

1. ZESPRI™ Gold kiwifruit lights up the fruit world

New Zealand's popular green-fleshed Kiwifruit was launched onto world markets in the 1960s, having originated from seeds brought from China in 1904 and for many years a hobby exotic vine plant. In 1925, with the fruit then known as Chinese gooseberries, an avid NZ horticulturist Hayward Wright produced the now market dominant green-fleshed Hayward variety. Kiwifruit is NZ's highest value export horticultural crop (\$539 million in 2003), is one of only 4 new fruit crops introduced to international trade in the 20th century and is now grown in many countries, notably Italy, Chile, Japan, Korea, USA and France.



This crop however was based on only one selection, from one species of one genus that has more than 70 species growing wild in Asia and comprising a huge diversity of shape, colour, taste, nutritional attributes and hairiness. The potential existed for NZ to extend its commercial base by adding a new cultivar to the product mix. The industry was eager to diversify its product range to reduce risks that existed with a monocultural crop.

Development of the new yellow-fleshed kiwifruit cultivar 'Hort16A', with the fruit marketed under the *ZESPRI™ GOLD Kiwifruit* brand, is a remarkable and innovative scientific and commercial success story. Using seed brought from China in 1977 and 1981, HortResearch scientists had 600 seedling crosses in development in 1987. By selecting for required quality attributes and then sensory evaluation by panelists from potential markets in Asia and Europe, a single new yellow-fleshed kiwifruit cultivar 'Hort16A' was chosen (the individual plant identified as plant number '16', row 'A'). Complementing the Hayward variety marketed as *ZESPRI™ GREEN Kiwifruit*, the fruit from 'Hort16A' plants had a different colour, fewer hairs, and a sweeter more tropical fruit taste.

The introduction of the new kiwifruit cultivar to international trade in 2000 was a remarkable outcome of the combined and focused vision and efforts of scientists, growers and Zespri International, the grower owned commercial company responsible for global marketing of kiwifruit.

Selection of 'Hort16A' was the start, but commercialising required, fast-track propagation, industry acceptance, research on vine management, quality and postharvest physiology, together with a focussed and imaginative international marketing campaign. By 2003 this had resulted in the new fruit being planted on about 1,800 ha in New Zealand with an export value of more than \$160 million. Keys to this success included:

- Awareness of scientists to search for new cultivars and the excellent cooperative relationships with China that allowed the introduction of seed material to NZ;
- Skilled scientists who chose the best parent plants for the original cross, and then the ability to select potential market winners;
- Early sensory evaluation using panelists from potential market countries identified the importance of its characteristic sweet taste and yellow flesh colour;
- Recognition of its potential by industry and emergence of a marketing champion;
- Major R&D effort by ZESPRI and HortResearch scientists who with industry specialists assisted growers develop and modify growing, postharvest handling and storage systems;
- Major marketing campaigns by ZESPRI International to create consumer awareness in international markets and to receive premium prices;
- Plant Variety Rights (PVR) obtained for 'Hort16A', allowing the industry to have plantings in other countries for year-round market supply under the ZESPRI™ brand, whilst receiving royalty payments and marketing commissions to flow back to NZ growers.

Development of the cultivar and subsequent crop management R&D cost just over \$20m. Market development costs are in excess of \$50m. By 2009, total gross revenues are expected to be about \$1 billion. Clear potential exists for more exciting kiwifruit cultivars to be developed in NZ and introduced to the world as innovative, differentiated, valuable and healthy products.

1. Background:

The kiwifruit industry is a relatively new contributor to New Zealand trade. Although Isabel Fraser introduced the original kiwifruit seeds to Wanganui in 1904, and selection of the preferred cultivar 'Hayward' was done in 1925, exports of this fruit did not commence until about 1959. Exports of kiwifruit have increased rapidly and today kiwifruit is the largest contributor to horticultural exports with an FOB value of \$539 million in 2003. Originally regarded as a curiosity and a novel garnish for cakes and desserts, it has today become an important part of global fruit trade, being produced in numerous countries in temperate and Mediterranean zones in the northern and southern hemisphere including Italy, Chile, Japan, Korea, France and the USA.



