Sustainable Horticultural Crop Production of New Zealand

Heath Bredeson, Undergraduate Student,

Hort 3002W, Sustainable Horticulture Production (Greenhouse Management),
Dept. of Horticultural Science, University of Minnesota,
1970 Folwell Ave.,
Saint Paul, MN 55108 U.S.A

Introduction

New Zealand is geographically isolated from much of the world because of its location in the southern pacific at 41° South and 174° East (U.S. CIA, 2010). Yet this country is able to be successful in the production of horticultural crops and research within sustainable practices that are integrated into production. The agriculture sector of New Zealand makes up 4.78% of the $127 billion GDP (U.S. State Department, 2009), and employs 7% of the total workforce of the country (U. S. CIA, 2010). The horticulture industry is dependent on exports and international trade due to its small population and its isolation from the rest of the world (Suckling et al., 2003). New Zealand exports range from dairy products, lamb, wool, wheat, barley, potatoes, fruits and vegetables (U. S. CIA, 2010).
The total land mass of New Zealand is 270,500 km and is distinctly divided in two main islands, North and South Island with smaller islands surrounding (U.S. State Department, 2009). Of this total land only 5.54% is used for continuous crop production, and another 6.92% is used for permanent crops, such as fruit trees (U.S. CIA, 2010). Having 15,134 kilometers of coastline helps give this country a mostly temperate climate with large variances between regions and some subtropical regions (U.S. CIA, 2010). New Zealand has coastal plains, but is mostly mountainous with the highest peak of 3,754 m, Aoraki-Mount Cook, located on the South Island (U.S. CIA, 2010).

The largest city in New Zealand and capital is Wellington, which lies in the southern region of the North Island. Another major city that contains close to one-third of the country’s population is Auckland also on the North Island (U.S. CIA, 2010). New Zealand has a population of 4,213,418 people (July 2009 est.) 87% of which live in urban areas (U.S. CIA, 2010).

According to a 2001 census 69.8% of the people are of European descent and 7.9% are Maori, the indigenous people of New Zealand (U.S. CIA, 2010).

New Zealand was chosen for research because of its distance from other parts of the world which gives it an exotic element, yet there is some familiarity with its exports because of their consumption in the United States. Research efforts within this country allow it to be a key player in the world horticulture markets and make significant contributions towards sustainable production systems of the future (The Horticulture and Food Research Institute of New Zealand Limited, 2005). The convergence of science and technology within New Zealand, coupled with the success of its production systems, allows New Zealand to have an important role in worldwide horticulture. Therefore the purpose of this research article is to provide a source of
information for others to use in continuing the goal of implementing sustainable horticultural systems.

**Sustainability Defined**

Within New Zealand the private sector is largely dependent on government sponsored research which allows them to benefit from proven methods (Hewett et al., 2005). These same industries are independent from the government in that they are not directly given incentives to embrace a specific production practice or provide a desired product (Fairweather, John R. and Campbell, Hugh R., 2003). New Zealand’s government sponsored horticultural research is carried out by a small number of organizations who collectively define sustainability and set standards that are embraced by the public and private sectors. Large government sponsored research organizations include HortResearch, Landcare Research and the Royal Society of New Zealand. By understanding how these research institutions define sustainability one can understand how the government defines sustainability.

Organizations may work in conjunction with the Ministry for the Environment of New Zealand to provide, “environmental management systems, including laws, regulations and national environmental standards, and national direction through national policy statements and strategies.” (Ministry for the Environment, 2010)

Current resource acquisition and management within New Zealand is largely based on one large legislative piece titled the Resource Management Act (RMA, 1991). Since its induction many changes have been made to address overlapping legislative enactments and changing perceptions of environmental concerns. These changes have been recognized through amendments to the Resource Management Act passed in 2009 to reflect current sustainability needs and address
overlapping laws. (Environmental Defence Society, ) Within the act section 5(2) defines sustainability as:

“managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while -

(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and

(b) Safeguarding the life-supporting capacity of air, water, soil and ecosystems; and

(c) Avoiding, remedying or mitigating any adverse effects on the environment.”

(Environmental Defence Society, ).

This definition can be used by government agencies to define whether horticulture practices are sustainable, however by not meeting the definitions (a) through (c) future practices could be allowed to proceed if deemed by courts to have considerably positive benefits (Environmental Defence Society, ). With this approach judgments can be made on a case by case basis as to whether or not a horticulture practice is considered sustainable outside of the RMA definition(Environmental Defence Society, ). This approach is a bottom-up approach as opposed to a top-down which utilizes many laws and regulatory agencies to enforce production methods on the industry.

HortResearch is a government run agency that works to provide “fruit and food products” to the private industry with its use of “unique resources in fruit, plants and environmentally sustainable production systems.” This agency meets its goals within the parameters of sustainability by “maintaining and enhancing the value of our soil and water resources.” Through focused efforts
on the irrigation of crops, plant nutrient need, and soil quality HortResearch is able to develop new products within its definition of sustainability. (The Horticulture and Food Research Institute of New Zealand Limited, 2005)

Other private interest groups have a more vague definition of sustainability; the New Zealand Society for Sustainable Engineering and Science define this term as, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs," (The New Zealand Society for Sustainable Engineering and Science, 2010).

