REFERENCES

Audus, J. W. 1950. The Australian Bushland. Robertson and Millers Ltd, Melbourne.

Cane, W. 1970. Selection, propagation and cultivation of native plants. *In* Lord, E. E., Shrubs and Trees for Australian Gardens. Lothian Publishing Company, Melbourne pp 177–179.

Carr, D. J. and S. G. M. (ed) 1981. People and Plants in Australia. Academic Press, Sydney. pp 416.

Dixon, K. W. 1987. Horticulture of Western Australian Plants: Past, Present and Future. Royal Australian Institute of Parks and Recreation, W. A. Region Seminar "Horticultural Practices into the 1990's."

Elliott, W. R. and D. L. Jones. 1980. Encyclopaedia of Australian Plants suitable for cultivation. Volume 1. Lothian Publishing Company, Melbourne pp 336.

Lamont, G. P. 1986. Report on Study Tour of the Nursery and Flower Industries of Japan and the United States. Misc. Report, N.S.W. Department of Agriculture. pp 41.

Woodruff, J. G. 1979. Tree Nuts. AVI Publishing Company pp 298–326.

REVIEW OF STOCK PLANT ETIOLATION—A "NEW" METHOD OF PROPAGATION

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Workers on stock plant etiolation at Cornell University in the United States have had outstanding success in improving rooting of many traditionally difficult-to-strike species. However, the practice of withholding light to improve propagation is an ancient one. Some of the most common cloning methods; layering, stooling and cuttings, involve keeping light from that part of the plant that propagators hope will form roots.

However ancient the practice, recent refinements are indicating that the technique will have realistic commercial viability. Etiolation is simply the growing of plants in the partial or total absence of light. Stock plant etiolation as a pretreatment to cutting propagation, generally refers to the initiation of new stock plant growth in the dark. These shoots are pale and succulent and they produce roots much more easily than do their counterparts grown in the light.

Banding is a pretreatment adjunct to etiolation, which excludes light from a zone of the cutting base. An opaque adhesive band (e.g. "Velcro") may be applied to the etiolated shoots, which subsequently are allowed to develop normally in the light, and thereby retaining the future cutting base in its etiolated base.

The band may also be applied to developing light-grown shoots which are still in the softwood stage, in which case the band is said to "blanch" the underlying tissue.

The goal is to develop this procedure to a technique by which propagators can take plants which they think are of value and get them into production on their own roots sooner than they can currently.

COMMERCIAL APPLICATION TO THE NURSERY INDUSTRY

Stock plant etiolation seems a viable alternative to other more expensive and labour intensive propagation techniques, such as grafting. The technique of etiolation and banding may be applied on any one of a number of scales, from single branches to entire hedges and even small potted trees. Furthermore, cost calculations suggest the process should only add 5 to 10 cents (U.S.) to the price of the rooted cutting. (2)

If this technique is to become commercially viable, it must be compared with current propagation practices. At Cornell University, trials are being run in cooperation with nurseries seeking to compare production schedules, costs, and plant quality of budded and etiolated plants in a commercial nursery.

Initial comparison of production schedules show that etiolation may be as fast or faster at producing the same sized plant as budding.

Table 1 summarizes a comparison in production schedules. It is produced in America but the seasons can be adapted for southern hemisphere conditions.

Table 1. Comparing production time schedules for budding with field and greenhouse etiolation.

Technique	Time of year—Seasons (U.S.A.—Winter, Spring, Summer, Autumn)							
	1987				1988			
	W,	S,	S,	A,	W,	S,	S,	A
Budding		—	—	—	—	—	—	—
Field Etiolation		—	—	—	—	—	—	—
Greenhouse Etiolation	—	—	—	—				

Adapted from (2)

Greenhouse etiolation considerably lessens the time it takes to produce a plant of comparable size. In winter dormant stock plants can be potted up and forced in the greenhouse, thereby producing rooted cuttings by spring or early summer of that same year. These can then be grown on in the same growing season to produce a finished plant by the end of the year.

Budded and field etiolated plants can be produced in size and quality in approximately the same time as one another. Budded plants are first planted out as seedling understock in spring, budded in the summer, and cut back the following spring to produce a finished plant in autumn of the second year. In the fields stock plants are etiolated in the spring, cuttings are taken from them in summer and rooted; these can then be planted out or put into a greenhouse for growing on. If placed out in the field they are grown on for another season and are ready in autumn of the second year.

The cost of production in these time periods is summarized in Table 2.

