VG98051
Technology Transfer to the Australian Carrot Industry

Doris Blaesing
Serve-Ag Research

Know-how for Horticulture™

VG98051

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Technology Transfer to the Australian Carrot Industry

HRDC Project VG98051

FINAL REPORT

Prepared for the

Horticultural Research and Development Corporation (HRDC)

by

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May 30, 2000

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HRDC Project VG98051 – Development of a national technology transfer strategy for the carrot industry

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Media Summary

The objective of the study was to collate and analyse information relevant to the development of a strategic technology transfer plan for the Australian carrot industry. A further aim was to improve communication and collaboration amongst carrot researchers and extension personnel.

The study documents national technology transfer needs, and highlights State or regional differences in industry structure, R&D and extension. The carrot industry's use of new technology and R&D was investigated. During the study, existing resources and relationships were utilised, and further links with carrot researchers, industry stakeholders and industry development officers were established.

Technology transfer systems used in other crops/industries in Australia were investigated prior to compiling the plan.

The outcome is a strategic plan for technology transfer in the carrot industry. The plan lists strategic issues that influence technology adoption, which should be addressed during implementation of the plan. It suggests how to deliver relevant information and reduce impediments for technology adoption.

The recommendations drawn from the study and development of the plan are as follows:

- Formation of a technology transfer team.
- Implementation of the technology transfer plan.
- Assessment of the plan's potential for technology transfer in other horticultural industries.

Technical Summary

The objective of the study was to collate and analyse information relevant to the development of a strategic technology transfer plan for the Australian carrot industry. A further aim was to improve communication and collaboration amongst carrot researchers and extension personnel.

As part of the study, technology transfer systems used in other crops/industries in Australia were investigated and are listed as references.

The results of the study are presented in two parts.

1. Foundation of the strategic plan

This includes a collation of information on Australia's vegetable and carrot industry and the current industry support system. Findings from surveys, field visits and grower meetings are presented and discussed. Part one also documents national technology transfer needs and highlights state or regional differences in industry structure, R&D, and extension and use of new technology and R&D was investigated. Existing resources & relationships were utilised, and links with carrot researchers, industry stakeholders and industry development officers were established.

2. The strategic plan

The plan lists strategic issues that influence technology adoption and should be addressed during implementation of the plan. It formulates key objectives and activities. Key activities address information needs, and improve the prospect of technology adoption. The aim is to deliver relevant information and reduce impediments for technology adoption.

3. Recommendations

The recommendations drawn from the study and development of the plan are as follows:

- Formation of a technology transfer team.
- Implementation of the technology transfer plan.
- Assessment of the plan's potential for technology transfer in other horticultural industries.

A. FOUNDATION OF THE STRATEGIC PLAN

Background

Each major carrot growing area in Australia has its own structure, resulting from different production and marketing environments, as well as tradition. The industry as a whole is facing common challenges, such as sustainability of resources, as well as area specific problems. Pack-outs of marketable carrots can be inconsistent and unpredictable, ranging from 30% to 90%. It is not clear whether this is a result of ineffective research, poor technology adoption or 'a fact of life' in carrot production.

Carrot research projects have been and are being conducted in different states. They are investigating topics, which are mainly relevant to the local industry. Research results have been, if not confidential, published in research reports, newsletters and industry journals. They have also been made available to growers at field days and in one to one discussions between industry members and researchers. Still, not all industry members and researchers have easy, timely access to the same pool of information. It is difficult, especially for producers, to access and analyse carrot information, which is available from a wide range of sources, due to time constraints and varying availability of these sources (eg. computer based systems, libraries, etc.). Research results and new technologies reported from different production areas, nationally and internationally, often need interpretation and adaptation to fit into specific commercial production systems.

Domestic and overseas markets have become very conscious of chemical inputs into vegetable production. They demand carrots with documented low inputs of chemicals and no residues, produced in a sustainable growing system. To enable the move to integrated crop management and sustainable production, a special effort has to be made in the area of technology transfer and adoption. Australian and international knowledge has to be collated, analysed and made available to the industry in a 'user friendly' format.

The carrot industry

The industry structure in Australia's carrot producing states has been investigated, using published data and personal communication with stakeholders.

A survey of carrot producers has been conducted using semi structured, exploratory interviews during farm visits and telephone interviews. Some growers agreed to record their answers on a survey form that was left with them during a visit or meeting, or sent to them after a telephone conversation. About 40% of growers returned their forms.

This method was preferable to just mailing questionnaires, as underlying issues would often only become clear in personal conversations. It proved to be valuable that the person conducting the interviews had previous involvement in carrot production and marketing.

Issues addressed in the industry survey:

- Area of carrots grown, markets, other main crops / activities;
- Percentage of a farm's total production area devoted to carrots;
- Major challenges encountered in carrot production;
- Naming and rating of information sources used to meet challenges (processing or marketing company field staff, prior experiences, own knowledge, magazine articles, rural press, observation, other growers, employees, family, rural merchants, courses, workshops, field days etc., grower associations, R&D publications, newsletters, Internet, television/radio, private consultants, other);
- What makes an information source useful;
- Chasing of information (reasons, method, frequency, topics);
- Changes or improvements to carrot operations as a result of research results (type, success of change, information source);
- Reason for not using research results in the past;
- Interest in using research results and reason for interest or disinterest;
- Constraints in communication between researchers and growers, and the need for change;
- Access and use of Internet and e-mail facilities;
- Possible value of a carrot Internet sites and types of information sought;
- Best way of providing information;
- Kind of information needed most, priorities;
- Best time of the year and day for attending courses, field days, etc.

Industry meetings and field visits

The project leader participated in industry meetings and conducted grower visits in Queensland, Victoria, Tasmania and Western Australia. The concept of the visits was to fit in with current industry structures and events rather than calling a specific meeting. Growers would already be involved in focus group meetings under the sustainable carrot production project conducted

by Sally-Ann Henderson, Agriculture Victoria (VG99029), and meetings organised by local groups. It was felt that being a visitor and observer at local meetings could also provide a better insight into the current industry structure and interaction between producers and researchers or advisers.

In Queensland, the Industry Development Officer (IDO) had initiated a series of meetings, which were supported by the Queensland Fruit and Vegetable Growers Association (QFVG). The intention was to establish R&D priorities for the vegetable industry. The meeting was held in the Fassifern Valley, where most of the vegetable growers produce carrots. A presentation on current carrot research was given to introduce this technology transfer project, which was given the name 'Carrot Crunch'. During the visit to Queensland, seven producers with properties of various sizes were visited to discuss their information needs and views on technology transfer. The visits were organised and attended by the IDO and QFVG representatives.

In Victoria, the IDO had planned a meeting between relevant government extension specialists from the Northern growing region, which included a representative from NSW, and the local HRDC root vegetable committee representative, to discuss R&D and technology transfer priorities. The project leader attended this meeting and also visited the four major carrot growers in the region.

In Tasmania, the project leader attended the focus group meeting conducted by Sally-Ann Henderson, and presented information on the 'Carrot Crunch' project. Special grower visits were omitted, as close contact to growers and the HRDC root vegetable group committee member already exists, due to work conducted on carrot diseases (VG96015, Hoong Pung), as well as the project leader's previous involvement in carrot production and export.

