

7. New Zealand's award winning hops produce exceptional beers

The success of the New Zealand hop exports is based on both the superior qualities of the hops produced using New Zealand bred varieties and the drive and innovation of the growers and their leaders who have developed the overseas markets. Science and technology will continue to be an essential component of the industry as the exports expand and nutraceutical products are extracted from the hop cones.



English and German settlers first planted hops in the Nelson region during the mid 19th century. Initially, they grew hop varieties brought from the home-lands, but a higher yielding USA variety was introduced in the 1920s. These hop plants became severely infected with a root rot disease during the 1940s. The issue has been to sustain a viable hop industry during the 20th century based on hop varieties that are well adapted to New Zealand conditions, are resistant to root rot, high yields of alpha acid and have excellent brewing qualities.

In the late 1940s, the hop and brewing industries asked DSIR to start a breeding and development programme for hops. The ensuing programme has gained wide recognition for its innovation and has become the new 'aroma centre' of hop breeding in the Southern Hemisphere.

- Hop varieties were bred with resistance to root rot and released to industry during the 1960s.
- The next step was to develop the world's first triploid hops, which were seedless. Brewers wanted seedless hops. These varieties had up to 50% more alpha acid (the bittering precursor in beer) than the introduced varieties being grown during the first half of the 20th century.
- The breeding focuses have now moved to building the flavour and aroma characteristics of the hops and thereby grow the demand for New Zealand hops among the international brewers.

The innovative development of seedless New Zealand bred hop varieties with high quality bittering and aroma characters has provided an excellent foundation for the export industry.

Failure to breed hop varieties with root rot resistance would have placed the industry in jeopardy during the 1950s. In the 1970s, the industry faced a second challenge because the higher alpha acid yields led to a potential oversupply on the domestic market. However, the continued improvement of aroma and bitter characteristics of the hops has encouraged the export industry to expand.

The growth of hop exports from 1986 onwards was founded on the innovative programmes of the previous decades. All the hop varieties grown in New Zealand today have come from this programme, which has now released some 15 varieties.

Hop exports have expanded from about 160 tonnes in 1986 to around 670 tonnes in 2004. The profile of hop varieties has changed during the 1990s as the aroma hops have increased from 15% volume in 1990 to about 50% volume in 2004. Export values have grown from \$1.4 million (fob) in 1990, to \$8.8 million (fob) in 2001.

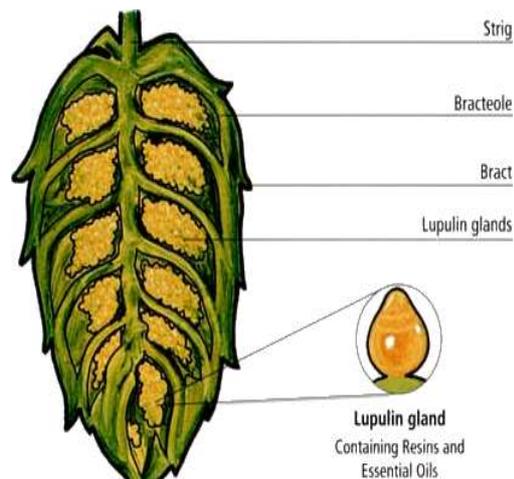
The internal rate of return on the R&D investment that led to the New Zealand bred varieties is estimated to be 9%, with a net present value of \$5.5 million at 2004. These values are projected to increase to 13% and \$16.4 million, respectively, by 2009

The case study illustrates how a partnership between industry and science is able to provide the sustainable production base for a niche export industry. The use of triploid varieties to produce seedless hops is an excellent example of smart botanical innovation.

1. Background:

The hop industry is based in the Nelson – Motueka region and comprises some 25 growers with about 420 ha of gardens. About 800 tonnes of hops are produced each year, with approximately equal quantities of alpha and aroma types. Suitable land is available for the industry to grow up to 1000 ha as the export market expands.