Sustainable horticultural practices are often defined by the farmers and producers in a country like New Zealand because policies do not encourage one practice over another through government subsidies. Producers often choose between an agro-ecological system which focuses on biodiversity, or they believe technology can help keep practices sustainable and they embrace genetic engineering. These two differing ideologies are seen as “opposing pathways to sustainability,” by some. (Fairweather, John R. and Campbell, Hugh R., 2003)

Production Practices of the Past

Integrated pest management (IPM) has been important for New Zealand to meet foreign market demands of pest free foods, yet also be pesticide free. Such practices also lead the horticulture industry down a path towards sustainability through reducing the amount of pesticides that are applied during production. Historically integrated pest management in New Zealand has begun with research yet implementation of proven methods was hindered by the relative affordability of broad-spectrum insecticides in the 1960’s through the 1980’s. It took a culmination of changes in consumer expectations, an increase in pest resistance to pesticides, and the Resource
Management Act in 1991 for producers to realize a potential for using integrated pest management. Integrated pest management allowed producers to abandon calendar applications of pesticides thus reducing the use of these harmful chemicals and their impact on the environment. The success of IPM is observed through programs titled ‘KiwiGreen,’ ‘Integrated Fruit Production’ (apples), ‘Integrated Wine Production,’ ‘SummerGreen’ (stonefruit), and ‘Avogreen’ (Avocados). The use of IPM within horticultural crops was rapid; by 2000 all “major industries in New Zealand had developed or begun to develop IPM programs…” Much of the continued research on IPM is carried out by growers, consultants, industry groups, and government sponsored organizations and very little is carried out by universities. (Suckling et al., 2003)

As the world-wide debate over genetically modified crops has continued over the past thirty years some have argued for their use and consider this technology to be sustainable in horticultural systems. New Zealand itself made a major decision on this issue in 2001 after the Royal Commission on Genetic Modification heard testimony from various individuals, both public and private, for over a year. They decided to allow this technology to be used along with tight regulation on production and marketing practices. (Ministry for the Environment, 2010)

**Current Production**

Important horticultural food crops of New Zealand originate from distinct regions within the country and are grown on both the North and South Islands of New Zealand. The subtropical crops of the north include *Persea americana* (avocado), *Actinidia deliciosa* (kiwi), and *Citrus* sp. while the south distinctly has temperate crops including *Malus* spp., *Pyrus*, *Vitis vinifera*, and stonefruit. (Suckling et al., 2003)
The exports of fresh fruit from New Zealand totaled 1343.2 million NZ$ (1743.5 million US$) in the year ending in June of 2008. *A. deliciosa* dominates this sector with 870.7 million NZ$ (1130.2 million US$) and *Malus* sp. (apples) come in second among fresh fruit exports at 344.9 million NZ$ (447.7 million US$). Fruit grown in New Zealand is also processed for juices and other products, and within this market there were a 113.2 million NZ$ (146.9 million US$) worth of exports during the 2007 through 2008 production year. (Plant and Food Research Institute of New Zealand Ltd., 2008)

