Horticultural Development, Knoxfield, Victoria on 20 September 1993 to discuss the problems of the cut flower and associated trades. It was convened by CSIRO Division of Entomology and Victorian Department of Agriculture under the auspices of, and with finance from, RIRDC and HRDC.

The workshop was attended by seventeen participants, representing RIRDC, HRDC, the cut flower industry, AQIS, state Departments of Agriculture and CSIRO. It was chaired by Mr Shaun Keenan, a member of RIRDC and also a grower and exporter of cut flowers.

Research
Participants set out to define the most appropriate strategy for dealing with the overall problem of delivering high quality product in the cut flower/nursery trade to the end purchaser. Because of the multitude of different flowers, pests and end requirements, and objective was to agree on targets that covered the major problems.

Outcome
The research strategy agreed was to:
- pursue immediate pest problems, with all available processes;
- move to less toxic chemicals where possible;
- concentrate on developing alternatives to methyl bromide; and
- establish research programs to produce long term solutions.

A need was identified to establish protocols with end users, particularly for interstate trade. Also, to involve researchers in bilateral negotiations with end users, such as carried out by AQIS, with a view to establishing discretionary tolerances.

It was agreed that existing facilities are probably adequate to research alternative methods but there is a clear need to increased communication and collaboration. An important outcome of the meeting was the personal contact made between researchers and industry in the cut flower/nursery area, and agreement amongst several participants to submit joint research proposals and continue to exchange information.
Overall, the workshop emphasised the urgent need to develop disinfestation processes for cut flowers, both native and traditional, to improve their 'exportability', particularly into Asia. These processes should not involve methyl bromide because of the likely restriction of that fumigant in the near future.

**Objectives**

- to identify a number of species of the genus, the range of which extends from Tasmania to Queensland (East coast only);
- to develop technology for rapid multiplication of selected clones using the shoot tip and embryo cultures;
- to investigate the relative importance of environmental parameters and genetic factors on timing, abundance and quality of flowering.

**Background**

*Blandfordia* is a native genus of outstanding beauty, already being exploited commercially by means of licensed collections from natural bushland, to serve the domestic Christmas cut flower market. The disadvantages of this include: no quality control; no guarantee of supply from year to year; no development of improved appearance or postharvest characteristics; damage to native vegetation; and no basis for development of export potential.

*Blandfordia* has become a new cut flower crop and has been successfully grown and marketed by a small group of growers and has been exported in small quantities to Japan and Holland for the past two years.

**Research**

Population studies were undertaken to establish the number of natural phenotypic variants. Sixty-one populations across the genus were studied and analysed and taxa separated on morphological characteristics. Data collected in 1989–1992 has been statistically analysed and isozyme analyses used to separate species of *Blandfordia*. The enzymes selected for analysis included peroxidase, esterase, acid phosphatase, superoxidase dismutase and glutamate oxaloacetate.

**Outcomes**

Five-year flowering succession and the post-fire flowering patterns of *Blandfordia nobilis* Smith have been established. It appears that the *Blandfordia* flowering pattern is very much dependent on changes in soil chemistry and suppression of other vegetative growth but this needs to be confirmed by field observations.

Micropropagation technology for the rapid propagation of selected clones is now available. Identification of species by pollen has shown minor differences within the genus, and to some extent within the species *B. grandiflora*. The conclusion could be drawn that SM for identifying *Blandfordia* cultivars could be a satisfying methodology.

Most of the enzymes analysed have been shown to exhibit isozyme systems in other plant species, and, in *Blandfordia* species isozymes were detected and their relative mobilities recorded.

**Implications**

Establishing micropropagation technology allows to clone selected plants for the production. The cost of production of one plantlet is about $0.45 at present.

The micropropagated plants take the same time to reach maturity (flowering) at present as seedlings and this is about 18–24 months. This technology is based on the cloning principles and the end product is a true type-to-type clone carrying desirable characteristics such as colour, number of bells in the raceme, stem length or stem diameter. The quantities of clones propagated can be easily controlled by timing tissue culture production cycle.
Having a pool of germplasm preserved under cold storage is of an invaluable importance for the future of this new industry, but further investigation of this system must be undertaken in order to establish parameters for the future long-term storage of propagules.

**Intellectual property aspects:**
There are clones of selected plants from a range of investigated populations already established *in vitro*. There are also hybrids which have been hand pollinated and seeds raised *in vitro*. All these plantlets have been stored under long term storage regime and await further trials such as post storage physiological changes and field evaluation for performance before they can be registered with PVR Authorities and before large scale production of chosen cultivars can take place.

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**64. LONG TERM STORAGE TECHNIQUES FOR SEA TRANSPORT OF AUSTRALIAN CUT FLOWERS**

**Objectives**  
To develop techniques for dry cold-storage of selected cut flowers to enable sea transport to export markets.

**Background**  
The export of cut flowers from Australia is a rapidly expanding industry. All exported cut flowers are currently transported by air freight, which is limited by lack of air freight space and high costs.

Sea freight offers advantages in that refrigerated containers are readily available and the cost is approximately half that of air freight.

**Research**  
Twenty-one cut flower and foliage varieties were placed in simulated refrigerated sea freight conditions for up to 35 days.

Pre-storage treatments involving a 24 h treatment with high concentrations of sugar or low concentration of wetting agents and more effective fungal control were investigated to improve out-term quality. Sugar pulses were tested on *Leucadendron* 'Silvan Red', wetting agents on *Thryptomene calycina*, and fungicides on carnations (chosen as they were particularly susceptible to rots and petal damage by certain fungicides)

**Outcomes**  
Eight varieties maintained a commercially acceptable vase life (7 days or more) after simulated sea freight. They included *Eucalyptus* foliage, *Leucadendron* 'Silvan Red', *Protea* species, Waratah, *Thryptomene* and *Verticordia* species
Poor quality after storage was due to an inability to recover from desiccation during storage, accelerated leaf blackening (Proteas), and, most commonly, the development of fungal rots (several Australian native species, such as Geraldton wax).

Pulsing *Leucadendron* ‘Silvan Red’ stems with 20% sucrose for 24h at 1°C prevented leaf desiccation during dry storage and significantly improved vase life after storage. Species most likely to benefit from pre-storage sucrose pulses include: all *Leucadendron* species; kangaroo paws; and *Protea* species.

Cut flowering branches of *Thryptomene calycina* were typical of a range of woody Australian native flowering branches in that they wilted quickly after harvest. Flower longevity was increased by measures that removed or prevented the formation of blockages in the stems, such as recutting the stems under water or by inclusion of anti-bacterial compounds or the wetting agent Agral-60 in the vase solution. Further trials indicated that species likely to be aided by the application of wetting agents to vase solutions (in low concentrations, such as 0.01%) include *Thryptomene*, Geraldton wax, *Verticordia*, *Eucalyptus*, *Boronia*, *Leptospermum*, *Hakea*, *Grevillea*, *Scholtzia* and *Baeckea* species.

A short dip in Bravo 500 (liquid form) proved very effective in preventing fungal rots during dry storage. A simple inexpensive boxliner comprising newsprint surrounded by a single sheet of thin plastic improved post-storage fresh weight in all varieties and significantly extended vase life.

**Implications**
The results of these trials indicate that sea transport can be a viable way to export Australian cut flowers. It is now possible that high volume, low cost export of popular cut flower crops can be undertaken not only from Australia to Asian markets, but South America to the U.S.A. and Africa to Europe.

Trial shipments of flowers have already been undertaken from South America to Miami, U.S.A. and there has been interest shown in the results of this project from ANL Ltd in Australia for export of flowers to Asia, and several South American cut flower growers. It is possible that sea freight of cut flowers will be a commercial proposition within five years.

It is recommended that commercial trials are undertaken to further improve the sea transport techniques developed in this project. These trials could run between Australia and Japan, and will help to solve potential marketing and distribution problems, as well as problems with quarantine. It could be possible to combine these trials with some of the new, chemical-free, controlled atmosphere, disinfestation methods being developed in Australia, New Zealand and the U.S.A.

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**65. ADDING VALUE TO GERALDTON WAX AS A CUT FLOWER**

**Objectives**
to develop waxflowers as an out-of-season greenhouse crop;
to justify higher costs associated with greenhouse productions;
to shorten production time by using growth regulators.
Background
In the past twenty years waxflowers have become established as a major cut flower crop both here in Australia and overseas. During that time there has been a transition from bush picking to plantation culture with varying degrees of environmental control. In the last five years the crop has also been developed as an indoor flowering pot plant, produced exclusively in greenhouse culture. Field-grown waxflower has been accepted world-wide as a decorative floral filler. However, in the important markets of Japan and Europe it is also being used as a flower in its own right and in Japan flowering stems are being sold individually.

The concept of a 'standard' waxflower type provides tremendous opportunities. The market development that has already occurred can be built on to establish this new type of flower at a premium price in the market place. This increased value should in turn help make greenhouse production economical and allow out-of-season production.

Research
Specific experiments or trials addressed the following:
- optimum temperature for growth of stems and stem number;
- use of pruning and cytokinins to increase stem number and/or flower number;
- the effects of temperature, light and CO₂ on flower development;
- the use of gibberellic Acid (A₃) to increase stem length and shorten production time;
- the use of paclobutrazol to control growth and inflorescence shape in large plants; and
- agronomic issues, including pest and disease control, plant spacing, varietal differences and fertilisation protocols.

Outcome
This project has demonstrated that *Chamelaucium uncinatum* ('waxflowers') can be grown for cut flowers under greenhouse conditions and has provided a detailed production schedule comprising information and protocols relating to plant material, vegetative growth, flower induction and flower finishing.

Implications
Greenhouse production of waxflowers will complement, rather than replace, the field grown crop as it will not be price competitive during the peak season (July–October). Greenhouses allow production all year if necessary to maintain continuity of product in both domestic and overseas markets, but it is more likely that the crop will be selectively produced for sale immediately before and after the natural flowering time.

This coincides with a gap in supply for the winter flowering varieties between Australian and northern hemisphere producers. Strong demand at these times should give high prices, particularly for long stemmed flowers, with dense inflorescences and minimal tip growth.

Adoption of this technology will not be immediate for several reasons. Firstly it will take two or three years of experience with the crop before growers are likely to feel confident that they can produce it reliably. This is based on experience with this species as a pot flower. Further development of agronomic practices will be needed, such as optimising plant spacing, choosing varieties, and fine tuning fertilisation and pest control procedures. Large scale production will also require investment in photoperiod-control equipment. Research inputs are now adequate for the first commercial trials. Further work is needed to refine the use of paclobutrazol or to find alternative growth regulators. The desirable inflorescence shape is basically the same as for potted flower production. At least one major nursery has an advanced breeding program to develop this compact inflorescence shape, without chemical use.

Further work may also be necessary in the areas of phosphorous nutrition, and environmental effects on flower finishing. Further cost/benefit analysis is premature as the first full scale assessment of commercial trials will not be completed until late 1994.
NEW PLANT PRODUCTS

RIRDC supports a diverse program of research as part of its charter to encourage the development of new industries for Australia. It also supports research and development for existing small industries which, although small, may have captured a profitable market niche from where they contribute to the Australian economy. Small industries have research and development needs as do larger, more prominent industries.

The new plants and plant products program is loosely categorised into four groups comprising industrial crops; tropical fruits, vegetables and nuts; grains and pulses; and miscellaneous crops. Many of the existing industry programs were developed from this program and the Corporation considers the program to be an important one from which individual industry programs can be initiated.

The program is tailored to the current size of the industry and its potential for future contribution to Australia. There is also a focus on potential industries where Australia can develop a strategic advantage. Small Australian industries will also be encouraged to build on available overseas technologies wherever possible and appropriate.
Objectives

to provide reliable cultivars suitable for the development of a viable jojoba industry in Australia;
to refine and test a chill model for breaking flower bud dormancy in jojoba;
to compare genetic diversity in natural stands of jojoba with that now available in Australia with a view of extending the range of our material.

Background

An attempt was made to develop a jojoba industry, during the mid-1970s in response to the demise of the whaling industry. This attempt failed to become a commercial reality due largely to a lack of basic agronomic knowledge and suitable cultivars.

Research has shown great variation in jojoba with only a few plants being consistently good producers. Consistent production must be achieved from jojoba each year if the crop is to be successful. This can only be achieved where growth and reproductive physiology are matched to the target climatic zone.

The environments in which natural stands of jojoba occur vary greatly, suggesting wide genetic diversity of material. A study tour of both natural stands and commercial plantings in North America provided an opportunity to assess this variability and collect seed material for evaluation in Australia.

Research

Field research studied the effect of water supply and evaporative cooling on the accumulation of chill units. Clones of plants with 'known' but different chilling requirement were subjected to intermittent shower and drip watering treatments each autumn, and then regularly sampled through winter-spring to determine effect of watering treatment on 'chill' requirement. The sampled branches were forced in a growth cabinet to determine the date each plant reached chill fulfilment (set-to-open condition or [STO]). Temperature sensors were placed in selected plants to obtain leaf temperature profiles for all treatments.

Seed collected from natural stands has been grown in the field to compare it with existing selected material.

Outcomes

Leaf temperature often differed from air temperature. The difference depended on geographic orientation of the sensor, height above ground level and watering treatment. There was no difference between watering treatment on enhancing 'chill' requirement, despite trends of enhancement in some genotypes. 'Chill' accumulation of buds is deemed to have been fulfilled (STO) at the date when less than 4800 GDH (18 days in the growth cabinet at 24°C) are required to open 50% of flowers.

The model uses daily meteorological data with some minor adjustment according to daily weather conditions to compensate for radiant heat or the effects of evaporative cooling. The results suggest that other factors apart from leaf or bud temperature may also be important in determining STO. Young plants, which have their canopy close to the soil surface, behave quite differently to older larger plants and the model appears to have little application for early selection.

Implications

Despite the limitation of using the model for the early selection of more suitable cultivars it is still useful for predicting suitable climatic areas to grow jojoba in Australia. Australia is in a good position to capitalise on the potential of jojoba. There are vast areas of cheap land potentially able to sustain yields of between 500–1000 kg/ha/yr under dryland conditions. Jojoba can be developed using land that has few other land-use options (cereal growing and wool), where it can not only diversify production and stabilise income, but also play a major role in combating land degradation from rising water tables and salinisation.
67. POSTHARVEST BROWNING OF RAMBUTAN FRUIT

Objectives
to provide baseline information on the growth and storage characteristics of rambutans;
to investigate the anatomy, histology, physiology and biochemistry of skin browning;
to develop postharvest strategies to control skin browning.

Background
Rambutan is gaining in commercial importance in northern Australia and is second in cultivated area to mangoes. Total production in Australia is about 400 tonnes/annum, but there is considerable potential for expansion.

When mature, rambutans are a bright red or yellow and are characterised by their attractive spinterns (or hairs). The market life of these fruit is limited by the susceptibility of the skin to desiccate and turn brown.

Research
Research was conducted over two years with four cultivars (three red and one yellow) brown near Darwin NT to provide knowledge about fruit development, fruit structure, physiology and he biochemistry of the fruit. This research was intended to provide the basis for developing practical methods for controlling skin browning.

Outcomes
Optimum harvest maturity was reached about sixteen weeks after harvest when the fruit were fully coloured. The fruit are non-climacteric.

Anatomical studies showed that the spinterns have a high density of stomata that remain open. The large number of stomata and the large surface area created by the spinterns explain the susceptibility of these fruit to water loss. The development of browning is dependent, at least in part, upon the amount of water lost. However, the susceptibility to browning increases with maturity. Storage at low temperatures and high relative humidity delays the development of browning. A temperature of 10°C seems most suitable, chilling injury develops in fruit stored at 5°C.

Browning appears to result largely from non-enzyme changes associated with desiccation and a small amount mediated by enzymic activity in mechanically damaged tissue.

Implications
Application of the results of this project should enable the industry to extend the postharvest storage life of rambutans. Harvesting at optimum maturity, careful handling, storage at 10°C in boxes and liners give an effective storage life of up to two weeks. An improved punnet system will be required for storage beyond two weeks. There is scope for the development of effective fruit coatings that will control desiccation.

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68. DEVELOPING A NON-ASTRINGENT PERSIMMON EXPORT INDUSTRY

Objectives

to undertake a final two year stage of foundation research of the non-astringent persimmon industry, focused on issues arising from three years work already undertaken;
to integrate results from production, postharvest, processing and marketing research so as to form a basis for the strategic development of the whole industry.

Background

Three years research integrating production, postharvest, marketing, and processing results, has already been completed by the University of Queensland, Gatton and the Queensland Department of Primary Industry. This final two year stage addressed particular technological and marketing issues and seeks to identify a strategy for industry development.

Non-astringent persimmon production is steadily expanding in Australia in response to export market opportunities, mostly in Asia. In 1994, total exports of 220 t were valued at $1.3M. Addressing the key technical problems of the industry at the same time as developing a coherent marketing and organisational strategy, is seen as crucial to a successful future for the industry.

Research

Production research focuses on managing crop loads and achieving fruit quality. Postharvest research addresses chilling injury during cold storage and managing the high ambient temperatures of Asian markets. Processing work aimed to develop value added dried and minimally processed persimmon products. Marketing research focused on coordinated, single brand products for targeted markets in Singapore and Malaysia.

Outcomes

Production and postharvest research provided guidelines for growers which could be used in producing large fruit of high quality and adequate storability. Processing research developed high quality dried products, but minimally processed product needs more research. A group of growers, from five states, markets single brand (‘Sweet Gold’) fruit through one agent, to importers with exclusive rights to the product in Singapore and Malaysia.

Implications

Integrating R&D across the key areas of production, postharvest and marketing, and combining it at the same time with involvement of the industry in its own strategic development has proved very successful. There may be lessons here for other emerging industries.

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69. CONTROL OF PRODUCTION PATTERNS IN TROPICAL FRUITS

Objectives

to understand the growth patterns and cultivar variations in these patterns for rambutan, carambola, pummelo, durian and mangosteen;
to understand the effect of climate and cultural practices such as fertilising, irrigating, pruning, shading and growth retardant chemicals on the growth and production of these crops.
Background
Tropical tree fruit crops at present have a rather narrow production window. The present peaks need to be shifted so that the industries can be more competitive against more established temperate and subtropical crops. Winter- and spring-produced tropical tree fruits are in short supply and thus an excellent market niche is available.

Effective manipulation of cropping will generate opportunities for both domestic and export markets. However, before trying to investigate methods for manipulating production it is first necessary to identify what natural variation already exists and what factors are contributing to this variation.

Research
the differences in growth patterns between 21 cultivars of rambutan, 5 cultivars of carambola, 14 cultivars of pummelo, and 13 cultivars of durian were identified for North Queensland. The physical attributes of the fruit of most of these cultivars were also described; the growth patterns of three cultivars of rambutan and two cultivars of carambola and pummelo were studied in relation to climate, nutrient patterns and cultural management; the growth patterns of mangosteen trees were studied as well as the effect of shading and growth retardant chemicals on changing these patterns; the dry matter and starch distribution patterns between the different sized branches and roots were established for rambutan, carambola and pummelo by removing mature trees; the distribution of the root system through the soil profile was identified for rambutan, carambola and pummelo by removing mature trees.

Outcomes
For rambutan, carambola, pummelo and durian the cultivar differences between most of the main cultivars were identified. Some progress was made in understanding the effect of climate and cultural practices on the growth patterns of mangosteen and the other four tropical species studied.

Implications
In the short term, the results of this project will allow growers to identify cultivars that will extend their current production period. In addition, it will allow them to modify their current fertilising and irrigating methods to improve yields. In the long term, the results will allow other researchers working on these crops to understand the effect of pruning, growth retardant chemicals and irrigation scheduling on the growth patterns of these crops.

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70. THE POTENTIAL FOR MIXED TRANSPORT OF SELECTED TROPICAL FRUIT

Objective
To determine the potential of road/rail transport of selected minor tropical fruit in mixed loads with bananas, avocados and mangoes.

Background
Major fruit commodities such as bananas, avocados and mangoes are largely shipped in an unripe condition to maintain product uniformity when ripened at the destination, and to abide by fruit fly regulations for some states. The increasing production of new exotic fruit, and the cheaper freight rates relative to air transport has led many transporters to ship these fruit in refrigerated, mixed loads. Some exotics are capable of producing sufficient ethylene to induce ripening of other fruit within the same load. Information on the ethylene producing capacities, ethylene tolerance, and compatibilities of fruit is either difficult to source or does not exist in many cases.
Research
Ethylene production rates of the principal exotic fruits grown in north Queensland were estimated over a range of potential transport temperatures for different transit durations. Sensitivity to ethylene was also estimated for the major fruit commodities. The efficacy of ethylene scrubbing devices was tested for use in mixed loads, and simulations were conducted to test the compatibility between exotic and major fruit commodities.

Outcome
Moderate to high levels of ethylene were produced by pawpaw soon after first colouring, and by carambola and rambutan in relationship to disease development. The latter occurred after at least 7 days storage at temperatures above 15°C. Ethylene sensitivity of bananas, mangoes and avocados was moderate, extremely high and moderately low, respectively. Ethylene scrubbing devices were found to be inappropriate or ineffective for use in mixed load transport.

Commercial transit temperatures of fruit often exceeded recommended temperatures, principally due to insufficient precooling prior to loading. Compatibility between fruit was a function of fruit temperature, transit time, ethylene production, ethylene tolerance, fruit ratio and container free space. A user-friendly computer package has been developed for use by transporters in determining fruit compatibility.

Implications
Co-shipment of exotic fruit with major fruit commodities is possible under a range of conditions. Actual fruit temperature however, can differ from the air temperature of the container and should be taken into account when planning mixed fruit shipments.

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Objectives

to develop and extend, for the lychee industry, a practical,

71. LYCHEE POSTHARVEST HANDLING AND MARKETING

integrated postharvest handling and marketing system which can also serve as a model for other developing tropical fruit crops;
to develop a quality assurance (QA) system.

Background
Lychee is a new and developing industry in Australia. Of all the new tropical fruits, it has the greatest possibility of developing into a stable, profitable industry. However, lychee is not well known by consumers, existing markets are limited and postharvest handling and quality problems, including skin colour loss and fruit rots, inhibit their expansion.

Production will more than treble by the end of the decade as trees already planted come into production and reach maturity. This will threaten the economic viability of the industry unless the marketing and postharvest challenges presented by the expected increase are addressed.

Research
Postharvest handling systems and techniques to prevent skin colour loss and fruit rots including SO2/pH skin modification, fruit waxing, hydrocooling, plastic film packaging and the use of ‘in-store’ lychee dispensers were investigated.
Improved marketing through formation and fostering of cooperating regional grower marketing groups, development of target markets emphasising exports, improvement of grower marketing skills and development of a preliminary production forecast model was also studied.

**Outcomes**

An effective postharvest handling system which minimises skin colour loss and fruit rots has been developed and adopted. This is based on rigorous grading underpinned by the QA system, temperature management based on fast hydrocooling systems, packaging in low density polyplastic bags and the use of 'in-store' dispensers. A commercial SO₂/pH handling system was developed but its use will be limited as domestic and export markets lower the maximum residue levels for SO₂. The waxing trials require further work.

The marketing of lychees has been greatly enhanced. Grower groups in North, Central and South Queensland now have approximately 100 members (25% of the industry). They sell under a single brand 'Sun lychee', through a single marketing coordinator and using the same QA system. Prices have increased despite a 300% increase in production over the last three years. Exports have increased rapidly reaching 44% of the groups production this season. The preliminary work on a production forecast model has been completed but it is felt that at least two more seasons' production data is needed to achieve a reasonable level of confidence in the model.

Groups have been established in two other crops (rambutan and beans) based on this model and a number of others are proposed including banana.

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**Objectives**

to investigate the morphological changes associated with the transition from vegetative to reproductive growth;
to determine the relationship between bud growth, temperature and floral development in lychee;
to develop orchard based pruning treatments to manipulate bud growth and tree structure;
to investigate the relationship between canopy size and yield;
to determine whether the floral stimulus the triggers flowering in potted marcots can be transferred to grafted seedling plants to stimulate precocious flowering.

**Background**

Prices for lychee have increased significantly in the past three seasons and there has been a marked demand in south-east Asia for this crop where it is well known and loved. The continued liberalisation of these economies offers even greater market potential for Australian exporters in the future. However, production is unreliable, and cannot meet present demands due to trees failing to flower or set and retain a crop. Lychees grow by successive terminal flushes. It had been observed that flushed in late autumn tended not to flower. Therefore treatments were applied to make trees dormant but this has not improved yields. The alternate hypothesis that flushes had to mature and commence growing during cool winter temperatures had not been tested.

**Research**

The structural changes in bud morphology were investigated using the scanning electron microscope. The ability of growing versus dormant buds was studied using potted plants in controlled temperature glasshouses.

The effect of assimilate supply on fruit development on girdled branches was investigated by varying the number of leaves on these branches.

Graft transmission of the floral stimulus was monitored on grafted seedlings of three cultivators on a single root stock.
TROPICAL FRUITS, VEGETABLES AND NUTS

Outcomes
This research has found that growing lychee buds were the issues most able to be stimulated to flower by the lower temperatures of winter. This is contrary to the previously held belief that dormant buds were necessary for flowering in lychee. In the orchard, initial results suggest that regulation of flushing patterns to obtain growing buds at appropriate time may be achieved by mechanical pruning, or use of chemical sprays to selectively remove immature vegetable flushes.

The crop borne by a lychee is determined by the available assimilates and therefore an efficient canopy structure is required.

Transmission of the floral stimulus via grafting could not be demonstrated, but seedlings flowered independent of these treatments.

Implications
The implications from this work are that management techniques need to be developed to promote bud growth during times when inductive temperatures are most likely to occur. We are now testing approaches that appear promising including hedging trees into regular shapes to allow mechanical removal of flushes formed at the wrong time. This procedure may also improve light interception to be optimised to maximise potential assimilate supply for fruit production. An alternative approach to regulate flushing is offered by chemical means. Under test conditions, ethephon was able to selectively remove immature vegetative flushes and the ability of chemicals such as this to regulate flushing will be tested.

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73. A STUDY OF SWEET POTATO VIRUSES IN NORTHERN TERRITORY

Objectives
To assess the impact of potyviruses in sweet potato cultivars being grown in the Darwin region;

to develop an assay to detect potyviruses in sweet potato plants and their native relatives.

To study mechanisms of resistance to these viruses in locally grown cultivars.

Background
Sweet potato has only recently been developed as a commercial crop in northern Australia. At the start of each growing season, selected cultivars are propagated from vine cuttings and this could allow viruses to be transferred. Since the industry is a young one, it is important that the virus status of mother plants propagated from plants imported from other states be determined. To do this effectively, a convenient assay for potyviruses in sweet potato is needed.

It is also important to test cultivars for levels of resistance to potyviruses and to understand resistance mechanisms. Because of technical difficulties with serological detection of sweet potato feathery mottle virus (SPFMV), it was decided to carry out the resistance mechanism studies on a closely related virus, papaya ringspot virus type W (PRSV-W) in rockmelon.

Research
Enzyme-linked immunoassay (ELISA) methods were found to be unreliable for detecting SPFMV in sweet potato. Therefore a membrane immunobinding assay, in which cut leaves or stems are blotted directly onto a membrane, was developed. Various parts of plants were tested and it was found that
blotting from leaf petioles gave a higher rate of virus detection. It was also shown that chloroform treatment increased test sensitivity.

During the virus study a mycoplasma-like organism (MLO) that was causing disease in 25% of plants in field trials was discovered. Some research was diverted into studying this organism and attempting to detect resistant cultivars. A molecular detection method has been optimised so that levels of MLO-DNA as low as 1 picogram can be detected. Molecular tools have also been used to study genetic relatedness between MLOs. Also, weeds are being tested for the MLO as it appears likely that they may harbour the organism which is then transferred to sweet potato by leafhopper insects.

Outcome
It may be possible to make recommendations to growers for control of weeds and leafhoppers to minimise infection of sweet potato by MLOs. One result of this work has been the development of a rockmelon cultivar that is resistant to PRSV-W. Attempts are being made to obtain a resistant cultivar that is isogenic to Jumbo, the most popular cultivar grown in the Northern Territory.

Implications
A focus of research into MLOs in sweet potato has been established with MLO–plant interactions being studied in detail at the molecular level for the first time in Australia. The assay procedure established for SPFMV in sweet potato will serve as a model for detection of other viruses in sweet potato.

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Objectives

to bring together research, extension, marketing and industry specialists for future collaborative networks;
to raise awareness of options for crop diversification and new export opportunities.

Background

The workshop was arranged because of the need for comprehensive scanning of all aspects of new crop commercialisation, production; extension, crop research, economics, food processing, industry structure and marketing.

Research

The workshop was structured into five sessions over three days to provide a comprehensive scanning, and examined a range of crops. Significant points were identified in discussion groups and carried into a concluding session.

Outcome

Two task forces were established: intensive grain legumes, and broadacre (Dryland) summer legumes. Four special committees were also established:

MRL's;
Genebank;
Rhizobia;
Entomology/Pathology.