The kiwifruit is native to China and some surrounding Asian countries; it is known that there are more than 70 individual species within the *Actinidia* genus, most of them growing as rampant vines in forests. Fruit has been collected from the wild and used by local residents for various food and medicinal purposes for hundreds of generations, but until recently there has been little commercial development. The impetus for this came from NZ.

The 'Hayward' cultivar was selected originally from one from about 40 seedlings by the nurseryman Hayward Wright, the seeds having been obtained from some of the offspring of plants grown in Wanganui following the original importation of seeds from China. This means that the kiwifruit cultivar currently grown in about 99% of world production is derived from one seed, from one of 40 plants, from a handful of seeds brought back from China, from one species of more than 65 species of the *Actinidia* genera.

Production based on only one cultivar is very risky from both a production and a marketing perspective. Scientists were well aware of the risks involved and also of the potential that existed for creating new cultivars based on some of the other species that existed. New Zealand was fortunate that strong linkages existed between scientists in China and NZ, and were able to initiate a formal kiwifruit improvement breeding programme during the

1980's based on a wide diversity of seed accessions from China obtained in the preceding 20 years. HortResearch holds more than 20 species of *Actinidia* today, with over 400 accessions of budwood, seed and pollen, more than any country in the world apart from China.

'The kiwifruit industry is unique among global fruit industries in being so totally dominated by one variety, the Hayward variety. Most consumers are not even aware that other varieties exist.'
(O'Rourke, 1998)

Thus HortResearch scientists embarked on a breeding programme, based at research orchards in Te Puke and Kumeu with the objective of developing a new, cultivar that would complement the existing 'Hayward' cultivar (now sold under the name of ZESPRI™ GREEN Kiwifruit).

2. Timeline for Development of the Yellow-fleshed Kiwifruit

A key reason why New Zealand was able to gain access to supplies of seed material from such a wide range of *Actinidia* species from China was because of strong personal friendships that developed between key scientists in both countries in 1943-44, and which exist to this day.

In 1943 a Chinese horticulture scientist, Li Lairong, was en route to China after graduate education in the USA when Pearl Harbour was attacked. His ship was diverted to NZ. Being a trained horticultural scientist, he approached the DSIR Mt Albert Research Centre to see if

he could get some work. He worked in Plant Diseases Division (PDD) with Dr Ted Bollard, who later became Director of PDD, and with whom a life long friendship was forged.

In 1944 Li Lairong departed to return to China, but the Japanese sank the ship in which he was travelling and he spent time in a prisoner of war camp. In 1948, when even his family thought that he was dead, he finally arrived back in China. Subsequently he had a distinguished career as a horticultural scientist, eventually being appointed Professor of Subtropical Pomology and Director of the Fujian Agricultural College in 1956. He remained a strong supporter and advocate for NZ.

In 1974 Ted Bollard visited China as a member the Royal Society of New Zealand. This was the first official scientific mission to enter China as it became more open to the West after the Cultural Revolution. The invitation to visit was in no small part due to the influence of Li Lairong, who by that time had become an important role in the Chinese Academy of Science, the hosts of the visit.

In 1975 Ted Bollard received a packet of *Actinidia* seed from Dr Li Lairong; this was the first *Actinidia* seed to come to New Zealand from China since the original introduction in 1904, although some budwood of other species had been introduced by Harold Mouat, DSIR, in 1955).

In 1977 Dr Don McKenzie, a respected fruit researcher in DSIR, known for his apple management and breeding work, visited China and arranged for further seed lots of *Actinidia* to be brought to New Zealand from China and Japan.

Seedlings from these accessions were planted at the DSIR Te Puke Research Centre as part of a long-term breeding and development programme.