In Western Australia, a CARD (Carrot Association for Research and Development) meeting was attended. This included a presentation on the current project and Australian carrot research. The meeting provided a forum for discussing technology transfer issues with six CARD members, including the HRDC root vegetable group committee representative and relevant WA Agriculture staff. The visit, organised by the WA Agriculture carrot researchers, was used to meet with the IDO, visit the Medina Research Station to view carrot trials, and conduct field visits.

South Australia has no formal structure for carrot grower meetings. SARDI scientists facilitated meetings with three major growers, including the HRDC root vegetable group committee member, a local consultant and the South Australian IDO.

The carrot industry in New South Wales does not have an industry organisation. It was not possible to organise a specific grower meeting, individual field visits or telephone interviews. This was not due to a lack of support from the NSW Department of Agriculture, but rather a lack of interest from growers. All Department staff that were contacted, were extremely supportive and provided information and grower contact details.

Research providers

Contact has been made with carrot researchers nationally to gain understanding of their project focus and who initiated their project. Most researchers provided summaries of their work to date for distribution at grower meetings and farm visits. The researchers' approach to technology transfer was discussed and, in a lot of cases, experienced during visits.

Current technology transfer

The existing system in each state has been investigated during grower interviews and contact with researchers, public extension officers, private consultants and industry development officers.

Steering committee

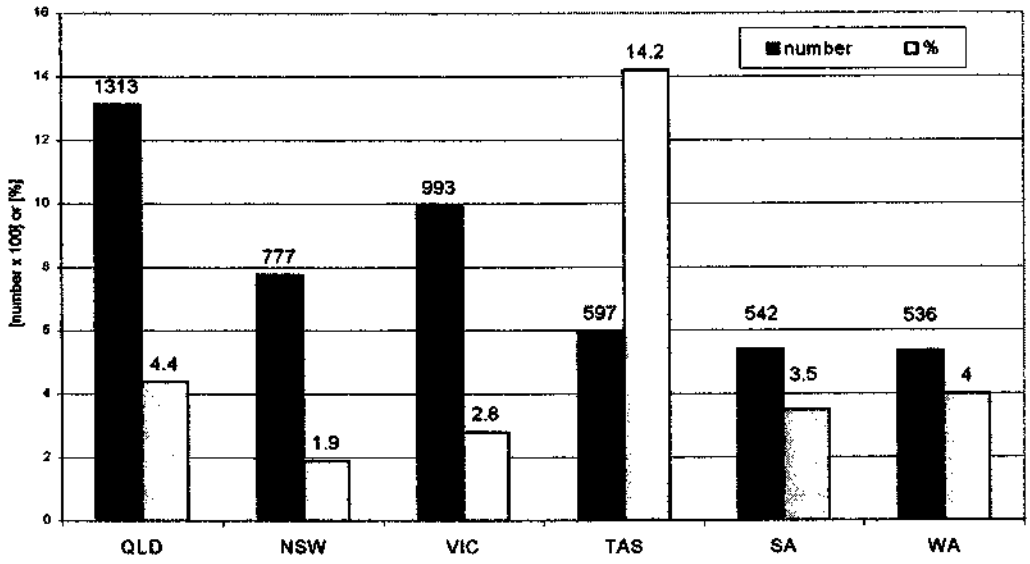
An advisory group, consisting of industry and research / extension representatives, has been put together to provide guidance at important stages of the project.

Collation and analysis of information

Information from industry surveys that were completed by growers has been collated in database format. All communication and meeting notes have been stored as hard copies or electronically for reference. Conclusions drawn from observations and communication have been used, if considered relevant. Literature listed under 'References and Bibliography' has been used to increase the understanding of technology transfer issues in agriculture. Not all sources are directly referred to in the following text or the plan.

Agriculture & Vegetable Production

Graph 1 - Number and percentage of agricultural enterprises producing vegetables in six states, (Australian Bureau of Statistics, 1998)



Queensland has the highest number of vegetable producers, whereas the percentage of Agricultural enterprises involved in vegetable production is highest in Tasmania (Graph 1). The areas of irrigated vegetable production in each State (Table 1) also indicate the relatively large number of vegetable producers in Queensland, and the reasonably high percentage of vegetable production in Tasmania. Victoria has the second highest number of vegetable producers and hectares under irrigation.

Table 1 - Area of vegetables under irrigation, (Australian Bureau of Statistics, 1998)

State	Area (ha)	% of total area
Western Australia	8,000	7.8
South Australia	11,000	10.7
New South Wales	16,000	15.5
Tasmania	18,000	17.5
Victoria	23,000	22.3
Queensland	27,000	26.2
TOTAL AREA	**103,000**	**100**

The Carrot Industry

Table 2 - National production figures

	95/96[1]	96/97[3]	98[2]	99[2]
Area (ha)	7,564		7,900	7,196
Tonnage	249,928	257,000	270,000	267,000
Marketable yield (t/ha)	33.0		34.2	37.1
GPV* ($m)	136	142	148	146

Sources: [1] *Australian Bureau of Statistics (ABS, latest available figures to March 1996)*
[2] *FAO (Food and Agriculture Orginsation)*
[3] *Australian Horticulture in the Global environment (HRDC/AHC/ABARE)*
**Gross Production Value*

Table 3 - State production figures

State	Queensland	New South Wales	Victoria	Tasmania	South Australia	Western Australia
Production (tonnes)[1]	29,427	22,757	91,123	21,256	39,996	45,369
Production (hectares)	1130	990	2400	500	1180	1000
Carrot production % of total irrigated	3.3	4.3	12	3.6	11	17.2
Major types grown	Imperator	Imperator	Imperator Nantes	Nantes Koroda Chanteney Imperator	Imperator Nantes	Nantes
Main months of production	5-11	1-12	1-12	1-8	3-11	1-12
Major markets	Domestic	Domestic	Domestic fresh & juice	Export, Domestic fresh & frozen	Domestic	Export, Domestic

Sources: [1] *Australian Bureau of Statistics (latest available figures to March 1996) and personal communication*

Table 2 shows that carrot production increased in area, tonnage and value from 1995 to 1998. In 1994/95, the Australian Bureau of Statistics recorded production at only 239,000 tonnes. In 1999 there was a reduction in area below that of 1995/96, however the tonnage was only slightly lower than in 1998 due to an increase in yield. This greater productivity may be due to changes in growing practices and varieties. During the last 5-6 years, Nantes (eg. Crusader, Hipac, Stefano, Ivor) and Koroda (eg. Coral 2) style carrots became increasingly popular and are preferred to the Imperator types (eg. Red Count, Red Hot). Koroda carrots are mainly grown in Tasmania for export to Japan. The Koroda style of carrots has steadily increased in popularity on the domestic market since its introduction in 1993.