The hop (*Humulus lupulus*) is a hardy herbaceous climbing plant and is a native wild plant of Europe and Asia. For centuries the dried cones (strobiles) of the female hop plant have been used in the brewing of beer, and it is the golden resinous material inside the cones (lupulin) which serves as an aromatic and bittering agent. The New Zealand hop industry began in the 19th Century in Nelson using hop varieties brought by the early settlers from Germany and England.



Throughout the 20th Century the New Zealand industry has faced and overcome significant technical and market challenges. A higher yielding variety was introduced from USA during the 1920s. This variety had become dominant by the 1940s but yields suffered as the plants became infected by root rot (*Phytophthora citricola*). In 1951, Dr R Roborgh was engaged by DSIR to breed root rot resistant varieties. The first root rot resistant varieties were released to industry during the 1960s. It is apparent that the Hop Research Committee at that time considered that breeding and selection of new varieties would provide answers to each fresh set of problems as they arose.

World Production: FAO statistics for 2003 place world production at 97,200 tonnes produced on 63,018 ha. About 75% production occurs in Germany, USA and China and these countries together with North Korea and the Czech Republic account for 75% of the cropped area. Global price fluctuations occur when adverse seasonal climates cause yield reductions in countries such as Germany (e.g. German production in 2002 was about 80% of 2003 production) and USA. Often growers react by increasing the planted area the following season in anticipation of a rise in price.

The best hop yields are recorded in Australia (annual production is about 1400 tonnes), where hops are grown in Tasmania and NE Victoria, and New Zealand (annual production is about 800 tonnes).

World's first triploid varieties. During the 1960s brewers began to ask for seedless hops. Using some smart botanical thinking Dr Roborgh produced the world's first triploid varieties by using diploids as female parents and tetraploids as male parents. The harvested hops are infertile and therefore seedless. The advent of triploids allowed the male pollinators to be grown in the garden with the females. The presence of males is believed to stimulate cone production leading to higher yields. In contrast countries growing diploid hops must remove the males in order to produce seedless cones.

These triploid varieties, which have about twice the alpha acid content of the commercial hops available at the time, were released to the industry during the 1970s. There was a downside to the higher alpha acid levels because the New Zealand brewers reduced the actual quantity of hops that they required. The challenge of finding a new market for the surplus hops was resolved by developing a successful

export industry based on the New Zealand bred varieties. Today about 85% of all hops produced are exported.

During recent decades the breeding programme has focused on the development of quality aromatic hops using traditional European noble hop varieties as parents in the crossing programme. Commercial production of New Zealand bred aroma varieties has been a major factor in the most recent growth of the New Zealand hop industry and reflects the demands by international brewers for these quality aroma hops, with reliable yields and good brewing properties.

Hops are a latitude (day length) sensitive crop and for this reason many countries maintain their own breeding programmes. The yields of aroma and alpha varieties introduced to New Zealand from Europe and USA, without any additional breeding, are about 50% and 25% respectively, below New Zealand bred varieties. Also, overseas varieties appear to have lower alpha acid levels when grown in New Zealand's mild temperate oceanic climate.

Absence of pests and diseases. The growing environment for hops in New Zealand is very favourable, which enables the use of chemical pesticides and fungicides to be minimised. Powdery mildew, downy mildew, verticillium wilt and hop aphids are not found in New Zealand. The only pest which may require occasional control measures is the two spotted mite (*Tetranychus urticae*), which can be effectively controlled biologically by predator mites. Consequently, New Zealand hops can be produced without the use of any pesticide or fungicide sprays, which provides a competitive advantage on the overseas markets. Spray-free hops are a premium product into Japan.

Harvesting. New Zealand hops are harvested in late February and March of each year. After cutting in the field, the hop vines are brought to stationary picking machines, where the mature hop cones are stripped from the vines by mechanical picking equipment and put through a series of cleaning belts to separate the hop cones from the leaves and the vines. Two types of drying kilns are used for drying the hop cones at the individual farm locations: flat bed drying systems and multi floor tipping kilns. Hot water radiators are the most prevalent source of heat. Hot water generated by boilers, is passed through large radiators where high capacity fans release heat to the kilns. This indirect heating method ensures the hops are not contaminated by exhaust gases.