In 1981 Drs Ron Davison and Michael Lay-Yee, DSIR, visited China and brought back further *Actinidia* seeds from a range of sources that were added to the collection in Te Puke and at the Kumeu Research Orchard.

A result of these two visits was procurement of raw, unimproved, unselected germplasm that would later become the base plants from which the new commercial yellow-fleshed kiwifruit, (*Actinidia chinensis* Planch. var *chinensis* 'Hort16A'; the fruit of which are marketed as ZESPRI™ Gold Kiwifruit, was developed.

In 1987 Dr Mark McNeilage performed the cross that led to the selection of Hort16A. Seeds from fruit resulting from these crosses grown on at the DSIR Te Puke Research Orchard, where they were put through a new and innovative 'fast track' propagation procedure developed by McNeilage and Sigrun Steinhagen to speed up the time from seeds to fruiting plants.

In 1989 650 seedlings arising from these crosses were planted out at Te Puke, and in 1990 75% of these seedlings flowered, just 18 months after germination.

In 1991 Russell Lowe and Hinga Marsh saw the first ever fruit on these young vines and based on desirable fruiting attributes they identified several promising selections, among them a seedling that they named 'Hort16A', for further evaluation trials. The name used was based on the position of the selected plant located in Block 37, Row 1, Bay 16 and plant position A in the orchard.

In 1991 fruit from some of these seedlings were ripened and tested for sensory attributes; 'Hort6A' and 'Hort16A' were identified for further evaluation. Wood from these plants was used to vegetatively propagate further plants for evaluation, sacrificing fruit for the following year.

1992 saw the kiwifruit industry in difficulties after anti-dumping order in USA, problems with retaining the crucial market in Italy (see #2 The KiwiGreen story) and development of significant industry debt.

In this same year grafted vines of 'Hort16A' were made available to selected growers for orchard evaluation and to have larger volumes of fruit available for sensory and taste tests in 1994.

In 1992 the NZ Kiwifruit Marketing Board, arranged to have 10 *Actinidia* selections from the DSIR breeding programme sensory tested by Colmar-Brunton using ethnic panels, using immigrants from Japan, Taiwan and Germany who had been in NZ for less than 3 months. Very limited supplies of fruit were available for these evaluations. Of these 10, 3 selections were short-listed for further evaluation, including 'Hort16A'; this was the selection with the most amazing taste, sweet flavour, pale yellow flesh, high productivity and very different from the usual green fleshed kiwifruit. However there was a potential problem with the protruding 'beak' at the distal end of the fruit.

In 1993 clonal trials of 'Hort16A' were established in order to obtain larger volumes of fruit for test marketing, and to develop appropriate vine management and postharvest handling strategies. A field day was held to introduce growers to this potential new cultivar. A new cultivar assessment protocol was developed by focus groups to improve the criteria defining optimum quality and market attributes and to ensure that any market testing was done with fruit of optimum eating quality. 'Hort16A' was a very appropriate candidate because of its and its productivity, which was more than double that of 'Hayward', and its high soluble solids, density and dry matter that signified sweetness and taste.

In 1993 the New Varieties Committee also recognised the need for further research on managing this potential new cultivar, particularly in reworking (top-grafting) scion wood onto mature 'Hayward' vines. An application for Plant Variety Rights (PVR) was initiated by HortResearch for the new cultivar under the denomination "Earligold", as it was believed at that time that 'Hort16A' matured earlier than the green kiwifruit. In reality fruit were harvested commercially at the same time as the green-fleshed 'Hayward' but at a more mature stage of development in order to obtain consistently yellow flesh, so the cultivar name 'Hort16A' was eventually adopted.

In 1994 a second Colmar-Brunton qualitative sensory evaluation confirmed earlier consumer preferences for 'Hort16A' because of colour and flavour. Decreased interest by industry in 'Hort16A' at this time was associated with possible postharvest problems and the lack of desire to top work existing 'Hayward' vines. It was however recognised that this selection could possibly be used in further breeding to try and get a new cultivar with better shape than 'Hort16A' while retaining flesh colour and taste of 'Hort16A'.