The State figures in Table 3 are from 1996, which was the latest available ABS information. Figures from 1998 for Western Australia (McKay, personal communication) show 60,000 tonnes of carrots grown there on 1,318 hectares. This means that the increase in Australian carrot production between 1995/96 and 1998, of about 20,000 tonnes, was mainly due to increased production in Western Australia (14,600 tonnes). With the expansion of carrot production in the Sunraysia area, Victoria experienced the second highest growth in production. The Western Australian figures from 1998 indicate an average packout of 45.5 tonnes per hectare, which is above the national average. The latest available figures on average yield per hectare are quite old (1991-93), and show a level of well above 40 t/ha for Western Australia and Tasmania, 34 t/ha for South Australia and 38 t/ha for Victoria. New South Wales and Queensland produced rather low yields, with 22 and 26 t/ha respectively. Considering the influence of soils and production systems seen during visits to different production areas, yield ratios between States would not have altered considerably.

Markets

Domestic fresh market carrots are sold in the following classes: Grade 1, Grade 2, juicing grade, processing grade (freezing & canning). Depending on the grade and market, most carrots are packed in 20kg bulk cartons or bags, and 1kg or 0.5kg pre-packs, which are sold in 20kg units. Retail juicing carrots are sold in 5kg pre-packs. Grower/packers sell carrots under their own brand. Supermarkets have developed strong relationships with their suppliers and demand stringent quality controls (approved supplier system). Larger producers supply their markets all year round by forming alliances in different climatic regions, if required. Nearly all of Australia's processing carrots for frozen products are grown in Tasmania. In other States, processing grade carrots from fresh market production are used for juicing, freezing and canning.

About 15% of Australia's carrot production is exported. Major export markets include Malaysia, Singapore, Hong Kong, Korea, Thailand and Japan. Japan is mainly supplied from Tasmania, but Tasmanian carrots are shipped to other Asian destinations as well. Western Australia, the largest carrot exporter, ships to Malaysia, Singapore, Hong Kong, Taiwan, the Middle East and Thailand (*Source: ABS and personnel communication with stakeholders).* Major competitors in export markets are China, Taiwan, New Zealand, USA and Malaysia. New Zealand has increased carrot production from 81,200 to 120,000 tonnes in the four years from 1995 to 1999 (*Source: FAO*). It is increasingly regarded as a major potential competitor in Asian markets.

Production

Queensland has small to medium sized producers as well two major growers. Main production areas are the Fassifern (75%) and Lockyer Valleys, and the Toowoomba and Stanthorpe areas. Soils range from black and red alluvial clay loams in the Fassifern and Lockyer Valleys to brown cracking clays in other areas. Due to the heavy soils, carrots are produced on potato mould type ridges, with 1-2 rows per mould, under overhead irrigation (ground water). Carrots are grown in rotation mainly with lucerne, maize, soybeans, barley and vegetable crops. In close rotations, soil fumigation is used to avoid the build-up of soil borne diseases. Most growers run their own packing operation. Only few supply larger growers. Smaller growers are feeling some pressure from the market regarding the varieties grown and sometimes presentation of product (eg. carton vs bag). Small scale production and packing may not remain profitable in the future. Growers will have to increase production, cease growing, combine forces or produce under contract for larger packers. There are three major producers but about 40-50 growers producing carrots on their farm.

Even though **New South Wales'** main production areas near Griffith (Riverina) and at the Central Coast were not visited, comments made above about smaller Queensland growers may apply. The Department of Agriculture named five main producers for the State.

In **Victoria,** the Sunraysia area has emerged as a large-scale carrot growing area. Four producers grow and pack carrots from over 1000 hectares. Further production is located in East Gippsland and the traditional, but decreasing, centres on the Mornington Peninsula and around Healesville and Cranbourne. Victoria has 52 growers, however only 10 are considered major producers. Soils are generally light to medium textured red sands and sands. In the Sunraysia area carrots are grown on beds under solid set or centre pivot irrigation, and are mainly rotated with brassica crops or fallow land. Close rotations have led to an increase in cavity spot. Growers maintain tight control of growing, packing, marketing and transport.

In **Tasmania,** a large number of vegetable growers produce carrots under contract as part of their rotation. Rotational crops include other vegetables, pyrethrum, poppies, potatoes, pasture and onions. Two major processing and two major fresh market companies control production, along with three smaller grower/packers. These companies contract about 60 individual growers. Company-employed field officers supervise planting and harvesting operations, and assist in crop monitoring. Carrots are mainly grown on Krasnozem soils, which are high in clay and organic matter. Depending on the variety, carrots are produced in beds or moulds. Due to the cool climate, Imperator and Chanteney carrots can be stored in the ground into winter. Nantes and Koroda carrots suffer exponential increases in disease (eg. crown rot) and cracking/splitting with the onset of cool, wet weather in May.

In **South Australia,** half of the State's production comes from red, sandy soils along the Murray River around Loxton, Barema and Renmark. Carrots are grown on beds on a large scale. Centre Pivots are the major irrigation systems. The remaining production originates from red, sandy loams around Virginia (North Adelaide Plains) and the South East near Mt Gambier, where carrots are grown on volcanic ash soils and grey sands in beds under overhead irrigation. In South Australia, damping off as a result of, often seed borne, *Alternaria* has been identified as a major disease problem.

In **Western Australia,** carrots are produced in sands in bed systems under solid set irrigation or centre pivots using ground water. The two largest producers run operations a considerable

distance from their packing houses in Perth. Traditional production is concentrated in the coastal plain 100km north and south of Perth. Rotational crops include other root vegetables, brassicas, some potatoes and onions. However, rotations are often short, leading to problems with cavity spot (*Phythium sulcatum*).

Surveys and Field Visits

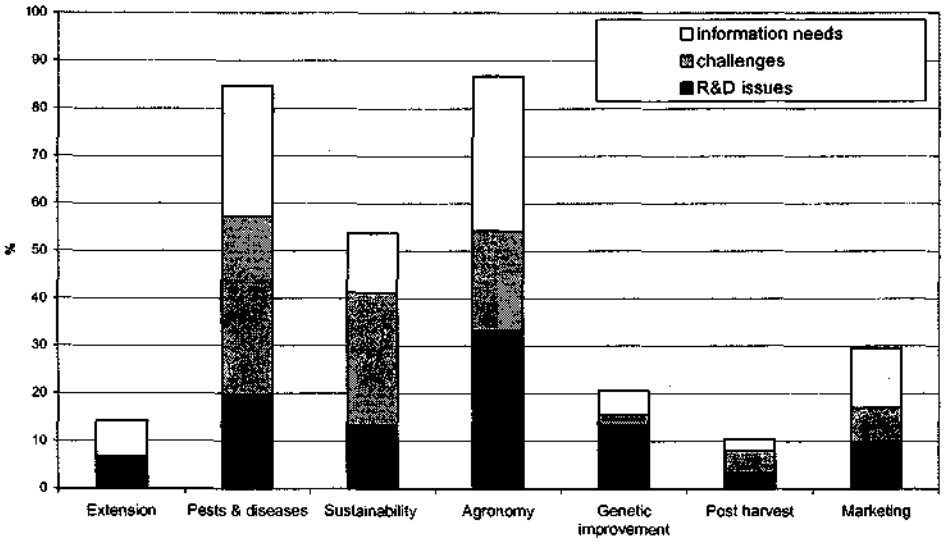
Completed survey forms and interviews conducted during field visits formed the basis for the following analyses. The total number of grower replies amounted to 31, which comprises approximately 10-15% of producers growing carrots, but 75% of Australia's production volume. It covers a range of company sizes, from 20 to 600 hectares of carrot production. Observations made during grower meetings and field walks were used in the discussion of survey topics.