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75. FINAL DEVELOPMENT OF SESAME CULTIVARS FOR AUSTRALIA

Objectives
To identify and multiply pure sesame genotypes suitable for north Australia.
To identify herbicides for weed control in sesame and undertake the appropriate steps to register these products in the Northern Territory.

Background
Australia imports $8 million per year of sesame. Sesame is well adapted to the semi-arid tropics and an embryonic industry has been established in the Northern Territory. However, the current commercial cultivar contains numerous physiological and phenological off-types. The variation of these off-types makes the decision of when to harvest difficult, and exacerbates harvesting losses. However some of these off-types have desirable characteristics, for example higher yield potential and disease tolerance, which, if selected for, would provide superior genetic material for the sesame industry in northern Australia.

Research
Research areas were cultivar improvement through selection for desirable characteristics, and weed control trials using applications of a variety of herbicides.

Outcomes
During the last 3 years numerous sesame genotypes have been evaluated over a range of cropping areas in the Northern Territory. A new high yielding sesame genotype that is less susceptible to lodging and disease has been identified and its seed multiplication has commenced. Adoption of the new sesame cultivar will be completed by the 1994–95 season.

Two herbicides, metachlor and trifluralin, were evaluated for their ability to control weeds in sesame. Both herbicides will achieve limited-use registration for application on sesame in the Northern Territory during the 1993–94 season. Preparation of a submission to the Australian Agricultural and Veterinary Chemicals Council is underway and growers will soon be able to legally use effective herbicides for weed control.

Implications
The new cultivar does not have capsule characteristics that minimise seed loss as the crop matures and capsules dehisce. Sesame breeding lines are available with capsule characteristics that will significantly reduce preharvest seed losses (up to 60% total yield). A new project proposing to cross sesame lines with superior capsule characteristics with the newly identified cultivar to reduce postharvest losses has been submitted to RIRDC.

Funding from RIRDC will allow work on sesame weed control to be extended to the search for more suitable herbicides to be used in integrated weed management and no-till studies.

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76. EVALUATION OF THE AGRONOMIC AND MARKET OPPORTUNITIES FOR T’EF
**Objectives**
to evaluate the market potential for t'ef in Australia, with particular emphasis on ethnic groups and the health foods and specialist restaurant market. To determine export opportunities for t'ef; to collect a range of t'ef lines from international sources. To bring these lines through quarantine; to conduct an experiment with lines currently on hand to determine the optimum planting times for t'ef in northern Victoria.

**Background**
T'ef is native to the highlands of Ethiopia and is the staple cereal in the diet of most Ethiopians, eaten as fermented flat bread 'injera'. T'ef is generally superior to other cereals in its value as human food. It has a protein content similar to bread wheat and is the only cereal which has an amino acid composition similar to human dietary requirements.

There are between 1697 and 3409 Ethiopians living in Australia, and around 4,000,000 living permanently outside Ethiopia around the world. The only area in which t'ef is available outside the Central Eastern African region is in the Middle East and North America.

**Research**
A market survey to assess demand for t'ef, importation of lines of t'ef and a field experiment in northern Victoria to determine best planting times were conducted.

**Outcomes**
The market survey has demonstrated an inherent domestic demand of between 30 and 56 tonnes for t'ef annually. This currently is restricted to the ethnic African population. For t'ef to be accepted into the wider community, promotion and education on its use will be required.

Detailed analysis of the export market potential for t'ef was beyond the scope of this project. However, it would appear that considerable export potential does exist in Europe. Our estimate is that this could be in the order of 9140 tonnes annually.

Three lines of t'ef have been successfully imported from England. The aim was to bring twelve lines through quarantine. Despite letters being sent to the t'ef plant breeding centre in Ethiopia, no replies were received and as a consequence the objective was not fully achieved.

A field experiment conducted in northern Victoria indicated that the optimum planting time for t'ef in this environment is in the late spring/early summer period.

A detailed cost of production and gross margin analysis indicated that t'ef could be a profitable summer crop. However, because of its limited size, the market could be quickly flooded if several producers grew the crop.

**Implications**
multiply pure seed lines; supply t'ef flour to the ethnic community and restaurants from which information will disseminate into the general community; conduct sensory research with 'injera' to evaluate the acceptance of the flavour and texture of this bread in the wider community; supply t'ef to specialist bakers to enable some experimentation with its use in speciality breads; conduct detailed research on the export potential for t'ef to Europe.


## 77. COMMERCIAL EVALUATION OF LIMA BEANS AND SUGAR SNAP PEAS

### Objectives
To assess the commercial opportunities for Lima beans and sugar snap peas in Queensland using the best overseas genetic and production/harvesting practices.

### Background
Australia's requirements for Lima beans (3000 t) are imported from the US in dried seed form. The development of a green-frozen Lima bean industry would eliminate imports and open up markets for the green-processed produce.

Sugar snap peas are processed in the US but have not been processed in Australia. Lack of the climatic adaptability of US varieties restricts production in warmer areas. Frozen sugar snap peas could be marketed as an additional vegetable or could be included in vegetable mixes.

### Research
Lima beans and sugar snap pea trials have been conducted at the Gatton Research Station in south-east Queensland over several seasons.

Six varieties of Lima beans were made in trials throughout the summer period to assess the suitability of these varieties for commercial production/harvest systems.

Five sowings of six varieties of sugar snap peas were sown in trials at Gatton Research Station to determine climatic adaptability and pod quality (stringiness) of imported varieties.

### Outcome
Australia could establish a Lima bean industry in South Queensland, comparable to the large industry in California. Results indicate Lima beans have a harvest window of approximately fifty-five days in South Queensland with an A grade yield potential of 4000 to 6000 kg/ha (comparable with California).

Commercialisation of sugar snap peas is unlikely with present varieties, because these varieties lack climatic adaptability. Whilst yields are acceptable (up to 48000 kg/ha), quality is affected by pods developing strings under cool conditions (night temperatures below 10°C) and becoming small under hot conditions (maximum day temperatures greater than 30°C).

### Implications
Market development would be required to sell high quality, frozen Lima beans in Australia as this product has not been marketed previously in Australia. Suitable harvesting equipment using pod-strippers is available.

The lack of climatic adaptability of present varieties indicates that it is unlikely that commercialisation of sugar snap peas will occur in Southern Queensland.

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## 78. IMPROVEMENT OF CULINARY BEANS FOR DOMESTIC AND EXPORT MARKETS
Objectives

to identify the most promising export and domestic markets;
to evaluate suitable varieties to meet production and market goals;
to test market assessment of selected culinary beans in chosen markets;
to analyse economics of production of respective market classes in various potential production regions.

Background

Currently all culinary beans are imported both for processing (Red Kidney, 4 bean mix in cans) and as packaged raw beans. The technology for production in Australia is identical to that for the established navy bean industry and production of culinary beans in Australia is feasible. Opportunities in export markets may be much greater than for the domestic market.

Research

Domestic and export market research was conducted, economic analyses were made for both gross margins and competing crops in potential production regions, selections were made from a large germplasm collection and assessed for both production and for domestic processing.

Outcomes

Japan was identified as best potential export market, with premiums for high quality raw produce. There is also scope to export partially or fully processed beans as required by the Japanese market. The most promising opportunity is to grow the large red Japanese dessert bean ‘Taisho Kintoki’ for an annual Japanese market of 19 500 tonnes valued at $192m. For the domestic market the largest and fastest growing segment is for medium size red beans. There is also export market potential for medium white beans.

Selections from over 2 000 germplasm as well as a range of imported accessions including ‘Taisho Kintoki’ and other Japanese varieties are currently being evaluated in national yield trials. Harvested samples will be forwarded to Japan for processing trials. Selected germplasm and newly bred lines with resistances to local diseases were screened for both agronomic performance and processing as culinary beans, and the most promising are in Queensland trials at 4 locations. It is planned from these to identify suitable varieties for commercialisation.

Continued plant breeding is necessary, to raise yield levels of culinary beans to be competitive with navy beans, locally adapted, resistant to current diseases, and suitable for domestic processing. The breeding of a locally adapted variety with ‘Taisho Kintoki’ type seed quality has also begun.

Implications

Production of culinary beans to achieve import substitution on the domestic market will require both a more suitable variety than the current Rimfire which is too viny for ease of harvest, and a more attractive price.

Important local competing crops are navy and adzuki beans. White culinary beans are uncompetitive with currently available varieties and current prices on the domestic market, and only marginally competitive for the export market.

The most promising opportunity is the Japanese market for very large red dessert beans with the variety ‘Taisho Kintoke’. If this variety is suitable both agronomically and for quality characteristics, then follow up evaluation of marketing options will be required.
Objectives
To evaluate the chemical and nutritional potential of grain amaranth varieties with the view of their production locally for inclusion into Australian food products by:

determining the composition and identifying biologically active components;
confirming reports that amaranth has cholesterol-lowering properties; and
identifying industries that could utilise amaranth and/or its functional fractions.

Background
Although generally regarded as a new crop, Amaranth has been cultivated in Mexico and South America for over 2000 years. The grain species with the highest commercial potential are *Amaranthus cruentus*, *A. caudata* and *A. hypochrondiacus*; the latter being the highest yielding and most robust. Amaranth is one of the few non-grasses with potential for becoming a cereal-like grain crop. Amaranth crops are hardy, provide good yields in dry and drought conditions, and therefore may be suitable as an alternative for sectors of the Australian rural industry.

Research
A number of animal feeding trials have been undertaken. Although the soluble dietary fibre content of grain amaranth is low, caecal fermentation was active and intermediate between wheat and barley. Total blood cholesterol in rats fed grain amaranth was also intermediate between the levels in rats fed barley and wheat. Squalene, a compound that inhibits cholesterol synthesis, is not commonly found in plant material. However, amaranth oil contains 5–8% squalene.

Features of grain amaranth:
- Amaranth oil (6–8% of the grain) is rich in squalene;
- contains tocotrienols, an unsaturated form of vitamin E;
- has very small starch granules (1–3 μm);
- Amaranth is gluten-free and has a pleasant nutty flavour when roasted;
- Amaranth grains (1–2 mm) will pop like popcorn;
- Amylopectin is the predominant (80–100%) starch present;
- protein content is high (13–19%) and, unlike many cereals, is rich in lysine;
- grains can be used directly in extruders;
- the starch has a low gelatinisation temperature and good freeze-thaw characteristics.

Implications
The cultivation and use of amaranth will increase as more information becomes available to exploit market niches for this high quality protein food with interesting functional properties. Popped amaranth, because of its unique characteristics, will attract considerable attention as it will provide the opportunity for processors to develop innovative products. Combined with amaranth’s ability to grow in areas of low rainfall and high temperatures, there is a place for amaranth in the Australian food industry.

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Objectives
To achieve a level of stability in the production of oats by providing information and assistance to breeders to produce rust-resistant cultivars by:
understanding the oat rust flora on

cultivated and wild oats;
introducing rust resistant lines from overseas; and
testing breeders' populations with known pathotypes of the stem and leaf rust fungi.

Background
The oat crop in Australia is one tenth the size of the wheat crop in area sown. The production of oats is severely hampered by the occurrence of stem and leaf rust fungi. The 1988 oat-leaf-rust epidemic in Queensland is estimated to have cost $70 million in lost productivity in the beef cattle and hay export
industries. This project has been variously funded for a number of years by RCDF, ASRRF AND RIRDC with the limited aim of following the evolution of the rust fungi and screening imported and local breeders' lines for resistance to the prevalent and virulent rust races present from time to time.

Research
The program is designed to:
understand rust fungi by surveying, accessioning and identifying rust samples using sets of differential cultivars some having known genes for resistance;
use known strains of leaf rust and/or stem rust (with known virulences) to screen introduced and breeders' lines for resistance.

Outcome
The 1992/93 survey year started on 1 April and by the end of the 1991/92 funding year, 75 accessions were received and processed. A total of ninety-four identifications from 410 accessions have been made to 6/12/92. The value of the program can best be measured by the degree to which breeders act upon the information supplied. It is clear they are now more aware of the importance of including resistance in their breeding program.

Implications
Further investigation is needed to understand the genetics of resistance in oats. It is not known, for example, how many, or which, genes are responsible for rust resistance in imported lines used in breeding. A major problem is the wild oat population which is an alternate host to the rusts and intercrosses with the cultivated hosts.

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PUBLICATIONS

81. A COMPARATIVE STUDY OF AUSTRALIAN AND UNITED STATES ISOLATES OF WHEAT FLAG SMUT

Objectives
To determine whether Australian isolates of the flag smut fungus differed substantially from United States isolates.

Background
The United States does not allow any admixed wheat seeds in oat shipments from Australia on the grounds that they may harbour strains of the wheat flag smut fungus (Urocystis agropyri) that might differ in virulence from United States strains of the same fungus. Since the disease is routinely controlled by the use of resistant cultivars, any introduction of strains of the fungus whose virulence differed from that of local strains might result in a breakdown in control of the disease.

Research
assessment of morphological characters;
pathogenicity trials.
comparative analyses of isozyme patterns;
comparative sequencing of rDNA genes.

Outcome
Minor differences between Australian and the United States strains of flag smut in the mean width of the fertile cell were recorded. However, differences of this magnitude could easily be caused by variation
in the condition of the spores and this difference is not considered valid grounds for concluding that the strains are distinct. When tested on cultivars it was found that the pathogenicity of samples cultivars to the Australian and the United States flag smut samples were similar. Isozyme studies were also unable to demonstrate consistent differences between the Australian and the United States isolates.

Particularly strong evidence for the similarity of Australian and United States populations of flag smut was seen in the molecular data in which a only a single DNA polymorphism was detected within the 693 base pairs sequenced for the rDNA ITS region, the same polymorphism occurring in one United States and one Australian isolate.

This suggests that while the populations of U. agropyri are not completely uniform within the two continents, the same variability is present in both populations and the populations therefore probably originated from the same source. The detection of a double stranded RNA molecule, thought to be a virus, in the DNA preparations from all isolates tested from both populations provides further, although more circumstantial, evidence of a common origin.

Implications

The comparisons of morphology, pathogenicity, biochemistry and molecular genetics support the widely held belief that flag smut in North America originated in Australia. They provide strong evidence that the Australian and the United States isolates of flag smut are similar, and suggest that Australian isolates of U. agropyri do not represent a threat to United States wheat crops.

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82. INTRODUCTION OF SELECTIONS FROM THE ICARDA NARBON BEAN COLLECTION

Objectives

To enable quarantine screening of twenty-two of the most promising lines of narbon bean forwarded by ICARDA, Syria.

Background

Narbon bean (Vicia narbonensis) is a winter growing legume with erect stems that make it an easy crop to harvest. In its natural habitat (Mediterranean countries) the narbon bean tolerates frost, is palatable to sheep when dry, and shows potential in areas receiving 250–300 mm annual rainfall.

Narbon bean lines have had their growth evaluated in Australia and it has shown good potential in low rainfall areas. A small program to improve the bean is carried out at the Walpeup Research Station, Victoria.

Research

Twenty-two promising lines of narbon bean were imported into WA from ICARDA, Syria by Dr Clive Francis. Under the quarantine controls, these lines required screening for any vital infection before it would be possible to increase the seed for field evaluation.

Soon after the project was financed, the senior investigator was replaced and the project transferred to the Centre for Legumes in Mediterranean Agriculture (CLIMA) where a re-evaluation of priorities
changed the emphasis placed on the species being evaluated. Only one line of narbon bean was put through quarantine and tested in the field. The remaining lines have been sent to Mr Alan McIntyre, Curator, Australian Temperate Field Crop Collection, Victorian Crops Research Institute, Horsham for storage and eventual virus screening.

Lines of vetch (*Vicia sativa*) were also put through quarantine and tested in the field.

**Outcome**

During 1992 one line of narbon bean (selection 2932) was released from quarantine and evaluated at a site in the Was wheatbelt (Muresk). The establishment was poor but the crop developed within a reasonable period (111 days to flower) for the WA wheatbelt environment. Crop height, leaf retention and pod shatter scores indicate that the line is worth evaluating further.

**Implications**

The diversity of the material held at the Temperate Field Crop Collection is likely to be of considerable interest to someone, perhaps at Walpeup Research Station, Victoria. The material is being held in store for future utilisation.

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Preliminary evaluation of *Lathyrus* and *Vicia* species in Western Australia, Davies C. L.; Siddique K.H.M. and Perry M.W. Division of Plant Industries Technical Report No. 58, March 1993

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### 83. ATTENDANCE AT THE FOURTH INTERNATIONAL OAT CONFERENCE

**Objectives**

To sponsor the attendance of a Western Australian Department of Agriculture researcher to the Fourth International Oat Conference, held in Adelaide, South Australia, 19–23 October 1992.

**Background**

The International Oat Conference is the major conference for all oat researchers.

**Outcome**

The conference was divided into general sessions, symposia, and a field trip. Delegates represented the full diversity of the oat industry. Topics covered the full range of industry problems from production, manufacture, and use to the research associated with each of these subjects.

Monday’s program included a symposium on ‘The Changing Role of Oats in Human and Animal Nutrition’. Several of the world’s leading human nutrition research workers discussed the latest theories on the effect of oats on lowering cholesterol levels. The next group of papers discussed oat grain quality and milling. There were then six papers on hull-less oats. Dr D Cuddeford gave a very informative paper on the use of hull-less oats as an alternative energy source for performance horses.

Tuesday’s program was a general session and included papers on economics and marketing, crop protection, breeding methodology and molecular biology. Several of the papers on crop protection presented novel ways to establish and maintain disease epidemics in the field to enable screening of breeding material.

On the Wednesday there was a field trip to inspect oat breeding and agronomy research and farming systems in the lower north district of South Australia. Thursday was another special symposium on ‘Wild Oats in World Agriculture’. Papers addressed two distinct views of wild oats. Firstly wild oats were considered as a serious weed of crops, with all the associated problems due to herbicide tolerance in
many wild oat populations. The other view was of wild oats as an important genetic resource for oat breeding, for example as a source of genes for rust resistance.

The final day of the conference was another general session covering a range of topics including genetics, cytogenetics, inheritance, physiology, crop development, adaptation to stress, and oats for forage and feed.

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84. OSMOTIC ADJUSTMENT — IMPROVING DROUGHT RESISTANCE

Objectives

to develop a rapid screening technique for osmotic adjustment in grain sorghum;
to determine the inheritance of osmotic adjustment in grain sorghum;
to quantify the contribution of osmotic adjustment to yield under water stress conditions.

Background

Sorghum is an important dryland crop in the north-eastern grain production region of Australia. Water supply is the main limitation to grain yield and crops generally experience water stress during growth. Previous research identified osmotic adjustment as a trait with potential to improve drought resistance and hence grain yield under water stress conditions.

Osmotic adjustment to water stress is a process whereby plant cells accumulate solutes, which assists in maintenance of turgor and volume as water stress increases. The maintenance of turgor assists growth during periods of water stress by allowing leaf and root growth to continue. The maintenance of cell volume assists survival during severe water stress conditions in grain sorghum.

Research

A series of controlled environment experiments were conducted to examine the conditions under which genetic variation for osmotic adjustment was expressed and to investigate the inheritance of the genetic variation.

Outcome

Two genes were identified which controlled expression of high osmotic adjustment in a selected set of grain sorghum lines. Current experiments are investigating the contribution of these genes to grain yield under water stress conditions. Screening genetic variation for osmotic adjustment in the field and in a controlled environment facility is time consuming and costly. Molecular markers for the osmotic adjustment genes are currently being sought to facilitate introgression of this trait into elite sorghum lines.

Implications

Identification of the two genes enables assessment of their contribution to drought resistance of grain sorghum. The results of current experiments will determine the value of these genes to grain sorghum breeders.

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85. WASP EGG PARASITOIDS FOR HELIOTHIS MANAGEMENT IN SORGHUM

Objectives

to monitor natural levels of Heliothis egg parasitism in field plantings of sorghum;
to evaluate inundative releases of egg parasitoids for Heliothis management in sorghum.

Background

Sorghum midge (Contarinia sorghicola (Coquillett) and Heliothis (Helicoverpa armigera (Hübner)) are the major insect pests of sorghum in Australia. The development of midge-resistant sorghum hybrids has elevated Heliothis to primary insect pest status. Heliothis has developed resistance to the chemicals commonly used to kill it and other forms of pest management need to be developed. Biological control using native wasp egg parasitoids is one possible tactic.

Egg parasitoids are very small wasps that attack the egg stage of moths, killing them before they hatch and cause damage. These wasps occur naturally throughout Australia, but are usually in insufficient numbers to adequately manage insect pests in agroecosystems. They may also be mass reared and released into crops to locate and attack pest eggs in the field (inundation).

Research

Heliothis eggs were collected from field plantings of sorghum to monitor natural levels of parasitism. Inundative releases of egg parasitoids against Heliothis in field sorghum were evaluated.

Outcome

Natural levels of Heliothis egg parasitism were highest in late plantings, sometimes exceeding 70%, suggesting that wasp populations built up throughout the season. Unsprayed sorghum therefore has the potential to be an enormous reservoir of egg parasitoids, with populations building up in the early plantings and moving into later plantings as they become attractive to ovipositing Heliothis moths.

Inundative releases of five wasps/plant increased the levels of egg parasitism in field trials, however the increases were insufficient to manage the high Heliothis infestations encountered. The wasps were released in unfavourable weather conditions and probably did not perform to their potential. There was also some evidence to suggest that Heliothis oviposition was greater on midge-resistant hybrids.

Implications

Inundative releases of egg parasitoids may have a role in increasing wasp numbers in early planted crops, or in crops where natural wasp numbers are too low to have a significant impact on Heliothis mortality. This needs further investigation.

Natural populations of wasps need to be encouraged by planting late crops (if possible), and avoiding insecticide applications until at least 80% of the crop has flowered. Alternatively, selective insecticides should be used against Heliothis larvae. This encourages the growth of all populations of beneficial insects and spiders, and allows the natural mortality factors (including egg parasitoids) to suppress Heliothis numbers.

An IPM strategy for Heliothis in sorghum, with minimal reliance on chemical toxins, needs to be developed and tested so that it is available should current chemical insecticides become unavailable or unsuitable. Native wasp egg parasitoids (natural and/or released) have the potential to contribute to Heliothis management in such an IPM strategy.
86. CADMIUM AND LEAD IN GRAIN SORGHUM

Objectives

to obtain the cadmium (cd) and lead (pb) status of Australian sorghum grain;
to identify possible sources of contamination should excessive levels be found.

Background
Cadmium (Cd) and lead (Pb) are heavy metals which may accumulate in plant and animal tissues to levels that may violate Australian and International food standards. Cadmium is readily absorbed from the soil by plants, while Pb more commonly occurs on the outside of grain and other plant parts, predominantly in dust.

Many governments are becoming sensitive to the levels of Cd and other heavy metals in imported produce, with maximum permitted concentrations (MCPs) being specified for many heavy metals in foods. It follows that countries importing or exporting primary food commodities should be aware of the expected concentrations of any heavy metal contaminants.

Research
A survey was carried out of Cd and Pb in sorghum grain grown in Queensland and New South Wales during 1994.

Outcome
This survey has demonstrated that the Australian grain sorghum crop, when examined in 1994, was relatively low in levels of Cd and Pb contamination. No grain samples tested contained concentrations which exceeded 1/2 of the Australian MPC for Cd (0.05 mg/kg) or 1/10 of the MPC for Pb (1.5 mg/kg). The means (0.005 mg/kg and 0.016 mg/kg) and ranges (<0.003–0.025 mg/kg and <0.008–0.09 mg/kg) of Cd and Pb in sorghum grain respectively, compared favourably with those obtained in surveys of sorghum grain overseas, and of Queensland and Australian wheat, barley and oats carried out by other researchers.

The highest Cd concentrations were found in sorghum grain from central Queensland. This accords with findings of a recent survey of Cd levels in wheat. A separate study is warranted to elucidate why cereal grains from central Queensland are accumulating above average concentrations of Cd.

Implications
As a result of this survey, the Australian sorghum grain industry may confidently assure its clients of the ‘clean’ nature of its product, in terms of its Cd and Pb status. This information should assist the industry in the promotion of its product.
MISCELLANEOUS CROPS

Objectives
to hold an industry seminar on bush food at Bangalow, New South Wales, on February 26, 1994;
to review the existing industry on the north coast of New South Wales;
to consider the issues being faced, and to plan for future growth and development.

Background
The North Coast Regional Office of Greening Australia the convening of a seminar to develop a coordinated approach for a wide range of issues on the industry's future direction. The initiative was taken in response to strong interest from the community seeking both technical and market information on aspects of commercial bush food production.

Research
The seminar began with ten keynote addresses from invited speakers covering major aspects of the industry. The formal talks were followed by a plenary session aimed at identifying industry needs and providing a guide to future development.

Outcome
Of two-hundred people who applied to attend the seminar, the majority wanted practical information on farming methods, species selection, site requirements as well as information on marketing and export indicators. Delegates represented the bush food industry, allied industries, aboriginal interests, other community groups and prospective growers.

The seminar identified information exchange and access as a major priority and expressed general support for the establishment of a Regional Association and National Network. A Steering Committee was elected to develop and implement an action plan arising from the seminar.

Implications
Communication in the bushfood industry should improve through the activities of the Steering Committee and result in more coordinated approach to growth and development.

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PUBLICATIONS
Papers from the Seminar have been published and are available together with a list of industry contacts.

88. EDIBLE FLOWERS — MARKET SITUATION AND PROSPECTS

Objectives
to assess the current uses of edible flowers by the restaurant industry, types of flowers used, the supply chain and identify any factors which are affecting their ability to obtain supplies;
to determine current production of edible flowers.

Background
Flowers have been used for many years in fashionable restaurants as plate garnish. In the late 1980s the market for edible flowers began to expand, possibly as a result of the requirement for all garnishes on plates to be edible.
In the United States the market for ‘pesticide free edible flowers’ for the restaurant and catering trade has been expanding rapidly.

In Australia a similar trend has been observed with many restaurants using flowers. Promotion of edible flowers has also increased in recent times.

**Research**

A survey of restaurants in Victoria was conducted to ascertain their current and potential use of edible flowers.

**Outcome**

Of the 142 restaurants that responded, 79.5% currently use edible flowers and only 5% have never considered using flowers. The majority used flowers in salads or as decoration or garnishing. Most producers of edible flowers and salad mixes that included flowers agreed that the industry had expanded significantly over the past five years, but some were reluctant to expand production of their product, except those involved in the salad mix area. There is a shortage of information on the edibility of many flowers and inadequate promotion. Many producers indicated fear of new competition.

Additional work is needed to increase knowledge as to which plants are edible.

There is a need for producers to expand their publicity and promotions effort. Producers could readily expand their market if they promoted flowers currently being grown. If they are not interested in doing this, then there may be an opening for new producers to enter the market.

**Implications**

There is a limited scope for expansion of edible flower production but adding flower petals to salad mixes appears to be an expanding market with export potential.

Currently this product is marketed in boxes or cartons and is readily available. However, there appears to be a niche market for prepacked punnets for home use.

The product observed in supermarkets and greengrocer shops usually lacked appeal as it had been picked over. Prepacked product would maintain its freshness longer.

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**89. PRODUCTION OF HIGH QUALITY SEED FROM ATRIPLEX SPP.**

**Objectives**

- to identify the factors that influence pollination fertilisation, seed set and germination of *Atriplex amnicola*;
- to develop techniques and practices to overcome the problems which contribute to poor seed quality in *A. amnicola*;
- to extend practical guidelines for the establishment of high quality seed production plots for *Atriplex* spp.

**Background**

Saltbush stands (*Atriplex* spp.) can be used to revegetate saltland and provide feed for grazing stock during autumn, a time of fodder deficiency. The most economically viable way to establish saltbush pastures is by direct seeding. Seed is generally collected from unmanaged plantations or would populations. The average fruit fill is around 20%, with levels as low as 5% not uncommon. This lack of quality is an important contributor to establishment failure, which results in increased costs, delays in land rehabilitation and a decrease in farmer enthusiasm for the use of these species.
MISCELLANEOUS CROPS

Research
The research examined the impact on seed fill and germination of: (a) soil salinity, plant spacing and waterlogging (b) fertiliser application (c) the ratio of male to female plants in a population (d) possible incompatibility between male and female plants and (e) the effects of shoot pruning.

Outcome
The results showed that the most important factor affecting fruit fill was waterlogging, which caused water deficits in the plants and consequent seed abortion. Plant genotype was also important. Fruit fill was also affected by the clonal parent(s). One clone growing on optimal sites has ~80% fruit fill. Plant sex ratio affected fruit fill. A ratio of at least 1:1 males to females was required to provide adequate pollen for fertilisation.

Implications
It will be possible to establish high quality seed production plots by careful selection of both clonal material and sites that produce high fruit fill. The environmental characteristics of such sites have been determined but further work is continuing on the selection of appropriate male and female genotypes for seed production.

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90. SUCCESS FACTORS IN THE DEVELOPMENT OF NEW AUSTRALIAN AGRICULTURAL INDUSTRIES

Objectives
- to record and identify factors that have contributed to the successful development of new agricultural industries;
- to record the relevant history of the development of new agricultural industries in Australia with particular attention being given to the role that R&D played in their development;
- to analyse historical information on the role of R&D to identify 'success' factors for the scope, type, organisation, and timing of R&D efforts, and the interaction of R&D efforts with other factors;
- to produce guidelines to assist the RIRDC to identify those agricultural industry initiatives offering the best prospects for economically viable and sustainable operations.