### Table 1

**Horticultural Exports (NZ$ million, fob)**

<table>
<thead>
<tr>
<th>Year Ended June</th>
<th>1975&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1985&lt;sup&gt;a&lt;/sup&gt;</th>
<th>1995&lt;sup&gt;b&lt;/sup&gt;</th>
<th>2005&lt;sup&gt;b&lt;/sup&gt;</th>
<th>2007&lt;sup&gt;b&lt;/sup&gt;</th>
<th>2008&lt;sup&gt;b&lt;/sup&gt;</th>
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<tbody>
<tr>
<td><strong>Fresh fruit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apples</td>
<td>19.3</td>
<td>108.2</td>
<td>343.6</td>
<td>387.0</td>
<td>343.3</td>
<td>344.9</td>
</tr>
<tr>
<td>Kiwifruit</td>
<td>2.9</td>
<td>171.2</td>
<td>320.8</td>
<td>720.2</td>
<td>765.1</td>
<td>870.7</td>
</tr>
<tr>
<td>Other fresh fruit</td>
<td>0.8</td>
<td>28.4</td>
<td>57.6</td>
<td>79.6</td>
<td>88.8</td>
<td>127.6</td>
</tr>
<tr>
<td>Total fresh fruit</td>
<td>23.0</td>
<td>308.5</td>
<td>722.0</td>
<td>1186.8</td>
<td>1197.2</td>
<td>1343.2</td>
</tr>
<tr>
<td><strong>Processed fruit</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Juices</td>
<td>0.1</td>
<td>9.6</td>
<td>30.5</td>
<td>34.1</td>
<td>40.2</td>
<td>38.2</td>
</tr>
<tr>
<td>Other processed fruit</td>
<td>1.7</td>
<td>40.3</td>
<td>44.3</td>
<td>65.7</td>
<td>56.8</td>
<td>75.0</td>
</tr>
<tr>
<td>Total processed fruit</td>
<td>1.8</td>
<td>49.9</td>
<td>74.8</td>
<td>99.8</td>
<td>97.0</td>
<td>113.2</td>
</tr>
<tr>
<td><strong>Fresh vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Onions</td>
<td>1.2</td>
<td>17.7</td>
<td>92.6</td>
<td>61.6</td>
<td>120.5</td>
<td>91.5</td>
</tr>
<tr>
<td>Squash</td>
<td>14.6</td>
<td>57.7</td>
<td>72.1</td>
<td>66.0</td>
<td>69.8</td>
<td></td>
</tr>
<tr>
<td>Other fresh vegetables</td>
<td>1.9</td>
<td>11.6</td>
<td>49.8</td>
<td>66.3</td>
<td>74.0</td>
<td>74.5</td>
</tr>
<tr>
<td>Total Fresh vegetables</td>
<td>3.1</td>
<td>43.9</td>
<td>200.1</td>
<td>200.0</td>
<td>260.5</td>
<td>235.8</td>
</tr>
<tr>
<td><strong>Processed vegetables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total processed vegetables</td>
<td>4.7</td>
<td>57.0</td>
<td>178.5</td>
<td>263.7</td>
<td>305.7</td>
<td>316.8</td>
</tr>
<tr>
<td>Wine</td>
<td>0.1</td>
<td>3.0</td>
<td>42.0</td>
<td>432.7</td>
<td>695.8</td>
<td>793.7</td>
</tr>
<tr>
<td>Flowers &amp; foliage</td>
<td>0.2</td>
<td>10.5</td>
<td>49.9</td>
<td>38.5</td>
<td>42.8</td>
<td>38.3</td>
</tr>
<tr>
<td>Seeds, plants, &amp; bulbs etc.</td>
<td>0.6</td>
<td>2.1</td>
<td>17.4</td>
<td>72.8</td>
<td>71.4</td>
<td>93.7</td>
</tr>
<tr>
<td>Sphagnum moss*</td>
<td>6.3</td>
<td>17.3</td>
<td>8.8</td>
<td>9.0</td>
<td>6.0</td>
<td></td>
</tr>
<tr>
<td>Total exports in current NZ$</td>
<td>8.2</td>
<td>33.5</td>
<td>481.2</td>
<td>1302.0</td>
<td>2679.4</td>
<td>2940.7</td>
</tr>
<tr>
<td>Total exports in current US$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticultural exports as % of NZ merchandise exports</td>
<td>2.0</td>
<td>4.4</td>
<td>7.0</td>
<td>7.0</td>
<td>8.0</td>
<td>6.9</td>
</tr>
</tbody>
</table>

*Source:* HortResearch (Plant and Food Research Institute of New Zealand Ltd., 2008)
The wine industry of New Zealand is also very large; the total wine exports were valued at 793.7 million NZ$ (1030.2 million US$). Exports from wine were larger than all the processed fruit, fresh vegetable, and processed vegetables combined in the year ending in June of 2008. Wine exports have been the fastest expanding sector of all horticultural products for New Zealand and are exported to 95 different countries around the world. (Plant and Food Research Institute of New Zealand Ltd., 2008)

In 2008 New Zealand produced 169,613 metric tons of Sauvignon Blanc grapes, which makes up 60% of the total varietal grapes produced (Plant and Food Research Institute of New Zealand Ltd., 2008). The production of Sauvignon Blanc in 1998 was only at 15,136 metric tons, which shows a sharp increase in production over a ten year period. Such a large dominance of one variety of grapes being produced could jeopardize the wine industry if market demands change or pest and disease threats were to increase. (Plant and Food Research Institute of New Zealand Ltd., 2008)

The production area of grape and wine within New Zealand covered 29,310 hectares in 2008 up from 7,580 hectares in 1998. This large increase in land use for grape and wine production over a ten year period shows that this industry is in a position to make management decisions that can be detrimental to the environment. Production practices have been made more environmentally sustainable with the use of the Integrated Wine Production System; an organized effort to utilize IPM in wine production (Suckling et al., 2003). Most of the wine and grape production occurs within the Marlborough region of New Zealand, which in 2008 encompassed 15,915 hectares
and produced 194,639 metric tons of grapes. (Plant and Food Research Institute of New Zealand Ltd., 2008)

Other important horticulture industries include flowers and foliage for a total of 38.3 million NZ$ (49.7 million US$) in exports. Many seeds, plants, and bulbs are exported from the country and were valued at 93.7 million NZ$ (121.6 million US$) through the year ending in June of 2008. (Plant and Food Research Institute of New Zealand Ltd., 2008)

The horticultural exports of New Zealand represent 6.9% of the total merchandise exports, and totaled 2,940.7 million NZ$ (3817.1 million US$) in value during the 2007-2008 production season. This magnitude of production allows New Zealand the opportunity to be a leader in sustainable horticultural practices for other parts of the world. However, with a large amount of the crop production being exported to far away countries one could easily argue that this system is not sustainable. (Plant and Food Research Institute of New Zealand Ltd., 2008)