Research and Information Needs

The **R&D issues** presented in Graph 2 have been identified during carrot grower workshops on sustainable carrot production conducted by Sally-Ann Henderson from Agriculture Victoria, in Victoria, Tasmania, South Australia, Western Australia and Queensland, during winter 1999. A complete report on findings is available from the HRDC (project code VG99029, Sustainable carrot production, workshops and development of priorities). Growers named major **challenges** as part of introductory questions in surveys and interviews. These can be understood as predominantly medium to long term concerns. In the context of communication with researchers, growers were asked about their most urgent **information needs**. These represent areas where growers feel that their current knowledge is not satisfactory and they would like immediate information.

Issues such as nutrition, irrigation, rotation and soil management, as well as splitting and cracking, have been summarised under 'Agronomy'. 'Pests and Diseases' includes weed control.

Graph 2 - R&D issues, information needs and major challenges



Graph 2 highlights that growers would like agronomy issues addressed in research and would like to receive more information on these immediately. However, as a challenge, 'Agronomy' rates lower than 'Pests & Diseases' and 'Sustainability', which were seen as long term threats. 'Marketing' related issues were of major concern to growers in Queensland and Victoria. Queensland growers wanted to gain a better understanding of consumer needs, and would like to develop new products and markets. This could be related to the fact that well presented Nantes and Koroda type carrots seem to be preferred to the Imperator types, especially by supermarket buyers. To meet that changing market demand, traditional varieties, growing and packing systems would have to be altered, unless a niche for 'Imperator products' can be found. In Victoria, the market related concerns were due to a seasonal oversupply of the domestic market and related price drops. In Western Australia, Tasmania and South Australia, 'Pests and Diseases" and 'Agronomy' were mentioned most frequently.

All of the topics listed in Graph 2 were also identified as essential R&D areas in an HRDC carrot planning workshop (VG98118) held in May 1998. HRDC root vegetable committee members and researchers from each State attended the workshop. In addition, two further issues brought forward in that meeting did not come up in this study, or at the Agriculture Victoria workshops. These were 'Quality Assurance' and 'Waste Management' (water & product).

The preliminary vegetable industry R&D priorities, as listed by the AusVeg HRDC root vegetable group, include issues raised in this and previous studies, but priorities are different. The Root Vegetable Product Group Summary reads as follows:

Priority 1 - Screening genetic material
Screening of new genetic material for best varieties.

Priority 2 - Our Industry Image – Consumers
Need to understand the image of our industry in eyes of consumer including quality of products.

Priority 3 - Pest & Disease control
Pest & Disease control – cavity spot, leaf blight, pythium etc of carrots.

Priority 3 - Crop rotation
Why can't growers produce more than three consecutive crops?

This summary places different priorities on issues, than are reflected in results shown in Graph 2, with more emphasis on genetic improvement and marketing, and less on the topics that came up as major overall issues in the studies presented in Graph 2. Agronomy does not rate at all in the preliminary HRDC R&D priority list, even though growers want to know more about nutrition, irrigation, soil management, density, etc., and their influence on pack-out, size, shape, splitting, cracking and appearance. One reason may be that the root vegetable group believed that adaptation and adoption of existing knowledge could address agronomy issues. Also, agronomy may have to be addressed on a regional, rather than a national, level.

Information Sources - Quality and Utilisation

Growers were asked how they rate the information sources that appear in Table 4, using the following scores: 1 = very useful, 2 = good, 3 = reasonable, 4 = poor, 5 = useless. In Table 4, sources are listed in order of ranking within each rating class. Rankings show that growers gave very high scores to 'own observation' or 'specific sources'. The 'specific sources' were either particular researchers, or specially valued industry people, who had proven particularly useful. Isolation of farms was mentioned several times as a reason for self-reliance.

Table 4 - Information sources and their quality ratings

Quality rating class	Information sources			
1-2	**Own observation**		**Specific, one-off sources**	
2.1-3	Prior experience & own knowledge	R&D publications & newsletters	Private consultants	Courses, workshops & field days
	Marketing or processing company staff	Other growers, employees, family	Magazines, rural press	
3.1-4	**Grower associations**	**Rural merchants**	**Internet**	**Television & radio**

Generally, the broader focused the source, the lower its quality rating. Most growers stressed that they would like to receive more relevant information, through concise newsletters or articles. They would also value increased opportunities to discuss specific issues one to one with (a) knowledgable, trustworthy individual(s). Field days and workshops are appreciated as an opportunity to meet with other industry members, while learning about new developments. Growers would like to see these events focused on pertinent topics rather than covering a broad range of issues.

Table 5 shows that growers usually rely on either their own experience or consultants to gain information. These sources were given a high quality rating (Table 4). They would also meet the quality criteria listed in Table 7. 'Specific sources', even though rated highly, are used by few, probably because they require some effort, or even luck, to find. The high level of self-reliance may be due to the difficulty of accessing high quality external sources. This lack of access may not necessarily be due to the absence of sources, but rather to difficulties in finding them, and their continuous availability (eg. stability of personnel in extension). According to a study conducted in 1999 for the HRDC by Richard Strategic Services, vegetable growers get most of their information from other growers, agents, and wholesalers. This confirms a relatively high level of self-reliance and circulation of information within the industry, rather than a flow from research or extension to producers.

Table 5 - Percentage of growers using particular information sources

Usage % by growers	Information Sources			
71-100%	**Prior experience & own knowledge**	**Private consultants**	**Own observation**	
41-70%	Magazines, rural press	Other growers, employees, family	Courses, workshops & field days	R&D publications & newsletters
	Marketing or processing company staff	Rural merchants	Grower associations	
≤ 40%	**Television & radio**	**Internet**	**Specific, one-off sources**	

Table 5 reveals that the Internet was not used regularly, and not rated highly in this study. The low level of training in computer usage in general, and in Internet 'exploitation' in particular, may explain this. Internet information on carrots, if found via a search engine, still has to be 'sieved'. Therefore, the Internet was considered as cumbersome, time consuming and of limited use for solving specific problems.

In a 'trial run' of looking for relevant carrot information on the Internet, the usefulness of sites varied widely, depending on the search engine used. Most sites are American, which are often quite general, and information has to be 'translated' into the Australian environment. Some information seemed to be conflicting and needed further interpretation or follow up. The only Australian site easily found and considered useful was put together by Agriculture Western Australia.

Most growers have access to the Internet, often with help of their children. In spite of the low usage and ranking, all growers showed interest in an easy to find, informative Australian carrot site. They would like to see the following contents:

- Industry news (people, facts & figures, rules & regulations);
- News on carrot issues internationally;
- Trends on domestic and overseas markets;
- Events calender;
- Research results;
- Nutrition, Irrigation, Pest & Disease control and other crop management information;
- Equipment, technology & machinery information;
- Table of useful contacts and links.