Background
RIRDC faces the difficult task of selecting new industries for R&D support and allocating funds between alternative R&D activities within selected industries. The current study examines factors affecting the successful commercialisation of new agricultural industries, and the reasons for the lack of success of a number of efforts.

Several criteria could be used to assess the success of an industry, depending on the objectives and priorities of the assessor. In this study, an industry's degree of success was measured at a given time by its estimated 1991/92 gross value of production and its simple average rate of growth in value since its first year of commercial production.

Research
The study recorded case histories of the development of thirty-five crop industries that became commercial in Australia since 1950 or were only small industries in 1950. In these case studies, presented in Volume 2 of the report, important factors that contributed to, or constrained, the industries' growth and development were identified. Factors were grouped into broad categories of production, processing, marketing, government involvement, R&D and others.

Volume 1 of the report presents analyses based on the success measures, industry characteristics, the most important factors influencing industry growth and development as identified in the case studies,
and the type and timing of R&D as recorded in the case studies. The bulk of the results of the study were derived from analyses of the frequency of occurrence of the most important factors as identified in the case studies, and the analyses of the relationships between these factors and the two success measures.

**Outcomes**

In contrast to previous work, the study showed that a large number of factors can contribute to or constrain the development of new industries. Furthermore, the most critical factors differed from industry to industry, but generally production and marketing issues were the most critical to industry growth and development. Among the production factors, R&D carried out in Australia was by far the most frequent positive factor, followed by the use of technology developed overseas. The marketing factors emphasised the need to identify, pursue and develop market opportunities, improve product quality and be aware of competition on the demand side.

The study suggests that in selecting industries for R&D support, the industry's prospects and the constraints to its development should be examined, particularly for current and latent market demand, opportunities for market development and product quality improvement, the expected profitability given existing technology, and the opportunities for productivity enhancements through improved technology. Greater emphasis should be given to identifying the most limiting constraints to growth at the time of setting R&D priorities, and to assessing the relative ease of, and benefits from, overcoming industry constraints.

**Implications**

- there should be increased efforts in locating and monitoring new crop technology developed overseas;
- government support for new crop R&D has been extremely important in the past and such support is likely to be critical for new crop development in the future;
- where a crop can be readily incorporated into existing farming systems there is an improved chance that the new crop industry will grow quickly and result in a sizeable new industry;
- although the involvement of large companies can be important in the growth and development of new crop industries, it is not always necessary for the successful growth and development of an industry;
- although a long payback period can constrain the development of some new agricultural industries, other factors are generally more critical in determining success;
- increased attention to the identification of market opportunities and the development of markets (including through promotion) is likely to bring improved growth and development;
- more attention should be paid to existing and potential competition on the demand side when assessing the potential of a new crop industry;
- industries have the potential to grow large and quickly regardless of the type of crop;
- industries that are geographically concentrated and have a greater degree of integration of production and marketing are not likely to grow more quickly or become larger than industries that are geographically dispersed and dominated by individual producers.

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**91. COMMERCIALISATION OF THE NEEM TREE IN AUSTRALIA**
Objectives

to determine the feasibility of an economically viable neem industry in Australia;
to carry out field trials to determine the efficacy of neem formulations;
to analyse seed from a range of trees to determine the range of azadirachtin content;
to study harvesting issues for neem relating to the preservation of seed quality;
to maintain current clones of neem in tissue culture.

Background

With an increased worldwide interest in natural pesticides, the neem tree (*Azadirachta indica*) has received considerable publicity. Extracts from the kernel of the neem seed have been shown to possess antifeedant and insecticidal properties against a range of insects. In Australia, there has been considerable interest shown by primary producers and investors in the possibility of establishing neem plantations in Northern Australia.

As yet, there is no industry organisation, and prospective producers have difficulty in finding reliable information on the potential economic viability of neem. With so many uncertainties about growing, harvesting, processing and marketing neem seed in Australia, the economic viability of any future industry was unknown. This project was initiated to address some of these unknowns, and to provide a framework for investment decisions.

Research

Field studies, laboratory studies and the economical analysis were centrally coordinated to ensure an integrated approach, with each specialist preparing a separate component of the final report. Industry input was provided by Neemoil Australia Pty Ltd and Comalco (Weipa).

Outcome

More than 140 trees from seeds from Mauritius, Indonesia and India, produced seed with similar azadirachtin levels (0.35–0.9%) suggesting that no particular source produced seeds with azadirachtin levels. Detailed study on changes in azadirachtin levels during seed maturation provided a sound basis on which to formulate harvesting options and postharvest storage requirements.

Biological efficacy of neem formulations tested on a number of insect pests of ornamentals land vegetable crops was disappointing, when compared with synthetic standard insecticides in a single application.

The economic analysis of production costs and potential returns indicates that cultivation of neem for seed production in Australia is not currently profitable, nor is it likely to be in the medium term. Any potential neem plantation in Australia would need to be vertically integrated with processing and extraction facilities.

Implications

Potential investors in neem plantations should be aware of the economics of production costs and the real expectations of demand and price for seed. Current prices and estimated demand would suggest that growing neem for seed production is currently not economically viable.

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92. ASSESSMENT OF COMMERCIAL PROSPECTS AND RESEARCH PRIORITIES FOR NEW INDUSTRIES

Objectives

to identify methods able to contribute to the development of industry models or sets of models suitable for assessing prospects, and R&D needs, of industries recognised by RIRDC as being eligible for support;
to develop a model or set of models for assessing prospects, and R&D needs, of Australia's tea tree oil industry. Such a model would be of immediate use to RIRDC for assessing the industry's likely growth rate, ultimate size and the likely effect of R&D. It would thus provide a critical input into RIRDC's newly developed portfolio analysis procedure; particularly in ex ante and progress evaluations; to assess the potential for, and value of, the development of industry models for the assessment of the prospects and R&D needs of other industries of interest to RIRDC.

Background

Increasing competition for limited funds for research and development in Australia, particularly over the past five years, has put increasing pressure on R&D Corporations and organisations to use funds more efficiently and effectively, as well as to show accountability for R&D management decisions. This has created a demand among such organisations for improved methods for allocating R&D funds.

Research

This study reviewed various methods for allocating R&D resources between industries and across R&D areas within industries. An experimental model of the tea tree oil industry was then constructed to examine the usefulness of such models for assessing the prospects for new industries in terms of potential size. The potential size of industries with and without R&D is one of many factors considered by RIRDC in setting priorities for R&D.

The model developed for the tea tree oil industry incorporated an investment analysis spreadsheet with estimated supply and demand functions. Functions were based on a survey of tea tree oil producers and marketers for willingness to produce or purchase tea tree oil at a range of prices.

Outcome

The model developed for the tea tree oil industry is a valuable tool that could be used in RIRDC's review of that industry. However, it should be used in conjunction with RIRDC's qualitative techniques, not in isolation.

Implications

There is the potential to develop similar useful models for other emerging industries, but insufficient data may inhibit the use of such models for very new industries.
NEW ANIMAL PRODUCTS

RIRDC supports a diverse program of research as part of its charter to encourage the development of new industries for Australia. It also supports research and development for existing small industries which, although small, may have captured a profitable market niche from where they contribute to the Australian economy. Small industries have research and development needs as do larger, more prominent industries.

The new plants and plant products program is loosely categorised into four groups comprising industrial crops; tropical fruits, vegetables and nuts; grains and pulses; and miscellaneous crops. Many of the existing industry programs were developed from this program and the Corporation considers the program to be an important one from which individual industry programs can be initiated.

The program is tailored to the current size of the industry and its potential for future contribution to Australia. There is also a focus on potential industries where Australia can develop a strategic advantage. Small Australian industries will also be encouraged to build on available overseas technologies wherever possible and appropriate.
93. EMU PROCESSING AND PRODUCT DEVELOPMENT

94. INVESTIGATION OF THE VIABILITY OF COMMERCIAL EMU FARMING IN TASMANIA

Objectives
- to monitor the performance of emus reared under Tasmanian conditions, using basic technical and commercial criteria and compare performance where possible with Western Australian experience, including comparative product evaluation;
- to identify the most suitable birds for commercial production from the three segregated genetic strains existing in the subject flock (from WA, NSW and Vic);
- to identify the critical issues requiring further detailed research, to achieve viable, commercial-scale emu production in Tasmania;
- to consider some integrated farming activities with fallow deer, to enhance the commercial performance of both species;
- to prepare financial models to examine enterprise returns.

Background
The lack of critical performance data for emu farming under Tasmanian conditions has been an impediment to further consideration, or expansion, of commercial farming. Additionally, investment and expansion was not likely to proceed without some initial investigation to identify commercial potential for Tasmania relative to the Western Australian industry, which relies on the use of cheap feed grain.

Research
A commercially orientated and pasture based research trial over three years was developed with a participating producer who provided the emus, land and labour. The emus were sexed, weighed and identified with hock straps and electronic chip implants. Western Australian producers were visited to obtain information on their emu industry.

Outcomes
Nutrition was found to have a crucial impact on production and reproduction. The importance of reaching target breeding weights before the start of egg-lay, and optimal growth rates of chicks to fifty weeks of age, not only impinged on the performance of the birds per se but had a potential bearing on the economics of the enterprise.

Based on the trial results, it was concluded that the traditional clover and perennial grass pastures will not effectively support commercial stock. Birds, however, were seen to thrive and gain substantial weights when given access to Aran rape without any supplementary concentrates-feeding. It was felt that other leafy and nutritious feed like chicory and lucerne may have a similar potential and were worth investigating.

Implications
Until lower cost nutritional regimes suitable for Tasmania and the key national issues of product development and marketing are clarified, significant commercial development is not anticipated. However, should this occur Tasmania will be well positioned to invest in efficiently managed production units.

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Objective
To assess processing demand nationally for deer and other game species and thence the capital and operating costs of processing.

Background
The size of the deer herd in Australia is not accurately known but is estimated to be about 190,000 head. Venison is processed in commercial abattoirs around the country but there are presently no dedicated works for deer. The value of deer has dropped from the high prices for breeding stock which previously prevailed. It is estimated that there are 15,000 to 30,000 head of deer available for processing each year.

The economics of a dedicated deer or farmed game processing works would be enhanced by collecting co-products worth about $35 a head. However, any new processing plant must compete with those in New Zealand, where the industry is 10 to 20 times larger and some operators are processing 50,000 head of deer a year.

Research
Discussions were held with participants in the deer farming and processing industry in New South Wales, Queensland, Victoria and Tasmania. In addition a survey was conducted among industry experts, advisers and government departments in relation to ostrich, emu and deer farming in all states of Australia.

Outcome
A survey of other farmed game in each state of Australia was conducted. The report sets out estimated numbers of emus and ostriches as well as deer. These industries are all in the early stages of development and accurate figures for herd sizes and potential slaughter numbers are simply not available.

The demand for and cost of processing deer in Australia were assessed, the latter with and without processing some other farmed game species.

The supply for processing can only be estimated over a wide range at present because most of the farmed game industries are at an emerging stage of development. Given that between 15,000 and 30,000 deer could be slaughtered per annum during the next ten years, the processing costs were calculated based on four processing volume options. Gross margins based on selected prices of venison and co-products were between 13% and 20% for slaughter numbers between 10,800 and 25,740 for one central abattoir. The inclusion of an equivalent time for processing other species in the abattoir could increase the gross margin for processing venison to 27%.

Implications
Based on these results it was concluded that a level of about 20,000 head of deer per annum is the minimum for a commercially viable operation. Alternatively, a facility which processes fewer than 20,000 deer may also be viable if it processes other species as well.

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Objectives
To identify the causal agent of giant cell enterohepatitis (GCEH) — a cause of debility, and often death, of crocodile hatchlings on farms.

Background
This disease was diagnosed almost ten years ago in a pathological study of hatchlings that died on one large crocodile farm. Subsequently, the disease, which is characterised by thickening of the intestine by inflammatory cells containing the presumed causal agent, has continued to be observed in hatchlings from this farm and several other farms which had received stock from the initial farm. The disease was also diagnosed in one hatchling crocodile in Papua New Guinea.

Research
Hatchling crocodiles, which were severely emaciated, were obtained from the initial farm then euthanased for detailed post-mortem examination and laboratory study.

Outcome
Pathological examination of up to fifteen emaciated hatchlings submitted on a number of occasions over a two year period revealed that approximately 205 of such animals were infected with the presumed causal organism. Extension of infection to other organs such as the pancreas, liver and lung was confirmed histologically.

Satisfactory electronmicrographs of intestinal lesions of giant cell enteritis were obtained and these indicated that the causal organism was probably a protozoan (Ladds, Donovan, Reynolds and Turton, 1994).

Whereas morphological studies were successful, repeated attempts to isolate the causal agent in tissue culture were unrewarding — even though several crocodile tissue culture cell lines were established.

As the study has progressed, fewer infected cases have been found and such cases have been milder infections than initially. Change in husbandry procedures, and in particular, the now routine chlorination of water for hatchling ponds may be the explanation for this. It is now becoming difficult and largely non-cost effective to identify infected animals.

Implications
Although decreased occurrence of this disease is welcomed, it is unfortunate that investigations and, in particular, isolation of the causal agent, were not completed as planned. It seems likely that GCEH will reappear sometime as crocodile farming expands, and better knowledge of its pathogenesis, diagnosis and epidemiology and, therefore, control would be of great value especially as there will inevitably be movement of (potentially GCEH) infected crocodiles between farms and perhaps interstate.

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NEW ANIMAL PRODUCTS

97. PRODUCTION CHARACTERISTICS OF FARMED BLACKBUCK ANTELOPE

**Objective**
To determine the production characteristics and performance of farmed blackbuck antelope.

**Background**
Blackbuck antelope (Antilope cervicapra) are native to the grasslands of India and Pakistan. They are small to medium sized antelope which were hunted close to extinction in their natural habitat. They are widespread in zoos and game parks. Alan and Barbara Rundell from South East Gippsland, Victoria, commenced farming a small herd in 1986 and subsequently commenced marketing the meat to Melbourne restaurants. Prior to this project there was no documentation of blackbuck antelope as a farmed species.

**Research**
Research components included a literature research on the biology and ecology of the species, monitoring performance of the Rundell herd, and evaluation of carcass and meat characteristics.

**Outcomes**
Blackbuck antelope normally run together as a herd and can be mustered by one person with a dog. Penned animals can be restrained by one person. Animals can be weighed, cartagged, and restrained in a crush. Blackbuck are a grazing animal capable of thriving on high roughage diets. They are non seasonal breeders and have a high potential reproductive rate. However predation and cold wet weather can cause high mortality in fawns. Both young and mature animals are susceptible to internal parasites, particularly in cold wet conditions. These parasites can be controlled by paddock rotation and anthelmintic applications.

Animals can be transported to an abattoir and processed on a sheep chain. Carcasses of castrate and entire males were both exceptionally lean. Measurements of pH (typically 5.4 - 5.7) and Warner Bratzler shear test (PF typically 2 - 4 kg) confirmed that there were no adverse effects from stress. The small supply of antelope meat marketed to a limited number of restaurants has achieved a major premium over venison from deer.

**Implications**
Blackbuck antelope are capable of being farmed and producing a quality meat product. Their greatest potential is in subtropical and tropical regions. However the farming of this species is currently not permitted in most states of Australia on account of its status as a vertebrate pest (Category 3A). It is suggested that lowering this status to Category 4B (the same as for deer) may be appropriate.

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PUBLICATION:

98. THE PERUVIAN ALPACA INDUSTRY

fabrics domestically and for export;

Objectives
to obtain information on the alpaca industry in Peru including the production systems, disease stating, fibre harvesting, processing of fibre, and the marketing of alpaca, fibre and
to assess the constraints and opportunities for the industry in Peru, and if opportune for both alpaca and llama in other parts of South America;
identify constraints, opportunities and action required for the further development of the alpaca industry in Australia;
to identify and evaluate recent, current and planned R&D for the alpaca industry in Peru;
to recommend the future R&D priorities for the alpaca industry in Australia;
to consider and recommend, if warranted, a visit by a R&D person from Peru and provide Terms of Reference for such a visit.

Background
The committee of the Australian Alpaca Association (AAA) was approached for the nomination of an industry representative to participate in the study tour. The AAA subsequently advised that its president Mr Alan Hamilton would accompany Chris Tuckwell to Peru. The purpose of the tour was to assess the alpaca industry as outlined in the above objectives.

Research
To investigate and access aspects of the Peruvian alpaca industry including:
- history and status of camelids in South America;
- past and potential fibre production;
- export of alpaca from Peru;
- disease and veterinary service;
- Peruvian university camelid programs;
- Peruvian alpaca industry leader;
- the future for the Peruvian camelid industries; and
- proposed research and development priorities for the Australian Alpaca industry.

Outcome
Of the South American camelids in Peru today, only the llama and alpaca are domesticated, the llama traditionally being a beast of burden and the alpaca being used for fibre and meat production. The textile industry regards Alpaca fibre as a specialty fibre, sought for its softness, warmth without weight, range of natural colours and strength. A large percentage of the Alpaca fibre produced in Peru is generally of poor quality and coarse. The only way to resolve these problems in Peru is by the design and adoption of rigorously controlled camelid breeding, fibre production, and quality assurance programs.

The Australian Alpaca industry is still very small, and based on sales of breeding stock. It is estimated that there are (1992) about 6000 alpaca in Australian today in 400 registered herds which produced about 10,000 kg of fibre in 1993. There is potential for the Australian industry to increase significantly its export of breeding stock and long term production of quality fibre. The industry aims to establish a fibre marketing organisation which requires objective information on the types and qualities of alpaca fibre in Australia to establish appropriate grading and marketing strategies.

It is vital that the Australian alpaca industry makes use of skilled geneticists to strongly discourage hybridisation of Llama and Alpaca. The breeding program may need to look closely at opportunities of artificial breeding and estimate the genetic and phenotypic characteristics of commercial importance and base the industry’s development on the selection indices determined. There is a need to investigate opportunities for the manipulation of the alpaca reproductive cycle to better align reproduction and pasture growth cycles.

Implications
The study tour led to the formulation of a set of recommendations for future research and development priorities, including:
development of knowledge of the characteristics and properties of fibres and textiles of Alpaca in Australia;
assessment of market requirements and market potential for Alpaca fibre textiles and garments produced in Australia;
development of a genetic improvement program for Alpaca in Southern Australia based on market requirements identified in 2 above;
the cooperative inter-industry development of protocols to allow the Australian Alpaca and Llama industries to access superior genetics from Peru; Research of camelid nutrition and development of efficient economical feeding systems for Alpacas and Llamas in Australia;
 improvement of the efficiency of natural reproduction.

RIRDC Project No: TUC-1A
99. IDENTIFICATION OF MEAT IN PRODUCTS FROM NON-TRADITIONAL SPECIES

Objective
To develop simple tests to identify both fresh and cooked meat from emu, ostrich, crocodile, buffalo and deer to maintain customer confidence that cheap meat from other species is not being substituted for these expensive meats.

Background
There is an expansion in the production of meats from non-traditional species to supply the tourist industry, local consumers and for export. There is a need to develop simple tests to determine the authenticity of both fresh and cooked non-traditional meats to protect consumers from unscrupulous substitution.

Research
The original aim of the project was to produce immunoassays or DNA probes for identification of exotic meats. After phase 1 of the project was approved, but prior to commencement, a new technique for species identification was published from a Canadian group.

Because this new technique appeared to offer a means of achieving the long term aims of the project, without the high cost of developing a wide range of immunoassays and DNA probes, it was decided to investigate its potential. If this technique worked then there would be no need for phase 2 of the project which would have taken over two years and at least $80,000. Equally important as the financial aspects, it would be possible to offer consumers and industry a test within a few months.

Outcome
The original objectives of the project have been achieved at a much lower cost than was anticipated. With the application of the new FINS (Forensically Informative Nucleotide Sequencing) technique, it has been possible to develop a method to identify the species of origin of any meat sample, cooked or fresh. The technique involved extraction of DNA amplification of part of the mitochondrial cytochrome b gene and automatic sequencing of about 250 nucleotides.

Improvements were made to the original procedure. With mixtures of meats the presence of more than one species can be ascertained but, for quantification, some further refinements are required.

Results have been published in the Proceedings of the 11th Australian Biotechnology Conference, in the international journal 'Bio Techniques' and in 'Australian Biotechnology'. The method was described to a meeting of the Royal Australian Institute (WA Branch) Analytical Chemistry Group and The Australian Institute of Food Science and Technology Ltd (WA Branch) in Perth and will be presented at the University of Berne in Switzerland in April. Copies of the Bio Techniques paper were distributed to emu farmers at their international meeting in Perth. Further distribution of information is planned.

Implications
Tests are now available to identify substitution of meats.
Objective
To assess the feasibility of implementing a genetic recording system for the Australian ostrich industry.

Background
The investigating institution, the Agricultural Business Research Institute (ABRI) had previously established a pedigree register which is now being used extensively in the industry.

Research
Given the absence of any worthwhile literature on the heritability of production traits in ostrich, ABRI consulted within the industry, and with Dr Hans Graser, Deputy Director of the Animal Genetics and Breeding Unit (AGBU) at University of New England.

On the basis that any genetic evaluation would be starting from scratch, it was agreed there was a need to build a substantial body of production data, and that its use would be constrained by environmental influences.

Outcome
Findings demonstrated constraints in introducing an effective genetic recording scheme. First, productivity variability might be more managerial than genetic and a performance recording system could partly reflect situation rather than a genetic difference per se.

Other constraints include:
only 25% of the flocks have currently more than 10 breeding age birds;
parentage can be difficult to identify if colony rather than pair mating occurs;
some flock recording measurements need to be more comprehensive.

Implications
Even though the project could not determine accurately the cost of establishing an all-encompassing-performance recording system for the ostrich industry, ABRI has developed an optional, low-cost module to record production of breeding ostrich.

The output of such a module will be a series of reports for the individual ostrich farmer detailing production from each breeding pair or colony, and comparing productivity with the average, best and worst in the industry. Currently ABRI is communicating with a number of larger producers to obtain feedback on the design of the module and the reporting formats.

It is intended to make use of PC computer software interfaces as soon as practicable, and the Australian Ostrich Company (which is the commercial ‘arm’ of the Australian Ostrich Association) has identified a West Australian software package ‘Ostrich Farmer’ as having the greatest potential in this regard. Discussions will continue with this and other software designers to maximise use of electronic data transfer in both the performance and registration procedures of the AOA Register.

RIRDC Project No: UNE-27A
ResearchER: Mr P A Rickards
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AGROFORESTRY AND FARM TREES

Agroforestry, the incorporation of trees into farming systems, has the potential to improve agricultural productivity, diversify and increase farm income, conserve land, maintain biodiversity and contribute to the national timber supply. Given appropriate research, development and extension, agroforestry could become a widespread, profitable and sustainable land use of the future.

RIRDC has noted the strong community interest in trees and Government efforts to plant more trees through programs such as the 'One Billion Trees' program. However, many of the current tree planting programs lack research and development support and an appropriate economic framework. In 1991 RIRDC undertook a comprehensive review of research and development for agroforestry in Australia. This review, together with the recommendations on research and extension from the conference on 'The Role of Trees in Sustainable Agriculture', forms the background to RIRDC's program for 1991-96 in agroforestry.

RIRDC also manages a joint agroforestry program with the Land and Water Resources R&D Corporation (LWRRDC). As part of that program, two major reviews have been conducted on low rainfall agroforestry and windbreaks research. A program in windbreaks research has been established. Background information on low rainfall agroforestry is available from RIRDC. Applicants for the joint RIRDC/ LWRRDC program should apply in this round of applications.
Objectives

to design, implement and improve action research methodology for farmer decision making in complex social systems;
to identify conditions and constraints impeding practical solutions to problems associated with tree management.

Background

Land degradation is a major problem in Central Queensland and poor tree management has been viewed as one of the most important causes of that degradation. Yet trees are viewed by many farmers as limiting the growth of pastures and thus reducing the productivity of the land. Tree management has not been a high priority among Central Queensland beef producers. It is necessary to establish the basis for poor tree management and to identify the gaps in producer (and expert) knowledge as well as the possible ways to address land degradation.

Research

The study was based upon action research involving fourteen families on beef properties south of Rockhampton. The families were taken through participative problem solving cycles. They helped collect and evaluate information and identify problems which they, as producers, believed they faced in relation to beef production and tree management. Action research included the use of semi-structured interviews, questionnaires and focus group meetings.

Outcomes

The participative action method used to involve farmers in discussions about environmental degradation was seen to have been successful in alerting farmers to the problems they faced in current tree management. It allowed local producers to share knowledge in a non-threatening manner.

There was seen to be a need to develop a more integrated approach to tree management on Central Queensland beef properties. Farmers had an historically derived preference for a ‘scattered’ tree landscape. This was an aesthetic preference which was out of keeping with best practice for tree management. The latter stressed the need for ‘tree corridors’ along creeks and waterways. Yet these were seen by farmers as harbouring ‘vermin’. Collaboration between producers, government agencies and grower organisations was viewed as crucial to the evolution of more environmentally sound, tree management strategies.

Implications

It is necessary for agents of the state to appreciate that farmers’ views and preferences have been formed over a long period. Increased sustainability will inevitably rely upon new ways to improve productivity while preserving the soil and vegetative cover. The challenge is to introduce new ideas into the system of farming which values an older (and environmentally less appropriate) way of managing natural resources.

One way of achieving this is by employing participative problem solving cycles where the farmers, themselves, identify problems and seek appropriate solutions. More research needs to be undertaken to identify the potential for group processes to improve simultaneously productivity and sustainability.
102. BIOMASS AS AN ALTERNATIVE ENERGY SOURCE

the energy cycle by:

overviewing energy demand and supply markets, and identifying likely components for supply opportunities from plant biomass-based resources (with scenarios for present markets and projections to 2010);

studying the availability of plant biomass resources for energy in the context of supply/demand scenarios for other energy resources;

identifying current and prospective technologies already under development, that could deliver plant biomass-based energy; and

developing a strategic plan to identify a specific course of action to maximise benefits in each opportunity area and to remove barriers or restrictions where possible in others.

Background
International debate on the greenhouse effect, ecologically sustainable development and more efficient resource utilisation have resulted in a renewed interest in reviewing the potential of biomass based resources and technologies.

Research
Studies were made of:

biomass resources including field crops, crop and forest wastes, and waste matter (municipal solid wastes, animal wastes and by-products of food processing);

energy market factors;

environmental considerations including: greenhouse gas emissions and global climate change; deforestation and land degradation; poor land use; loss of biodiversity;

technologies of two major types—thermal/chemical and biochemical—for converting biomass to energy;

a model for assessing the cost of converting biomass to energy; and

the demands for energy from now to 2004–05, based on 1993 forecasts from the Australian Bureau of Agricultural and Research Economics.

Outcome
After evaluating the complete range of resource and technology options, two promising systems were chosen for further analysis. These were: electricity generation by direct combustion, gasification and anaerobic digestion; and ethanol production from lignocellulose, food processing wastes and waste paper.

Implications
The report proposes various projects to develop and promote the biomass-based energy industry in Australia, based on the most promising systems. Recommendations for further technical assessments include: compiling inventories of biomass sources; analysing waste disposal costs; studying technologies for producing electricity and ethanol from biomass; analysing price and demand for by-products; and studying the social, economic and environmental benefits and impacts of biomass-derived energy.

Further recommendations are made for marketing and promotion, industry development (forming a Biomass-based Energy Industry Association (BEIA) government support and budget requirements and funding options for the BEIA.

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Objectives

to adapt an existing process-based model of tree growth (BIOMASS) and apply it as a tool for evaluating potential productivity of *E. globulus* plantations in south-west Western Australia;
to develop spacing and thinning strategies to alleviate key constraints on productivity of plantations established on farmland in this environment.

Background

Establishment of at least 100,000 hectares of plantations will be required to provide resources for a proposed world scale pulp mill in the south west of Western Australia.

Currently the State (Department of Conservation and Land Management) controls 8,152 hectares and Bunnings Treefarms 9000 hectares of *E. globulus* plantations of ex-farmland. Bunnings Treefarms has planted 4600 hectares in 1993 and expects to maintain new planting at about this level for the next ten years. The Albany Plantation Company of Australia Pty Ltd, a venture company formed by Oji, Japan's largest pulp and paper manufacturer, and Itochu, Japan's biggest trading house, plans to establish 20,000 hectares of *E. globulus* plantations over ten years.

Prospects are excellent for a commercially viable plantation industry integrated with current farming enterprises and the WA State Government has called for expressions of interest in construction of a pulp mill within seven years.

Research

A physiologically based model of tree growth (BIOMASS) has been adapted to simulate growth of *Eucalyptus globulus* and applied to study effects of factors which determine growth rates at five sites in the south-west of Western Australia.