Table 2. Summary of production costs (in U.S. Currency)

Method	Total Cost Per Plant/Cutting
Field etiolation	$ 0.43
Greenhouse etiolation	$ 0.48
Budding	$ 0.80

Adapted from (2)

The cost, in both field and greenhouse etiolated cuttings, is well below that of budded stock and when related to its production time the etiolated methods compare favourably.

It potentially results in increased productivity, freedom from root transmitted diseases and pests, no grafting and budding costs, or incompatibility problems. Further work is underway refining the commercial viability of this technique.

ETIOLATION AND BANDING IN AUSTRALIAN NURSERIES

The connection is a clear one. Firstly, the technique can readily be applied to many of those species that have been trialed successfully and are used frequently in Australia.

It is the range of difficult-to-root plant species that this method could be potentially used for; that is its greatest asset, especially if the lower costs and shortened production schedules are any indication.

There is no reason why these factors should not apply here in Australia. For example, *Eucalyptus ficifolia*, the red flowering form, is a good example of a species with potential application for this technique. Its cost and demand warrant its trial. In fact there are many Australian native species that are subject to variation from seed that could potentially be propagated by this technique.

The expertise needed to apply this technique is minimal, and no more demanding than those already employed in Australian production nurseries. The principles of etiolation are well established and accepted, so its application in this form to plant propagation should not be considered suspect.

Nurseries can use existing facilities such as field and growing-on areas and greenhouses for production. There are no large outlays in capital and expenses that would be associated with other "new" techniques of plant propagation, i.e. tissue culture.

HISTORICAL ASPECTS OF TREATMENT

Etiolation as a stock plant pretreatment has been used successfully on woody plants since as early as the 1920's. However, the procedures of stock plant etiolation and banding which have revived recent interest has essentially remained unchanged since work by Gardner in 1936 (3).

Several research groups in the 1960's and 70's looked into the anatomical and physiological changes that occur in an etiolated shoot. Although observing increases in rooting potential they were still unsure as to why it was occurring. (5, 6, 7).

Although results from this group were inconclusive, Howard and co-workers at the East Malling Research Station, Kent, U.K., refined the technique of etiolation and banding and perhaps made the greatest contribution to our understanding of etiolation as a practical pretreatment to cutting propagation (4).

Their work, using *Malus* (M9 apple), *Tilia,* and other difficult-to-root woody species, examined the optimum timing and duration of etiolation and banding as well as the influence of temperature and humidity in the promotion of rooting by etiolation. (1, 6, 7)

Bassuk and co-workers at Cornell picked up from Howard and recently have been investigating the usefulness of etiolation and banding techniques in a wide range of difficult-to-root woody plants. In the course of their work they developed the use of "Velcro" for the banding technique.

REVIEW OF BASIC TECHNIQUE

Stock plants for etiolation can be maintained in a greenhouse where, in winter, they have several months lead time to produce rooted cuttings. They can also grow outside in the field or growing area where bud break occurs at normal pace.

After bud swell, when shoots began to break, either entire plants, or individual branches, are placed into darkness.

Etiolation may be done in the greenhouse covered by black cloth, or in a frame built over a hedge or single stock plant. Even a single branch may be covered with black cloth.

With shading there is some leeway. Research has shown that shade greater than 70% is the best. This allows for two things. Firstly, it provides for ventilation and secondly, it permits one to check on the progress of shoot extension every two to three days. This does not appear to compromise the benefits of etiolation. (2, 6, 7)

The structure is left in place until the shoots have elongated enough that they are suitable for cutting propagation (5 to 15 cm).

At the time that etiolation is completed the banding material is applied to the base of the etiolated growth. Caution must be exercised at this point because etiolated shoots, lacking protective pigmentation, are susceptible to sun scorching.

The practice should be to apply the banding material and then replace the shading cover partially. This allows for the entry of a small amount of light. Over the course of a week, the cover should be gradually rolled back bit by bit, allowing shoots to green up. After one week or so the shoots should tolerate exposure to full sunlight; however the speed at which shoots adjust to higher light levels varies among species. Some common sense should be all that is needed to avoid disaster at this point.

HORMONES

Hormones, especially powdered forms, may also be applied with the "Velcro" band at the time that the shoot is banded. Bassuk and co-workers found that hormones helped get rooting underway while the rest of the shoot turned green. Cuttings can be treated with IBA in talc (3,000 to 8,000 mg/kg) and put into a rooting medium. (1, 5, 6, 7).