Looking at the location of New Zealand in relation to the rest of the world leads to the question: Where are all these exports going? Fruits, vegetables, and flowers were exported to 118 different countries in 2008. Five countries purchased over 300 million NZ$ (389.4 million US$) in horticulture exports from New Zealand in 2008. Australia purchased the largest amount of these products, 596 million NZ$ (773.6 million US$) in 2008. Japan also purchased a significant amount of horticultural crops spending 423 million NZ$ (549.1 million US$) during the same time period. (Plant and Food Research Institute of New Zealand Ltd., 2008)

Kiwifruit, *Actinidia deliciosa*, is the most exported fruit crop in New Zealand with 12,186 hectares of production and 2,727 growers or suppliers in 2008. This amount of *A. deliciosa*
production has remained unchanged since 1998 and is the single largest horticultural crop exported from New Zealand. Organic *A. deliciosa* exports began in 1991 and as of 2007 there were 160 growers in this niche comprising of 3.5% of the total kiwifruit production. (Plant and Food Research Institute of New Zealand Ltd., 2008)

Apples, *Malus* sp. are the second largest fruit crop produced in New Zealand behind the popular kiwi (Plant and Food Research Institute of New Zealand Ltd., 2008). Some 446,000 metric tons were produced on 8,832 hectares by 509 growers in 2008 (Plant and Food Research Institute of New Zealand Ltd., 2008). Production totals, growers and land use for *Malus* spp. have decreased from production in 1998 (Plant and Food Research Institute of New Zealand Ltd., 2008). At that time there were 1,500 growers utilizing 14,976 hectares for production resulting in a yield of 529,000 metric tons produced (Plant and Food Research Institute of New Zealand Ltd., 2008). The largest *Malus* spp. producing regions in New Zealand are Hawkes Bay and Nelson (McKenna et al., 1998).

Flowers, plants, and seeds are also an important part of the horticulture industry of New Zealand. The *Orchidaceae* (cut flowers) industry has been prosperous since 1985 with 2.8 million NZ$ (3.63 million US$) in exports during that year. And the growth of that industry lead to orchid exports totaling 20.4 million NZ$ (26.5 million US$) in 2008. Other notable cut flowers exported are *Hydrangea* at 2.4 million NZ$ (3.1 million US$) and *Paeonia* at 1.6 million NZ$ (1.2 million US$). The largest consumer of these cut flowers is Japan with 17.1 million NZ$ (22.3 million US$) in imports in 2008. (Plant and Food Research Institute of New Zealand Ltd., 2008)
These horticultural exports represent large increases in production to meet the changing market demands over the past thirty years. Horticultural exports were less than 200 million NZ$ in 1980 and rose to over 2 billion NZ$ in 2003 (Hewett et al., 2005). This has forced the industry to adopt new production methods and grow different cultivars (Hewett et al., 2005). New Zealand has shown the world its “innovation, production, quality maintenance, distribution and marketing,” in the horticultural industry (Hewett et al., 2005). This allows this country to lead the way into the future towards continued sustainability in horticultural production.

**Current Production Practices**

Current production practices of New Zealand focus on sustainability while emphasizing economical goals by providing “growth and prosperity for New Zealanders.” Sustainability is important in respect to the people and defined by ensuring “healthy New Zealanders and a vibrant rural community.” The environmental needs are sustained by maintaining and enhancing the natural environment. Achieving such goals requires research conducted by the primary sectors of New Zealand that is further supported with government resources. (The Ministry of Agriculture and Forestry, )

The Ministry of Agriculture and Forestry (MAF) currently funds research in areas of sustainable horticulture production. Producers can apply for a grant through the Sustainable Farming Fund sponsored by the MAF to receive financial assistance for their research projects. Such information gleaned from this research is then publicly available to other producers to assist in their production needs. Allowing businesses within horticulture industries to work together in areas of research facilitates the industry in becoming more sustainable economically, socially, and environmentally. (The Ministry of Agriculture and Forestry, )
Improvements in responsible pesticide applications have been enabled by the Sustainable Management Fund (SMF) project which started in 1998 and supported by the Ministry for the Environment along with the various Regional Councils and Montana Wines. This fund addressed the need for “support tools” to aid agricultural and horticultural producers in making pesticide application decisions.

This united group of industry professionals, Regional Councils, and The Ministry for the Environment formed the “Guidelines for the Sustainable Application of Agrichemicals” in the year 2000. Guidelines were based on databases for pesticide movements through various soil structures and groundwater, and included information on the active ingredients of these pesticides.