Major factors considered were climatic variation and soil physical conditions. Soil characteristics at these sites differed widely, but as the plantations were established on farmland where fertilisers had been applied over a number of years, soil fertility was moderate to high.

Thus, availability of soil nutrients, which is known to affect growth rates, is not a major factor determining differences in growth rates among these plantations.

Outcomes

Simulations were moderately successful in explaining differences in growth rates among the various plantations and in relating these differences to soil and climatic factors. Major constraints on use of simulation to predict production rates are the uncertainties in defining root depths and allocation of photosynthates to biomass components.

Simulations of seasonal variation in soil moisture contents gave results which agreed well with measured values where the plant-available soil moisture and depth of root penetration could be estimated reliably. However, at sites where the depth of root penetration is difficult to estimate or where watertables may be accessible to roots, agreement between simulated and measured moisture contents of the top 3m of soil was less satisfactory. In the drier period of the year simulated patterns of soil water variation gave values that were lower than was measured. A probable explanation for this difference is that soil water was extracted from greater depth than 3 m. Application of ‘BIOMASS’ model to provide information about potential production and drought risks in regions with Mediterranean climates is discussed.
104. THE ROLE OF MYCORRHIZAL FUNGI IN SUSTAINABLE LAND USE

**Objective**
To provide a definitive assessment of the potential for practical and economic field assessment of mycorrhizas.

**Background**
Support received from the RIRDC was used to contribute to travel expenses for international speakers to participate in the International Symposium on Management of Mycorrhizas in Agriculture, Horticulture and Forestry.

**Research**
The approach was to invite leading international scientists to review the state of knowledge and to identify areas where further research is required. Additionally, there were a large number of invited and contributes posters. Scientists from twenty-eight countries attended the meeting; 110 of the 180 participants were from Australia.

**Outcomes**
There is considerable potential to obtain greater benefits from the mycorrhizal symbiosis in broad-scale agriculture, agroforestry and the reclamation of degraded soils. Management options that are possible are:
- choice of fertiliser practices, tillage and rotation;
- choice of genotype;
- prevention of erosion; and
- nursery or field inoculation of plantation tree species with ectomycorrhizal fungi.

In broadscale agriculture it is unlikely that the introduction of inoculant mycorrhizal fungi will be feasible. The potential for inoculant use in horticulture is greater, however use of high levels of phosphate fertiliser will reduce successful use of the symbiosis. Inoculation of trees with ectomycorrhizal fungi is a practical option for increasing seedling establishment and plant growth, however the functioning of the symbiosis requires further investigation in order to obtain maximum benefits.

**Implications**
The main biology/ecology research needs include:
- to develop approaches that will distinguish among the fungi colonising roots;
- to understand changes in colonisation with time within and between growing seasons;
- to estimate the numbers and types of propagules in soils and their response to farming practices.

In relation to the functioning of the symbioses, the major research needs include:
- the requirement for detailed studies of mycorrhizal functioning in the field
- to define differences among fungi in their ability to enhance plant growth and soil aggregation.
- to examine whether mycorrhizas us the same source of phosphorus os non-mycorrhizal roots.

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Objective
To augment the existing TREEDAT/MPTDAT data set to provide a sound basis for selection of appropriate tree species and provenances for farm plantings in south-eastern Australia.

Background
Tree planting in south-eastern Australia has become a critical issue because of its role in preventing/slowing land degradation and for its potential to diversify farm income through the provision of saleable wood and non-wood products. These benefits can only be realised if the trees planted realise their expected potential.

The main factors affecting this realisation of potential can be divided into silvicultural and genetic components. The silvicultural factors are those which affect the trees growing environment such as site preparation, weed control, fertiliser and irrigation.

The genetic factors relate to the selection of species, provenances, families or clones which are best adapted to the planting sites. The combination of good species selection with appropriate silviculture will result in successful plantations.

Research
Information was collected for the MPDAT and TREEDAT databases on silviculture and genetic factors from trial across south-eastern Australia.

Outcomes
This project has collected growth, and associated site, management and genetic information from south-east Australia to be used as a basis for predicting tree performance.

Implications
The data collected allow prediction of species performance in sites where no trials have been carried out. The potential productivity of a particular species, provenance or family could also be estimated if enough well documented sites were held in the database.

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Objectives
to compile species/provenance performance data from research trial for incorporation into the national database MPTDAT;
to enable researchers access to this data base so that improved species/provenance recommendations may be made.

Background
There has been a dramatic increase in tree planting by individuals and community groups in recent years. However, tree planting projects are more effective when appropriate species and provenances (seed sources) are used. Many revegetation research trials on species and provenance performance have been established throughout Australia, but results have not been readily available to other researchers and general extension staff.

A tree database is one way to improve accessibility. MPDAT (Multi-purpose Tree Database) was developed in 1990/91 by the CSIRO Division of Forestry in conjunction with Winrock International Forestry/Fuelwood Research and Development Project (F/Fred). It is a PC database designed to present experimental data from field trials in a summary form. Despite some limitations, MPDAT provided a suitable medium for collecting and collating research trial and field data.
Research
An experienced Scientific Officer was engaged, on contract, to compile, collate and enter data on species performance from selected research trials around South Australia into the CSIRO MPTDAT data base.

Outcomes
Data on species performance has been collected from 61 research trials and 46 sites around South Australia and forwarded to CSIRO for incorporation into the national MPTDAT data base.

When distributed by the CSIRO, researchers will have wider access to species/provenances performance data. A training seminar on MPDAT for various interested researchers and extension staff was held at State Flora, Murray Bridge on 16th June 1994.

Implications
If MPDAT is to realise its potential, there will need to be wide participation, a policy for distribution of the information to non-participating organisations, more effective software developed to allow easier use/access of the data and a central distribution arrangement.

The effect of improved species/provenance recommendations are expected to be a reduced use of species beyond their range, more extensive revegetation stimulated by more successful projects and increased numbers of suitable species considered for a project.

This will help increase total farm productivity by improving shelter from taller windbreaks, increasing life spans and service from plantings because of better species selection. It effectively locates plantings to protect crops, stock and land, lowers costs; and produces more reliable results and greater benefits for the same investment in revegetation,

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Objectives
To provide a stimulus to the development of teaching and research in agroforestry in Australia by presenting a course of lectures at each of our four universities, and advising on the development of agroforestry teaching and research.

Background
Agroforestry is an emerging technology in Australia with potential benefits to productivity and sustainability of agricultural and pastoral systems. A number of universities are developing courses and research programs in the area and encountering predictable difficulties.

On the one hand, development is restricted by a shortage of published information and trained staff. On the other hand, there is the long-term nature of field research in agroforestry that makes the selection, establishment, and maintenance of research sites difficult and expensive. Researchers and funding bodies must develop confidence that research objectives and plans for implementation are optimally chosen to justify the time and resource involved.

Research
Professor Peter Huxley of Oxford, England (formerly Director of Research at ICRAF, Nairobi, Kenya) was engaged on a ten-week consultancy. He presented a public lecture and an intensive short course on agroforestry over two-week periods at the Universities of Melbourne, New England, Western Sydney, and Adelaide. During those visits he also discussed research activities and plans, and visited experimental sites. The final two weeks was spent at the University of Melbourne where he prepared the report of the project.
**Outcomes**

- specific recommendations for each of the four universities involved in the project;
- proposed syllabus for third or fourth year elective subject in agroforestry;
- structure for an undergraduate program in agroforestry;
- improved contact between academics and scientists involved in agroforestry in Australia;
- bibliographies of useful international publications in agroforestry;
- impetus to develop integrated course material suitable for Australian Students;
- encouragement to undergraduate students of the opportunities, challenges and importance of postgraduate training in agroforestry.

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**Objectives**

to ascertain whether native vegetation (trees and shrubs) on farms promotes or enhances the effectiveness of scarab parasitoids;
to Identify and quantify the potential parasitoids and hosts and determine their relationship with specific vegetation components.

**Background**

Tree loss from repeated insect defoliation (e.g. Christmas and Pasture beetles) is affecting the quality of the Australian environment. Tree planting in pasture areas to redress the problem is costly and risky with no assurance they will survive in the long term.

Anecdotal evidence suggests maintaining or recreating the natural biodiversity (plants and animals) would retard the tree mortality rate by allowing natural control agents of scarabs (parasitoids and predators) to function normally. Scientific data on the potential parasitoids, their hosts and an understanding of their relationship with vegetation and environmental parameters is lacking.

**Research**

Parasitoids were sampled by Malaise traps on two properties at twenty sites up to 400 m from remnant vegetation. Scarab larvae were obtained from transect sampling. Scarab beetles were obtained by light trapping. Sampling occurred during severe drought conditions.

**Outcomes**

Parasitoid wasp numbers declined with distance from the remnant vegetation and increasing drought severity. The genera *Prosena* and *Senostoma* increased under drought conditions. Some tachinids are better able to handle the conditions of open pasture than others.

Larvae of tree-feeding scarabs (Christmas and pasture beetles) peaked in the open pasture adjacent to the remnant vegetation; non tree-feeders attained their maximum well into the pasture. The abundance of parasitoid pupae depended on soil characteristics and/or the occurrence of tea tree (a major nectar source for adult parasitoids). Parasitoid pupae and scarab larvae were non-randomly distributed in the forest and open pasture.

Movement of adult parasitoids and scarab beetles is strongly seasonal, and then subject to meteorological conditions (particularly rainfall and wind speed).

The low parasitoid populations (adults and pupae) taken away from the remnant vegetation suggests they have limited influence on the scarab larval complex damaging pasture in the open. In the open, in
moister areas, merthid nematodes and bird predators (ravens, ibis, magpies and currawongs) appear
to have a greater impact on scarab numbers than the potential parasitoids.

Implications
The tiphiids, scoliids and selected tachinids are beneficial on farms for pest control. Their distributions
are highly dependent on that of the remnant vegetation, particularly the shrub component. The wasps
and larger tachinids remained close to, and were most frequently taken from their energy sources. These
energy sources, particularly Leptospermum, Baeckea and potentially Eucalyptus spp., are a small subset
of the available flowering plant species.
Planting Leptospermum and Baeckea on farms would increase the available energy sources, hence
activity, of these adult parasitoids.

The regular spacing of windbreaks across pasture (intervals <800 m) would maximise biological control
by these parasitoids. Windbreaks should be interconnected with existing remnant vegetation to provide
corridors to aid parasitoidal dispersal.

RIRDC Project No:DAN-68A

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109.REX 95: A NON-SPECIALIST TREE INFORMATION DATABASE

Objectives
to develop, evaluate and market a tree information database suitable for non-specialist users;
to tap existing technical databases as an information source.

Background
Revegetation activity around Australia is rapidly expanding and placing heavy demand on all sources of
tree information. In particular, agency extension staff are hard pressed to meet requests for often quite
routine information. Scientific and technical tree performance databases are developing but need
interpretation and more friendly presentation before being suitable for non-specialist users.

The abundance of information and the emerging multi-media capability of computers provides the
opportunity to develop a comprehensive and efficient revegetation information system for general use.

Outcomes
REX 95 has 2000 species and 800 fields and operates in a Windows environment. The system
incorporates expert knowledge in the form of Tours, Wizards and Knowledge Base. It has more than 400
high quality colour photographs of species. User evaluation is nearly complete and indicates that REX
should appeal to both specialist and non-specialist home, farm, industry and professional users. Release
is scheduled for winter 1995. The release version will have a southern Australian focus.

Agreements have been concluded for marketing and maintenance of REX. A large proportion of revenue
will be reinvested in further data collection with the aim of producing an annual version. The Western
Australian state agencies (Conservation and Land Management, Department of Agriculture, Greening
Western Australia) manage REX. A national forum will be constituted to guide future development.

Implications
If the first release version of REX is commercially successful it should stimulate a vigorous national
forum to oversee rapid expansion in coverage and capability. the aim will be to develop a widely used
national revegetation information system.

RIRDC Project No: CAL-1A
Objectives
To establish reasons for failure of trees to regenerate in the Belah-Rosewood country of western New South Wales and hence to devise strategies to ensure tree regeneration on pastoral leases.

Research
The study concentrated on the following arid woodland tree species: Callitris glaucophylla, Cypress pine, Casuarina pauper, Belah, Geijera parviflora, Wilga, Hakea leucoptera, Needlewood, Acacia loderi, Nelie, Acacia melulei, Yarran, and Alectryon oleifolius ssp. canescens, Rosewood.

For these species the natural composition of the associated communities were determined by reference to relatively undisturbed examples and their regeneration characteristics were determined through:

- assessment of germination characteristics through glasshouse trials;.
- use of simulated grazing trials;
- assessment of stem diameter histograms from sites subject to specific management;.
- assessment of the effects of disturbance, in particular chaining and 'ringing';
- assessment of regeneration within exclusion plots.

Outcomes
Analysis of the communities at 250 sites across the study area demonstrated that they naturally have a diverse shrubby understorey but that in most instances this understorey has been severely depleted by grazing.

Assessment of reproductive strategies in the field indicate that despite the age and senescence of many of the remaining trees, flowering and fruiting is prolific with large quantities of seed produced in most years.

This seed viability and high production ensure the availability of viable seed when soil conditions are suitable for germination. Simulated grazing trials under glasshouse conditions showed that young seedlings were reasonably tolerant of grazing pressure and persistent defoliation was needed to kill them.

Indications are that the communities have been severely depleted due to harvesting of timber and clearing of overstorey trees in an attempt to increase growth of grasses. The form of trees has been severely modified through lopping for fodder and high browsing by stock and goats.

Assessment of stem diameter histograms from sites with a varied grazing history indicate that areas subjected to heavy long-term grazing have shown little or no regeneration for the past 100 years. Regeneration is particularly prolific where there has been major soil disturbance prior to good rains.

Implications
The long term survival of these communities is under threat unless steps are taken to modify grazing levels to allow regeneration when there is suitable climatic events such as occurred in 1973–74–75.
Regeneration can take place alongside moderate stock grazing provided grazing pressure from rabbits, goats and kangaroos can be kept at a low level.

It is too soon for exclusion plots established in north-west Victoria and south-west New South Wales to show clear-cut results, but there is evidence of recovery of tree dominants and associated woody species when protected from grazing. The study is an ongoing one and both field study sites and exclusion plots in Victoria and New South Wales will continue to be monitored.

Extension work has raised awareness of this widespread conservation issue. Some of the plants from glasshouse trials are being used in a major display prepared by the National Museum of Victoria to improve public understanding of useful plants of the arid zone.

Objectives
- to assess the growth potential of a number of high value rainforest trees when grown in plantation conditions under optimum conditions;
- to determine appropriate planting densities at which some of these might be grown to yield both timber and pasture.

Background
Attempts have been made in the past to grow rainforest timber trees in plantations. Although some results were promising these early trials were effectively abandoned. *Araucaria cunninghamii* (hoop pine) was the only native rainforest tree to be included in an extensive planting program. The cessation of most logging in natural rainforests in Australia in the late 1980s has created a shortage of many of these timbers and there is now anecdotal evidence that their prices are starting to rise.

The project seeks to address two of the several issues needing resolution. One is — which of the many species present in rainforests are potential plantation candidates? The second is — how might these be grown by a landholder wishing to retain present pasture production while the trees and the pasture productivity at the various tree densities are being monitored.

Outcomes
Of the sixteen species tested a least six have grown rapidly since the trial began while most others have grown reasonably well. The faster growing species include *Cedrela odorata*, *Elaeocarpus grandis*, *Grevillea robusta*, *Rhodospaera rhodanthema*, *Acacia melanoxylon* and *Flindersia brayleyana*. These all grew more rapidly than *Araucaria* (which is currently being used in plantations) during the four year study period. It is known that *Araucaria* usually grows well after a slow start and this ranking may alter over the few years. Tree form varied within and between species and there is clearly scope for improvement.

The trees in the agroforestry trial have also grown well. The higher density plantings have begun to affect pasture production but a longer period of study is needed to observe the tree–pasture interaction.
Implications
The results show there are at least several Australian rainforest species with potential as plantation trees as well as several exotic species. The performance of these at a wider variety of sites now needs to be evaluated and more work is needed to develop appropriate silvicultural treatments for these.

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AGRIBUSINESS AND TRADE

Agribusiness covers many activities including the supply of materials and services to farm businesses, the farm business itself and also the transportation, transformation, packaging and marketing of products once they leave the farmgate.

While the contribution of the farm sector is assessed by the Australian Bureau of Statistics at less than five per cent, the overall contribution by the agribusiness sector as a whole is estimated at 25 per cent. The Department of Industry, Science and Technology estimates that the farm sector spends $2.86 billion on services each year and that up to 95 per cent of the final value of farm products is added post-farmgate.

The agribusiness sector offers significant scope for improving the efficiency of rural industries and for adding greater value to farm products before sale in Australia or export.

RIRDC's strategy is to directly address the key ‘off-farm’ agribusiness issues in this program. The ‘on-farm’ issues are addressed in other RIRDC programs and also in the programs of counterpart research and development corporations.

The issues will be addressed through four inter-related sub-programs, namely:
Australian agribusiness structures and linkages;
Asian agribusiness and trade research;
market-based innovation; and
educational and support activities.

As the interests of other research funding agencies overlap this program, the Corporation will either promote or join program funding consortia where appropriate. Jointly funded research, strongly supported by industry, will be favoured.
Objectives

to develop optimum processing parameters for an advanced heat pump dryer which results in low-cost, high-quality dried products;
to evaluate the energy/cost savings and the quality advantages of products dried by the heat pump system as compared to products dried by conventional methods;
to investigate the use of the low cost, low temperature drying that these pumps offer to dry-heat susceptible products;
to inform and demonstrate to relevant industries the application and advantages of the heat pump technology.

Background

Heat pump drying is a new technology for the food industry. It utilises a refrigeration system to dehumidify and reheat the drying air, normally in a closed recirculation system.

In principle, air from the product is cooled to below its dew point by passing it over the evaporator of the system, condensing water from the air stream. The air then passes over the condenser, reheating it before it is returned to the drying chamber to complete the cycle. The system recovers the latent heat of evaporation from the water in the air stream, and so is highly energy efficient. It also enables effective drying at lower temperature, offering quality advantages with many food products.

Research

An advanced heat pump dryer was fitted with instruments to allow measurement of temperature and humidity throughout the cycle. Product weight during drying could also be monitored. A range of food materials were dried using the system, including fruits (e.g. mangoes, pineapple, apple, banana, strawberry), vegetables (e.g. onions, mushrooms, broccoli, carrots, capsicum, tomatoes), macadamia nuts, ginger, herbs (basil, parsley), scallops, prawns, beche-de-mer, meats, and biscuits. Quality of the dried products was assessed.

Only limited trials were carried out for most of these products, at the request of growers or processors interested in commencing production. Ginger, mangoes, and mushrooms were studied in greater detail. The effects of parameters such as air velocity, temperature, and product size were evaluated.

Outcome

The research contributed significantly to the efforts of a larger team working in this area. Commercial processors have now installed heat pump dryers for the processing of products including macadamia nuts, peanuts, biscuits, mangoes, bananas, leather, tomatoes, carrots, and beche-de-mer. The team was awarded the 1993 National Energy Award (Industry Category) and the 1994 Food Innovation Award (presented by the Australian Institute of Food Science and Technology) for their work.

Implications

While a large range of products were tested briefly, there is still a lack of detailed information drying characteristics the heat pump system.

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Objectives
To identify opportunities to increase exports of perishable goods through structural improvements to the air freight transportation chain by identifying barriers to perishable goods, use of existing air freight capacity, and ways of overcoming these barriers.

Background
Australia exports around $9 billion dollars worth of perishable goods by air per annum. Even though Australian air freight is relatively cheap and available capacity often under-utilised, it is perceived to be expensive and incapable of meeting demands. This study is based on the hypothesis that there are a number of structural barriers that constrain the use of export air freight capacity and therefore a greater volume of exports of Australian perishable goods.

Research
Demand for, and supply of, air freight capacity were compared between Australia and New Zealand, a country in which available air freight capacity, although dearer, is more fully utilised. Research focussed on three fundamental goals:
- obtaining evidence for under-utilisation of air freight capacity in Australia and how this can be related to the demand for capacity and to the patterns of air freight use for perishable goods;
- defining the commercial and regulatory structure of the distribution chain from Australian grower to overseas buyer and end user and how this compares with the New Zealand distribution chain;
- identifying barriers against, and incentives for, use of air freight that are present in Australia but not New Zealand; and recommending appropriate action to encourage greater use in Australia.

Outcome
This study has indicated that by overcoming barriers to the use of export air freight services Australia may be able to increase the volume and value of perishable goods exports by up to $750 million per annum. Furthermore it is likely that similar barriers could be identified for sea freight and the increased value of exports would be even greater. The major impediment identified is poor marketing of Australian products. This in turn has led to an inability to afford further investments in export marketing and an inability to add value throughout the export marketing production and distribution chain.

Implications
It was concluded by the researchers that there are significant opportunities to increase the extent of export air freight use and they stressed the need for organisational structures and transportation systems to be seen as the first-level building blocks to export development. The report contains a great deal of useful information and suggestions for stimulating perishable goods exports that will prove invaluable to food producers, exporters, researchers, agricultural extension officers, and others involved in Australia’s food and transport industries.

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114. RESEARCH AND DEVELOPMENT NEEDS IN PACKAGING OF AUSTRALIAN PRODUCE

**Objectives**

to review the existing packaging and handling (including transport and storage) research for agricultural produce in Australia;
to develop a priority list of goals, strategies, and potentially collaborative programs so that an effective R&D in packaging and handling management might be undertaken and funded

**Background**

In the development of overseas markets, poor packaging of Australian produce has often been a significant problem. Yet the packaging industry must play a most important role in augmenting the quality and appeal of products. To enable agricultural products to gain a niche or a competitive edge in such markets, the packaging industry must focus its efforts on packaging design, performance evaluation and manufacturing technology. With an increasing trend, world wide, towards the consumption of convenience “shelf ready” foods, packaging remains a significant technological problem.

**Research**

The above objections were accomplished by conducting a literature review, interviews, questionnaires and meeting with personnel involved with research in packaging, handling and transport for agricultural production in Australia and for export.

**Outcome**

As a result of research the following goals for the immediate future were established:
to develop a systems approach to the provision of appropriate packages for horticultural products for the improved delivery of healthy, fresh and safe products to end-user markets;
to develop innovative packaging technologies to meet needs identified in market research, particularly in Pacific rim countries;
to improve adoption of research by growers, packers, transporters, marketeers.

**Implications**

It is recommended that Researchers adopt an integrated, co-operative approach to the research needs of the industry. This should be facilitated by funding bodies by the encouraged development of multi-discipline, multi-institute research programs with clearly identified budget, objectives, outcomes and appropriately managed by a single supervisor.

Research should be urgently conducted in the following areas:
continued development of knowledge of the physical and physiological factors of produce and the interaction of such factors with various parameters of packaging, transport and storage;
economic models for the packaging, transport, storage and marketing of specific horticultural products;
development of acceptable standard testing procedures for packages.

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115. APPLICATION OF PREDICTIVE FOOD MICROBIOLOGY TO IMPROVE THE QUALITY AND SAFETY OF FOOD
**Objectives**

to derive, and validate in industry, mathematical models to predict the effects of environmental factors on the rates of growth of spoilage and pathogenic microorganisms; to enable prediction of the shelf life and microbiological safety of food products; to make the results available to industry by developing computer software to interpret the effects of processing and storage conditions on bacterial proliferation.

**Background**

The assurance of microbiological quality and safety is a prerequisite for maintaining existing markets for food products and developing new ones. Hygienic processing operations can minimise the level of contamination by pathogenic bacteria but cannot be relied upon for total elimination. The opportunity exists to prevent these problems by developing systems to monitor and predict the extent of microbial growth. Knowledge of the growth responses of microorganisms to environmental conditions enables objective evaluation of the effect of processing, distribution and storage operations on the microbiological safety and quality of foods.

This area of research has come to be known as ‘predictive microbiology’, and has received considerable international interest, both in industry and research organisations, some of which have undertaken major collaborative projects as a result of major food poisoning incidents.

**Research**

Growth rates of microorganisms, isolated from a variety of foods, were determined in artificial broth media under many conditions of temperature and water activity. Mathematical models, based on thousands of data for a number of bacterial species, including psychrotrophic pseudomonads and *Listeria monocytogenes*, were developed. Predictions from these models were validated in the laboratory in food products before being incorporated into computer software.

**Outcome**

Professionally written software, embodying the results is currently undergoing industry evaluation to assess its accuracy, ease of use and reliability to predict the proliferation of bacteria in foods. Feedback from industry will be used to prepare final versions for general release.

**Implications**

Use of predictive food microbiology will benefit the food industry by:
- minimising the risks of food-borne disease outbreaks;
- allowing better estimates of product shelf life, allowing development of more distant markets;
- enabling rational development of microbiologically ‘safe’ food products and processes; and
- Objective, quantitative, assessment of deficiencies in processing and distribution systems.

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The Market for Processed Food and Beverage Products in Urban China

Objectives
To empirically evaluate consumer expenditure patterns, consumer characteristics, market size, and market growth prospects.

Background
Previous analyses show ongoing and new opportunities for Australia to market processed food and beverages in Asia where the Chinese economy appears set to emerge as the single largest prospect for growth in food consumption. Seizing opportunities such as these is an economic priority for Australia.

Research
The immediate purpose of the survey was to find out who is buying what products and in what quantities. The primary data used in this study comprise over 5150 observations from face-to-face interviews with Chinese consumers patronising urban processed food and beverage shops in four cities. They relate to 79 individual product items within 10 product categories.

Outcomes
For 90 per cent of shoppers the number of products did not vary by over four, irrespective of distance travelled to the shop, gender of the shopper, whether or not the shopping was the main shopping, the income level of the shopper, or the size of the family for which the shopping was being undertaken.

Non-alcoholic beverages, meat products, cereal products and fruit and vegetables account for the majority of consumer expenditure on processed food and beverage products.

By far the majority of processed food and beverage products purchased is more 'Western' than 'traditional'. The surveyed urban customers are estimated to spend about 55 percent of their income on food, with about 45 per cent of it consumed in processed form.

The average market growth rate is around 3.7 percent per year, leading to a conservative estimate of the urban market in China in the year 2000 as being worth about $28 billion in the main cities and about $53 billion in urban areas.

Implications
The available evidence tends to question the appropriateness for China of the Western model of retailing with greater centralisation of the retail function in supermarkets and hypermarkets.

The change in Chinese dietary preferences away from traditional home preparation to commercially processed food and beverages could provide marketing opportunities for Australian industries, in a range of processed food and beverage products.

There is a market growth potential for processed foods and beverages in urban China as income per person rises over time with increasing economic growth.

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117. A PRELIMINARY EVALUATION OF VEGETABLE MARKETING CHANNELS IN AUSTRALIA

**Objectives**
To develop a financial model which could be used by growers to evaluate which of the three domestic selling options — agency, merchant or direct — offered them the best financial returns.
To test the validity of this model through a series of grower case studies.

**Background**
The fresh fruit and vegetable industry is fragmented and atomistic and experiences wide fluctuations in market prices and net returns to growers. Traditionally, the major selling channel for fresh horticultural produce has been through the central markets which operate in each capital city. The majority of these transactions between farmers and central market operators have been conducted on a merchant basis, although in many cases, farmers think these transactions occur on an agency basis.

Over the past five years, there has been significant growth in direct sales to supermarket chains.

**Research**
A series of personal interviews were conducted with vegetable growers in the three major horticultural areas of Queensland to identify all possible transactional costs associated with each of the three selling channels.

The resultant financial model was then validated against 306 consignments offered for sale by the cooperating growers.

**Outcome**
The financial model captured the identifiable costs associated with selling fresh vegetables through the alternative channels available to growers.

The analysis of the consignments failed to demonstrate the financial superiority of one selling system over another. However, this analysis was hampered by the small number of directly comparable consignments, the large number of different commercial relationships between grower and ‘agent’ and the lack of a uniform specification system between consignments.

**Implications**
None of the selling systems have an obvious advantage over the others which indicates that each has its place in the selling strategies of horticultural producers as they attempt to spread price risk.

The study did show a growing dissatisfaction by growers and retailers with the central markets. The need for better consumer information flows between central market operators and growers was urgently required.

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Objectives

to classify wheat/sheep farmers into groups on the basis of their strategic approach to farm business management;
to ascertain whether business performance varied across groups;
to ascertain whether the use of business planning aids varied across groups and to identify approaches for increasing the use of such aids within each group.

Background

A long-standing objective of the farm management profession has been the development of decision aids for use in farm business planning. This objective has been based on the assumption that the provision of more sophisticated aids will lead to improved farm business performance. The development of better aids continues as is evidenced by the interest of the profession in computer-driven decision support systems.

This interest by members of the farm management profession in developing better planning aids appears not to be supported by the majority of farmers. In other words, while some members of the farm management profession believe farmers need better planning aids, only a minority of farmers make regular use of the aids that are already available.

The usefulness of planning aids to farmers will depend on the types of planning activities they undertake. These activities, in turn, are a function of the types of strategies farmers follow in managing their farms. The relationship between strategy, performance and use of planning aids was investigated in this study.