Hop Chemistry. The dried mature female flowers (called cones) contain all of the major chemical compounds used in brewing. A mature hop cone produces golden resinous glands that contain a group of compounds called alpha and beta acids. These groups of acids are the precursors to the bitter flavour of beer. The characteristic aroma of the beer comes from a complex mixture of essential oils also contained within the lupulin glands of the cone.

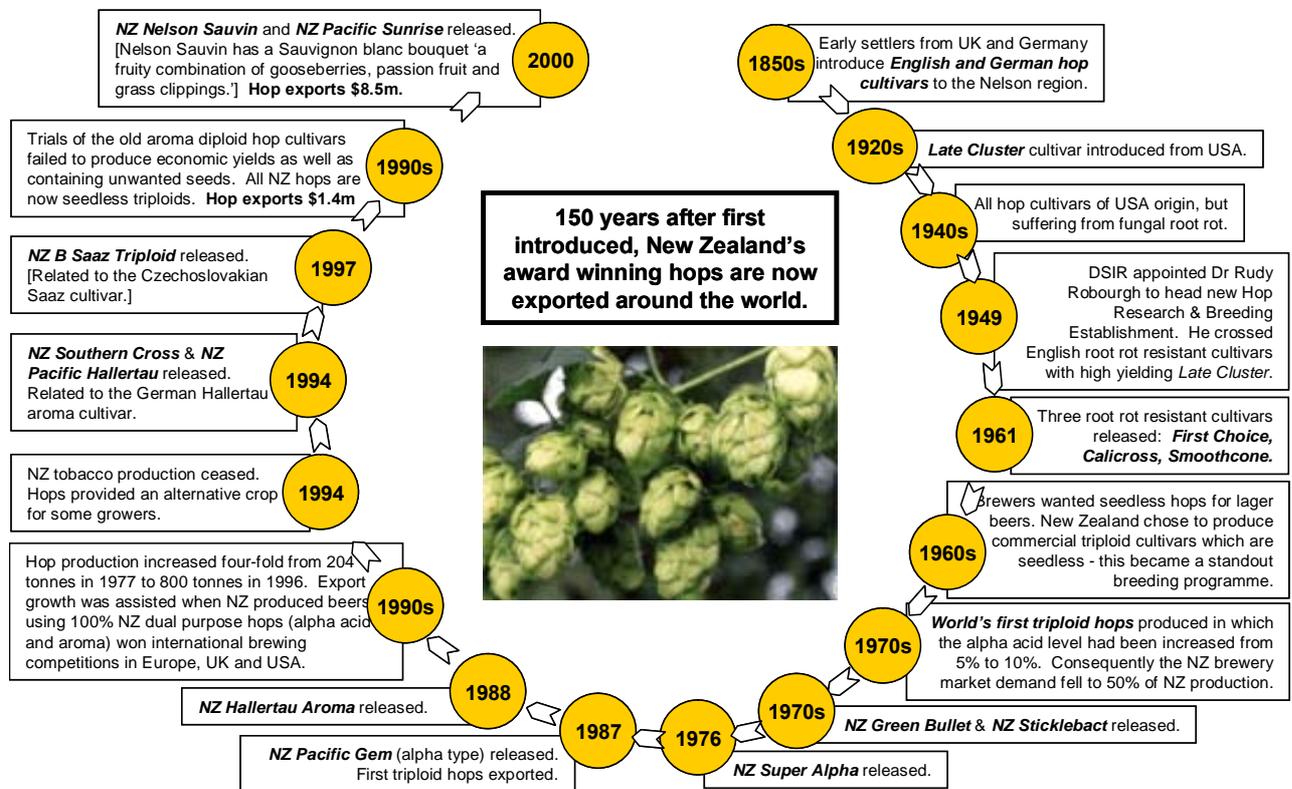
Marketing and processing. New Zealand Hops Ltd (NZHL), a grower controlled company, is the coordinated marketing and promotion organisation for the New Zealand hop industry. They also process, and arrange shipment for the entire New Zealand hop crop. The New Zealand hop industry also part-owns Extract Solutions Ltd., which commissioned a supercritical CO₂ extraction plant in 2002. This plant adjoins NZHL's headquarters in Appleby, near Richmond, Nelson. Over 60% of the annual hop crop is now processed through this plant.