Providing a list of relevant site addresses to growers, eg via newsletters, to eliminate the time spent searching and sieving, can foster Internet usage. A second option is to set up an 'Internet Starter Kit', following the example of the Australian Potato Industry Council (APIC). The National Farmers Federation (NFF) Internet site (www.farmwide.com.au) would also be a good vehicle to provide carrot information or links. The NFF conducted a trial of 1000 Australian farmers and their families' use of on-line services (June 1996 – June 1998). The final report is available through their web site, and should be considered when developing the concept of providing information via electronic media. Information and links can also be provided via the Department of Agriculture Internet sites from different states.

Most growers indicated the use of a variety of information sources (Table 6). However, the fewer sources they use, the higher the average quality rating. This may mean that growers who have selected sources, which give them good value, stay with them. On the other hand, it could reflect findings presented earlier, that growers often are, have to, and prefer to be, self-sufficient.

Table 6 - Number of sources used by growers, and their average quality rating

Number of sources	% Usage by growers	Average quality rating
≤ 4	31.3	2.1
5 – 9	25	3
≥ 10	43.8	3.3

Table 7 lists criteria, mentioned as important, for acceptance of an information source. In summary, these were 'relevance' and 'reliability'. These criteria were emphasised in all field visits and meetings. It was also made clear that an information source can lose credibility much faster than it can gain it.

Table 7 - Quality criteria for information sources

What determines the quality of an information source	Mentioned by growers %
Relevance to crop, district, situation, current practice	32.1
Reliability, accuracy, credibility, knowledge base, loyalty	25
Accessibility, availability, turnaround	17.9
Ability to view, compare and discuss	14.3
Easy to understand (language, presentation)	14.3

Growers who are using consultants, stressed the importance of a long-term relationship and loyalty, but also, the need for access to a broad knowledge base.

Research conducted by the Rural Industries Research and Development Corporation (RIRDC) has identified key competencies for people involved in extension. As they are considered to be extremely important for successful technology transfer, and match growers comments, they are listed here:

Interpersonal Skills
Ability to relate to others, including attributes such as empathy, cooperation, negotiation and group facilitation skills.

Verbal Communication
Ability to clearly, concisely and logically articulate ideas and arguments to individuals, groups or audiences, to test/confirm effectiveness of communication/comprehension and to listen and comprehend when spoken to.

Written Communication
Ability to prepare clear, concise and logical reports, articles and other written information, to understand

reading levels, reading ease and psychology of readers, and to tailor documents to the appropriate client group.

Information Dissemination
Ability to assess audiences' information needs, to present information in a range of forms to suit the particular audience or preferred method of learning, and to disseminate information via rural community communication channels, media and video methods, and use of modern information transfer technologies.

Electronic Communication
Ability to work with personal computers and electronic data exchange systems and be aware of the potential/limitations of electronic information technology.

Knowledge of Rural Communities
Understanding of the interacting factors affecting people and functioning of rural families, communities and organisations, and the principles of social psychology, with the ability to interact with rural communities and influence community development based on an understanding of local and regional planning, ecological, social and economic factors.

Knowledge of Human Behaviour
Understanding and application of the general principles governing human behaviour and motivation, learning theory, adult learning, knowledge systems and means of fostering client participation.

Market Research
Understanding and application of techniques for assessing client needs, including preparation, application and analysis of surveys and other qualitative and quantitative methodologies and understanding scientific and systems approaches to inquiry.

Project Planning and Management
Ability to plan, design and conduct extension projects and events. Knowledge of basic extension theory, business planning, adult learning and experiential learning principles to determine courses of action and responsibilities, to set targets, prioritise tasks, define and meet milestones, allocate resources, establish and manage teams and, evaluate and report on progress.

Project Evaluation
Ability to monitor and evaluate extension programs and plan to improve process and output as a result of reasoned assessment of achievement of benchmarks and client satisfaction, including ability to accurately determine and compare cost/benefits of work activities.

Agri-Industry Knowledge
Understanding of rural industry components (production, processing, marketing, services), inter-relationships, organisations, government and commercial influences, with particular relevance to emerging extension policies and operations and the relationship between public and private benefits and costs.

Market and Business Knowledge
Holistic understanding of the way farm/rural businesses operate, and the market factors which influence the demand, supply and profits associated with rural goods and services.

Ethics
Understanding and meeting professional, social and ethical responsibilities to employer, clients, colleagues and the community.

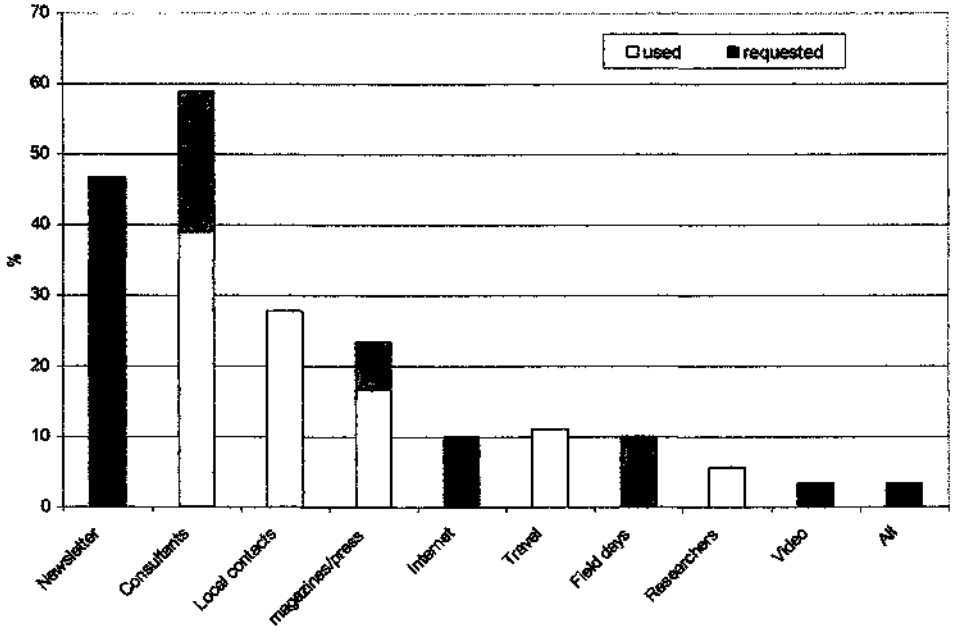
(Source: RIRDC Publication No 96/25)

Findings (Cont.)

Graph 3 shows that growers are happy to receive information via traditional media such as newsletters, consultants and field days. The reasons for low usage of the Internet and the possible contents of an Internet site have been discussed above. Very few growers travel to gain information, mainly because they find it hard to justify the time away from their business. This was especially a problem for smaller enterprises, where it was also difficult to replace the owner, in his role as manager, for extended periods of time. Still, many growers mentioned that they would like to "get around more often", as seeing and discussing technologies would improve adaptation and encourage lateral thinking.

In general growers used consultants and local contacts, when actively chasing information. These sources were selected as they fulfil the quality criteria mentioned in Table 7. When discussing the value of magazines, the American publication 'Carrot Country' was often praised. It is available via the Internet, and could be used as an example for a good publication on carrots. The Australian market will not support a magazine of the same style and frequency of publication, but a suitable adaptation may be possible.