Research

Data on farm management strategies were gathered by means of a mail survey of farmers in the wheat/sheep zone of southern Australia. Cluster analysis was used to classify farmers into groups. Statistical analysis revealed that farm business performance (as measured by equity) and the use of planning aids differed significantly across the groups. Set correlation analysis indicated that differences in farm business performance were the result of differences in strategy.

Outcome

A major finding of the study was that, on both theoretical and empirical grounds, those farmers who followed strategies which entailed a high level of tactical planning and frequent use of decision aids were the most likely to exhibit superior business performance.

These results cast considerable doubts over the usefulness of existing farm planning tools as aids in the strategic management of farm businesses.

Implications

It is hoped that the results of this project will be influential in bringing about a reorientation in the farm management profession towards the study of the strategic management approaches used on farms. We believe that an improved understanding of how and why farmers manage their businesses in the ways that they do may provide a foundation for the development of a different set of planning aids with greater application to the particular strategic approaches in use on farms.

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119. SHELF-LIFE EXTENSION OF FRUIT SALAD

tropical/subtropical fruits in a fruit salad;
to investigate the application of modified atmosphere packaging for extending the shelf-life of minimally processed fruit.

**Objectives**
to extend the shelf-life of fruit-containing salads beyond four days at 5°C using a Hazards Analysis Critical Control Points approach;
to incorporate

**Background**
The trend towards high quality, 'all-natural', 'healthy' foods is leading to a higher consumption of fresh fruit at the expense of processed fruits. In 1989, RIRDC identified value-adding and new plant products as priority areas in its R&D program. Similarly, fruit processing had been identified by the subcommittees of the Queensland Fruit and Vegetable Growers responsible for passionfruit, pawpaws, mangoes and pineapples as a priority research area. Furthermore, oversupply of fresh tropical and subtropical fruits has been reported by the Industries Assistance Commission and minimal processing of such fruits would provide a market for surplus supplies.

**Research**
Three areas of research were undertaken. First, the length of time a fruit salad could be stored before there were detectable changes in its sensory characteristics was determined. Second, changes occurring in individual components of the fruit salad were studied. Finally, using rockmelon dice as a test, fruit pieces were stored under modified atmospheres to see what effect this had on shelf-life.

**Outcome**
Results indicated that fruit pieces, whether or not they were included in a salad and irrespective of variety, had a short shelf-life. Honeydew and pineapple had the longest shelf-lives, 11 to 14 days, of any fruit tested. Storage of rockmelon dice under modified atmospheres extended their shelf-life from four-days to at least thirty-eight days. To achieve these results, rockmelon pieces free of microorganisms were prepared. Procedures for large-scale production of low-microorganism-count fruit dice are needed for the commercial production of extended shelf-life rockmelon pieces. Results from the research have been transferred to industry via articles in journals and magazines and through media releases and conference presentations.

**Implications**
The project has highlighted a need for more research on the microbiology of fruit. Notably, the existence or otherwise of a resident microflora within the tissue of sound fruit needs to be established so that appropriate treatments for the control of microbial growth can be designed. Also, the growth of disease-producing organisms under low oxygen and high carbon dioxide atmospheres used in modified atmosphere packaging needs to be tested.

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PUBLICATIONS:
and ports and the implications for Australia’s rural exports.

**Background**

International liner shipping through the 1970s and 1980s came under significant cost pressures; and cost rationalisation has meant the emergence of new shipping networks and land transport arrangements. Particularly, container vessels now commonly hub on major ports and link inland destinations by rail and road.

These developments have significant implications for Australian export movements generally and for large volumes of high-value rural exports particularly. Will direct shipping services between Australia and Europe, for example, continue to be a dominant pattern? Or will there be a trend to hubbing on one of the major hubs? The project focused on these issues.

**Research**

The Centre carried out detailed analysis of container shipping operations to and from Australia. Computer analysis of ship movement data provided insight into the structure of present networks and assessment of liner shipping capacity and operations was made from a number of databases.

**Outcomes**

The Centre suggested four hypothetical scenarios:

- a ‘minimum change’ scenario. Despite far-reaching changes in the Northern Hemisphere Australian exports continue to be handled by direct services;
- ‘Feeder’ scenario. The Asian feeder networks extend into Australian services with major trades handled via Asian hubs;
- ‘Megacarrier’ scenarios. One or more of the megacarriers links Australia into Round-the-World or Pendulum services;
- ‘Hybrid’ scenario. In the short and medium term Australian trades are served by two or more types of service.

Currently, Australian liner shipping is in a state of flux. Feeder services are actually operating Fremantle–Singapore; Brisbane is focussing traded volumes via Singapore and/or Hong Kong; trans-Pacific trades are increasingly hubbing on Singapore; but no megacarrier yet hubs on an Australian port and direct services continue.

**Implications**

Rural and other exporters can find significant new flexibilities for cargo routing in the 1990s and must be aware of the new opportunities afforded by intermodalism and hub-feeder operations.

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Climate change and the so called ‘greenhouse effect’ pose both opportunities and threats for Australian agriculture. Higher carbon dioxide levels will enhance plant growth rates, lower rainfall, and reduce soil moisture availability. Reduced productivity overseas will offer market opportunities, but a climatic shift in Australia may reduce our production base.

RIRDC has a small strategic program of research on climate change specifically orientated to the likely impact on agricultural industries. It is co-ordinated with the core program established by the Prime Minister which is focusing on advanced climatic modelling for Australia as a whole together with international liaison. RIRDC provides a co-ordinating role for rural industry research funding interest in climatic change and greenhouse effect issues.

The Corporation will continue to sponsor research, reviews and workshops that advance understanding of the phenomenon of climate change and foster debate on how its impacts might be exploited or ameliorated, as the case may be, in either policy or practical terms.
121. SIMULATION AND PREDICTION OF LARGE SCALE RAINFALL VARIABILITY

Objectives

to simulate, with a global climatic model, years with observed enhanced rainfall over Australia, and to reproduce with the necessary accuracy the spatial, temporal and quantitative rainfall variations observed;
to identify positively the precursor mechanisms, particularly the role of local sea surface temperature (SST) anomalies around the coast of Australia;
to conduct predictive experiments involving either hindcasts or actual predictions of enhanced rainfall situations.

Background

Numerous observational studies have established that interannual rainfall anomalies over many parts of the globe can be related to sea surface temperature (SST) anomalies in the equatorial Pacific Ocean. This suggests that, if such anomalies can be predicted seasons in advance, then prediction of rainfall outcomes for the same timescales could be made.

In addition, studies have also indicated there may be a relationship between SSTs to the north and the west of Australia and rainfall during winter. This relationship may be a source of seasonal predictive skill beyond that associated with the Pacific SSTs. Climate models are now being used to simulate these types of relationships and are also being tested as a means of predicting rainfall anomalies given SST predictions.

Research

Relationships between Australian rainfall anomalies and SST variations have been investigated by a series of model experiments involving:
a coarse resolution model and observed SSTs for the period 1950–1988;
a moderate resolution model and observed SSTs for the period 1979–1988;
a high resolution model using observed SSTs for 1993; and
a very fine resolution, limited area model using the observed SSTs for July 1978.

Real-time rainfall predictions for 1991 and 1992 were conducted using predicted SSTs from a research group in the USA.

Outcomes

The coarse and medium resolution models are capable of reproducing some of the large scale SST-related climate but less so at the regional scale. An improved, high resolution model provides a better representation of seasonal mean rainfall over Australia and also appears to better simulate observed anomalies during 1993. July 1978 was a time when the relationship between rainfall and SSTs to the north and west of Australia was apparently very strong.

The results from both the coarse and very fine resolution models did not reveal any significant impact of mid-latitude SST anomalies in the Indian Ocean on simulated rainfall. In 1991 and 1992 extensive droughts occurred over eastern Australia and southern Africa. These outcomes were broadly predicted correctly, particularly the situation over Australia in 1992 when contrasting dry/wet outcomes late in the year were obtained.

Implications

Current models adequately simulate the large scale relationships between El Nino events and rainfall in the tropics. There is little evidence of a strong relationship between Indian Ocean SSTs and simulated winter rainfall. The development of higher resolution models appears to be necessary if more accurate dynamic seasonal predictions are attempted in the future. Also needed will be accurate ocean models which can lead to more comprehensive and accurate prediction schemes.

RIRDC Project No: CSG-2A
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Objectives
to quantify the rate of emission of the greenhouse gas, nitrous oxide from legume-based pastures in south-eastern Australia;
to examine the role of liming as a possible management strategy for reducing these emissions.

Background
One of the current environmental issues facing the Australian rural industries is the possibility of climate change due to the enhanced greenhouse effect, particularly the contribution of the rural industries to anthropogenic gas emissions. In the National Greenhouse Inventory 1988 and 1990 for Australia, the major emissions of trace gases from the agricultural sector were listed as methane and nitrous oxide, with nitrous oxide making up about one-fifth of the combined emissions.

Research
Research was carried out to establish the relationships between the rate of nitrous oxide emission from legume-based pasture and measurable controlling factors: (1) the proportion of legume cover in the pasture, (2) dry matter production and its nutrient content, (3) organic carbon and nitrogen levels in the soil, (4) nitrogen fixation and denitrification rates (determined by isotopic methods), (5) animal grazing via urine deposition and (6) weather conditions. The influence of liming on emission rates was also measured.

Outcomes
The annual average emission of nitrous oxide from the legume pasture was about 0.35 kg of nitrogen per hectare, the highest emission rate observed so far on an annual basis from Australian agricultural or natural ecosystems. The annual emission rate of nitrous oxide measured was 0.12 kg of nitrogen per hectare from a native forest in Gippsland in Victoria.

Legume pasture in Australia emitted nitrous oxide at a rate of 5–50% of most grazed grasslands in the northern hemisphere. This is presumably because the soils in Australia generally are much poorer and, while nitrogen fertilisers are used on pastures in the northern hemisphere, they are generally not used on legume pastures in Australia.

Adding lime to legume pasture did not significantly affect the emission of nitrous oxide.

The transformation of fixed nitrogen into free nitrogen and its return to soil via urine and faeces results in an extremely non-uniform increase in gaseous nitrogen losses. Between 0.1% and 0.2% of urine nitrogen was found to be released as nitrous oxide. For a stocking rate of 11 sheep per hectare, an annual emission of nitrous oxide of 0.2 kg of nitrogen per hectare was calculated.

Implications
This study has provided the current best estimate of the combined methane and nitrous oxide greenhouse gas emissions from improved grazed pasture to be nearly 20% less than that previously estimated in the national inventory. The study indicates that the estimate of nitrous oxide emissions from grazed legume pasture in the national greenhouse gas inventory should be substantially reduced.

RIRDC Project No: CSD-47A
Objectives
To carry out a regional analysis of the economic effects of policy actions, at both the state and national level, to reduce greenhouse gas emissions in the Australian agricultural sector; and to study the effects of greenhouse gas reducing technologies on agriculture.

Background
Based on agreements reached at the Toronto conference on Atmospheric Change and Global Security, the Australian government proposed to reduce aggregate emissions of all greenhouse gases to their 1988 levels by the years 2000 and by a further 20 per cent by the years 2005.

This proposal, which may be modified before final policies are put in place, is subject to similar action being taken by other countries and provided such action will not substantially affect the comparative advantage of Australian industries.

Research
The effects of reducing emissions of greenhouse gases on the agricultural sector in Australia were analysed using a non-linear agricultural sector model. A preliminary, and highly aggregated version, of the proposed model had already been developed by ABARE.

A disaggregated version of this model was developed that allowed analysis at a state-by-agricultural-zone-level, thus giving sixteen regions in Australia. The model was used to explore the impact of a hypothetical emissions tax on Australian broadacre agriculture and the practicability of reducing greenhouse gas emissions by technical changes such as increased adoption of minimal tillage for crops, and alteration of methane emissions from ruminants by changing livestock and pasture management.

Outcomes
On average, the effect of reducing greenhouse gas emissions from Australian broadacre agriculture by 20%, using an emissions tax, would be to reduce farm cash incomes by 36%. There would be considerable variation in the impact on regional farm incomes. The least affected region is the high rainfall zone of Western Australia while the most affected regions would be the Northern Territory where the average loss of farm cash income is estimated to be $50,345 per farm. Thus an emissions tax is likely to lead to major structural adjustment in the longer term as a result of the estimated short term changes in farm cash incomes.

Changes in cultivation practice can reduce the loss of soil carbon associated with cropping, and changes to ruminant nutrition and stocking rates can reduce methane emissions. Changes, such as these, are unlikely to produce very large individual reductions in greenhouse gas emissions but there may be potential for a useful cumulative reduction if greenhouse gas emissions are taken into account in planning for research and extension in livestock and cropping industries.

Implications
The main implication of this analysis is that policies designed specifically to reduce greenhouse gas emissions from agriculture, in all states and regions, should concentrate first on encouraging the
adoption of low emission technologies and the build up of carbon sinks. This is because a direct approach to reducing emissions from crops and livestock, such as the emission tax simulated in this analysis, would impose large costs on farmers to achieve the target level of greenhouse gas emissions with current technology.

It can be inferred from the simulations presented that substantially reducing greenhouse gas emissions from Australian broadacre agriculture by an emissions tax would be costly. However, some reduction could be achieved at a relatively low cost by adjusting farm management practices. On this basis, an emissions reduction policy for Australian broadacre agriculture would be best directed toward research and extension to encourage the adoption of low emission practices and to build up carbon sinks rather than be directed at industry specific emission taxes.

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124. GCTE WORKSHOP ON POTENTIAL IMPACTS OF GREENHOUSE GAS REDUCTIONS ON AUSTRALIAN AGRICULTURE

Objectives
To bring together researchers, research planners and funding agencies to consider the economic implications of ABARE Research Report 94.5 Potential Impacts of Reductions in Greenhouse Emissions on Australian Agriculture: a regional analysis as part of the Global Change in Terrestrial Ecosystems Workshop on the impacts of global change on rangelands and improved pasture.

Background
The estimated cost of meeting the emissions target of a 20 per cent reduction in greenhouse gas emissions from Australian broadacre agriculture is $652 million. The estimate is based on modelling of farms producing wool, sheepmeat, beef, cereals and other grains. The modelling was carried out by ABARE with financial support from the RIRDC and is designed to assist in the development of greenhouse gas response strategies for the Australian agricultural sector at a state and regional level.

Research
The ‘Global Change and Terrestrial Ecosystems Workshop’ was held from 12 July to 15 July in Canberra at CSIRO Division of Wildlife and Ecology in Gungahlin. The workshop was to consider the driving forces of climate atmosphere and socio-economic externalities and how they would effect the underlying ecological system, before drawing conclusions for different land uses and regional policy making in the Australian Rangelands. The initial emphasis was heavily scientific with some sociological input. RIRDC assistance allowed for an economic input from ABARE which would not otherwise have existed.

Outcomes
The results of the workshop are incorporated in the workshop report. It was published as a GCTE/CSIRO working paper.

The main outcomes of this RIRDC funded project was to increase the level of economic input into the technical workshop which would otherwise have been entirely scientific. The value of this input was expressed by the organisers.
The Meeting of the Parties to the Rio treaty in Geneva next month is likely to refocus attention on greenhouse gas emissions from Agriculture. In particular, new estimates of emissions from tree clearing for agriculture suggest that this is a very large source of greenhouse gas emissions, possibly second only to electricity generations.

**Implications**

The limited number of economists taking a direct interest in greenhouse gas emissions from Australian agriculture suggests that further presentation of results of research in this field is needed before useful discussions can be held. A presentation on the research was made at Orange and Sydney in July 1995 and a further presentation is planned for Melbourne later in that year. Both these presentations are funded by RIRDC as part of the original research reported in Research Report 94.5.

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### 125.GCTE WORKSHOP ON IMPROVED PASTURES AND RANGELANDS

**Objectives**

to develop a state-of-the-science statement of the likely impacts of global change on the Australian rangelands, as an input to the development of the National Strategy for Rangeland Management (NSRM), and as a case study for the international community;  
to further develop international work on the effects of global change on rangelands and improved pastures, by defining an initial set of projects for GCTE Task 3.1.3 and identifying gaps in the coverage of representative agroecosystems.

**Background**

Global change is the combined effect of humans on the atmosphere, climate and land use. There is still uncertainty about the precise extent of impacts on the climate, and projections for the other factors depend on the response of governments and people over the coming decades. However, there is no doubt that the composition of the atmosphere has changed due to human activities, nor that land use changes have taken place.

In this context, Australia is developing a national strategy for the management of its rangelands (NSRM). This strategy must incorporate a longer term view of how external factors such as global change may drive the future of the rangelands.

In conjunction with the Global Change in Terrestrial Ecosystems (GCTE) Core Project of the International Geosphere-Biosphere Program, the Commonwealth Department of Environment Sports and Territories (DEST), the Meat Research Corporation and CSIRO Division of Wildlife and Ecology, this project therefore developed a state-of-the-science study of the likely impacts of global change on the Australian rangelands, from an inter-disciplinary point of view.

**Research**

A carefully structured workshop gathered about sixty delegates with expertise relevant to global change and rangelands, from Australia and internationally, to a workshop in Canberra in July 1994.

**Outcomes**

a written report on potential impacts on the Australian rangelands was completed and provided to the NSRM Working Group. It also identified some opportunities for RIRDC;
Implications
There are numerous implications identified in the full report (summarised on pp53–56). Some key points are:
industry must keep a watching brief on the range of global change scenarios currently believed possible, and maintain producer awareness of these; a number of existing trends, such as managing for climatic variability and extremes, and coping with woody weeds, will be exacerbated.
there are significant opportunities for industry which result from the impacts of global change on the SE Asia region — a workshop is needed to explore this for long-term planning (rice is a key example);
there are also implications for research, including: the need for a better understanding of hydrological processes; landscape redistribution of water; some soil processes in relation to C, N and P dynamics; and carbon sequestration options in rangelands. Importantly, GCMs are still not able to predict inter-annual variation in rainfall, including the effects of ENSO.

Objectives

to evaluate the opportunities and costs of changing management to reduce greenhouse gas emissions from the Queensland beef and sheep pastoral industries;
to establish methodologies for a similar evaluation of wheat cropping and temperate sheep grazing systems.

Background
Global climatic changes have been widely forecast to result from increases in the atmospheric concentration of radio-actively active (or ‘greenhouse’) gases such as carbon dioxide, methane and nitrous oxide and the Australian Government has made commitments to reduce emissions of these gases. Australia's agricultural industries are significant emitters.

Hence, there is a need to determine whether there are practical, economically and environmentally sound management options that will allow agriculture to reduce emissions, and if so, what costs are associated with different levels of emission reduction.

Research
Existing simulation models of sheep/wool, beef cattle and wheat cropping enterprises in Australia have been adapted to include carbon and nitrogen flows and storages and emissions of methane, nitrous oxide and other greenhouse gases.

These models evaluate the effects of management decisions (e.g. changing stocking rate, clearing trees, changing burning regime, crop variety, time of sowing etc.) and climatic variation on pasture condition, animal performance, crop yield and farm financial status. They are suited to a wide range of ecosystems throughout Australia and are accepted by the farming community as giving practical results.

The modified models have been used to investigate management options relevant to each industry, to determine the opportunities for reducing emissions and to determine the costs involved in emission reduction strategies.
Outcomes
In the temperate sheep and tropical beef grazing systems investigated, there appear to be management options that can result in cost-effective reductions in greenhouse gas emissions.

In the tropical systems, these options include reducing stocking rates where these currently result in greater than 30% utilisation of pasture and optimising burning and clearing practices.

In the temperate systems, alteration from the current practice of autumn lambing to spring lambing and concurrent adjustments to stocking rates may also reduce emissions without economic penalty. Preliminary studies with the tropical sheep grazing and wheat systems model suggest similar results.

Implications
The management practices investigated here that provide cost-effective ways to reduce greenhouse gas emissions are often those promoted in Landcare. Hence, there exists an opportunity to quantitatively link Landcare and climate change issues. However, there remain challenges in validating these modelled results, extending this information effectively and incorporating the greenhouse benefits of Landcare activities in the National Greenhouse Gas Inventory.

Objectives
To allow an exchange of information on the changes in

127. LAND USE AND LAND COVER CHANGE IN AUSTRALIA

land use and land cover in the face of global change.

Background
The Academy of Science, The Academy of Technological Sciences and Engineering, the Academy of Social Sciences in Australia and the Institute of Agricultural Science joined to hold this Symposium as an initiative of the Science Academy's National Committee for the International Geosphere Biosphere Program.

Research
RIRDC assisted four key speakers to attend the symposium.

Outcome
Many of the papers presented provided an overview of land use change, the relevance on global climate change models and the ways we can plan for future change. The land related problems the symposium was concerned with include: soil degradation (salinity, acid soil, compaction, nutrient depletion, organic matter levels), soil loss (erosion), loss of prime agricultural land, soil organic carbon levels, biodiversity, anticipation of the impacts of climate change, socio-economic pressures and implications for economic growth.

Implications
The symposium facilitated review of the body of work which now exists which details opinions and possible solutions to land related problems from the perspective of both Natural Scientists and Social Scientists. This is a valuable resource for those continuing to investigate this area of science, and may lead to further investigation, as a result of questions raised.
CLIMATE CHANGE

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The proceedings of the symposium are available in a special issue of ‘Land Degradation and Rehabilitation’ published by W.J. Wiley. Volume 5, No.2, available from the Australian Academy of Science.
EXTENSION AND INFORMATION SYSTEMS

The evaluation and adoption of new technologies by Australian industry is critical to their continued development. The Corporation requires that the extension phase be considered in all individual projects and programs. Additionally, the Corporation believes a specialist program in extension and technology transfer is warranted.

Extension as we have known it is changing; its operating environment is changing and the needs of our stakeholders in rural industries are changing.

Advances in communications technology have exposed Australian industry and researchers to a massive amount of new information.

The cost and relevance of information systems have also been a factor in farmer decision making and adoption of new information technology. New generation equipment and processing software may resolve some of the earlier problems with detail and cost. Research groups within Australia and overseas have also been progressively developing applications for agricultural industries.
**Objectives**

to develop a library of digitised images managed by a database with the aim of making these images more widely available;

to develop a training and support program in pest identification for use at a range of levels of expertise;

to emphasise three areas — stored product pests, pests of imported and exported plants and fresh produce and timber.

**Background**

Access to insect images has been restricted by the cost of publication. The ability to reproduce images cheaply on CD-ROM permitting their further usage in print, video etc. and to have a library that can be consulted on a Bulletin Board extends their availability nationally and internationally.

Insect identification is restricted by the difficulty found by non-professionals in reading traditional insect keys. This limitation can be reduced by the development of keys on computer that rely mainly on images. Appropriate training material can improve pest management skills and performance of Quarantine Inspectors and others involved in trade in commodities.

**Research**

The project aimed to acquire suitable equipment, develop expertise in handling images and digitise a large number of the illustrations held by the Queensland Department of Primary Industries (QDPI). These images were used to develop suitable text, video and keys for the training and support of Quarantine Inspectors. This approach is applicable to a range of the needs of rural industries.

**Outcomes**

A library of 4000 digitised images is now held on computer in QDPI and the Cooperative Research Centre for Tropical Pest Management (CRC TPM). A database for the management of these images is nearing completion. The images have been used for training and support in text, video and as computer-based images for Quarantine Inspector on pests of stored product, timber, fresh produce and plants. The material on stored product and timber will be further adapted to supply the needs of industry in pest management and the development of quality assurance programs.

The library and the equipment have facilitated the CRC TPM in the production of computer-based software tools for training and support. These include *Diagnosis, Wincirus* and *Wincotton*. This work will continue with plans for the development of computer-based keys and software to permit teaching about pests and pest management.

**Implications**

There is considerable potential to expand the resources established by this project and their exploitation to improve rural production and export potential.

RIRDC Project No: DAQ-142A

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Objectives

to update and expand the Australian Rural Research-in-Progress (ARRIP) database to include all publicly-funded rural research in Australia;
to promote the database to encourage its use either on-line via AUSTRALIS, or by CD-ROM, by research and extension workers, research managers, administrators, research organisations, agribusiness, the media and producers;
to encourage the electronic transfer of data into the database and the production of publications and requested information from the database.

Background

ARRIP is a comprehensive and valuable information source of rural research-in-progress throughout Australia, and is easily accessed on-line via CSIRO’s AUSTRALIS information system.

Research

regular contact was made with contributors, and all departments and large contributors encouraged to provide project data electronically;
Australian AGDEX codes were replaced with more comprehensive International codes (AGRIS);
data input forms were redesigned to incorporate a unique project identifier;
the manipulation of ARRIP data into specialist publications was encouraged;
alternate types of media for outputs from the database were developed.

Outcome

Four state government departments of agriculture are now providing data input to ARRIP via electronic transfer. Terminology and guide terms have been improved to make the search fields easier to understand and more compatible with those of overseas agricultural databases.

Implications

The substantial increase in search requests and the provision of information packages and specialist material demonstrates the value of ARRIP in: providing rapid access to up-to-date information on rural research; promoting better coordinated rural research; reducing research duplication; and providing rapid access to agricultural information on an international basis.

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Objectives

to evaluate the effectiveness of the Hamilton Environmental Awareness and Learning Project (HEAL) in providing a landcare extension service;

Background

HEAL is concerned with promoting awareness and learning related to ameliorating land degradation and to environmentally-enhancing land management practices. HEAL visits had a significant impact on the ideas and thinking of most visitors — both farmer or landholders and tertiary students. Many visitors presented detailed and extended expositions of ideas they had derived from the visits, indicating that the ideas formed were strongly held.
Research
Within these objectives the study sought to establish the extent to which people develop and use knowledge gained from using the HEAL service.

Separate studies of the two major groups of demonstration visitors: farmer/landholders and tertiary students were undertaken. Information was also obtained from Landcare facilitators or coordinators about aspects of the HEAL program.

Outcome
There was considerable behaviour change as a consequence of HEAL visits — 60% of farmer/landholder visitors nominated activities they had undertaken as a result of the HEAL visit. At least half the farmers in the focus groups indicated they had undertaken some activity, or had been reinforced in existing activities, as a consequence of the HEAL visit. Half of the tertiary visitors indicated that they intended to do something different in work or private life as a result of the HEAL visit. Tertiary and farmer visitors frequently claimed they had been enthused, and sometimes inspired, as a result of the visits to HEAL sites.

Implications
Environmental extension programs, such as the HEAL program, once they are established on a commercial basis, are a potentially efficient way for a large number of people to observe and learn about land management systems, practices and techniques. When established on a fully commercial basis, they may provide an additional source of income for participating farmers. Recommendations related to the development of similar environmental extension programs are considered in the report.

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131. VEGETATION WATCH — NEAR REAL TIME SATELLITE INFORMATION FOR VEGETATION MANAGEMENT

Objectives
To set up, calibrate and evaluate a system in WA for producing and distributing near-real time AVHRR satellite measure of green vegetation cover and change.
To distribute this information to managers of vegetation dependant systems across the state to evaluate its use for making tactical and strategic decisions.

Background
Vegetation systems, by feeding our population, moderating our climate, assimilating our waste and providing a major sink for fossil fuel CO₂, play a critical role in modulating whole-earth responses under increasing population pressure and climate change. By virtue of their capacity to regenerate, after-use vegetation systems are renewable resources that are essential for ecologically sustainable development. However persistent mismanagement of these systems continues to contribute to major land and environmental degradation.

Research
Green vegetation cover was measured by the difference between near infrared and visible reflectance divided by their sum to give the Normalised Difference Vegetation Index (NDVI). The individual reflectances and thermal infrared temperatures were used for other purposes such as fire scar mapping.
Outcomes
A largely automatic end-to-end system for the routine processing of AA-AVHRR satellite data into a number of image products was developed.

The Bus Fires Board successfully deployed fire fighting resources in areas of fuel load build up identified from the NDVI images. Improved forecasts of fire risk were made in the south-west using estimates of fuel flammability based on estimates of grassland curing from the decline in NDVI.

The Department of Agriculture, Western Australia and Northern Territory Department of Primary Industry successfully used the time series of NDVI from 1991 to 1995 to advise Government of the major drought affected areas in 1994. WATBAL estimates proved unreliable because pastoralists often corrupt their rainfall records to produce an outcome in their favour. The time series were also incorporated into DAWA’s pastoral lease report to the Western Australian Pastoral Board to provide a more accurate assessment of seasonal conditions and were seen as a method for providing tactical advice on stocking rates by regional officers.

Significant correlations of the NDVI between July and September with final wheat yields, indicated the potential for use in crop forecasting in agricultural areas.

Implications
Successful use of the NDVI time series and images for such management and forecasting tasks requires a high level of quality control to remove the not insignificant effects of trends caused by changes in the AVHRR sensor and from cloud effects.

Accurate interpretation of the changes in NDVI requires integration with other geographic information sets.

The wide range of applications in near real-time NDVI indicates that this is now a novel source of information of changes in green vegetation cover.