The international market place for hops is characterised by a few large brewing conglomerates which concentrates the buying power into the hands of relatively few players of any scale. On the supply side a few large operate in a vertically integrated

environment where they buy pressed and dried hops at the farm gate for processing and sale as pelleted or extracted hops and downstream products which are in demand by the larger brewers. These merchants have a significant level of investment and control in all hop industries, except for New Zealand and Japan. New Zealand Hops Ltd. With the support of its growers provide these facilities to New Zealand's entire hop industry. This contrasts with Australia where over 80% of the industry is owned by offshore parent companies that are seeking supply of high alpha acid hops at favourable prices.

Northern Hemisphere brewers want to purchase some out of season hops from the Southern Hemisphere producers. They also recognise that New Zealand has bred unique varieties, which produce quality aroma hops. About 48% of New Zealand exports (by value) are to USA with a further 40% being split among Germany, UK and Japan.

2. Timeline



3. Science and innovation features:

The commercial release of New Zealand bred hop varieties with resistance to root rot enabled this small industry to be sustained after the 1950s.

During the 1970s the commercial release of New Zealand bred triploid hop varieties, which were seedless and with high alpha acid levels, enabled the industry to move forward with confidence.

Subsequent science has focused on developing three groups of hop varieties:

- High alpha varieties (13% to 15% alpha acid) - used primarily for imparting bittering properties to beer.

- Aroma varieties (6% to 8% alpha acid) - used primarily for imparting fine aromatic properties to beer.
- Dual purpose varieties (10% to 12% alpha acid) - used for both their bitterness and aromatic properties.

The aroma hops are a quality product, which is emphasised by the willingness of northern hemisphere brewers to undertake brewing trials on New Zealand varieties during the later stages of a breeding programme.

The industry structure is uncommon on the global scene. The industry is independently owned by the local growers and New Zealand hops are marketed directly to brewers in niche markets, rather than through merchants. This feature enables NZHL to give brewers the quality and quantity of hops that they desire and to build brand awareness.

4. Benefits:

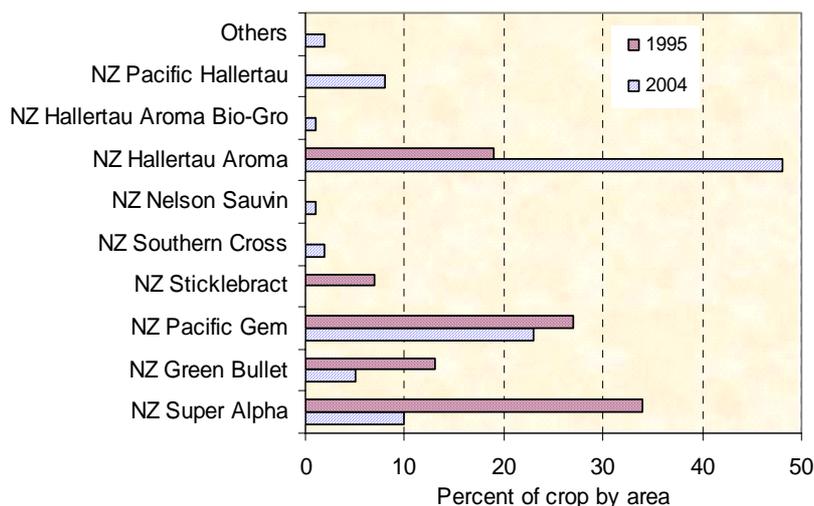
- The early New Zealand varieties led the world in high alpha acid production together with favourable aromatic properties and are still in production today to offer the brewer dual benefits of both pleasant aroma and economic bittering. The regular success of New Zealand's leading beer brands in international competitions is testimony to the attributes of New Zealand hops.
- New Zealand bred hop varieties form the basis of a growing export industry. They have a high alpha acid content, are all seedless triploid varieties with relatively consistent yields from season to season.