Graph 3 - Sources <u>used</u> by growers searching for information and methods of providing information <u>requested</u> by growers



It is obvious from Graph 3 that growers do not often contact researchers to gain information. Researchers were infrequently mentioned as 'specific resources'. They were considered valuable when 'uncovered', but were seldom approached. This may be explained by constraints in communication with researchers, as mentioned by growers. About one third of producers said that they never actually see a researcher, especially not on their farm. The technical language used by most scientists was also frequently referred to. Some growers indicated a perceived lack of relevance of research, or lack of research altogether. This seemed to have been one reason for NSW growers' reluctance in participating in this study.

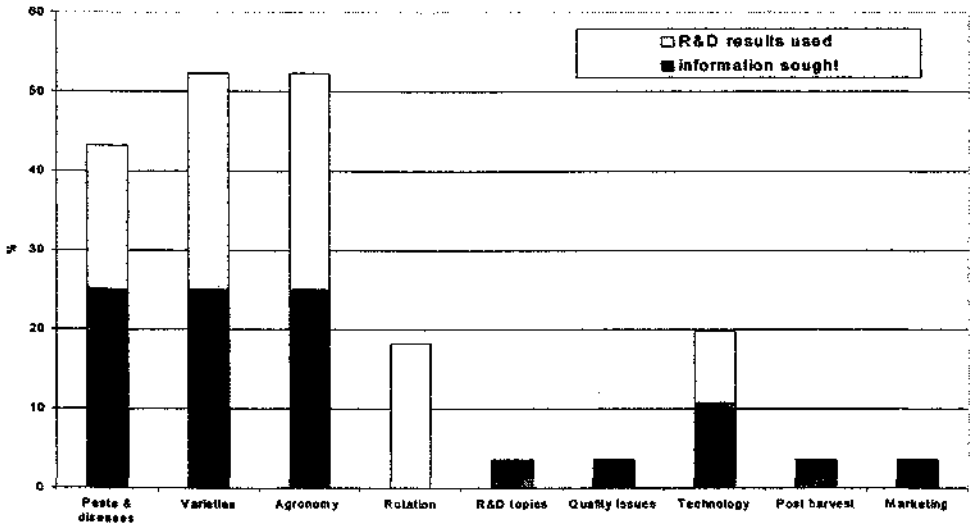
Researchers seem to have an image of aloofness and impracticability, which together with the 'language barrier', may hinder growers from approaching them. Researchers' contact details and areas of expertise are often not known to growers and are hard to obtain. Nonetheless, all growers were keen to improve communication, even if only to find out how their levy payments were used (receive value for money).

The communication barrier between growers and researchers could be broken up by:

- Training growers to better understand 'technical language';
- Training scientists to confer results in 'simple terms';
- Increasing contact between both groups with opportunities to socialise (eg. field trips);
- Providing well-edited written and electronic information (newsletters, articles, Internet);
- Assuring that growers can easily find out 'who is who' in research;
- Assuring relevance of research.

More than 50% of growers acknowledged that they have used research results in the past to make changes to their operation (Graph 4). They received the relevant information via consultants and local contacts, confirming the two sources as possible 'information brokers' to growers. It may be cost effective to focus on information transfer to consultants, extension officers, and local industry stakeholders, rather than trying to reach every grower. The information would, however, only reach 'information seekers', and only convey information on topics where growers have a perceived knowledge gap. It will not easily facilitate lateral thinking or the dissemination of new technologies. In Queensland and South Australia, some growers commented on a lack of good quality one to one consulting. This means that growers located in areas lacking a good extension network could miss out, if 'brokers' were the only medium being used for technology transfer. Still, extension specialists have to be considered as important intermediaries between researchers and growers, potentially providing information and feedback to both sides.

Graph 4 - Comparison of areas where R&D results were used by growers and areas where information was actively sought



Graph 4 also shows the areas in which growers made changes as a result of research findings. 'Pests & Diseases' and 'Agronomy' were often mentioned here. These areas also came up frequently as still needing investigation (Graph 2). Interestingly, growers used and looked for variety information, which was not obvious from their responses regarding research needs (Graph 2, 'genetic improvement'). It was, however, identified in the AusVeg priority list made by the HRDC Root Vegetable Committee (Page 13). Growers may think of variety information as either regional or confidential.

According to a study conducted for the HRDC by Richard Strategic Services (1999), 62% of vegetable growers are aware of the existence of an R&D program, but only 15.8 % indicated that they know 'quite a bit' about it. Nearly 30% of vegetable growers believed that research was not relevant to their operation. Generally , the smaller the size of the company, the less relevant research seemed to their owners. Fifty percent of vegetable growers specified that they would like more input into R&D programs. However, they either did not know how to go about it or thought it would probably not make a difference to their business.

Industry Support

Table 7 - Number of key research agencies, agricultural advisory services, rural newspapers, irrigated crop areas, and agricultural & horticultural establishments

State	Queensland	New South Wales	Victoria	Tasmania	South Australia	Western Australia
HRDC Key R&D Agencies[2]	1	1	1	2	2	1
Farm & Agricultural Advisory Services[1]	98	225	109	18	76	88
Farm Supplies[1] (appr. figures)	900	1700	1200	150	500	1000
Rural Newspapers[1]	28	32	31	2	6	10
Area of Crops and Pastures Irrigated (1000 ha, 1998)[3]	463	1,053	597	65	149	37
Number of Agricultural & Horticultural Establishments(1998)[3]	29,556	40,852	35,125	4,205	15,101	13,372

Sources: [1]Australian Yellow and White Pages, [2]Horticultural Research and Development Corporation (HRDC), [3]Australian Bureau of Statistics

The numbers of farm and agricultural advisory and supply services listed in Table 7, give an indication of the possible support available to carrot growers in different states. Numbers relate well to the area of irrigated crops and number of establishments. How many actually provide

services to carrot growers would have to be investigated. There is definitely an opportunity to "get the message out" through industry support services other than R&D agencies.

Most growers subscribe to a rural newspaper, which could be used to convey relevant research information. Apart from the US publication 'Carrot Country', magazine titles were not specifically mentioned. According to a study conducted for the HRDC by Richard Strategic Services, 21% of vegetable growers do not read magazines.

Every state has a range of industry associations. Only Western Australia has a Carrot Growers Association for Research and Development (CARD), which will be introduced in the next paragraph. The Queensland Fruit and Vegetable Growers Association (QFVG) conducts regional vegetable growers meetings, which provide a forum for carrot growers. Each State has a subsidiary of the National Farmers Federation (NFF), of which some carrot growers are members. There is no national carrot growers' body.

Australia United Fresh (AUF) is an Industry Association comprising mainly fresh fruit and vegetable packers and merchants. The AUF tries to increase the industry's image with the general public, running promotional and educational programs. The AUF could be a recipient, producer and conveyer of information, especially in the areas of post harvest, marketing and quality management.