In 2004 the Growsafe® Calculator was made available to horticultural professionals and regulatory agencies at no cost. This tool allows managers to predict and compare the impact of using all available agrichemicals in New Zealand on 33 different crops among various soil types within different regions. The release of such an innovative product was achieved by a “partnership of science, industry, and regional authorities” utilizing 20 years of data. (Aitken et al., 2005)

Horticultural industries are in a position to integrate environmentally conscientious decisions that make a big reduction in waste and utilize recycling programs. One such program is Agrecovery which collects and recycles plastics in the form of chemical containers and sillage wraps from industry professionals. This program also handles chemical waste from farms to dispose of it sustainably. The non-profit trust was started in 2005 with private and public interest along with financial support from various companies working in different horticultural sectors. By April of
2007 the program was operational and leading towards a goal of 52 collections sites across New Zealand. (AGRECOVERY, 2010)

A major step towards sustainable fruit production in New Zealand has been achieved by adapting the Integrated Fruit Production (IFP) management strategies which evolved from the Integrated Pest Management (IPM) to focus not only on the pest within a production system but to utilize a “more holistic view of the fruit production practice.” New Zealand has led the world in industry acceptance and utilization of IFP since its introduction to the A. deliciosa production sector in 1991. Such sustainable principles began to be introduced into the production of pipfruit; Malus spp. and Pyrus sp. in 1996 and in 2001 all pipfruit exports were produced with these management principles. (Jonathan W. Wiltshire, 2003)

Integrated Fruit Production allows producers to use thresholds and guidelines when deciding on management practices throughout the production cycle to meet sustainable goals held by the fruit industry. The industry seeks to provide safe fruit that is accepted by consumers worldwide and is economically and environmentally sustainable. IFP emphasizes “ecologically safer methods, minimizing the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health,” as defined by the International Organization for Biological Control (IOBC). (Jonathan W. Wiltshire, 2003)

Since the results of the pipfruit industry focusing on management practices regarding weed, insect, and disease control were released during the introduction of IFP, there has been a large reduction in the use of pesticides and herbicides. Soil and water management strategies were later adapted into the IFP model because many of these management practices had already been in use by growers. This program has resulted in a 50% reduction, from 1996 to 2003, in
insecticide applications on pipfruit crops and a 95% reduction in applications of organophosphate insecticides in apple production. This success has been facilitated with an increase use of biological control of insect populations. (Jonathan W. Wiltshire, 2003)

Fungicide use also has been reduced in pipfruit production within New Zealand. Applications of dithiocarbamate fungicide have been reduced by 50% and further reductions are limited due to the wet climate of New Zealand. Reducing the use of this fungicide allows for the further integrated control of mite populations in apple production. (Jonathan W. Wiltshire, 2003)

The Integrated Fruit Program has also led to a reduction in the residual herbicide application rates within apple orchards. Guidelines set by this program allowed 75% of the orchards in New Zealand to all together abandon applications of herbicides, and 22% using one application per year. This practice has been more easily used in established orchards with large trees that shade out competing weeds. (Jonathan W. Wiltshire, 2003)

Apple growers in New Zealand are enjoying the benefits of the IFP through their reduced exposure to harmful pesticides. These businesses are better positioned to market their fruit as sustainable and safe by utilizing IFP. Producers share knowledge about their experiences through the IFP Discussion Groups; creating a sustainable community through communication within the industry. The future of Integrated Fruit Production will largely be driven by consumer demands due to New Zealand’s dependence on foreign markets, but will also be determined by the innovative research and production systems within this country. (Jonathan W. Wiltshire, 2003)
Greenhouse production systems in New Zealand grow a variety of horticultural crops; including significant amounts of nursery crops, flowers, and mixed greens (Tony Ivicevich, 2004). Greenhouse tomato production totaled 5.6 million NZ$ (7.3 million US$) in fresh export revenue from 2007 to 2008 (Plant and Food Research Institute of New Zealand Ltd., 2008). However open trade with other countries has recently compromised this area of greenhouse production with small businesses losing to corporate production. Old tomato greenhouses have been all together dismantled or restructured for production of lettuces. Much of the old greenhouses date back to 30-40 years ago and are considered not efficient for current production standards. (Tony Ivicevich, 2004)

New greenhouse structures include Venlo types imported from the Netherlands, which are the most modernized with tempered glass and roof ventilation; some are completely computerized. Growers of *Rosa spp.* most often use the high tech Venlo glass greenhouses with “full environmental control and CO2 enrichment” to maximize production. Plastic structures are also common and are composed of double skin flexible film. Vegetable production largely utilizes this plastic type of greenhouse with some believing it is superior to the glass greenhouse within the region of Auckland, NZ. The estimated 40 hectares of *Cymbidium* production in New Zealand utilizes both types of these structures. (Tony Ivicevich, 2004)

As with greenhouse production in other parts of the world, New Zealand horticultural industries are in a position to be more environmentally sustainable through reduction in energy consumption. Heating is a large energy input that allows greenhouse growers to control temperature, but energy is also needed to maintain desired humidity and CO2 levels. Attaining
optimal growing conditions in conjunction with sustainable energy consumption is a challenge for New Zealand growers.