Table: Hop varieties grown in New Zealand during 2003

Varieties season	2003	Quantity (kg)	Alpha acid (%)	Year released	Type	Share (%)
NZ Super Alpha		105,058	13.3	1976	alpha	13.5
NZ Green Bullet		47,886	12.2	1972	alpha	6.1
NZ Pacific Gem		186,871	15.5	1987	alpha	23.9
NZ Pacific Gem Bio-Gro		1,458	16.7		alpha	0.2
NZ Sticklebract		3,109	13.8	1972	alpha	0.4
NZ Southern Cross		17,286	13.8	1994	alpha	2.2
NZ Nelson Sauvin		9,562	13.2	2000	dual	1.2
NZ Pacific Sunrise		6,988	14.6	2000	alpha	0.9
NZ Hallertau Aroma		332,830	8.5	1988	aroma	42.6
NZ Hallertau Aroma Bio-Gro		3,276	9.9		aroma	0.4
NZ Pacific Hallertau		60,340	6.4	1994	aroma	7.7
NZ B Saaz Triploid		1,869	9.5	1997	aroma	0.2
Various (Trials, etc.)		4,283				0.5
Total		780,816	10.6			100.0

Source: www.ewhops.co.nz

- The swing from high alpha acid varieties to the aroma varieties over the last decade is shown in the adjacent figure. This is a key outcome of



the New Zealand breeding programme.

- The table above illustrates the total dependence of the industry on New Zealand bred hop varieties, which have made an essential contribution to the ongoing economic and technical sustainability of the hop industry.
- The retention of market access is assisted by the very low incidence of pests and diseases of hops in New Zealand. The very low use of agrichemicals is valued by brewers.
- The establishment of the Supercritical Extraction Plant in Nelson enables the direct production of hop extract, and other products, in New Zealand. This reduces shipping costs to overseas markets.

5. Return on R&D investment

The return on R&D investment was assessed by comparing the industry performance with the innovation in place to that of a counterfactual¹ situation which identifies a possible industry performance, had the innovation not happened.

Key Information used in the analysis:

1. Hops are only grown in the Nelson - Motueka district. The current area of hop gardens is about 420 ha. The industry is based entirely on New Zealand bred varieties.
2. The annual hop production is about 800 tonnes, with approximately equal quantities of alpha and aroma hops harvested. Production has steadily increased from about 275 tonnes grown on 160 ha in 1986.
3. Hop exports have increased from 160 tonnes in 1986 to about 670 tonnes in 2004. Domestic sales were relatively steady at about 115 tonnes until 1993, and were about 15% of production in later years and declining to nearer 10% in 2004.
4. During the early 1990s aroma types made up about 15% of the national crop but rose to be over 50% of the crop by the 2004.
5. Assumed that it takes 10 to 12 years to breed a new hop variety and that a new cultivar is released every 2 years, on average.

Counterfactual: (What would have happened if this innovation had not occurred?)

The key elements of the counterfactual are as follows:

- Assume that the industry grows only imported USA and European hop varieties that have not been bred or selected for New Zealand conditions.
- Assume a 50% reduction in yield for imported aroma varieties and 25% yield reduction for imported alpha varieties.
- Assume a reduction in alpha acid levels of 10% across all varieties.
- Assume that the annual domestic demand for hops is about 15% of total production.
- Assume that the area of hop gardens in imported varieties would be the same as for actual area for the New Zealand bred varieties.

¹ Refer Appendix

Assessment results:

	as at 2004	as at 2009
Internal Rate of Return ²	8%	13%
Net Present Value ³	\$4.8 million	\$16.5 million

The 2009 assessments are based on the assumptions that:

- Hop production continues to be 8000 tonnes/year.
- Domestic consumption of hops continues to be 15% of total production.
- The present swing towards growing aroma varieties continues at the rate of a 3% reduction in alpha acid varieties each year.
- Export prices continue at current levels.

6. Quotes:

*“Whilst already producing nearly 50% of the New Zealand crop as Aroma hops, which are sold to International Breweries in Europe, USA, and Japan, and the new "special unique flavour", and new smooth flavoured bitter hops, are taking the New Zealand Hop Industry into an interesting position as we begin the new millennium. **The new aroma centre of world hop breeding, at least for the Southern Hemisphere, is very likely to be New Zealand.**”* Source: NZ Hop Marketing Board’s Spring Report 2000.