Generally the bands are left on for four weeks, although they can be left on anywhere between 2 to 6 weeks. When a green shoot with an etiolated base is obtained the cutting is made by severing the shoot from the stock plant just below the band making the etiolated zone the base of the cutting. See Figure 1 below.

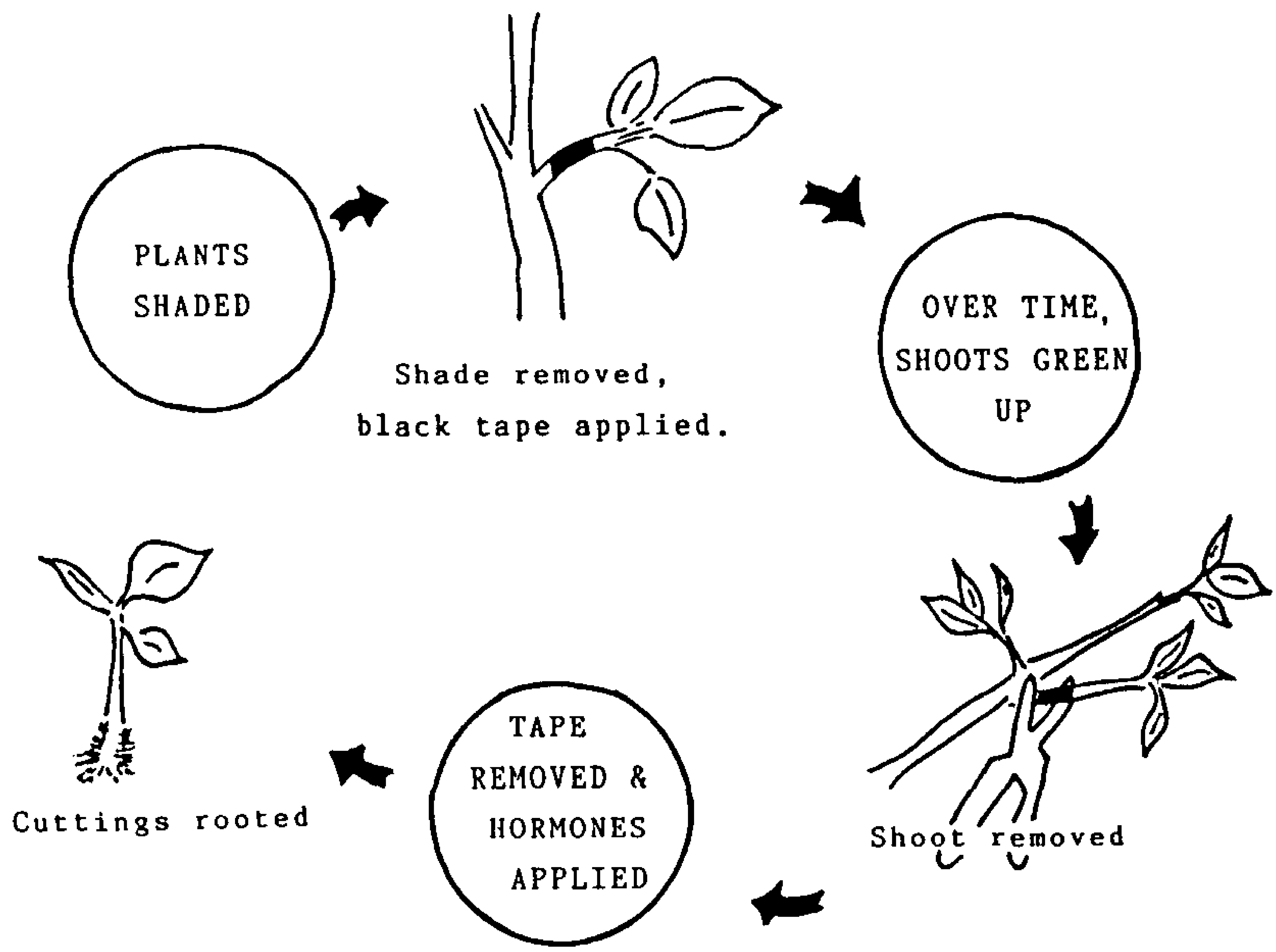

Figure 1. A graphic representation of the stockplant etiolation method. Adapted from (1).

SUCCESS OF ETIOLATION AND BANDING

Actual data for plants rooting response to these techniques has been promising indeed. In the Cornell trials the treated plants rooted significantly more than did the untreated controls.