In 1995 HortResearch received Plant Variety Rights approval. PVR provided international protection for the cultivar, thus enabling offshore plantings later. Further plant material was made available to growers under trial licensing agreement. A decision was made to delay the release of this new cultivar 'Hort16A' to industry so that postharvest research could be undertaken to generate detailed recommendations to industry on how to prevent physical damage during handling, 'Hort16A' had a protruding 'beak' on one end and a relatively soft skin, both of which made fruit susceptible to physical damage during handling, storage and distribution

In 1996 at its August meeting, the kiwifruit New Variety Development Committee recommended to the kiwifruit R&D Committee and thence to the then New Zealand Kiwifruit Marketing Board that the cultivar 'Hort16A' be released to industry. It was recommended that technical support to growers be provided through production of a technical manual and field

days to demonstrate grafting techniques, with research required urgently on pest and disease susceptibility and management, vine productivity, fruit quality, optimising colour uniformity, harvest maturity and storage requirements.

In 1996 Kiwifruit industry personnel, David Jenks (marketing aspects) and Mike Muller (technical aspects), presented a road show to growers throughout all the kiwifruit growing areas, to introduce growers to the commercial option of diversifying of their orchards with a new GOLD selection. The kiwifruit industry realised that with total reliance on one cultivar, 'Hayward', it had very little flexibility or diversity of product in the market, a very high-risk strategy. It was agreed that any new selection adopted if marketed effectively would not compete, replace, or 'cannibalise' the position of Hayward in the market; but rather it complement it. Growers had an expectation of a 20-30% premium price for Hort16A due to its potential Asian appeal. Senior, influential and experienced growers accepted the rationale being offered and the industry followed this leadership.

1997 saw increased grower acceptance of the idea of growing a new selection and greatly increased pressure from industry to launch the preferred selection, 'Hort 16A', even though little was known about storage life or vine management needs.

- Test marketing in several countries was undertaken, with some favour in the UK, moderate acceptance in Japan and enthusiastic acceptance in Taiwan.
- 'Hort16A' chosen for further development because of superior, sweet unique taste and flavour, that was particularly suited to the Asian palate. This new cultivar could be introduced to the market using the extensive market structure already established by the industry for Hayward. Although pruning and management costs were higher, potential defects greater and shelf life shorter than Hayward, Jenks was convinced that the higher yield of 'Hort 16A' together with the price premium in the market would make this new cultivar very profitable for the grower.

"Taste is the king. You give me the tasty fruit and I can market and sell it profitably".

Quote from David Jenks, marketing, Zespri International.

In 1996 orchard production of 'Hort16A' commenced with fruit coming from a few vines onto which new scion wood had been top worked earlier onto existing 'Hayward' vines.

In 1998 first ZESPRI™ GOLD Kiwifruit fruit were exported to Asia. First export of 4000 trays of ZESPRI™ Gold occurred, followed in 1997 with 32,000 trays; the rest is history (see Figure).