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**Research**

From the outset, Digging for Profit was combined with a larger, but very similar project called Right Rotations (funded by GRDC). All cereal root disease activities undertaken as part of Right Rotations were financed by Digging for Profit, including 83 cereal root disease workshops throughout the State in the winter months of 1991 and 1992. These locally convened, half-day workshops involved about 2200 farmers with 'hands on' activities, and were supported by high quality extension materials. Both the cereal root disease workshops and the larger Right Rotations program were evaluated.

**Outcome**

Participants were very positive about the cereal root disease activities. Post-workshop surveys showed that more than 90% said they were in a better position to assess their crops for root disease, while 85% indicated they were willing to change the way they farmed because of the workshops.

When participants were resurveyed after three years in the program, the root disease workshops were considered the best and most effective of the five activities offered under the Right Rotations program. Furthermore, of those making the change to disease resistant and/or break crops to control root disease, most had been influenced to some extent by the root disease workshops.

**Implications**

The basic success of Digging for Profit and Right Rotations can be attributed to:

- its management by a group of practising farmers, using external funding to employ a professional communications consultant for program development and coordination;
- communicating the extension message by using a well-established and functional network;
- involving farmers in their own environment, with hands-on activities, farmer-to-farmer discussions, and novel, but high quality extension materials; and
- encouraging them to address problems — and solutions — at the local level, thus helping farmers to improve their management skills at low cost and lift their profitability through crop rotations.

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**133. TRAINING ACTIVITIES TO IMPROVE BUSINESS MANAGEMENT SKILLS OF FARM FAMILIES**

**Objectives**

- to evaluate the success of a series of farm business management workshops in central Queensland;
- to improve the effectiveness of future workshops and training activities;
- to provide a model for improving the farm business management skills of farm management teams;
- to provide evidence of the contribution computer based approaches can make in agricultural extension.

**Background**

In central Queensland, the Queensland Department of Primary Industry is conducting a series of workshops to improve the business skills of farm families. This work has revealed that while we have ideas about what the ideal record keeping and management system might be, our knowledge of how farmers (including farm families) presently manage their farms, and to what extent they are prepared to accept systems we propose, is relatively poor.

**Outcomes**

Three surveys of producers in central Queensland have been conducted. The accounting skills of the general farming population are very varied. These surveys have shown that the skills that producers are
learning at workshops are being incorporated into bookkeeping practices but the influence on decision making was less direct.

Financial decision-making skill has traditionally been thought of in terms of extent of use of standard quantitative tools such as cash flow budgets or gross margin analysis. The farmers' view of decision-making is far more qualitative. The research emphasizes that appropriate indicators of decision making ability would also include communication and information-integration skills.

Implications
The workshops in central Queensland have been very successful in equipping a broad cross section of farmers with tools to improve their business management. This has provided a firm base on which to further develop their decision-making skills. A new follow-up training course has now been developed to focus on the process of decision-making. Training in farm management processes needs to be based on real farm decisions.

Objectives
- to improve the adoption of effective farm business management and promote farm and family viability;
- to provide skills enhancement programs through forty business management groups designed to accelerate learning from, and sharing information with farmer peers, scientists, agribusiness, consultants and policy makers;
- to create a funding and resource partnership between farmers, agribusiness and RIRDC and evaluate this approach to non-government funded extension.

Background
Leading farmers were concerned about the delivery of extension services in the late eighties. There had been a noticeable withdrawal of government services of a direct face-to-face nature. At the same time emerging, intensive, broadacre farming systems were causing grower concern.

Research
The project was evaluated by John Cary, The University of Melbourne, School of Agriculture and Forestry. The purpose of the evaluation was to assess the impact of the project on participating farmers' management behaviour and outlook.

Outcomes
Between 1992 and 1994 the number of business indicators used by Farm Managements' 500 members increased significantly. There was increased and more sophisticated use of analyses and indicators for judging the success of farm businesses; and there was a significant increase in members' use of computers in the farm business. More than three quarters of members considered computers to be very useful or essential in their farm business.

Farm Management 500 members were less conservative, had much stronger disposition towards planning, and a greater sense of control in management-decision making than other Australian farmers in the agricultural and grazing industries.

Business Management Practices. Members are now very actively monitoring:
- preparation of budgets and monitoring flow;
- reviewing estate plans on a regular basis;
- taking soil samples/tissue tests and conducting nutrient audits.

Computers in Business. Ownership of computers is increasing with 72% of members using them in farm/business planning. Software is being used for financial, farm and family management. Farm Management 500 is pro-active in creating, testing and recommending relevant business planning software.
Business Planning. Members' assessment of their abilities to undertake management planning tasks vary and they are using a wide range of indicators by which members judge the economic health of their farming business.

Implications
By most standards, Farm Management 500 has been a very successful model of management extension and farmer education. It should not be assumed that such a program is easily replicated. The development of the project involved multiple commercial sponsorships. It was not possible to convince the farmer members to assume full financial ownership. Strong project leadership and a group of 15 independent consultants to work as a team is also a unique achievement.

If government is serious about the development of sustainable broadacre farming they will have to focus on skills enhancement for families at the sharp end of agriculture. Improved farm business management will lead to improved profitability and the ability to fund sustainable development.

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Objectives
- to increase the rate of uptake by farmers of newly released pasture seed cultivars;
- to develop a model for release of new pasture cultivars based on coordination of production, marketing and extension in chosen target areas;
- to comprehensively evaluate the model so as to allow definition of factors affecting uptake of technology by farmers.

Background
Concern within RIRDC’s of implementation projects involving new pasture cultivar development highlighted a need for more effective models for release. Existing problems and concerns have been outlined in the reports to RIRDC ‘Development of National Projects in Extension’ and ‘A Survey of Australian Demand for Temperate Pasture Seeds’.

A system of release that avoided possible restriction of new cultivars to low volume niche markets with premium prices and high add-on costs is a desired outcome for funding bodies supporting public breeding efforts with the expectation of gaining income from royalty streams.

It is also desirable that new cultivars with superior merit over existing lines be more rapidly and widely taken up by farmers to maximise the flow of benefits to them.

Research
The project was implemented by developing an integrated model for the commercial release of new pasture cultivars. Three suitable new cultivars were selected and two main target areas chosen in which to comprehensively implement and evaluate the model for release.

Outcome
Commercially, the project was very successful in gaining rapid and widespread uptake of all three new cultivars both in the target areas and over a wider region of temperate Australia. This was despite a particularly difficult period in the pasture seed industry with low profitability and widespread drought in the second year of the project.
A survey is currently being conducted both within and outside of the target areas involved in the project in an attempt to evaluate the effect of the model; and to further define the factors behind farmers decisions to renovate pasture and use new cultivars.

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Objective
To provide critical input into the Extension Conference activities from an extension users' perspective by sponsoring extension users to attend the Australia-Pacific Extension Conference

Background
In October the Queensland Department of Primary Industries conducted the Australian Pacific Extension Conference under the auspices of the Standing Committee on Agriculture and Resource Management (SCARM). SCARM recommended that the Conference be structured around: the changing nature of public extension services; future relationships between public and private extension; and extension and environmental issues.

Research
To expand the number of perspectives focusing on extension practice and theory, and to provide critical input into the Extension Conference activities, thirteen extension users from around Australia representing a broad cross section of industries were invited to participate in the conference.

Outcome
The value of having extension users involved in the conference was apparent. Two presented papers and one presented an address in the plenary session. All participants were conspicuous in the question periods that followed papers or poster sessions, and in informal discussions at other times. They suggest that extension providers/funders/policy makers need to communicate underlying extension processes far better than is currently being done.

Implications
The success of involving extension users in this process of critical review suggests that extension users participation be expanded to other scientific conferences, and other processes even down to individual project planning and implementation. Procedures to fund extension users in these roles need to be created. The benefits of user participation will be a widening of the perspectives brought to bear on a problem situation and ownership of the work from the beginning.

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FARM HEALTH AND SAFETY

The health and safety of the rural workforce is not only a key factor in industry productivity but is also integral to achieving the Government’s aim, through the rural research and development programs, to improve the well-being of Australians.

Health and safety is reflected in the farm business as a cost associated with workers compensation, accident insurance, absenteeism and, all too often, death from tractor accidents, etc. Social costs accrue from stress, allergies, loss of physical or mental ability and from family break-up, etc.

The Corporation has determined a need to actively support community farm safety groups and the extension of Worksafe Australia programs within the rural community.
137. NATIONAL FARM CHEMICAL USERS TRAINING PROGRAM (WA)

Objectives

to raise farmers' level of competency to improve understanding and selection of farm chemicals and to ensure that they are adequately trained in transporting, storing, handling, applying and disposing of chemicals;
to conduct an independent survey to measure the effect of the course on how farmers use chemicals.

Background

Society is becoming increasingly concerned over the use of chemicals in agriculture, horticulture and service industries. Australia's reputation as a producer of clean, green food and fibre relies on everyone in the industry taking a responsible attitude towards chemical use and safety. Extensive controls at State and Federal Government levels and registration and clear labelling go part of the way, but ultimately the chemical user is responsible. To assist chemical users, the National Farmers Federation and the Rural Training Council of Australia have jointly developed a voluntary, self regulatory national Farm Chemical User Training Program for primary producers and service industry users.

Research

A Management Committee of representatives from the Department of Agriculture, the agricultural chemical industry, the Agriculture Veterinary Chemical Association, the Country Women's Association and the Agricultural and Pastoral Industry Employment and Training Council was convened and a marketing plan commissioned to develop the program.

Outcome

An intensive one-day course was developed. It is run by one of ten trainers with a sound knowledge of the use of chemicals in agriculture and uses the West Australian Program Manual. The manual covers six main topics: the product label; personal and environmental safety; employer liability; more informed choice of chemical use; integrated pest management; and record keeping. The course has been approved and accepted by the Skills Standards and Accreditation Board (WA).

Implications

This program will:
improve knowledge of personal and environmental safety for users of agricultural chemicals;
help employers understand how to reduce accidents with chemicals;
maintain and improve industry competitiveness as a producer of 'clean food';
allow more informed decisions about the correct use of chemicals; and
through improved knowledge, result in more efficient crop and animal production.

Phase two of this program is its evaluation by the Curtin University School of Public Health. Funding has been carried over to support the completion of the evaluation and its report will be included in the next RIRDC Research Report.

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138. BETTER COMMUNICATION OF INFORMATION ON CHEMICAL LABELS

Objectives
To determine how:
- farmers currently gain information from chemical labels;
- readily farmers recognise the meaning of graphic symbols related to chemical use; and
- to overcome limitations to the effective communication of label information.

Background
The safe use of chemicals relies on users being willing and able to read and understand agricultural chemical labels. Preliminary observations suggest that labels are too complex in presentation and language.

Research
Surveys and controlled experiments were employed and two widely used chemicals with markedly different toxicities selected. These were glyphosate, which is only slightly toxic, and paraquat, which is highly toxic. A set of pictograms was obtained from GIFAP (the international association of manufacturers of agrochemicals).

Outcome
Farmers were clearly of the opinion that pictograms add to the ease of obtaining information from chemical labels. However, the effect of pictograms in improving the communication of information was incomplete. Even if pictograms present safety information to chemical users in a way that is easier for them to understand, changed behaviour will not necessarily follow.

Until chemical users become familiar with pictograms, it will be difficult to test whether pictograms will change the way chemical users read chemical labels.

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PUBLICATIONS:

139. AN INVESTIGATION OF PERSONAL PROTECTION EQUIPMENT

Objectives
To survey Australian farmers’ current usage and acceptance of personal protection equipment (PPE);
- to conduct a comparative test between various makes of PPE;
- to present a series of feature articles within Farming Ahead.

Background
There is a need for the industry and farm sector to address issues of community concern such as spray drift, operator health, transport and storage and proper disposal of chemical containers. Other personal protection issues such as operation of noisy equipment must also be addressed through education of farmers and equipment operators.
Research
Questions were asked in the National Agricultural Survey in 1992 on personal protection equipment usage. A comparative test was conducted in two parts. Firstly a laboratory test was conducted by Work Cover technicians and included a sample of respirators, eye goggles and gloves commonly used in agriculture were tested against Australian standards. The second part included a test panel review of the products by 14 farmers as to practical useability.

Outcomes
Articles were published in the magazine 'Farming Ahead' to educate farmers on the effectiveness and useability of protective equipment, to stress the need to dispose carefully of chemical containers, and to alert farmers to the risks of industrial deafness associated with use of farm equipment. A ready reference chart was produced and distributed.

Implications
The information generated from this project has been received as credible and practical and should assist in real uptake at the farm level. There is scope for further work on Personal Protection Equipment and repackaging of the existing report to reach further into agriculture.

140. THE ECONOMICS OF FARM SAFETY IN AUSTRALIAN AGRICULTURE

Objectives
- to estimate the incidence of work related accidents in the NSW cropping and grazing industries;
- to estimate the returns to further investment in improved farm safety extension programs;
- to analyse producer attitudes towards safety practices and the identification of incentives and disincentives for farm workers to adopt safety practices;
- to assess the impact of farm safety extension programs in raising farmers’ awareness of safety practices.

Background
A study of work related deaths in Australia from 1982 to 1984 revealed the occupational category “farming, fishing, hunting and timbergetting”, as having the third highest incidence of work related fatalities. Growing community concern resulted in the first national farm safety conference, Farmsafe “88, and the subsequent setting up of local community based Farm Safety Action Groups (FSAGs). The FSAGs sought information on farm safety in the Australian context to guide their activities, but of the studies then available, none presented a comprehensive profile of occupational injury for rural Australia. Research was required to obtain such data.

Research
Following a pilot survey conducted in the Armidale area in 1991, a farm-work related injury survey was conducted over 919 farms in the Shires of Gilgandra, Carrathool and Yallaroi in the wheat/sheep belt of NSW during 1992 and 1993. An injury was defined as where the person required professional medical treatment, one day off work or five days working at a restricted capacity. An injury that required five or more days off work was considered a “serious” injury.

Particulars emphasis was given to the collection of data on personal risk factors, and on the incidence and cost of injuries. Information from 425 farm injuries was analysed using statistical methods to
determine the most common injuries, their associated costs, including medical treatment, transport to
treatment, damage to plant and equipment, replacement labour and production losses, and the
relationship between injuries and risk factors.

Outcomes
One in five properties in the sample reported at least one injury every year, and each farm injury cost an
average of $1000. One in 12 properties reported a serious injury. The costs associated with these
injuries ranged from nil to $26,000 per injury but averaged $2,500. Medical costs made up about half of
these amounts, transport costs for treatment about 15% and costs of farm losses (direct production
losses, damage to plant and equipment, extra labour required) about 35%.

The farm workshop or shed was the most common location for injuries to occur, and almost 25% of all
injuries were of a sprain nature. Age was identified as a risk factor, having a negative relationship with
risk of injury. Previous injury status was also a risk factor, having a positive relationship with risk of
injury. The day time drowsiness scale (proxy for sleep quality) and the level of education were found to
be marginally significant risk factors.

Information form this project has been widely disseminated in the media and at professional conferences
since early 1991. As a consequence of the exposure, it is expected that producers are now much more
aware of farm safety as a significant issue and much more aware of the potential costs to themselves and
their properties of farm injury.

Implications
A large number of specific recommendations were made relating to the survey method and the
measurement of particular variables, to the use of the injury profile and cost of injury information as an
incentive to improve farm safety practices, and to the scattered evidence on attitudes to far safety.

In relation to the last group, while a substantial proportion of producers claimed they were aware of
farm safety issues, unfortunately there still seemed to be a large gap between the acknowledgment of
farm safety as an issue, and the use of improved work practices and personal protective equipment on a
consistent basis. So even though the message is getting through to producers, there needs to be further
effort to encourage producers to convert the changed attitudes into actions.

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to the 36th Annual Australian Agricultural Economics Society Conference, Sydney, February.
Low, J M and G R Griffith 1994. Australian farm work injuries: 1. the diversity of damage, Australian
Low, J M and G R Griffith 1994. Australian farm work injuries: 2. the relevance of risk factors,
paper presented to the 37th Annual Australian Agricultural Economics Society Conference, Wellington,
February.
EDUCATION AND TRAINING

Research and industry skills are key elements in achieving the Corporation's overall objectives for primary industry. Skilled people, prepared to work in the many areas of special interest and responsibility of the Corporation, are a valuable resource.

New industries typically are led by industry entrepreneurs, only some of whom have the resources and management skills for the development of successful new enterprises. Many new marketing, management and leadership skills are required to make the fledgling industries succeed.

In the multi-industry area the issues are generally more complex and there are many more agencies and individuals involved. These factors require our training and education programs to adequately cater for people with multi-industry research and development skills.

The Corporation, through a series of community and industry workshops, has identified leadership skills to be a key constraint in the future productivity and well being of rural Australia. It has taken up the challenge to address the issue and, with the support of industry, has established a highly successful rural leadership program which commenced in 1992-93.
Objective
To enhance the competitiveness and profitability of rural industries through the development of a strong network of highly capable leaders in an international context.

Background
Rural industries are experiencing a period of significant change in markets, infrastructure, significance in the national economy and political support. Leadership development is in its infancy in Australia, especially when compared with our international competitors. In general, access to advanced leadership development courses in Australia has been limited.

Research
RIRDC extensively consulted the rural community on the formation of the training program and drew upon the experiences of the Californian Agricultural Leadership Program and the Williamson Community Leadership Program. The Australian Rural Leadership Foundation then developed the training program as three sub-programs: the participants; the course; and the organisation and structure.

Outcome
The first program started in April 1993 with a one-day leadership course in the Kimberleys. During the next eighteen months, the participants spent a week in each of the five states and the ACT learning about subjects as diverse as production and conflict resolution. Included in the program is a two-week overseas trip to examine export opportunities in Asia. There were twenty-nine graduates of the first course which finished in September 1994.

Implications
The course program has received strong support from the National Farmers' Federation and commodity peak organisations. For an estimated cost of around $35,000 per participant, community, industry and individual benefits should accrue over a subsequent twenty to thirty years of working life.

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PEST AND DISEASE CONTROL

Pest, weed and disease control costs Australian farmers an estimated $800 million per year in chemical and biological control agents before the addition of application costs. Yet without their application an estimated one third of the harvest, valued around $3 billion in 1990, would be lost to pests and diseases.

While pest and disease control is a major economic issue to rural industries, it is also a significant social issue for the community in general which is becoming increasingly concerned about possible harmful effects of residual chemicals in the environment and in food or fibre products.

Pest and disease control is also of multi-commodity concern and while the control of individual pests may be beyond the capability of a particular sector it could be within the resource capability of the industry as a whole. RIRDC recognises a need to work closely with other rural industry research funding corporations and research agencies in pest and disease control and to take a lead role in co-ordination of effort in some circumstances.

The Corporation believes there is an urgent need to reduce the environmental and social impacts on other industries associated with both chemical and biological pest and disease control. It also recognises that pests and diseases are part of a biological system themselves, are continually evolving, and therefore will require ongoing attention.
**Objective**

To collate and promulgate the results of a comprehensive study of aphids and their natural insect enemies and mutualists in Australia by means of a readily accessible computer database and by publication.

The database will provide information in electronic form and in print on the identity, biology, hostplant ranges and preferences, phenology, flight activity, abundance and distribution, vector status, insect natural enemies, mutualists, economic importance and biological control of aphids in Australia.

**Background**

Aphids are important phytophagous pests inflict damage directly as sap suckers, toxifiers and pollutive excretors, and indirectly as vectors of plant virus diseases. Three-quarters of the 170 known aphid species in Australia are exotic, many having been accidentally introduced, and most of these are noxious.

Because of the presumably restricted genotype of many of the introduced species, and the large differences between their original environment and Australia's, aphid performance in Australia is in many respects peculiar to Australia and results of overseas' aphidological studies are often not applicable to Australian aphids.

**Research**

'APHID' Database has been developed. the database is managed by the relational database management system 'INFORMIX-SQL' which runs on a 'SUN' mainframe located at CSIRO Division of Entomology, Canberra, and is equipped with a graphical-user-interface (GUI) using 'INFORMIX-Hyperscript' tools, designed to give the end-user easy-to-use access to database information.

Each uniquely numbered entry is a record of a collection or a citing of an aphid species and any associated biota, if any, and has separate fields in four relational tables for recording the aphid species; aphid morph(s); hostplant data; locality data; collector(s); parasites; hyperparasites; predators; attendant ants; vector activity; literature references; and comments.

Details of classification and nomenclature of all the insect species involved, and the bibliographical references, are entered in four further relational tables. Sundry reports, and graphs and maps of seasonal and geographical distribution, can be generated.

**Outcomes**

The computed data will form the basis of publications, after which the contents of the database will be directly available to other workers. Its continuity and permanence are assured.

**Implications**

'APHID' Database can include, without modification, extra-Australian regions. The application also has the capacity, with little or no modification, to include other biotic systems up to a tetratrophic level; for instance, could be used to investigate host-specificity in Psylloidea (psyllids); or biological control of Coccoidea (scale insects, mealybugs), and Aleyrodidae (whiteflies). The database will be of inestimable value to any workers whose work is aphid-related by providing access to valuable, time-saving starting points and reference sources for almost any aspect of aphid study in Australia.

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Objective
To provide a definitive assessment of the potential for practical and economic field assessment of mycorrhizas.

Background
This support received from the Rural Industries Research and Development Corporation was used to contribute to travel expenses for international speakers to participate in the International symposium on Management of mycorrhizas in Agriculture, Horticulture and Forestry.

Research
The approach was to invite leading international scientists to review the state of knowledge and to identify areas where further research is required. Additionally, there were a large number of invited and contributes posters. Scientists from 28 countries attended the meeting; 110 of the 180 participants were from Australia.

Outcomes
There is considerable potential to obtain greater benefits from the mycorrhizal symbiosis in broad-scale agriculture, agroforestry and the reclamation of degraded soils. Management options that are possible are:
- choice of fertiliser practices, tillage and rotation
- choice of genotype
- prevention of erosion
- nursery or field inoculation of plantation tree species with ectomycorrhizal fungi.

In broadscale agriculture it is unlikely that the introduction of inoculant VA mycorrhizal fungi will be feasible. The potential for inoculant use in horticulture is more optimistic, however use be high levels of phosphate fertiliser will reduce successful use of the symbiosis. Inoculation of trees with ectomycorrhizal fungi is a practical option for increasing seedling establishment and plant growth, however the functioning of the symbiosis requires further investigation (see point 3) in order to obtain maximum benefits.

Implications
There is a need for much greater understanding of the biology and ecology of the fungi and the functioning of the symbiosis to be able to predict and implement the most appropraite strategies for management.

Within the biology/ecology area, the main research needs are:
- to develop approaches that will distinguish among the fungi colonising roots
- to understand changes in colonisation with time within and between growing seasons,
- to estimate the numbers and types of propagules in soils and their response to farming practices.
- to understand the relationship between classifications based on morphological characteristics and the biology of the fungi.

In relation to the functioning of the symbioses, the major research needs are:
- the requirement for detailed studies of mycorrhizal functioning in the field
- to define differences among fungi in their ability to enhance plant growth and soil aggregation.
- to examine whether mycorrhizas us the same source of phosphorus os non-mycorrhizal roots,
- to investigate the role of soil microfauna in the functioning of mycorrhizas
- to examine the role of mycorrhizas in soil structure and water use.
144. EVALUATION OF EGG PARASITOIDS FOR HELIOTHIS MANAGEMENT IN SORGHUM

Objectives
- to collect egg parasitoids of *Heliothis* from field plantings of sorghum and monitor natural levels of egg parasitism;
- to establish laboratory cultures of these parasitoids and develop mass rearing facilities;
- to investigate the oviposition of *Heliothis* on different sorghum hybrids;
- to evaluate inundative releases of parasitoids for managing *Heliothis*.

Background
The development of midge resistant sorghums has elevated the status of *Heliothis* as a pest on this crop. Currently, the use of insecticides provides the only means for controlling the pest. The development of resistance, environmental contamination, and the high cost of developing new insecticides make it imperative that the dependence on insecticides is reduced. Other forms of pest management, including biological control therefore warranting investigation.

Research
In this project, naturally occurring egg parasitoids of *Heliothis* were collected from sorghum in the field. Methods of laboratory rearing and mass production were evaluated, and the effectiveness of inundative releases of the parasitoids were tested in the field on crops of sorghum at different stages of crop growth. The potential for commercially managing *Heliothis* using the egg parasitoids *Trichogramma* and its relatives was then determined.

Outcome
Egg parasitoids of *Heliothis* were successfully recovered from the field, laboratory culturing and mass rearing methods developed, and inundative releases made in sorghum crops at different stages of maturity.

The parasitoids were shown to parasitize eggs of *Heliothis*, but the populations of parasitoids which subsequently developed, were not able to reduce numbers of *Heliothis* sufficiently to prevent crop damage to acceptable levels in all cases.

Implications
The use of egg parasitoids alone, will not provide an economically acceptable level of control of *Heliothis* on sorghum. Their use together with minimal application of insecticides in IPM programs probably warrants further investigation. The rapid increase in the level of resistance to insecticides developing in *Heliothis*, will provide the impetus for this to occur.
Objectives

to investigate the pathology, host range and potency of a baculovirus for the tobacco looper, *Chrysodeixis argentifera*;
to determine the conditions for optimal production of the virus;
to assess the efficacy and persistence of the virus in the field and make a preliminary assessment of the capacity of the virus to achieve economic and non-disruptive control of loopers.

Background

Loopers are caterpillar species which are able to defoliate a wide range of crops, such as grain legumes, oilseeds, tobacco, vegetable crops and ornamentals, but are frequently inadvertently controlled by chemical sprays directed at other pests, such as *Helioverpa* spp.

The development of more selective pest management strategies (with increased reliance on biological control), while highly desirable, is likely to allow loopers to escape from current constraints and elevate them to a more serious pest status. The use of conventional insecticides against loopers could then disrupt effective biocontrol, particularly parasites and predators.

Baculoviruses are exclusively pathogens of arthropods and usually infect a narrow range of hosts. Baculoviruses are prime candidates for looper biocontrol, as their hosts feed openly on foliage rather than in concealed locations, and the viruses would be compatible with other biocontrol agents in an IPM program.

Research

The virus morphology, tissues infected and symptomology were studied in *C. argentifera*. The age-related susceptibility of *C. argentifera* larvae was determined by laboratory bioassay. In addition, the virus was assessed for infectivity for larvae of the taxonomically related species, *C. eriosoma, Diachrysia orichalcea, Helioverpa armigera, H. puntigera,* and *Spodoptera litura*. Optimum conditions for virus production were determined by quantifying virus yield in larvae infected at different ages.

Potted bean and tobacco plants were infested with loopers and sprayed with virus to determine primary levels of infection. The behaviour and food consumption of treated and untreated larvae was recorded. Field plots of soybeans were sprayed with graded rates of virus, and larval mortality and virus persistence was recorded.

Outcome

The virus was highly potent for neonate *C. argentifera*. Susceptibility decreased with increasing age, however an increase in food consumption with age was found to compensate for developmental resistance for larvae up to seven days old. The virus was infective for both *C. eriosoma* and *D. orichalcea*, however neonates of both species were less susceptible than those of *C. argentifera. H. armigera, H. puntigera,* and *S. litura* neonates were not susceptible.

Larvae died on average seven days after infection, however food consumption and general activity declined rapidly after three days. Neonates were the most efficient producers of virus, but maximum yield per larva (2.2 x 10^{10}PIBs) was obtained from larvae infected and six-day-olds.

Virus applied to field plots of soybeans at a rate of 1.9x10^{11} PIBs/ha gave >5% mortality. However, the virus was readily inactivated on the crop, with 40% mortality recorded at two days post-spray and <5% at four days post spray.

Implications

The looper virus shows potential as a looper-specific, non-disruptive biocontrol agent compatible with all other insect control agents and should be used as part of an IPM program. The future use of the virus is dependent on the severity and regularity of the looper problem in the future, which in turn depends on agricultural practices that allow looper infestations to develop, and the effectiveness of natural biocontrol.

### 146.EFFECTS OF PHOSPHORUS ACID ON CONTROLLING PANAMA DISEASE IN BANANAS

**Objective**
To explore whether potassium phosphonate or a derivative prepared from it could be developed as the basis of control of Panama Disease in Bananas.

**Background**
Potassium phosphonate is now used widely within Australia to control diseases caused by members of the genus *Phytophthora*, for example *P. cinnamoni* the cause of avocado root rot and eucalypt die back. The full spectrum of activity of potassium phosphonate is not known and there have been scattered reports which suggested that it could control diseases caused by other classes of fungi and by bacteria.

These reports included one in which some control of Panama disease in bananas had been obtained following stem injection with phosphonate. Given that there is presently no suitable chemical control for *F. oxysporum* var Cubense and only limited banana varietal resistance against race 4, it is important to follow any lead that might give rise to cost-effective chemical controls.

**Research**
The effects of potassium phosphonate on the growth and metabolism of *F. oxysporum* grown in culture were examined. The methods used allowed its effects on a wide variety of metabolic pathways to be observed.

**Outcome**
The study showed that potassium phosphonate strongly inhibited growth of *F. oxysporum* var Cubense (Race 4), but only under conditions where phosphate was present in very low (non-physiological) conditions. Under conditions where growth of the organism was inhibited by phosphonate, the alternations in phosphate metabolism characteristic of phosphonate effects in *Phytophthora* spp. were not observed.