The Cornell workers have also found that the use of hormones is not always necessary. It is advisable that at first, all treatments including a control, should be chosen for each species. For example, *Castanea mollissima* (Chinese chestnut) was found to have a 100% rooting success when etiolated, banded, and with a hormone application. It showed 44% success when only etiolated and not banded. It did not root at all when light grown, even when banded. (5)

The techniques used at Cornell include either etiolation and banding by themselves or a combination of both. When "Velcro" plus hormones were used, in nearly every case the area under the band was swollen by the time the bands were removed after 4 weeks. In fact in two of the species tested, *Betula papyrifera* and *Carpinus betulus,* visible root primordia formed under the band on the stock plant. Cuttings made from these pre-rooted shoots rapidly developed root systems. (5)

The majority of the taxa tested are known to be particularly difficult to root. Included were *Castanea mollissima, Quercus palustris, Quercus robur, Corylus americana,* a number of *Syringa vulgaris* cultivars, *Pinus strobus, Acer* spp., and *Taxus* × *media.* (1, 2, 5, 7)

The results obtained with several of these species represent, to the best of the researcher's knowledge, the best rooting responses yet achieved. Notable examples were *Carpinus betulus* (96%), *Castanea mollissima* (100%), *Quercus coccinea* (46%), *Quercus palustris* (50%) and *Quercus rubra* (30%) (5). The age of the plant material varied. There appears to be no strict rule as they have used 1 yr old seedling stock to 30 yr old hedges and mature trees.

The results have only just begun to show that traditionally difficult-to-root plants can be successfully propagated with this technique.

LITERATURE CITED

1. Bassuk, N., D. Miske, and B. Maynard. 1984. Stock Plant Etiolation for improved rooting of cuttings. *Proc. Inter. Plant Prop. Soc.* 34:543–550.
2. Bassuk, N., B. Maynard, and J. Creedon. 1987. Stockplant etiolation and banding for softwood cutting propagation—working towards commercial application. In house publication. Dept. of Floriculture and Ornamental Horticulture, Cornell University. Ithaca, New York.
3. Gardner, F. E. 1937. Etiolation as a method of rooting apple variety stem cuttings. *Proc. Amer. Soc. Hort. Sci.* 34:323–329.
4. Howard, B. H. 1977–1984. "Plant Propagation." Ann. *Rpts. E. Malling Res. Stn. for 1976–1983.* East Malling, England.

5. Maynard, B. and N. Bassuk. 1985. Etiolation as a tool for rooting cuttings of difficult-to-root woody plants. *Proc. Inter. Plant Prop. Soc.* 35:488–495.

6. Maynard, B. and N. Bassuk. 1987. Stockplant Etiolation and blanching of woody plants prior to cutting propagation. *J. Amer. Soc. Hort. Sci.* 112(2):273–276.

7. Maynard, B. and N. Bassuk. 1987. 'Understanding the dark—researchers grow plants under cover for better cuttings.' *American Nurseryman* April 1,:124–131.

VEGETABLE PRODUCTION IN AUSTRALIA WITH EMPHASIS ON THE POTATO

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To describe the Australian vegetable industry of 1988 in a short treatise is almost impossible. I consider there are four key elements that make up the industry. They are marketing, technology, the environment, and industry organization.

Marketing. There is no doubt the vegetable industry is consumer driven and the sooner that is fully realized, the better. Buyers are no longer prepared to take what growers or agents think they want. Vegetables are competing with a whole range of other foodstuffs and as difficult as it may be to change vegetable products, it must be done. The customer is always right.

The marketing of vegetables starts when a grower first decides what type of vegetable to grow and the cultivar and the production system he will use. These all influence the product he finally sells. In Australia many growers make these decisions on what they did last year or perhaps what their agents or neighbours tell them. In Sydney we have Flemington Markets, one of the largest wholesale markets in the world. The agent/merchant system has an enormous influence on what is produced. A lot of produce that is sold in these markets comes from interstate and these growers rely heavily on their agents for advice. The development of rapid road transport has meant vegetables from anywhere in Australia can be economically marketed in Sydney. The increase in the export market has probably been the most significant change in vegetable marketing in the past five years. This market has grown from $15 m in 1981/82 to $60 m in 1986/87.

Technology. Whilst the industry is market-driven the technology must be available to produce the product. Basic vegetable research and development in Australia is limited compared to the size of the industry. Production system development has largely come from taking overseas technology and developing it to our local

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