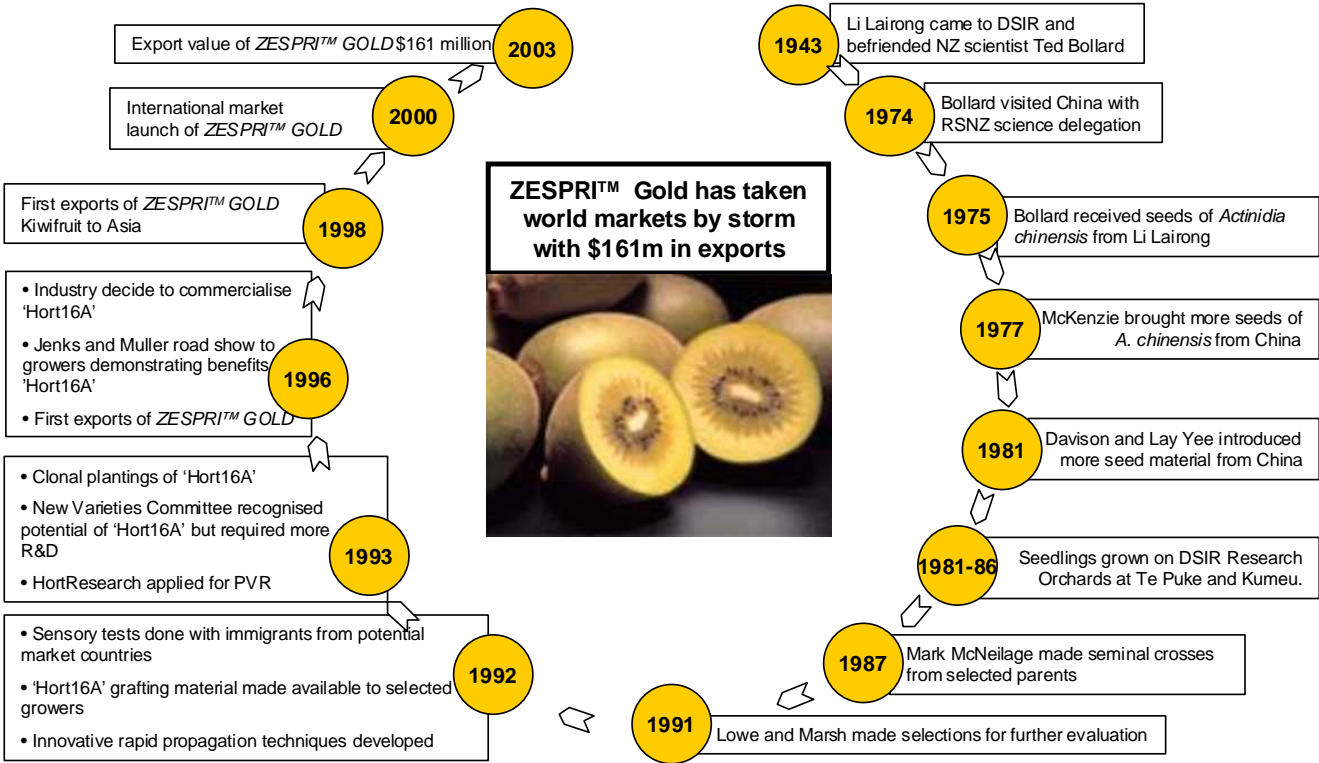
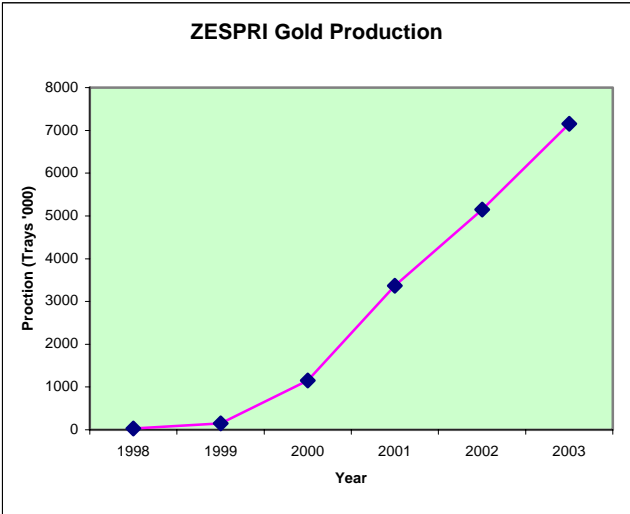
In 2000 the new cultivar 'Hort16A', its fruit being marketed as ZESPRI™ GOLD Kiwifruit, was officially launched into international markets.