Current R&D and technology transfer for carrots

During the study, it was obvious that the national HRDC projects on *pythium* (Agriculture WA) and celery mosaic virus (Agriculture Victoria), which include surveys and sampling of carrot crops nationally, facilitate exchange between researchers. They also increased the awareness of growers, on R&D projects, as the research included farm visits. The workshops on sustainable carrot production conducted by Agriculture Victoria also provided an opportunity for growers to meet and exchange ideas.

Table 8 - Summary of strengths and weaknesses of R&D and extension in each state

State	Strengths	Weaknesses
Queens-land	QFVG & IDO supporting research and technology transfer. Good research capabilities. Production concentrated in 3 major areas.	Lack of one to one consulting and research conducted in the state.
New South Wales	Good links between Department extension personnel and growers. Department supporting variety work.	Fragmented industry, low opinion of relevance of R&D. No IDO established. No HRDC funded research.
Victoria	IDO facilitating extension. High R&D capacity at Agriculture Victoria. Consulting is available.	Imbalance between size of production and research conducted in the state. R&D capacity mainly city based resulting in considerable distance to some production areas.

Table 8 - Summary of strengths and weaknesses of R&D and extension (Cont.)

State	Strengths	Weaknesses
Tasmania	Good, long term links between and amongst researchers and industry. Concentration of industry in a relatively small area. Relatively high number of researchers, consultants and field officers.	Researchers mainly communicate with representatives of four major packers / processors. Individual growers may miss out, if technology transfer from contracting companies to growers is insufficient.
South Australia	IDO facilitating extension, high R&D capacity at SARDI (South Australian Research and Development Institute). Current HRDC project demonstrates relevance of R&D to growers.	Short history of research conducted in the State. R&D capacity mainly city based - isolation of and distance between production areas.
Western Australia	Good long term links between researchers and industry. Grower association, newsletters, field days and consistent R&D staff facilitating communication.	None apparent.
General	National projects facilitate communication between researchers. National R&D strategies focus on priorities. IDO support available in four States.	Local issues cannot be fully addressed in nationally focused projects. Competition between producers creates a need for confidentiality of some information. Lack of a national technology transfer strategy. Lack of IDO in two States. Immense workload of IDO's and thus little attention per crop.

Western Australian growers had, through their export focus, identified a need for carrot R&D prior to the HRDC levy system being introduced. This had led to the establishment of the CARD group, which provides guidance to researchers, and disseminates information through their newsletter. The close relationship between researchers and industry has provided the basis for relevant research, addressing problems for the local industry. While the focus was on local issues, research outcomes are useful to other growing areas, and have received international recognition. Agriculture Western Australia has published R&D findings in their 'Farm Notes', which are a valuable source of information on carrot production. These Farm Notes are available from the Internet.

In **Queensland**, the fruit and vegetable growers' organisation (QFVG) has been active in initiating relevant research and technology transfer prior to the introduction of a national levy. Growers seem to be reasonably content with the system, however carrot producers commented on the lack of R&D on carrots, and would like to see a return from their levy money.

Minimal carrot research and extension has been conducted in **South Australia** prior to 1995. South Australian growers commented on the lack of communication between industry members and research, but also amongst industry members, due to the distance between production areas in the State.

Findings (Cont.)

The **New South Wales** Department of Agriculture has been screening varieties for local industry. Results of that work can be accessed via their local Department extension officers. Growers did not seem to see much value in research or national technology transfer. They did not comment on the reasons for this attitude.

In **Victoria,** the amount of R&D conducted does not represent the scale of carrot production. Growers are, and seemingly prefer to be, mainly self sufficient. They search for information themselves and 'learn by doing', and if required, hire private consultants.

In **Tasmania,** links between industry members, researchers and extension personnel are relatively strong, and current research projects have all been initiated by industry. This is partly helped by the concentration of production and R&D agencies in a small area, compared to other states.

Critical Comments

The assimilation of new, relevant technologies into agricultural industries is considered crucial to succeeding in a global market.

Slow technology adoption in horticultural industries does not necessarily originate from a gross lack of information, but rather from failure to apply existing information and technologies.

A wide range of issues influences the adoption and adaptation of research results and new technologies. These have their origin in customs, attitudes, education, training and competition, as well as mutual understanding of all sectors involved. Economic and ecological production environments have a major influence on the capability of industry to adopt certain technologies.

Policy changes that have affected the traditional public sector extension structure, and the resulting increase in private sector consulting, have an influence on information flow and feedback between research and practice. Researchers have, in many cases, lost previously associated extension staff, and thus the opportunity to get feedback on the value of R&D results and research needs.

Producers actively seeking information, to either solve problems or explore opportunities, have become more demanding regarding the effectiveness of solutions. This applies especially to situations where they have to pay for services.

The rate of technology adoption may not only be a result of the amount and quality of research conducted and results communicated back to industry, but also of training levels and the capability to assimilate information.

Issues have become more complex, and often require integration of information from a range of disciplines in research and extension. A broad knowledge base or multi-discipline team approach is required, to address complex problems. However, competition for professional recognition and limited research funds sometimes obstruct teamwork across, or even within, R&D agencies.

Clearly, the best technology transfer methods can not compensate for irrelevant or ineffective research. There is a concern that the strong focus on immediate commercial benefits of R&D, may get in the way of long term and basic research, which might be the only way of solving complex problems and meeting future challenges.

Despite the national focus of research programs, issues of predominantly regional relevance need addressing. It has to be considered that markets have become increasingly competitive, causing regions and individual growers to fight for market share. Therefore, producers have a desire to generate, own and protect information. With the reduction of public sector extension, the desire to protect intellectual property, and the increasing need to pay for services, the publicly available knowledge pool may dwindle in favour of information being owned by enterprises that can afford to pay for its generation and protection.

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- Patrick Ulloa, Industry Development Officer, Victoria;
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- Barry Nicols, Carrot Producer, HRDC root vegetable committee member, South Australia.

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B. THE STRATEGIC PLAN

Technology Transfer Vision

Australian carrot growers are adopting R&D results and new technology rapidly, and at a high rate, because:

- They have an input into the development of R&D priorities;
- They are aware of their R&D program and its goals;
- They consider their R&D program and its outcomes as highly relevant;
- They are familiar with and can identify and understand relevant sources of information and advice;
- They can measure the effect of technology adoption as improvement in profitability, sustainability and / or market demand.

Strategic Plan Mission

- To develop an effective technology transfer system for the Australian carrot industry, which
    - supports the flow of information and feedback between research providers, industry advisers, and carrot producers,
    - facilitates technology adoption, and
    - assists technology adaptation;
- To fit the technology transfer process into State or area specific industry structures and relationships;
- To set out how to measure benefits of technology adoption.

Strategic goals

- Documentation and analysis of information relevant to the strategic technology transfer plan for the Australian carrot industry;
- Documentation of different technology transfer needs, based on regional or structural differences within the Australian carrot industry and its support network;
- Feasible, achievable technology transfer objectives;
- Delivery of relevant information in an appropriate, consistent manner to all industry members;
- 'Self sufficiency' in technology adoption for the carrot industry;
- Regular evaluation of information and assumptions underlying the plan, thus maintaining flexibility and orientation on results;
- Measure the efficacy of the plan.