Expensive technological inputs are available from Europe to increase efficiency and reduce energy consumption but are not subsidized in New Zealand. This technology includes thermal screens and computer programs designed for greenhouse production. Producers interested in using this technology would need to have energy savings outweigh the cost of this input in order to make these changes in their production system. The milder winters of the North Island minimize such energy savings, and the South Island has access to cheap coal as a heating source. Horticultural industries need an incentive from the government or from consumer expectations in order for these investments to be made. (Nederhoff and Houter, 2007)

The relatively young greenhouse production systems of New Zealand are not equipped to adopt all of the available energy saving technologies. This forces the grower to be more educated in other areas to reduce energy consumption. Understanding plant physiology can enable producers to maximize production at current energy consumption levels. This includes improving climate control, pest and disease management, and plant nutrition. (Nederhoff and Houter, 2007)

**Production Practices Compared: From History to Present**

The horticulture industry of New Zealand has limitations in achieving an economic, social, and environmental level of sustainability due to its large dependence on foreign market demands for its products. The industry has changed significantly in the past with technological advancements in production and shipping strategies that in many respects meets goals of sustainability set by New Zealand and the international community. However an argument can be made that
continuing to supply global markets is inherently not sustainable and production before the increase in exports was more socially and environmentally sustainable.

A historical overview of production practices and legislation affecting sustainability is shown in Table 2. Some events and practices are ambiguous and to understand if these are sustainable they need to be contextualized. For example current exports are helping New Zealand fund research and develop a strong economy, but in the context of the environment this is not sustainable due to our current understanding of global warming and energy consumption.

Table 2. Horticulture Production Practices and Legislation of New Zealand

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Not Sustainable</th>
<th>Sustainable</th>
<th>Yet to be determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950-1989</td>
<td>Use of broad spectrum insecticides not environmentally sustainable.</td>
<td>Export industries are not largely developed thus allowing socially sustainable horticulture within NZ</td>
<td></td>
</tr>
<tr>
<td>1990-2000</td>
<td>Royal Commission accepts use of genetically modified of crops in horticulture in 2001. Not economically sustainable with for NZ and its dependence on Europe markets which are sensitive to GMO technology. Export industries are largely developed changing social structures within the country</td>
<td>Resource Management Act, 1991 Abandoned broad spectrum insecticide use, and adoption of IPM IPM further evolved to IFP and use begins in A. deliciosa fruit production “Support tools” utilized to make informative decisions about pesticide applications</td>
<td>GMO acceptance may or may not be environmentally sustainable GMO acceptance within NZ is varied and may or may not be socially sustainable</td>
</tr>
<tr>
<td>2000-2010</td>
<td>Export industries are largely developed for foreign markets not environmentally sustainable</td>
<td>Export industries are largely developed leading to economic stability for NZ Data analysis improved</td>
<td></td>
</tr>
</tbody>
</table>
of ground water, soil structure, and pesticide impacts
Funding for research among producers is supported by Ministry of Agriculture and Forestry
Changes in greenhouse structures and imports of energy efficient production systems

Horticultural production using pest management practices has made great strides towards environmental, social, and economical sustainability. New Zealand has gone from being dependent on pesticides to greatly reducing their use. The reasoning for these improvements have been previously outlined and the benefits of Integrated Fruit Production, research funding, and communication among professionals are continuing to be realized.

The technology and research carried out by horticultural professionals today allows New Zealand to be a world leader in innovation (Hewett et al., 2005). This is economically more stable than the isolation this country had from foreign markets only 40 years ago (Hewett et al., 2005). Without these advancements, New Zealand would not be able to sustain business in the world trade markets of today given its small size and relatively small GDP.

Technology in areas of genetic modifications for crop improvements has only been used in New Zealand for ten years. The world as a whole still needs to learn more about the affects of using genetically altered crops which will come in time. Optimism is high that this technology will lead to a more sustainable future. There are other rational reasons to be concerned about its use and how the sustainable practices of past may be more sustainable.
These practices have been ranked by the author in Table 3 below. Such ranking is based on all areas of sustainability: economic, social, and environmental. Sustainability is defined within these three main contexts by New Zealand and the horticultural industry. The practices are also ranked by their potential to be implemented in the future. The highest scores are the most sustainable and are significant in their future use in horticulture production.

Table 3 Production Practices Ranked

<table>
<thead>
<tr>
<th>Production Practice or Legislation</th>
<th>Sustainability</th>
<th>Future Use Potential</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated Fruit Production</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Discussion Groups</td>
<td>5</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>Greenhouse Technology</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Exporting Practice</td>
<td>3</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>Government Role</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Genetically Modified Crops</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

These rankings are largely based on information gleaned from research and the author’s opinion. The successes of the Integrated Fruit Production program are well documented and have future use in growing new crops within New Zealand. New Zealand will continue to need to diversify its products as markets change. Current greenhouse technology is not sustainable in regards to energy consumption; however it is economically sustainable for this country due to low energy cost and mild winter weather. Future use of technology in the greenhouse is dependent on government assistance and market demands. New Zealand cannot continue to be dependent on foreign markets for a sustainable economy. This ranking is largely based on the author’s opinion that the future of food and other horticultural production will focus on local production.
as fuel cost rise and water resources are further limited. The role of New Zealand’s government has been to deregulate primary industries and use research to allow for a bottom up approach to supporting horticulture. This approach has been very successful, but may need to change as the markets change and resources may need to be more tightly controlled when they are limited. Genetically modified crops are in their infancy for use and need to be further explored. More research and experience with these crops will reveal if they can be used sustainably.