In 2001 the kiwifruit concluded first collaborative arrangements with growers in Italy to produce 'Hayward' kiwifruit under the ZESPRI™ System for counter-seasonal marketing by Zespri enabling 12-month supply into supermarkets worldwide. Similar arrangements currently exist in the USA, Japan and Chile. This programme is continuing with ZESPRI™ GOLD Kiwifruit.

During the period 2000-2003 major marketing and promotion activities were undertaken by Zespri International Ltd. to launch this new kiwifruit, known as ZESPRI™ GOLD, in international markets. This involved fighting for new shelf space in supermarkets, creating awareness of the presence of a new fruit in the market, providing ready to eat fruit for consumers to taste in-store, and making good quality fruit available for 12 months of the year.

In 2003 export value of ZESPRI™ GOLD Kiwifruit was more than \$160 million.

The working relationship with Chinese scientists continues to this day and collaborative research and breeding programmes are underway. Utilisation of germplasm from China continues to be an important aspect of plant breeding for potential new cultivars.



3. Science and innovation features:

The close links that developed and continues between New Zealand and Chinese scientists enabled introduction of more than 400 accessions from 23 species of *Actinidia* to be grown on and evaluated at HortResearch stations. These accessions were the base material that HortResearch plant breeders chose for controlled crosses that led to the production and eventual selection of 'Hort16A'.

The success of 'Hort16A' has resulted from innovative science and concerted collaboration between the kiwifruit industry and science providers. Key factors included:

- Recognition by scientists of the need for new cultivars that would exploit the tremendous diversity within the *Actinidia* genus; initially *A. chinensis* was first considered by non-scientists to be a curiosity and too similar to the existing green kiwifruit to be of much commercial value;
- Specialised skill and knowledge of plant breeders in a planned intentional cross combining characters known in the parents having the potential to result in fruit attributes of size, colour, and flavour and vine productivity, thus producing progeny with highly desired fruit attributes that would satisfy consumer needs;
- Rapid sensory evaluation organised by industry in conjunction with scientists that identified selection with appeal to targeted market in Asia;
- Development of rapid propagation techniques by scientists that enabled plant material of the new selection to be provided quickly for grafting onto existing mature Hayward vines.
- Boldness of key growers who had to commit to large-scale 'beheading' of 'Hayward' vines to allow top-grafting with the new, untried 'Hort16A' cultivar with concomitant loss of production for 3-5 years before there was any significant production of fruit;
- Commitment by industry for information transfer, using scientific and market information to ensure growers were aware of the market potential of the new selection, as well as transfer of the technical details required to manage the new selection to produce quality fruit, by using a 'road show' format in all kiwifruit producing districts.
- Intense research effort to develop vine management and postharvest strategies to produce quality fruit and maintain premium condition during storage and distribution to international markets;
- Adapt and incorporate KiwiGreen and Taste ZESPRI™ principles and practices into sustainable production and postharvest practice;
- Willingness of growers to risk planting a new cultivar, and to utilise technical information provided by scientists and consultants;
- Major commitment to marketing by Zespri International to create consumer awareness of this new fruit internationally.

Because of the integrated structure of the kiwifruit industry it was possible for corporate decisions to be made rapidly and transmitted to growers. Industry funding was available to initiate the regional road show, as well as to fund much of the research needed to develop vine management and postharvest recommendations and to mount an intense marketing campaign.

4. Benefits:

- Domestication outside China of a species that traditionally grew wild in the forests of China; the Chinese had started growing the yellow-fleshed *A. chinensis* about 16 years before New Zealand;
- Advanced plant breeding resulted in NZ-owned cultivar basis for an international industry. The cultivar 'Hort16A' (marketed as ZESPRI™ GOLD Kiwifruit with the branded name

protected by Trademark for ZESPRI) has Plant Variety Rights (PVR) protection, and can be planted in other countries that recognise and police PVRs.