However, subsequent to the study, new methods have shown that phosphonate does alter the production and distribution of polyphosphates in *F. oxysporum* var Cubense. This suggests that there is at least one site of action common to the different organisms and increases the probability of developing an effective control based on phosphonate derivatives. Novel phosphonate compounds which are assimilated more rapidly by *F. oxysporum* var Cubense in the presence of phosphate were synthesised and have been shown to be effective inhibitors in the presence of physiological concentrations of phosphate.

**Implications**
Research showed that *Fusarium oxysporum* var Cubense is sensitive to phosphonate, but that the compound is not assimilated at the concentrations of phosphate found in plants. Since there appears to be at least one site of phosphonate action common to both *Fusarium* and *Phytophthora* it will be possible to synthesise compounds based on phosphonate but which can be readily assimilated under physiological conditions. However, a great deal of developmental work will need to be done to determine whether these compounds can be developed into commercial agrochemicals.

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Objectives
To undertake a state and territory analysis of the diseases caused by Phytophthora. For each state and territory the problem to be broken down into:
the Phytophthora species involved and the crops affected;
economic impact;
current management;
current research;
Research and development priorities and potential returns; and
general conclusions and recommendations.

Background
In Australia, diseases caused by Phytophthora species occur in a wide range of horticultural industries, in pastoral, ornamental and forestry industries and in many national parks and reserves. Diseases caused by Phytophthora are of significant economic importance and impose limitations on the productiveness and further expansion of many crops Australia-wide. In national parks, reserves and state forests, Phytophthora threatens conservation values, reduces species diversity and may cause species extinction. Economically it also affects tourism, reduces timber quality and harvestable volumes and may indirectly increase salination of water supplies.

Outcome
Plant pathogenic Phytophthora species are responsible for significant economic losses across horticultural, ornamental and pasture crops in Australia. It was estimated that direct loss due to Phytophthora disease was at least $223 million across these industries in 1991–1992, equivalent to 3.23% of the estimated gross value of these industries in Australia. Losses to the forestry industry in both softwood plantations and state forests and cost of disease management are significant in Western Australia, South Australia and Victoria. Phytophthora disease imposes severe limitation to the expansion of several industries especially in the ornamental sector.

In 1993, 84% of diseases caused by Phytophthora species were considered able to cause greater damage and loss or are unable to be controlled. Phytophthora cinnamoni is the most widespread and causes disease in many plant species across a range of commodity species and in national parks and state forests in most states.

Other species that are widespread and cause considerable damage and loss include P. clandestina (subterranean clover), P. cactorum (pome and stone fruits), P. nicotianae (tomato, ornamentals), P. infestans (potato), P. cryptogea, P. megasperma, P. parasitica, P. citricola (ornamentals, native species).

Implications
Five key areas were identified for R&D on Phytophthora in Australia:
development of diagnostic kits;
phosphorous acid;
breeding for resistance or tolerance;
integrated management; and
biocontrol

RIRDC Project No: ANU 16A
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Objectives
To develop a rational approach to the use of fungicides to control diseases by:
screening for resistance among natural populations of pathogen;
development of rapid tests for determining resistance levels; and
studying the mechanism of resistance.

Background
Many plant pathogenic fungi are not crop specific and consequently fungicide use on one crop can affect
the development of fungicide resistance in diseases of other crops. It has become necessary to plan the
use of fungicides to extend their effective life and this is aided by research on the mechanisms of
resistance related to fungicide uptake, fungicide detoxification, alterations to the fungicide binding sites
and altered membrane properties.

Research
The uptake of iprodione, lipid peroxide content and the activities of both catalase and superoxide
dismutase enzymes in dicarboximide-sensitive and dicarboximide-resistant strains of *Botrytis cinerea*
from grapevines were studied.

Outcomes
*B. cinerea* resistant to benzimidazoles and dicarboximides occurred in several grape growing regions in
Australia. A rapid resistance test for dicarboximides using catalase as a biochemical marker has been
developed. This test can be validated using a wide range of fungal pathogens resistant to dicarboximide
fungicides.

An understanding of the mechanism of action of dicarboximides obtained in this project suggests that
dicarboximides may cause the formation of reactive free radicals in the fungal cells. This project has also
demonstrated that dicarboximides caused lipid peroxidation of fungal membranes.

This project shows similarities in the uptake of dicarboximides by resistant and susceptible strains of *B.
cinerea*. The uptake of benomyl was found to be concentration-dependent. The importance of such work
is efficient use of chemicals to reduce bunch rot of grapes, which starts with primary infection of the
flower clusters by *B. cinerea*. The systemic action of a fungicide will lower the inoculum within the
flowers. Benomyl would serve that purpose. The role of iprodione would be to protect the flowers from
infection over a relatively longer period.

Implications
the occurrence of fungicide resistance in vineyard populations of *B. cinerea* implies that an analytical
approach to resistance prediction is urgently required. One such approach is resistance-monitoring,
since it measures not only the existing degree of resistance but also alerts to the possibility of a problem
arising in susceptible areas;
this project has developed a rapid test for dicarboximide resistance using catalase as a biochemical
marker. This will expedite the screening of pathogen populations for resistance to dicarboximides;
an understanding of the mechanism of action of dicarboximides obtained in this study suggests that
dicarboximides may cause the formation of reactive free radicals in the fungal cells. µ-Tocopherol
(Vitamin E) reversed the growth inhibition caused by dicarboximides (iprodione). This study has also
demonstrated that dicarboximides caused lipid peroxidation of fungal membranes;
the results on uptake of benomyl and iprodione by grapevine flowers showed the systemic nature of the
former and the relatively greater persistence of the latter chemical.

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149. REVIEW AND CATALOGUING OF PLANT AND SOIL NEMATODES IN AUSTRALIA

Objectives
To make available a comprehensive list of the plant parasitic nematodes present in Australia, which:
includes the most recently available data;
covers material maintained in herbarium collections;
is consistent with currently accepted concepts of nematode taxonomy and nomenclature;
indicates botanical range (the host plants on which, or associated plants around which the nematode
has been found); and
indicates the geographic range of the nematode’s distribution.

Background
Previous bibliographies listing the presence and distribution of plant parasitic nematodes in Australia,
have been produced on an irregular basis since 1938. The most recent, produced in 1986, is now well
out of date.

The taxonomy of plant parasitic nematodes is an area which has received little scientific study or
financial support in Australia, relative to other countries, and yet it is an area fundamental to the
development of effective practices for controlling nematode diseases. If we do not know what nematode
we are dealing with, how can we develop effective control practices? Furthermore, knowledge of the
presence and distribution of nematodes is a vital element of the effective operation of our national
quarantine service.

Research
The project aimed to build on previous listings of the presence of plant and soil nematodes in Australia
by:
reference to general, technical and scientific publications;
checking accession records in the various States;
obtaining information from various plant disease diagnostic operations; and
soliciting information by personal communication with fellow nematologists.

Outcomes
The project has resulted in a 150 page publication, entitled ‘Plant nematodes of Australia listed by
plant and genus’. The publication is divided into three sections:
a listing of nematodes by host/associated plants;
a quick reference list of nematodes by genus and species; and
a listing of nematodes by genus and species, including host range and geographic distribution.

Implications
With the rapid demise of nematode taxonomic services both nationally and internationally, this
publication will provide a valuable reference source to nematologist, and to quarantine authorities
(AQIS).

With better information available on the presence and distribution of plant parasitic nematodes, it will
now be possible to develop new and improved control strategies that rely less on the use of chemical
methods.

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Objectives
To develop strategies that can both detoxify soil of pesticides and protect plants. Specifically, to extend the promising new technology of chemically-induces nodulation of plants to the following areas:
the incorporation of pesticide degrading microbes into nodular structures on the roots of plants, with the aim of providing a plant-microbial system capable of accelerated degradation or protection from chemicals; and
nodulation with microorganisms antagonistic to plant pathogens, such as the 'damping off' fungi or using insecticidally-active agents such as Bacillus thuringiensis.

Background
Biodegradation of certain pesticides in soil is a well known phenomenon but the use of plants inoculated with pesticide-degrading microorganisms had not previously been considered for this purpose. This research was stimulated by successful artificial induction of associations between bacteria and plants for biological nitrogen fixation. Similar associations between pesticide-degrading bacteria and plants with potential value of agriculture might be engineered, allowing the 'clean up' of soils and by providing protection from the effects of residual pesticides. A related goal was to provide plant protection by incorporating protective or antagonistic microorganisms into such systems.

Research
The biodegradation of 2,4-dichlorophenoxyacetate (2,4-D) was selected as a suitable model chemical system. This system was chosen because it is well understood genetically, it is possible to transfer the genetic capability between different species of bacteria with reasonable ease, and the activity is capable of fairly straightforward chemical analysis. In future applications of this approach, however, it would be necessary to use microbial strains with appropriate pesticide-degrading activity as the situation requires.

Outcomes
using canola and wheat plants as hosts, associations with a soil isolate of Acinetobacter carrying 2,4-D degrading ability have been formed in laboratory systems. These associations accelerated degradation of 2,4-D, and completely destroyed the herbicide within 24 hours; Alcaligenes eutrophus, well known as a 2,4-D degrading organism did not colonise roots as effectively; the 2,4-D degrading plasmid was transferred by conjugation from Alcaligenes to strains of Rhizobium naturally forming root nodules on subterranean clover and white clover plants. Such transconjugants were stable, retaining their 2,4-D degrading ability indefinitely, and were found to provide protection of the clover plants from the effects of herbicide. These clover plants were also capable of fixing atmospheric nitrogen.

Implications
This area of research has a long way to go before practical benefits will be available to agriculture. The results from this project, however, form an excellent basis for an ongoing bioremediation project within the CRC for Sustainable Cotton Production at Narrabri, and funded by CRDC.
151. DEVELOPMENT OF CONTROLLED RELEASE NEMATICIDES

Objectives
- to formulate cost-effective controlled release nematicides;
- to develop a rapid biological assay to detect levels of nematicides and residues of new controlled release nematicides;
- to identify the amount of controlled release nematicide needed to keep parasitic nematodes below an economic threshold.

Background
While plant parasitic nematodes will ideally be controlled by ‘non-chemical’ methods, there will be a continuing need for minimal use, low cost, environmentally safe nematicides which can be integrated with other control measures such as resistant cultivars, or crop rotation. These newer nematicides will probably be formulated as controlled release granules, because they are considered to be safer than other formulations. Controlled release formulations, as their name implies, release small amounts of their active constituent in localised areas over long periods ranging from weeks to years.

Research
Two controlled release formulations of the non-volatile nematicide carbosulfan (F M Corporation), containing 18.6% and 44.2% of active constituent were developed for a evaluation against the entomopathogenic nematode *Heterorhabditis bacteriophora*. A nematode bioassay was developed, using either a terrestrial or an aquatic system, and the mortality of nematodes was assessed after they had been exposed to the controlled release formulations for varying periods of time. The tests were also conducted for comparative purposes, using conventional formulations of the same nematicide-active constituents developed by the manufacturer.

Outcomes
- two controlled release granular formulations of carbosulfan were prepared in a silica matrix;
- A rapid bioassay was successfully developed to screen controlled release and other formulations of non-volatile nematicides using the entomopathogenic nematode *Heterorhabditis bacteriophora*;
- results show that the formulation containing 18.6% of active constituent of carbosulfan was the more effective of the two formulations developed in control of nematicides;
- both formulations were potent insecticides with 44.2% active constituent the most effective.

Implications
Controlled release formulations of the non-volatile nematicide carbofuran have been shown to be effective in these tests. Further work is required on the controlled release nematicides developed during this project to identify the right eutectic mix of controlled release and conventional nematicide for target crops such as perennials and methods of application such as bare-root dip or irrigation.

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152. SAFE DISPOSAL OF WASTE HERBICIDE EFFLUENT

in removing organic agricultural chemicals from water at concentrations typical of those used in spray application and resulting from equipment washing.
Background
There are many operations and processes during which potential hazards to health or environmental safety may be present. Disposal of water based effluents containing pesticides is one area where there is potential for environmental contamination. These effluents can result from washing of agricultural spraying equipment, chemical manufacturing plant and used chemical containers and from unused spray liquors and other areas.

The Sentinel Effluent Treatment Plant has the potential to help in the disposal of effluents containing pesticides. The plant and the treatment process have been developed in the United Kingdom by E Allman and Co. and ICI. The unit was developed to treat water-based effluents containing organic chemicals. It removes the chemicals by a process of flocculation and activated carbon filtration allowing safe disposal or recycling of the water component and concentrating the chemical to a solid form for disposal.

Research
A Sentinel unit was provided for the tests by ICI Australia and located at Rutherglen Research Institute. The unit was modified and tests carried out on a range of chemicals. Levels of chemicals in treated water and in the solids from the process were determined. The chemical analyses were conducted by the State Chemistry Laboratories in Melbourne.

Outcome
The Sentinel Plant reduced the concentration in water of the pesticides examined to low levels, except for glyphosate. For the pesticides, other than glyphosate, levels after treatment were close to the national standards for drinking, fresh and marine water. However the most appropriate method for disposing of treated water is likely to be into an on-site seepage or pondage system or into the local sewer (subject to appropriate approval or recycling). Disposal of solids as toxic waste would be the approved means. A leachate test on solids showed disposal in land-fill tips would not be appropriate.

The unit was simple and easy to operate. Close monitoring of the activated carbon filters to ensure early detection of carbon saturation would be necessary for safe operation of the unit.

A multi-prong approach to dealing with waste effluents containing pesticides will continue to require the major emphasis, as in the Operation Clean Rinse program by AVCARE and other initiatives, aimed at reducing the levels of effluent.

Implications
The unit could be valuable for dealing with waste spray liquors and equipment washing by spray contractors, farmers and farm cooperatives, contract disposal of stock dipping liquors, in the washing and disposal of spray containers and in the AVCARE Operation Clean Rinse Program. Disposal of solids from the unit would restrict its value because of the cost of toxic waste disposal.

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153.DEVELOPMENT OF FORECASTING SYSTEM FOR HELIOTHIS MIGRATION INTO EASTERN AUSTRALIA

Objectives
- to understand the broad scale population dynamics of Helicoverpa punctigera and H. armigera over large areas of eastern and central Australia, including non-cropping regions;
- to use this understanding to develop forecasting methods which will allow optimisation of current chemical control methods and assist in managing insecticide resistance;
To provide information of value for the development of long-term alternatives to chemical control, such as biological control and area-wide management.

**Background**

*Helicoverpa* is a major insect pest, particularly of cotton and grain crops. Most populations of *H. armigera* in northern New South Wales and Queensland have developed resistance of the pyrethroid insecticides and their management by chemical means has become difficult and expensive for growers. If levels of resistance continue to increase at current rates, pyrethroid insecticides will no longer be effective, and alternative chemical control options will be considerably more expensive.

This project was part of a larger project jointly funded by GRDC, CRDC, CSIRO, University of Queensland, University of New England and QDPI.

**Research**

The population dynamics and migration patterns of *Helicoverpa* spp. were monitored throughout areas of New South Wales, Queensland, Victoria, South Australia, and the Northern Territory (including remote inland areas), using a well established network of sixty pheromone and light traps serviced by a wide range of paid and voluntary operators. Catches were recorded and analysed weekly at the University of New England. On the basis of these accumulated data, forecasts were made in the spring as to the likely severity of outbreaks occurring during the summer (i.e. for crops such as cotton, sorghum, etc.)

**Outcomes**

- the prospects for routine forecasting of early-season infestations are good;
- the spring influx of *H. punctigera* extends across state boundaries;
- forecasts of the magnitude of early-season infestations are potentially valuable to growers, pesticide manufacturers/suppliers and pest controllers;
- the size of the benefit to potential users is uncertain.

**Implications**

- an operational forecasting service would require its own staff and facilities;
- the cost of providing a service of the desired magnitude and quality for both eastern and western Australia is estimated to be about $600,000/year;
- costs could not be recouped by selling the forecasts to individual users because the information cannot be kept confidential;
- further research is needed to refine and validate the forecasts, but the Corporations involved to date are not prepared to continue funding the project;
- it is unlikely that a commercial forecasting service will be established.

**Publications**


154.RESTRUCTURE OF THE PESKEM DATABASE INTO A STAND-ALONE, PC-BASED, PESTICIDE SYSTEM

180  R I R D C
Objectives

to create a PC-based database on agricultural chemicals from the existing mainframe database;
to develop a database which is both user friendly and easy to use using feedback from potential users of
such a system;
to market the database information as soon as possible.

Research

A survey of 200 of the current PESKEM clients was conducted to determine the need for an up-to-date and
user-friendly database containing information on registered agrochemicals in Australia. The feedback
from more than 150 potential clients on the content of the database was used in the structure of the PC-
based database. Techniques for data processing and retrieval to minimise client time costs were
investigated.

Outcome

A stand-alone easy-to-use pesticide information database available to the community with updates
available every three months was developed.

As well as being a Pesticide Product and Use Register with over 1700 products and 100,000 use entries,
the new restructured database now contains Dangerous Goods Codes and Hazchems and Packaging
Groups. It also includes the Product Critical Comments and expanded Use Critical Comments and
registration for aerial application. The products prices for all pack sizes can be entered into the database
by the client. This additional information considerably enhances the user’s ability to make appropriately
informed and productive choices.

This PESKEM PC-based system is the only such service available to all sectors of the agricultural
community and is the only comprehensive national pesticide registration information system. The NRA
had hoped to have a system up and running by 30 June 1992 to service the needs of Government
Departments. This system will not now be available before 30 June 1995.

Implications

The results of this project are servicing industry and the community needs for access to pesticide
registration and related information. The PESKEM PC for Windows database is an addition to the already
established information source of published hard copy books and customised information printouts. It is
proposed that the results will be transferred directly from the research organisation, the Centre for
Pesticide Application and Safety, to the paying customer. This will keep costs and time delays in the
supply of the product to a minimum and assure the customer receives the current PC discs.

The PESKEM PC based database on agricultural chemicals developed by the project is now available to all
sectors of the community including agricultural chemical companies, agricultural consultants,
educational institutions and public interest groups. The new PC version of PESKEM developed during this
project has benefits that could flow outside the agricultural sector to areas such as health, the
environment, education and to the community in general.

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AGRICULTURAL SYSTEMS

At a time when the contribution of agriculture to the national economy has been sharply declining, the agricultural systems that have evolved across Australia are coming under increasing scrutiny. Vulnerability to market uncertainties and erratic climate changes has been compounded by a growing awareness of sustainability issues.

At a national level, the Australian government initiated an ecologically sustainable development (ESD) strategy in response to international concerns about the harmful effects that human activities can have on natural resources, and hence the capacity to sustain such practices into the future.

The Standing Committee for Agriculture (SCA) responded to this initiative and established a Working Group on Sustainable Agriculture to work with an ESD Working Group to develop and implement strategies for agriculture. The enormity of the task is clear in the agreed definition that sustainable agriculture comprises the use of farming practices and systems which maintain or enhance:

- the economic viability of agricultural production;
- the natural resource base; and
- other ecosystems which are influenced by agricultural activities.

While efforts to focus on sustainability issues have intensified and inevitably will lead to the development of new opportunities for agriculture in Australia, changes from traditional practices and agricultural systems will not be made quickly or easily.

In general terms, clear guidelines are needed by the farming community to maintain long term productivity while at the same time protecting the biological and physical resource base. Until such guidelines have been developed, evaluated, and subsequently incorporated into decision making support systems, management decisions will continue to favour agricultural practices based on short term profits and tend to overlook to a large extent the longer term sustainability issues.

While work on existing agricultural systems must proceed, opportunities for diversification and alternative systems could well prove a profitable area for research. Conversely, a number of areas facing unique problems, such as peri-urban environments, will need to be given special consideration.

155. RAINMAN: RAINFALL INFORMATION FOR RURAL COMMUNITIES

Objectives
To produce a computer package (RAINMAN version 2.0) for extending better information on rainfall probabilities to primary producers, their advisers and agribusiness agencies throughout Australia. At appropriate locations, particular attention will be given to change in rainfall probabilities caused by influences such as the El Nino/Southern Oscillation phenomenon.

Background
Primary producers lack easy access to long-term climatic records and analysis of these records. As a result, their expectations of rainfall are often biased by recent experience. In areas where there is rapid turnover of farm ownership, new owners lack long-term experience of the environment and may attempt inappropriate management practices.

Research
Steps taken in the development of RAINMAN included:
- consulting clients on product design and screen presentation;
- selecting locations with at least 80 years of rainfall records;
- checking the accuracy and continuity of long-term daily rainfall records and using nearest-neighbour techniques to replace missing values;
- developing innovative climate analyses; and
- preparing context-sensitive help notes.
**Outcome**
The software package AUSTRALIAN RAINMAN was launched by the Minister for Primary Industries and Energy in October 1994. The software includes a variety of tables, graphs and maps of rainfall information that highlight climatic risks and opportunities, including the changes in risks associated with the El Nino/Southern Oscillation.

**Implications**
Use of AUSTRALIAN RAINMAN should improve the productivity, profitability and sustainability of Australia's rural industries by providing a high quality and easily accessible database of rainfall with comprehensive analyses.

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*This project was jointly funded by RIRDC, QDPI, the Bureau of Meterology, WA Dept of Agriculture and the Meat Research Corporation.*

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**156.PUBLICATION OF AUSTRALIAN SALTLAND USERS MANUAL**

**Objectives**
To increase the rates of revegetation of saltland throughout Australia by publishing a 'state of the art' Australian Saltland Users Manual. The proposed manual will focus on educating farmers, advisers and landcare practitioners about the benefits of saltland revegetation. The manual will play a major role in: training fanners and advisers in saltland revegetation; increasing the areas being revegetated; and improving chances of success.

**Background**
Research has shown that there can be substantial increases in farm profitability when halophytic shrub species are planted on saltland. However, saltland revegetation is limited by the availability of reliable sources of up to date information. Information on saltland revegetation is currently to be found in a wide range of scientific papers and extension publications. The proposed manual will draw together and synthesise the information from these and other unpublished sources.

**Research**
The main research strategies were: (a) matching species to sites; b) seed production and testing; (c) overcoming problems of establishment; (d) maximising production; (c) animal use and response; f) economic benefits to farmers; and (g) extension and training.

**Outcome**
This project has provides up-to-date information on saltland revegetation in Australia by publishing a 'state of the art' Australian Saltland Users Manual.

**Implications**
The manual will be used as the major resource in the extension of saltland revegetation throughout Australia

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157. DEFINING STOCKING RATE STRATEGIES FOR Viable AND SUSTAINABLE PRODUCTION

Objectives
- to use the knowledge of producers and scientists to develop an objective suite of strategies for setting stocking rates for grazing industries in Australian rangelands, in the context of market and climatic variability;
- to define and report on how this decision framework could be used by producers.

Background
The key management tool of arid zone farmers is the setting of stocking rates. Deciding what stocking rate should apply in a paddock at a particular time is complex. Various systems exist but there is no overall framework to help managers use the packages.

Research
Producers and extension personnel will be widely consulted and then a workshop will be held to analyse existing and future and potential approaches to stocking rates.

Outcome
From consultations with producers key influences on stocking rate decisions were identified as: climatic zone; vegetation type; distance to market; distance to fodder sources; property structure; and socio-cultural factors such as age.

These factors formed a basis for discussion, and recording of further factors regarded as important for stocking rates, at a national technical workshop held in March 1993.

Implications
The consultations and workshop will assist manager-level decision-making in all industries concerned with setting stocking rates in the rangelands.

RIRDC Project No: CSW-28A

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PUBLICATIONS:

158. FUTURE DIRECTIONS IN IRRIGATED CROPPING SYSTEMS

Objectives
- to hold a workshop to identify opportunities, and to analyse the barriers to improvements in sustained production;
- to develop action plans to overcome the identified limitations;
- to build strong links between the groups involved in irrigated cropping, and to form teams of people to implement the action plans developed at the workshop.

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Background
The irrigation areas of northern Victoria and southern New South Wales have long had the potential to be some of the most productive agricultural areas in the world. The dairy, horticulture, rice and a number of smaller industries have been consistently profitable and use about half of the irrigated land and water. Most of the remainder of the resources is used by the less, and sometimes unprofitable, mixed farming sector – dominated by sheep and beef.

Research
Participants were invited from industry groups and organisations including: irrigation farmers and their organisations; marketers and processors, research and development organisations; state water corporations; industry consultants; and research and advisory staff from CSIRO; state departments of agriculture and universities.

Issues discussed included: sustainable environmental management; market focussed production; skills and training needs; production systems; and infrastructure.

Outcome
A coordinated action plan for a profitable and sustainable future for mixed farming in the southern Murray-Darling Basin, is now available. Areas identified for attention were: production systems; skills for farmers in production, management, and marketing; product storage and handling; transport; links to market and consumer requirements; and continued emphasis on environmental management.

Implications
It was recommended there be a continuing Southern Murray-Darling Basin Irrigated Cropping Forum to achieve the outcomes and to ensure progress. An secretarial group or the forum will oversee the development of an integrated program entitled A New Era for Irrigated Cropping.

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159.USING EARTHWORMS TO IMPROVE THE PRODUCTIVITY OF BRIGALOW LAND

Objectives
To find native or naturalised species of earthworm that might improve productivity of brigalow soils, to test the survival of these species and to evaluate their effect on productivity.

Background
In perennial grass pastures that have been established on land previously cleared of brigalow, there is a marked decline in productivity as the pasture ages. Similarly, annual crops, such as sorghum, or tree crops, such as citrus, can have problems that are associated with poor nutrition and poor structure. While elsewhere earthworms have been shown to have beneficial effects on pasture and crop production, their numbers in brigalow soils are understood to be very low. It has been proposed that the low productivity of brigalow soils could be alleviated if an active earthworm population was present.

Research
Initially, a survey in southern and central Queensland was done to determine the extent and composition of earthworm populations. Results from twenty locations confirmed patchiness and seasonal variations in distributions as well as the relative sparseness of earthworms in brigalow soils. Nevertheless, seventy-five species were collected, including twenty-seven new species.
Subsequently, glasshouse studies were used to examine survival and effect on productivity to identify the most promising species. From these studies, twelve promising species were selected for field trials.

The field trials were established at two sites in replicated blocks to monitor the survival of introduced earthworms and measure the effect on pasture production. These trials encountered exceptionally dry conditions. Even so there was survivors at both sites and some evidence that the introduced worms increased pasture growth.

**Outcome**
The study has provided considerable unexpected new information about earthworms. Significantly, the wide diversity of species in the study area was unprecedented for Australian soils. Under experimental conditions the earthworm survival rates and effects on plant yields were found to vary greatly, emphasising the importance of matching species and soils and the need for appropriate methodology.

**Implications**
Although research in this area will not pay immediate dividends, the results reported here shows useful directions for the future. These would include longterm testing in the field to cover variations in several conditions and identification of productive combinations of species of earthworm and agricultural systems.

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### 160. THE EFFECT OF FARMING PRACTICES ON HONEYBEE FORAGING BEHAVIOUR AND CROP YIELDS

**Objective**
to characterise bee pollination of entomophilous crops (e.g. cucurbits);  
to determine the influence of registered pesticides on honeybee foraging behaviour in these crops and consequent effects in pollination efficiency, yield and quality of produce.

**Background**
Many fruit and vegetables require insects for pollination and with declining populations of natural pollinators honeybees have been widely used. Clearly, profitability depends on optimum pollination, which in turn is strongly influenced by crop management practices.

Hence, it is essential in formulating management strategies, to take account of bee biology, crop biology and bee/crop interactions. The use of pesticides is obviously a direct threat to pollinators but it is also suspected of having detrimental effects on other pollination parameters. Better information is required to remain internationally competitive in the production and marketing of horticultural crops.

**Research**
Studies on a range of cucumber crops were done to investigate:  
the effect of agricultural chemicals (insecticides, fungicides, acaricides and various combinations of sprays), on pollination and crop performance;  
the contribution of bees to pollination;  
the floral and fruit biology of cucumbers;  
the effect of delaying pollination and fruit development by removing pistillate flowers for varying periods after floral initiation.

**Outcome**
The significance of bees to pollination was clearly demonstrated where the presence of bees increased fruit set and doubled the number and weight of fruit harvested by comparison to caged controls.
Significantly, agricultural chemicals had no effect on the foraging behaviour of honeybees although pollen viability was significantly reduced. This reduced viability was of minor importance as it had no measurable effect in terms of effective fertilisation, and hence yield.

**Implications**

Some $600 million worth of Australian crop production depends on insect pollination. This study has confirmed the vital contribution of bees in ensuring effective pollination and resultant high yields of quality produce. The effect of agricultural chemicals on bees and pollination reported in this study need to be fully considered in developing effective crop management strategies.