**Finalized Sustainable Development Strategy**

The current production of horticultural crops in New Zealand is widely accepted to be sustainable. Past research supported by government funding and shaped by market demands have allowed New Zealand to gain recognition for its sustainable developmental strategies. There are challenges however that New Zealand faces in improving its sustainable production within the horticultural industry.

One such challenge New Zealand faces is meeting market demands that rise from its distant consumers. Such separation between New Zealand and the consumers leads to a lack of understanding when it comes to product expectations. It forces New Zealand to have a sufficient market analysis program that may foresee any potential market changes that jeopardize the economical sustainability of this industry.

Along with being economically unsustainable, this distance between producers and consumers is seen by many as environmentally and socially unsound. Consumers are becoming more interested in knowing where their products are from and how they are being produced. This is especially the case in respect to food crops. If consumers can afford organic or sustainably
produced food they are willing to do so because of environmental and social concerns. The local food movement is especially on the rise in America and continues in Europe. Knowing more about producers and their management strategies allows consumers to make informed purchases. Such knowledge is considered socially sustainable. Consumers are likely to pass up a kiwifruit, *A. deliciosa*, simply knowing that it came from a distant country.

The consumers may not always have all the needed information or simply do not understand what is and what is not environmentally sustainable. For example; apples produced in New Zealand are shipped long distances to consumers directly after harvested. Another consumer option is to choose apples produced locally and refrigerated for months after harvested only to be available at a later peak market-value time. Which apples are more sustainable? Local apples are considered more sustainable when ignoring the refrigeration factor. When considering energy efficiency, current shipping practices are efficient enough that apples produced from distant countries may be more sustainable than apples that are refrigerated for many months. Consumers often lack the information needed to make a truly sustainable purchase.

Can New Zealand bridge the knowledge gap between consumers and producers? Providing knowledge about what are truly sustainable practices to distant consumers needs to be emphasized by the horticultural industry of New Zealand. There is currently a lack of knowledge by consumers that New Zealand is capable of providing. New Zealand’s past research along with its reputation as being progressive in the horticultural industry allow it to bring knowledge to consumers worldwide. Continued market analysis and progressive advertising for the horticultural industry will lead New Zealand towards a more sustainable future.
Horticultural greenhouse production of some crops within New Zealand have shifted from utilizing mostly unheated plastic or glass structures towards more technologically advanced Venlo type greenhouses from the Netherlands. These greenhouse implementations have been largely adopted by *Solanum lycopersicum* (tomato), *Capsicum spp.* (chili peppers), and other vegetable crops. The floral industry largely utilizes these glass structures for *Rosa* (rose) and *Cymbidium* (orchid) production. Utilization of glass greenhouse structures has largely been dependent on the size of the producer and its capacity to afford the added expense. (Tony Ivicevich, 2004)

The use of Venlo glass greenhouses compared to other plastic structures needs to be researched more in respect to which may be more sustainable. This is especially the case in a temperate climate such as the North Island of New Zealand where a heated structure may not be warranted. Heated glass houses may be more sustainable when used on the colder South Island. The crop being produced also plays an important role in determining whether or not this technology should be used. (Tony Ivicevich, 2004)

*Cymbidium* production constitutes 43% of New Zealand’s total flower exports which use approximately 40 hectares of land for greenhouses. This total greenhouse production includes converted poultry buildings, modern plastic structures, and glass houses. The use of plastic for this crop may be advantageous over glass in a system that seeks to grow flowers sustainably. This is because plastic has a higher retention for humidity and softer light penetration compared to glass. Which production system is more economically, socially, and environmentally sustainable? Are these systems regionally dependent? Such questions have yet to be answered by producers in New Zealand. In many cases, the glass Venlo greenhouses have been used
because they allow larger corporate growers to be more comfortable. Future research comparing plastic double skin flexible skin inflated greenhouses to glass Dutch Venlo greenhouses with environmental controls is warranted. (Tony Ivicevich, 2004)

The advantages of such research is that producers would be able to employ sustainable, both economical and environmental, practices that have been proven over other methods. If such research were funded by the New Zealand public sector, as past research has, the horticulture industry as a whole would benefit financially from the results of this research. Energy costs are much greater in glass greenhouse production with environmental controls compared to plastics greenhouses that have minimal automated temperature, light, water, and CO$_2$ controls. (Tony Ivicevich, 2004)

To reach conclusive results comparing these two types of greenhouse, exhaustive research will need to be carried out. This will have multiple disadvantages. Public funding may be limited in supporting this experiment, and other areas of horticultural research may be delayed. Comparing greenhouse structures will require a large amount of land, and replications in various regions would provide a better comparison of the two systems at a higher cost. Maturation of *Cymbidium* plants is slow and as such growing this crop may not be reasonable in a practical amount of time. Growing other crops that need humidity and have a shorter maturation time may be an option for this research.