- Final decision on selection of 'Hort16A' as a commercial cultivar was consumer driven and based on creating new, intense taste and flavour.
- Generated much excitement both in the New Zealand and international industries and with consumers around the world with its yellow flesh and unique taste and flavour.
- Helped rejuvenate a flagging kiwifruit industry in New Zealand.
- The kiwifruit industry has a very successful, complementary new and exciting cultivar creating a broader market base. Its export value has exceeded \$160 million within 3 years of its official launch on international markets;
- Risks for growers and the industry are spread as they no longer have to rely on only one cultivar;
- Selection of a new cultivar was just the first step of the important process of commercialization; of major importance in this commercialization process was the combination of scientific, horticultural and commercial expertise and commitment combined into one package, where skills were complementary to each other and where all were required for success
- Development in NZ of all steps from germplasm collection, breeding, selection, sensory and marketing evaluation, orchard and postharvest R&D to maximise quality; able to use of existing ZESPRI marketing infrastructure and innovative marketing strategies to create and promote customer awareness of this new fruit internationally;
- Significant science investment went into solving downstream problems such as production management systems, post harvest handling storage and distribution.
- Growers introduced and implemented many new production innovations to ensure high quality fruit is produced. Such development of new orchard management technologies has been leveraged internationally.
- This has led to plantings being developed in Italy, USA and Chile under strict conditions, that allows complementarity of marketing using southern and northern hemisphere produced fruit.
- Eventually this will create substantial income streams back to the New Zealand industry (and hence to growers and shareholders) through innovative royalty payments based on fruit production, and on commissions on all such fruit that will be sold under the ZESPRI™ brand.
- New Zealand was the first country, apart from China, to commercially cultivate a yellow-fleshed kiwifruit on a large scale. Because New Zealand was first, the standards for vine management and fruit quality that are set by the New Zealand industry are becoming THE international benchmark against which all other competitive yellow-fleshed cultivars will be assessed in the market place.
- The successful development and commercialization of this new kiwifruit cultivar demonstrated the extraordinary potential of further R&D to select new and different types of kiwifruit, exclusive to the NZ kiwifruit industry. Opportunities abound for plant breeders in both New Zealand and China to collaborate and continue to develop novel and attractive fruit, thereby broadening the genetic base of the kiwifruit industry. Within the 65-70 species that are known to exist, there is an amazing range of fruit and vine attributes that will provide a rich and diverse base for breeding new and innovative fruits with varying colour, taste, texture, hairiness, nutritional and health conferring properties.

5. Return on R&D investment

- Some of the costs of breeding the new cultivar 'Hort16A' are of generic benefit to ongoing kiwifruit breeding and could be reduced by partial allocation to new cultivars being developed currently;
- Export value of ZESPRI™ GOLD Kiwifruit in 2003 was \$160 million; it is estimated that the total returns from this cultivar from local and international plantings could be in excess of \$1 billion by 2009;
- Total R&D costs (plant breeding only) involved from 1980 to 1991 when the selection of 'Hort 16A' as a potential new cultivar was made were \$7.7 million;
- Subsequent R&D costs for developing and implementing vine management and postharvest systems (1992-2003) were \$12.8 million;
- Therefore total R&D costs (1980-2003), excluding a 10% opportunity cost and an adjustment made to cost all R&D at 2003 \$ value, have been \$20.5 million for a crop that in the period 1996-2003 had accumulated export value of \$344 million;
- Substantial marketing costs (in excess of \$50 million) have been expended in developing awareness of the new kiwifruit by international consumers, and these have not been included in this analysis;
- Because exports of ZESPRI™ GOLD Kiwifruit have only been underway in any volumes since the international launch in 2000, calculations of the Internal Rates of Return² (IRR) of R&D investment, and of Net Present Value³ (NPV) will have little meaning. However, by 2009 both are expected to be significant and to have reached an IRR of 10% and the NPV is calculated to be \$28.8 million.