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**161. SUSTAINABLE HORTICULTURE USING IN-SITU MULCHES**

**Objectives**

To develop practical, sustainable vegetable production systems based on in-situ mulch crops and drip irrigation, incorporating the following specific goals:
- Identifying the essential physiological, environmental and morphological characteristics of in-situ mulch crops which permit viable vegetable production and improve soil structure;
- Characterising the efficacy of mulch crops in suppressing weed growth;
- Determining the operating requirements for drip irrigation of mulch and vegetable crops; and
- Determining the requirements for transplanting and direct seeding equipment for mulch and vegetable crops.

**Background**

Most vegetable production in Australia is irrigated and intensively cultivated. Severe overwatering occurs in almost all of the irrigated area. These combined pressures have led to severe soil structural decline which requires increased levels of inputs of water, fertiliser and soil ameliorants to maintain productivity.

Work at Sydney University has demonstrated that winter-grown legume crops which senesce in Spring leaving a protective *in-situ* mulch have great utility in maintaining and improving soil structure while maintaining crop yields. When the irrigation method is changed to drip irrigation, significant reductions in water and fertiliser usage occur. The marriage of the two systems promises the basis of a more sustainable system of vegetable production.

**Research**

Most of the experiments were conducted in the field, on a realistic commercial scale. The main areas investigated were the production levels of crops grown with and without in-situ mulches; effects of the mulches on soil properties; ability of the mulches to suppress weeds and irrigation requirements of crops grown with the mulches.

**Outcome**

In the well-watered clay loam we used, the crops grown with subclover mulches generally grew about as well as those grown with zero tillage and cultivation. Ryegrass always showed a phytotoxic effect on the vegetable crops. The soil under subclover mulches showed a greater accumulation of organic matter and nitrogen than cultivated soil. Subclover appeared to be the best mulch for suppressing weeds, but had the potential to become a vigorous weed itself in after vegetable crops. Wetting patterns were studied and effective placement of water from drip lines in the root zone was demonstrated.
Implications
Overall, our impression is that the mulches certainly have a lot to offer in a marginal cropping system, where beneficial effects on soil structure and strength have been observed. On a well managed farm where the soil has good structure, this advantage is less important and the beneficial effects of non-chemical weed suppression, prevention of erosion and amelioration of extreme soil temperatures have to be balanced against the necessity for finely tuned management, the possibility of the mulch becoming a weed and a possible increase in soil-borne pathogens.

Objective
To develop improved management techniques to reduce the impact of phosphatic and nitrogenous fertilisers applied to vegetables grown on sands on the water systems of the Swan coastal plain.

Background
Western Australia is Australia’s major exporter of carrots, cauliflowers, Chinese cabbage, lettuce, celery and cabbage as well as significant quantities of onions and potatoes. The value of vegetable exports from Western Australia in 1991-92 was $31.3m or 36.6% of total vegetable exports from Australia. Most of these export crops are grown on the sandy soils of the Swan coastal plain. These sands have low nutrient and water holding capacities. Leaching of fertilisers (especially nitrogen and phosphorus) applied to horticultural crops have been implicated as one of the contributors to the pollution of the ground and surface water bodies (lakes, rivers and estuaries) of the coastal plain.

The future of vegetable production on the coastal plain is under threat because of these environmental concerns. Relocation of vegetable production would increase freight costs and reduce grower returns. There is considerable benefits in maintaining these industries in their present location. Current fertiliser and irrigation practices are not efficient and have contributed to the problem. Improved fertiliser and irrigation practices should reduce environmental impact and reduce the risk of relocation.

Research
Experiments were conducted to determine phosphorus soil test standards for carrots, cauliflowers, lettuce and onions grown on Karrakatta sands. Other experiments compared the relative benefits of placement (broadcast versus banding) of phosphorus on vegetables. The interaction of irrigation (rate, method) with nitrogen fertiliser application was also examined to develop more efficient management techniques.

Outcome
Phosphorus soil test standards were developed and finalised for carrots and cauliflowers on the Karrakatta sands with preliminary information developed for lettuce and onions. This information showed that growers could reduce their current application of phosphorus substantially at high soil test levels.

The benefit–to–cost ratio of adopting phosphorus soil testing on the coastal plain was eight. By contrast there appeared little benefit in banding phosphorus to carrots, cauliflower or lettuce compared with broadcasting although, with onions, banding appears more efficient. Application of nitrogen in small quantities frequently using fertigation after planting rather than less frequent broadcasting demonstrated savings in nitrogen.
In particular, a substantial reduction, or possible elimination, in application of nitrogen preplanting could be achieved if fertigation of nitrogen was used. For example daily fertigation of nitrogen to lettuce was shown to be more profitable than broadcasting weekly because of higher yields and more efficient use of nitrogen.

**Implications**
The adoption of improved nitrogen, phosphorus fertiliser and irrigation practices resulting from this project has the possibility of enabling vegetable production to be carried on the Swan coastal plain with minimal environmental impact, whilst at the same time saving growers money. This should reduce the pressure on the vegetable industry to relocate further from the coastal plain with increased costs, such as freight and reduced grower profits.

**Objectives**
To use video and state-of-the-art instructional design and distance education techniques to:

1. Improve the financial business management skills of Australian farmers, particularly those with poor education and those in isolated rural areas; and to
2. Improve the ability of Australian farmers to manage financial risk and cope with rapidly changing financial circumstances (such as large changes in commodity prices and interest rates or reduced income due to drought).

**Background**
More farmers are realising that their futures depend on improving their business skills. However, a large number of Australian farmers have not had the opportunity to undertake any formal training in business management.

**Outcome**
The video package, *The Farm Business*, provides easy-to-use materials to teach the basics of farm business management, financial planning and financial risk management. It is a step-by-step guide to better farm business management.

Part 1 (22 minutes) offers advice from specialists in banking, business and office management, rural counsellors and the law about transfer of the family farm. It also includes farmers who tell how better business management has improved their position.

Part 2 (26 minutes) contains four tutorials:

- setting up a cashbook;
- filling in a cashbook;
- handling a cash entry;
- bank reconciliation

**163.STRATEGIC FARM PLANNING — BY OPEN LEARNING**

RIRDC Project No: DAN-90A
RESEARCHER: Brian P Walsh and Jennifer Laffan
ORGANISATION: New South Wales Agriculture

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**Implications**
The adoption of improved nitrogen, phosphorus fertiliser and irrigation practices resulting from this project has the possibility of enabling vegetable production to be carried on the Swan coastal plain with minimal environmental impact, whilst at the same time saving growers money. This should reduce the pressure on the vegetable industry to relocate further from the coastal plain with increased costs, such as freight and reduced grower profits.

**Objectives**
To use video and state-of-the-art instructional design and distance education techniques to:

1. Improve the financial business management skills of Australian farmers, particularly those with poor education and those in isolated rural areas; and to
2. Improve the ability of Australian farmers to manage financial risk and cope with rapidly changing financial circumstances (such as large changes in commodity prices and interest rates or reduced income due to drought).

**Background**
More farmers are realising that their futures depend on improving their business skills. However, a large number of Australian farmers have not had the opportunity to undertake any formal training in business management.

**Outcome**
The video package, *The Farm Business*, provides easy-to-use materials to teach the basics of farm business management, financial planning and financial risk management. It is a step-by-step guide to better farm business management.

Part 1 (22 minutes) offers advice from specialists in banking, business and office management, rural counsellors and the law about transfer of the family farm. It also includes farmers who tell how better business management has improved their position.

Part 2 (26 minutes) contains four tutorials:

- setting up a cashbook;
- filling in a cashbook;
- handling a cash entry;
- bank reconciliation

RIRDC Project No: DAN-90A
RESEARCHER: Brian P Walsh and Jennifer Laffan
ORGANISATION: New South Wales Agriculture
Objective
To investigate the role of rare earth elements (REE) in the nutrition and productivity of agricultural plants.

Background
Over the past fifteen years Chinese scientists have established that trace amounts of rare earth elements (seventeen chemically similar trivalent cations) can increase crop and livestock production. This has resulted in a large extension program to promote the use of rare earth elements in Chinese agricultural systems. In 1993, 3.73 million ha of crop, horticultural and pasture land was treated with REE. Yield responses in the order of 8 to 15% are typical and claims for improved quality of produce have been made.

Australia has considerable reserves of REE. To date, exploitation of these resources has been confined to manufacturing and processing industries. Experience in China raises the prospects that these resources might also play a role in Australia’s agricultural industries.

Research
Rare earth elements were applied, either as additions to the nutrient solutions in which corn and mungbean (Vigna radiata) were grown, or as foliar sprays.

Outcome
When added to nutrient solutions, the REE lanthanum (La) or cerium (Ce) were toxic to the root elongation of corn and mungbean seedlings at concentrations ranging from 1 to 20 mM (0.1 to 3 parts per million). When exposed to concentrations of La or Ce from 0 to 1.4 mM, the total dry matter production of corn was unaffected, although root growth was increased by 36% in the presence of 0.19 mM La. The root growth of mungbean was increased 21% in the presence of 0.19 mM La, although the total dry matter yield of mungbean was unaffected at this La concentration and was severely depressed by higher concentrations of La or Ce.

Corn and mungbean plants were sprayed with the REE-containing fertiliser obtained from China (called ‘Nongle’ = happy farmer). The rates of foliar application were those recommended in China and included 0, 0.025, 0.05, 0.1, 0.5 and 1.0%. There was a trend for 0.1% ‘Nongle’ to increase the total dry matter production of mungbean, but concentrations of ‘Nongle’ above 0.1% were toxic to corn and mungbean.

Implications
Rare earth elements are toxic to plants in most situations that we have studied. Corn is more tolerant to the application of REE than is mungbean. If beneficial effects of La or Ce are to be found in a species such as mungbean, they are likely to occur at external La or Ce concentrations less than 0.2 mM. If the foliar application of REE is beneficial to plants then the effects are likely to be small and concentrations less than 0.1% need to be evaluated further.
165. MACHINERY RESEARCH AND DEVELOPMENT FACILITATION

**Objective**
To facilitate agricultural machinery development ensuring more farmer inventions reach commercial production sooner.

**Background**
Many of Australia's agricultural inventions and new machinery concepts originate at the farm level. Unfortunately, most inventors are not interested in pursuing the idea beyond their own needs or do not have the time or expertise to develop a business plan to take the idea into commercial production. Thus many significant inventions are under-utilised and benefits of them unrealised.

**Research**
- locate farmer inventions worthy of further development;
- select from the inventions those worthy of evaluation;
- evaluate inventions by a select committee of farmers and industry representatives;
- develop a business plan for commercialisation of selected inventions;
- develop prototypes.

**Outcome**
Many of the innovations were not deemed to be worth developing by the commercial sector. With this in mind, the methodology of the project was modified slightly to ensure the objective remained a realistic one.

A preliminary assessment of the results indicate that some of the inventions evaluated have the ability to save Australian farmers considerable time and money. It is not possible to quantify this because of the imprecise nature of the work. We do know that about forty farmers have followed up, and purchased, detailed plans from Kondinin as a result of promoting various devices/equipment in *Farming Ahead*.

**Implications**
The final methodology adopted by Kondinin for this project has led to a low cost method of collecting and transferring information on new machinery and equipment. The project is near to being self funding and the Kondinin Group intends to continue with the project and fund any shortfall from consolidated revenue.

RIRDC Project No: KDI-13A

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166. ORGANIC ANIMAL HUSBANDRY

**Objectives**
To provide growers with information on what is involved in organic animal husbandry systems. This will be available for all growers seeking to reduce their reliance on synthetic agricultural and veterinary chemicals.

**Background**
Interest in organic farming has grown rapidly over the last several years and outstripped available information on the topic, particularly in the area of animal husbandry. What information does exist on animal husbandry is not compiled in one publication.
Research
A study was made of various factors that affect organic animal production including:
- soil condition;
- proper diet;
- breeding and genetic make-up;
- shelter from adverse weather (wind, hail, cold, heat);
- the stockpersons’ handling of livestock in a low-stress manner; and
- disease prevention through close observation of stock and early treatment of problems.

Outcome
A resource guide on organic animal husbandry has been published, distributed and widely advertised. The guide includes sheep, cattle, pigs and poultry with an emphasis on sheep and cattle.

Implications
The adoption of practices described in the guidebook will depend on:
- producers’ awareness of its availability; and
- availability of products used in organic, or low-input sustainable, farming systems; and
- delays in commercialisation of research into organic livestock production.

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Objectives
- to determine the effects of two contrasting earthworm species (A. trapezoides and A. rosea) on the release of total CO2 and 14CO2 from (a) freshly added plant materials, on the soil surface or incorporated, (b) older plant residues and (c) the native soil organic matter;
- to determine the role of earthworm activity in exposing physically protected soil organic matter to biological decomposition;
- to examine the influence of soil type on the above processes.

Background
Earthworms are an integral part of sustainable farming systems. They have considerable impact on soil through their feeding, burrowing and casting activities. Earthworms are known to have positive effects both physically and chemically on soil properties. To effectively manage farming systems, it is essential that the role of earthworms in carbon dynamics is established and quantified.

Research
Earthworms were confined in containers filled with soil moistened to -10 kPa, compared to field bulk density and amended with 14C-labelled plant materials. They were incubated within 1 L sealed glass jars at 16°C and the 14CO2 and 12CO2 released monitored. At the beginning and end of the incubation microbial biomass and distribution of microaggregates were measured.

Outcome
Under the experimental conditions, earthworms did not increase the rate of decomposition of high C/N ratio, wheat residues or low C/N ratio legume residues on the soil surface or incorporated into the soil. Earthworms did, however, significantly increase the decomposition of ‘native’ soil organic matter, A. rosea being more effective than A. trapezoides.

This was accompanied by a decrease in silt-sized aggregates in many soils. Some soils were more susceptible to aggregate breakdown than others but no correlation could be found between soil properties and susceptibility to microaggregate breakdown.
Implications
Although this was only a laboratory experiment, implications are that earthworms have little overall effect on residue decomposition under optimal moisture conditions but may have a negative effect on soil microstructure in certain soil types.

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168. HIGH RESOLUTION SPOT SATELLITE IMAGERY FOR PREPARING PROPERTY MANAGEMENT BASE MAPS

Objective
To determine if high resolution SPOT digital satellite imagery could be used as an economic substitute for the currently produced, manually assembled, aerial photography, property management plan (PMP) base maps.

Background
Queensland Department of Primary Industries (DPI) currently encourages land holders to prepare their own land management plans. Preparation of these plans ensures that both land conservation factors and agronomic factors are considered when deciding how to manage agricultural land. Land holders are assisted with the preparation of Property Management Plans by attending PMP Workshops run by DPI. A PMP kit is supplied at a nominal charge to land holders attending these workshops, and a base map of the land holder’s property is included in the kit.

Research
The suitability of SPOT panchromatic satellite imagery for use as a property management planning mapping base for Central Queensland grazing and cropping properties at scales of between 1:10,000 and 1:40,000 was evaluated. In addition, panchromatic and multispectral SPOT imagery were compared and evaluated for use in cropping property management.

The grazing and cropping properties selected for this evaluation project were chosen in consultation with DPI field staff from Rockhampton and Emerald. ‘Namoi Hills’ (located near the town of Dingo) was selected as the grazing property, and ‘Mount Lowe’ (located near the town of Capella) was selected as the cropping property.

Outcomes
It was concluded that use of SPOT panchromatic imagery was very practicable for preparing grazing property base maps, where property size if 4000 hectares or larger and the maps are produced at scales of 1:20,000 or smaller. Using SPOT panchromatic data as an alternative to the current air photo mosaic technique reduces the overall cost of producing grazing property PMP base maps.

Production of base maps utilising satellite imagery for properties less than 4000 hectares at scales larger than about 1:20,000 produced images that were too ‘blocky’ for landholders to use effectively.

It was concluded that routine use of SPOT imagery for preparing typical cropping property base maps was not practicable due to the small property size and the need for large scale (>20 000) mapping. However, where cropping properties were large (>4000 ha) SPOT panchromatic imagery could be used as an alternative to aerial photography as the mapping scale would be 1:20 000 or smaller.

It was concluded that mapping costs using SPOT Panchromatic imagery were very similar to the costs of producing aerial photograph mosaics. There is, however, a substantial saving that can be made in the data purchase prices with SPOT imagery.

RIRDC Project No: DAQ-150A
Objective
To develop management strategies that accelerate the physical and chemical rehabilitation of degraded soils by establishing and encouraging soil macro-biological activity.

Background
Long-term declines in the structure and fertility of farming soils are being reversed through farmer adoption of practices that reduce cultivation and conserve plant organic matter. However, merely halting practices that degrade the soil only results in a slow recovery of the natural processes that restore soils. The development of management practices that encourage biological activity would accelerate the natural recovery processes in soils. Earthworms, through their burrowing, casting, and mixing activities, offer the potential, in combination with appropriate soil management, to rapidly accelerate the natural recovery of degraded soil.

Research
Field studies surveyed earthworm populations from different soil types and environments across north-east Victoria and southern New South Wales, and under different farming practices.

Postgraduate studies at LaTrobe University focused on how the growth of plant roots in compacted soil is improved by the discontinuous burrow systems formed by the earthworms commonly found in farming soils. In particular, the impact of burrows filled with earthworm casts on the growth of ryegrass roots was examined.

Outcomes
The survey found low numbers of earthworms in both cropping (51 m⁻²) and pastoral (63 m⁻²) soils. Across all sites, the diversity of earthworm species was low (2 site⁻¹) and introduced earthworms were dominant. There were no earthworm species that actively burrow below 0.2 m depth. High mortality and low reproduction rates characterised the mass-rearing of one deep-burrowing species which is established in Tasmania. More earthworms were found under cereal stubbles left standing, or mulched, than with incorporated stubbles.

The PhD studies showed that, where earthworms had burrowed through compacted soil, the mass of ryegrass roots increased. About 80 per cent of the burrows were filled with casts. In dense soils, roots prefer to grow in open burrows, although root growth can decrease because of the reduced contact between roots and soil. In burrows filled with earthworm casts, root growth is greater than in compacted soil because the casts are less dense, and softer than the surrounding soil. In addition, the casts shrink slightly after they are deposited, allowing roots to grow between the burrow wall and the casts.

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170. INTEGRATED MANAGEMENT OF WATER NUTRIENT AND SALT REUSE SERIAL BIOLOGICAL CONCENTRATION

Objectives

to identify two sites for investigation of the feasibility of the SBC concept; one with a saline pumpable aquifer and the other without a pumpable aquifer;
to determine the rootzone soil salinity status of the proposed sites under SBC and its impact on productivity;
to assess the technical feasibility of applying the SBC concept at the sites;
to assess the economical feasibility of applying the SBC concept as an alternative salinity management option for the B and C land management units in the Shepparton Region.

Background

The Shepparton Irrigation Region, which covers 500,000 hectares is responsible for much of Victoria’s dairy and horticultural production. Approximately 40% of the region is subject to shallow water tables which translates to an estimated loss in agricultural production approaching 20 million dollars.

Research

The feasibility study investigated two sites, one where pumped groundwater was concentrated through one stage of saltbush on a heavy soil type, the second where tile drainage water is concentrated on a light soil type, firstly through a plantation of River Red Gums integrated with salt tolerant grasses, followed by a crop of saltbush.

At each site the SBC system was designed to allow intermittent ponding of the irrigation water to promote leaching during the summer and reduce salt accumulation. Tile drains were designed to collect drainage water predominantly over irrigation season to reduce the volume of artesian flow intercepted and avoid the need for winter storage dams. Crystallisation ponds were incorporated into evaporation basin design to prolong their lifespan and aid in salt harvesting.

Outcomes

Until the Region exceed its salt disposal entitlement, the SBC system is likely to be isolated to areas where there is no access to disposal and there is low productive land available for concentration of the drainage water.

The study revealed a deficiency in the technical knowledge on the leaching fractions on the duplex soils when irrigated with highly saline irrigation water. Also, there is limited information on the proportion that artesian flow contributes to tile drainage flow in shallow water table conditions which may be a critical factor in obtaining concentration of the drainage water. A pilot project would need to address these issues, especially with regard to the sustainability of the system on heavy soil types.

Implications

The SBC concept, developed in California, provides a system for managing moderate to highly saline water in irrigation regions.

The SBC system will apply mainly to the dairying industry in the region since it has both the financial capacity to pay for salinity mitigation and land available for the salt tolerant crops to concentrate the drainage water.
Economically, it would be more attractive to utilise the heavier soil types since a single concentration phase would achieve the desired reduction in the volume of drainage water. However, the sustainability of the system is unknown and needs to be investigated in the field.

Saltbush or a combination of salt tolerant grasses would be the crops most appropriate for the SBC system. If the nutritional value of saltbush, for cattle as a pure stand could be improved, then saltbush would be the preferable choice in all situations due to its high salt tolerance and productive capacity.

A pilot study would need to address the problems of a lack of awareness in the farming community, deficiency in technical knowledge on the leaching fractions on the duplex soils and a lack of knowledge as to the proportion that artesian flow contributes to tile drainage flow in shallow watertable conditions.

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Societies, including the primary industries, are characterised by ongoing pressures leading to economic and social changes. The economic and social well-being of all Australians, either directly or indirectly, are affected by the way that the primary industries and persons associated with those industries respond to the pressures.

Both the public and private sectors provide considerable resources to assist in the structural adjustment processes in the primary industries through, for instance, education and training, research and development and targeted schemes such as the Rural Adjustment Scheme. It is important that these resources are utilised effectively and efficiently.

This small RIRDC program provides independent research support for operational and policy analysis within the industry and the Primary Industries and Energy portfolio.
Objectives

- to trace the experience of a sample of non-farm businesses in selected industries in several towns in rural New South Wales over a period spanning pre-recession and recession in the two key agricultural industries;
- to document the changes in economic performance experienced by businesses in different industries, of different sizes, and ages, in towns of different sizes and other characteristics over time;
- to document the adjustment actions taken by non-farm businesses in rural towns during a period of depressed agricultural incomes;
- to interpret the results in ways that are informative for parties interested in the factors influencing the performance of non-farm businesses in rural areas, including business groups rural communities, and researchers.

Background

The economic health of rural towns has long been assumed to depend mainly on the economic health of the farm sector in their adjacent regions. While the economic restructuring of Australian farms, has over the long term, weakened the economic linkages between farms and their nearby towns, during severe rural downturns fears are commonly expressed that rural towns will suffer dramatic, inevitable, and irreversible decline in economic activity and well-being. The rural recession which started in about 1990 offered the opportunity to investigate these influences in some detail.

Research

About 240 non-farm businesses in six towns in northern New South Wales were surveyed twice to trace changes in their business performance over the period 1988–89 to 1992–93, and the reasons for these changes.

Outcomes

Analysis focused on the changes in financial performance reported by different types of respondent businesses and by businesses with different degrees of dependence on farmers, over the course of the recession. A minority of businesses reported receiving over half their takings from farmers. As was expected, this group reported a higher incidence of declining revenue throughout the recession.

The pattern was not uniform from town to town, however. While smaller towns tended to have a higher incidence of farmer-dependent businesses and therefore of falling takings, in larger towns other factors seemed to explain the changing performance of non-farm businesses.

Considerable evidence was found that factors other than the rural recession explained observed changes in non-farm business performance: businesses tended to maintain their pre-recession trend of performance. That is, declining businesses continued to decline, while growing businesses were more likely to continue to grow.

Implications

Failure to demonstrate stronger linkages has implications for the responses of governments to financial stress experienced by non-farm rural businesses. In particular, it undermines arguments for extending assistance (such as that available under the Rural Adjustment Scheme) to these businesses during times of cyclical downturn in the farm sector. While some businesses might be able to demonstrate the direct influence of farm recession and the absence of contributing causes, no case can be made for general or widespread eligibility of rural non-farm businesses.

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172. FAMILY FARM BUSINESS TRANSFER IN A CHANGING RURAL SOCIETY

Objectives

to explore the nature and processes of the transfer, of family farming enterprises from one generation to the next and to evaluate their effectiveness;
to work with farming families and those who service, or could service, their needs in this area, to improve the quality and outcomes of the farm transfer process.

Background

Although considerable research has been conducted on farm transfer in North America and Europe little is known about this in Australia. Furthermore, overseas research has been conducted from within a single discipline whereas this research involved a multidisciplinary approach. In addition we chose to use the action research methodology as the framework within which we would conduct our research activities.

Research

The research was primarily undertaken in two contrasting locations, a mixed farming region Tottenham/Nyngan, New South Wales; and a dairy farming region Maleny, Queensland.

In the first instance the research was negotiated with farming families and farmer organisations and government representatives. Research then focussed on groups including accountants, solicitors, financial advisers, family therapists and social workers. After this, 42 farm families, 22 of which were involved in two generation farms (totalling 122 respondents) were surveyed by mail and interview.

In the fourth phase, four case studies were undertaken with two families from each region. These were then followed by key informant interviews with representatives of farmer organisations, government departments, professional bodies and individuals. The last phase was a strategic planning workshop.

Outcomes

The research has shown that the decision whether to transfer the family farm business to the next generation is both complex and difficult for all those involved. Farm families find it extremely difficult to discuss the future of the family business and in the main they have treated it like a closet subject.

In many cases one or both spouses in the first generation see farm transfer as something they have to deal with in relative isolation to other family members and without the assistance of professional advisers. It was evident that those who are involved in two generation farms are juggling three objectives — treating all their children fairly, maintaining a viable farm for the next generation and providing for their own retirement.

The second generation (those who have returned to the farm) have a strong need to be involved in discussions about the future of the family business. Their concerns were primarily based upon a lack of knowledge as to the future of the family business and their involvement.

The research supports the need for an integrated approach to the provision of advice and the development of farm transfer strategies. Advice on the issue is very fragmented and does not reflect the fact that farms are often two generation businesses.

Implications

A more integrated approach amongst the private sector advising on the issue is clearly needed. There should also be a professional development programs to train advisers. Government programs need to recognise the difficulties being faced by families transferring the family farm business.

RIRDC Project No: HAC-7A
Objectives

to document successful case studies of people who have developed new agricultural enterprises;
to use these cases to draw out the basic principles of successful enterprise development;
to promote the findings of the study through publications and regional workshops.

Background

For the past nine years the Victorian Department of Agriculture and the State/Commonwealth Bank of Victoria have cooperated in running the Victorian Farm Entrepreneur Award. During this time over eighty new enterprises have been judged and a huge amount of data accumulated.

At the same time, the government has been encouraging the development of new enterprises through the Rural Enterprise Victoria scheme. The Commonwealth government has also recognised the value of this scheme and has given extra funds under the Business Advance Rural Areas program, to be run in conjunction with REV and targeted towards smaller towns in farming areas.

The REV scheme reported increased enquiries for information about new farm enterprises and how to go about developing them.

Thus there was a need to document and publicise information built up via the Entrepreneur Award and the REV/BARA scheme.

Research

Twenty-two successful case studies were used to illustrate the principles of successful enterprise development. The case studies were chosen from past entrants in the Victorian Farm Entrepreneur Award and represented enterprises diverse in nature and size.

Outcome

The end result was a 270 page book titled ‘Don’t Dream It, Do It — Making Money From New Farm Ideas’. A series of five regional workshops were run throughout Victoria in conjunction with Rural Enterprise Victoria. In addition, there were other talks and workshops held as a result of the project.

A national promotion campaign was carried out by Agmedia, the Department’s publishing section who were responsible for the printing and promotion of the book.

Implications

This will be an ongoing program within the Department of Agriculture and REV and the outcomes of this project will be very useful in promoting these principles.
Objectives
To examine, at an introductory level, the issues that affect the mobility of capital in Australian broadacre agriculture. In particular:
the financial performance characteristics of agriculture.
whether agriculture is a reasonable investment alternative.
if there are inherent structural impediments to the mobility of capital in agriculture.

Background
Agriculture is one of Australia’s large industries. Because of its historical development, farm enterprises and the attached household have a unique interaction. Approximately 86% of all farms are classified as family farms. The bulk of farm enterprises are small to medium sized businesses.

Research
Ten-year, industry-wide, performance data was disaggregated and then grouped into five performance groups ranging from the bottom 50% of performers to the top 5%. With this data, farm enterprise returns to capital were identified. In a similar fashion, the financial performance characteristics of Australian corporate agriculture were determined. These were bench-marked against other commonly used investments (asset classes) to determine the desirability of investment in agriculture.

Outcome
investment returns to broadacre agriculture do not compare favourably with other traditional investments and therefore are of low attractiveness to professional investor and fund managers;
broadacre capital assets are overvalued relative to other investment alternatives. This phenomenon is most apparent in the smallest enterprises where quality-of-life values distort commercial worth;
greater than 75% of Australian farms are achieving negative or at best break-even returns to capital;
smaller farm enterprises have very low capital efficiency ratios (i.e. the bottom 50% of farms (by turnover) replenish farm capital by off-farm income);
the analysis revealed a very skewed financial return profile in favour of larger, more capital efficient farm enterprises;
the medium to large farm enterprises face a conundrum with respect to growth. Debt-financed growth is risky and is not suited to most broadacre enterprises. Failure to grow will result in an erosion of existing capital base.

Implications
A number of impediments exist to the entry and mobility of capital in the agricultural sector. The study identified a need to develop additional structural adjustment mechanisms to allow primary producers to expand their operations, allowing them to access operating efficiencies available to larger operators. Further examination of this problem is required.