Production Environment

- National and State economy;
- World trade;
- Markets: size, share, location, access, requirements, changes, fluctuations in demand;
- Increasingly demanding customers (market domination by supermarkets);
- Climate, water and soils;
- Environmental protection;
- Labour origin, skills, knowledge, training, availability, turnover;
- Demographic and social trends;
- Government regulations.

Industry

- Infrastructure and organisations;
- Complexity of knowledge, skills, goods and services required for production management and marketing;
- Capability to exploit the industry support structure;
- Capability to pay for information;
- Company structure and communication within company;
- Awareness of R&D and new technology;
- Perception of R&D benefits;
- Access to information systems;
- Availability of information and advice (private vs public good nature, unpublished results, experience level and location of extension personnel);
- Availability of time to pursue, comprehend and trial R&D information;
- Timing and location of formal extension activities;
- Acceptance of ownership of problems and solutions;
- Competition between producers, States or regions;
- Food safety, Quality Assurance requirements;
- Speed of technology changes;
- Origin of technology and need for adaptation;
- Rationalisation – company size, diversity;
- Stagnant farm inputs relative to farm output and purchasing power in last yen years;

- Increasing demand for knowledge-based farm inputs (advice, one to one contacts);
- Prevalent learning techniques used by producers (eg. informal, home based, production group / social network based, learning on the job);
- Problems or opportunities seen in relation to impact on profit in the short term;
- Precarious nature of major production factors.

R&D, technology and extension

- Training, professional development of researchers and extension personnel;
- Research and extension functions resting with the same person;
- Workload other than R&D and/or extension;
- Travel distances to and between farms;
- Interpersonal skills;
- Language, terms used by researchers;
- Predominant extension techniques (eg. shift from one to one, to group based extension methods);
- Flexibility in the delivery of information;
- Extension costs;
- Appreciation of commercial production environment into which R&D results have to fit;
- Administration increase in public sector;
- Retainment of staff and thus knowledge and relationships by public sector;
- Rationalisation, location of major R&D providers in city environments;
- Regionalisation, rationalisation of extension;
- Efficiency of extension system;
- Change of extension from public sector based to increasingly private sector based;
- Bias towards industries or individuals on the basis of ability to pay, or State politics;
- Availability of information with public and private good nature;
- Intellectual property rights, confidential research;
- Feedback to researchers from industry, and industry support groups;
- Competition for funds and reputation amongst research providers;
- Cooperation, willingness to share information amongst research providers;
- Specialisation of researchers (eg. when integrated approach to problem solving is needed);
- Focus of different R&D providers or research communities (eg. scientific kudos, technology adoption by industry, cost recovery);
- National levy (information produced has to be everything to everybody).

Farm inputs other than research

- Completeness of support structure (eg. availability of product and technology);
- Product knowledge and range;
- Specialisation;
- Location.

Banks

- Presence in horticultural production areas;
- Understanding of the horticultural production environment and value;
- Willingness to provide funds to 'risk industries'.

General

- Cooperation and coordination between all sectors;
- Distance (isolation).

The above issues have to be considered when establishing the technology transfer program. They have to be categorised as intrinsic and extrinsic factors, and prioritised according to their effect on technology adoption. The program has to be instrumental in addressing priority issues that will have a significant impact on technology adoption. There will be some that cannot be dealt with as part of a technology transfer program. They must, however, be brought to the attention of appropriate groups or organisations.

Key objectives

Information disseminated to growers will be:

- Highly relevant;
- Provided constantly and consistently;
- Delivered appropriately for the topic and target group.

The technology transfer personnel will be:

- Well connected with all industry, and industry support sectors;
- Adequately resourced;
- Consistent;
- Capable;
- Committed;
- Reliable;
- Flexible.

The team as a whole will have skills and knowledge in the following areas:

- Project planning, management and evaluation;
- Agri-Industry and rural communities;
- Interpersonal relationships and human behaviour;
- Verbal written and electronic communication;
- Information dissemination;
- Markets and business management.

(Adapted from: RIRDC Publication No 96/25)

Key activities

The team responsible for the implementation of the plan will perform the key activities.

Key activities encompass two components, which should commence concurrently.

A) Address information needs

1. Compile relevant information.

Seek assistance from researchers, extension specialists, consultants, etc.

2. Disseminate information

Prepare newsletters or utilise existing publications, which are known to reach carrot growers in a cost-effective way. The information must also be distributed to relevant members of the industry support structure.

3. Investigate the use of electronic media for the distribution of information.

- Internet site,
- E-mail newsletter,
- Webcast of seminars and courses,
- Others.

4. Better utilise extension specialists and consultants to assist in the implementation and initiation of R&D.

Facilitate communication between people involved in extension and relevant researchers. This could, to some degree, be achieved as part of the collection and dissemination of information.

5. Monitor the recipients of information to assess the quality of the media used and its contents.

This can be done with the help of surveys or focus groups.

6. Monitor changes in information needs.

This can be part of the monitoring process. Researchers should be informed of changes.

Key activities (Cont.)

B) Improve the prospect of technology adoption

This has to consider present differences in technology transfer and attitudes between States, which may lead to a slightly different approach in each State or region.

1. Prioritise strategic issues, and plan how to address them.

Criteria to be considered in rating issues are:

- Relevance to technology transfer and adoption,
- Urgency of the need to change,
- Chance of success, feasibility,
- Costs associated with change,
- Time frame required,
- Resources available.

2. Address known priority issues.

Following is an example of a process of addressing strategic issues, which have repeatedly been highlighted as impediments to technology transfer and adoption in previous studies. They are, therefore, considered highly relevant and urgent, and should be taken up immediately by the project team. The issues relate to training, knowledge, skills, awareness, communication and cooperation of all relevant sectors.

Phase 1 - Gap analysis of training, knowledge, and skills relevant to technology transfer, adaptation and adoption.

The following groups should be considered:

- Producers
- Researchers
- Public extension personnel
- Consultants
- Other relevant industry support organisations

Phase 2 - Development of a program outlining steps to be taken to narrow gaps.

Steps have to be feasible and may have to be selected through analysing success rates of similar programs.

Phase 3 – Creating awareness and promotion of the program.

Media used could be the same as those used for technology transfer.

Phase 4 – Implementation of the program.

This would involve skills development, training and reduction of impediments. A selected representative group may have to be addressed in a first round of

2. Address known priority issues (Cont.).

implementation to test the effectiveness of the program, and make adjustments, if required.

Phase 5 - Development of self-reliance.

Program participants are further informed on how to find, evaluate, adapt and apply relevant information. They are trained in how to assess and prioritise information needs. A major aim of this phase is that communication and cooperation between all sectors will begin to function without continual facilitation.

Progress monitoring and evaluation of the program's success

The progress of each phase, 1 to 5, has to be monitored against an activity based time plan (Gantt chart). The evaluation of progress and success of each phase must be conducted prior to commencing the next phase. Evaluation criteria have to be developed by the project team. They have to provide a way of clearly measuring the impact of each phase.

Assumptions and facts underlying the program have to be checked for continuing relevance during each monitoring process. Changes to these have to be reflected in changes to the program.

Risk assessment

Risks of failure have to be identified, reviewed and addressed as part of the monitoring process.

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