Counterfactual¹: (what would have happened if this innovation had not occurred?)

The key elements of the counterfactuals are:

- Assumed 5% loss of market value globally due to competition from ZESPRI™ GOLD Kiwifruit sales;
- Assumed static market share for 'Hayward' from 2000-2003;
- Assumed vines top-grafted with 'Hort16A' onto 'Hayward' to ZESPRI™ GOLD Kiwifruit caused consequent loss of Hayward production and export value every year from 1997-2003;
- A slow decline in the enthusiasm and confidence amongst growers, ZESPRI personnel, and kiwifruit scientists if this innovation had not occurred. This innovative new cultivar gave all parts of the industry a remarkable stimulus and confidence returned as the industry flourished.

6. Quotes:

"The extraordinary success of ZESPRI™ GOLD Kiwifruit must be acknowledged. "In just five years this exclusive, new, sweet-tasting kiwifruit has become one of the top three New Zealand horticultural export earners, after ZESPRI™ GREEN Kiwifruit and apples. Its commercialisation is not only testimony to the entrepreneurial spirit of growers – and scientists – but also a unique example of how to take a promising cultivar, commercialise it through promotion and partnerships, and importantly protect the intellectual property for the benefit of the pioneer investors and producers, New Zealand growers, and for the nation."

Craig Greenlees Chairman of ZESPRI Group Ltd., Annual Report July 17 2003.

"You can recognize the new golden kiwifruit from the outside by its smooth, bronze skin and the pointed cap at one end. Inside, it is a burst of sunny yellow sweetness that's hard to resist. While this golden gem has a tantalizing flavor that is all its own, it has been described as a luscious blend of melon, peach and citrus flavors - a sweet indulgence for the palate. Biting into a juicy, gold kiwifruit is a unique taste experience, a striking complement to the vibrant, tangy flavor of traditional green kiwi".

Michael Marks, Your Produce Man, Sacramento, CA., USA.

"People in South Korea, are apparently "buying ZESPRI™ GOLD Kiwifruit in sixes and eights" and are "fascinated by this new fruit and very keen indeed to buy it."

Source: Tony Marks, former CEO, ZESPRI International, 2002.

8. Information Sources:

Information supplied by:

- Dr Ross Ferguson, HortResearch, scientist Mt Albert
- Dr Kevin Patterson, HortResearch, scientist, Mt Albert
- Dr Mark McNeillage, HortResearch, scientist Mt Albert
- Dr Alan Seal, Team leader Kiwifruit Breeding, HortResearch, Te Puke
- Peter Berry, past chair, NZ Kiwifruit Marketing Board Research Committee
- Bob Martin past secretary, NZ Kiwifruit Marketing Board Research Committee, Zespri Group Ltd.
- David Jenks, Marketing, Zespri Group Ltd.
- Annual Reports of Zespri Group Ltd from 1997 to 2003.

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Editorial comments on this case study were received from:

Dr Ross Ferguson
Bob Martin

Appendix:

The working definitions used in this assessment are as follows:

¹**Counterfactual:** Counterfactuals are the statement of what would have happened (or could happen) in the absence of a specific event, programme or action. Counterfactuals are the "alternatives to actual history"; they imagine what would have happened, in this case, if a specific R&D advance had not occurred.

²**Net Present Value (NPV):** Net Present Value represents the benefits, less the costs, converted into equivalent values today. In the case of R&D, we have summed the benefits of an identified R&D advance, taken away the costs and used a 7% discount rate to calculate the NPV.

³**Internal Rate of Return (IRR):** The Internal Rate of Return calculates the interest rate received from an investment over a specific period. By examining the costs, and when they occur, compared to the benefits (income) over time, the IRR calculation is the rate of interest at which the present value of future cash flows become exactly equal to the initial capital investment.

This case study is one of a 21-part case study series aimed at demonstrating the value of science and innovation in New Zealand's leading edge bio-science industries... and their significance to New Zealand.

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