*“As a brewer, I find that the high quality consistency of New Zealand hops is a key ingredient supporting the **success of the many superb beers of New Zealand - and an ever increasing number of fine beers worldwide**.....This degree of success in the world of brewing relates to the smooth bittering qualities, to the fine aromatic essences and to the good cultivar of hop styles and hop characteristics available from New Zealand grown hops.”* Keith Armstrong. Source: New Zealand Hop Marketers Ltd website.

Joh Barth & Sons list New Zealand Hallertau on their website (www.johbarth.com) with the comment. *“General Trade Perception: A Hallertau aroma with an ability to retain its clean taste even in older beers and **used for its aroma qualities by major brewers.**”*

7. Related activities:

“New Super-Critical CO₂ Extract Plant Commissioned In New Zealand: The New Zealand Hop Industry group has established a Joint Venture, Supercritical Extraction Plant for the manufacture of CO₂ Hop extract produced from New Zealand hops. The Supercritical Fluid Extraction processing plant, constructed in Nelson, New Zealand, and commissioned in May 2002, will process a large portion of the New Zealand hop crop. This extract plant is thought to be the only supercritical extraction facility of this commercial size in the Southern Hemisphere. The plant has 3 extraction vessels each of 850 litres, capable of extraction of up to 500 bar pressure, but also has the capability to extract hops at much lower pressures.”

“This extraction facility is also designed to extract nutraceutical products (natural health products with pharmaceutical like properties) on behalf of the 50% Joint Venture partner, Nutrizael Ltd., a New Zealand based nutraceutical company. The Joint Venture company is registered as Extract Solutions Ltd.

² Refer Appendix
³ Refer Appendix

The principal benefits of this new development to brewers will be the direct production of hop extract on a site adjacent to the existing hop processing plant, in the centre of the hop growing area in New Zealand, eliminating the need to ship pellet hops to extraction plants across the world, in the Northern Hemisphere, for processing.”

Source: www.nzhops.co.nz

Over 60% of the hops are processed through the extraction plant. The availability of the plant provides further versatility for the industry, such as producing nutraceutical products that remain after the hop extract has been removed from the cones.

8. Information sources

Information supplied by:

- Dr Ron Beatson, HortResearch, Nelson Region. Leader of the hop breeding and development programme.
- Mieke van Drunen - Executive Officer, NZ Hops Ltd.
- New Zealand Hop Marketers Ltd website: www.nzhops.co.nz
- Joh Barth & Sons website: www.johbarth.com
- “Regulatory structure of the New Zealand Hop Industry”. Sept 1997. MAF Policy, Public Information Paper, Wellington, NZ.
- “The colonization of hops in the South Pacific - The New Zealand experience.” 2004. Tom Inglis. The BREWER International Vol. 4 Issue 8 August 2004 www.igb.org.uk

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Editorial comments on this case study were received from:

Ron Beatson
Mieke van Drunen
Tom Inglis
Kim McGlashin

Appendix

The working definitions used in this assessment were 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 “what ifs”, “thought experiments”, “alternatives to actual history”; they imagine what would have happened to an economy, an industry or a business if, contrary to fact, some present conditions were changed, in this case, if a specific R&D advance had not occurred.*

²**Net Present Value (NPV):** *Net Present Value represents the stream of benefits, less the stream of costs, converted into equivalent values today, using an appropriate discount rate. In the case of R&D, we have summed the benefits of an identified R&D advance, taken away the stream of 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 for an investment consisting of costs and income that occur over a specific period. By examining the costs, and when they occur, compared to the benefits over time, the IRR calculation estimates the return from the project as an interest rate calculation. It is the rate of interest at which the present value of future cash flows is 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.

Martech Consulting Group is a strategic consultancy based in New Zealand. The growingfutures case study series was in part based upon Martech's extensive work with sector representative groups, science providers and organisations that interact with science providers to achieve consensus on co-ordinated actions, improve governance, develop sector-based strategies and improve innovation processes.

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