The possible financial and environmental rewards for carrying out this type of research needs to be understood. Along with *Rosa*, the *Cymbidium* flowers are the most important flower crop in New Zealand. The export of Orchidaceae flowers totaled 20.4 million NZ$ (26.5 million US$) in 2008 (Plant and Food Research Institute of New Zealand Ltd., 2008). This magnitude of
exports gives this sector the opportunity to make large strides towards sustainable production practices with great financial rewards that can outweigh the cost of research. Environmentally there are opportunities for improvement with this crop that the approximate 200 growers in New Zealand may utilize.

**A Future Sustainable, Controlled-Environment Production Facility**

Questions remain about what is the most sustainable growing system for *Cymbidium* production within New Zealand. An experimental production facility will be designed to address such questions. An emphasis on sustainability will be the focal point of this facility and defined as meeting the economical, social, and environmental needs of New Zealand.

There are four main regions in New Zealand that currently dominant production of *Cymbidium*: Auckland, Northland, Waikato, and the Bay of Plenty (The Ministry of Agriculture and Forestry, 2005). All four of these high *Cymbidium* producing regions are similar in climate and near each other in the northernmost section of the North Island. The test production facility will be located in the Northland region. This location was chosen based on the large number of growers in this region that provide a valuable resource for information. The growers of Northland will also benefit as this research will be a joint effort among public and private sectors. This region is climatically ideal for *Cymbidium* production; it experiences 12 ground frost days and 1,964 hours of sunshine each year (Plant and Food Research Institute of New Zealand Ltd., 2008). These regions are close to shipping ports for exportation of this high valued flower to foreign markets.

This production facility will be comparing the success of *Cymbidium* in two different greenhouse structures. To replicate the experiment two of each type of greenhouse will need to be built, thus
a total of four experimental units will be tested. Carrying out more than two replications would most likely be too expensive as this research intends to use public funding which may be limited.

The first greenhouse will be the Venlo Dutch type with full environmental controls. This will be the more expensive of the two greenhouses. The controls will include automated watering, heating, cooling, and CO₂ components, as well as light and humidity sensors. The sensors will be important because current growers have contended that humidity and light environments are superior in the plastic greenhouse systems (Tony Ivicevich, 2004).

The second treatment will utilize a double skin inflated greenhouse. To eliminate unwanted variables this treatment will include similar environmental controls and sensors. The light and humidity sensors within each greenhouse will record these measurements daily. This information can be used to determine if there is a significant difference in light and humidity levels between the glass and plastic systems as claimed by *Cymbidium* growers.

A large limitation with this production test facility is the length of time this crop takes to be market-ready. *Cymbidium* producers in New Zealand may wait up to two years to get new plant material when looking to expand with a new variety. With plant material started it can take another five years for the *Cymbidium* plants to produce flowers. (The Ministry of Agriculture and Forestry, 2005)

Such a lengthy time for maturation would limit this experiment to one production cycle. Shortening the research by using mature plants that are one to two years away from flowering may be advantageous. However this would limit the conclusions drawn from the results of the research. Connecting the growing conditions with the flower quality and sustainability factor is
an important piece to this research. Such a connection would be weakened if mature plants were used in place of vegetative propagules.

A long research period gives a more accurate picture of which system may be more sustainable. The independent variables will change from year to year allowing a more definite understanding of how they affect the dependent variable of sustainability. These changes include weather, cost of production, and value of product. This test production facility intends to utilize this information to bring about a more evaluated connection between these variables and believes that the length of time for research is an asset not an impediment.

Monitoring sustainability would be an important factor with this research. The experiment would include a cost analysis of both types of greenhouses to understand the economical benefits these growing structures. To gain an understanding of the social sustainability factor, research would need to be carried out on the number of jobs, long and short term, created by each structure. Growers’ attitudes towards each type would be an important factor to consider. Social sustainability includes monitoring the health of employees within greenhouses. Environmental sustainability will be researched and include understanding where the materials come from, and the carbon footprint caused by making and delivering such materials. On site inputs will be calculated within each system for a comparative analysis.

**Conclusion**

New Zealand has and will continue to be a worldwide leader in sustainable horticulture production. Evidence for such success can be seen in the research-based improvements made to IPM programs that were widely adopted within various horticultural sectors within New Zealand.
in a relatively short time period (Suckling et al., 2003). Research is largely funded with public
grants that allow private entities to continue New Zealand towards a sustainable future. This
progression is further enabled by the bottom-up approach to regulating the horticulture industry
within New Zealand that allows producers to make responsible decisions leading to a sustainable
production system (Fairweather, John R. and Campbell, Hugh R., 2003). The horticultural
industry of New Zealand is an example for the rest of the world as to how environmentally,
socially, and economically sustainable progressions can be realized.

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