

Sustainable Horticultural Crop Production in Sweden

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Introduction to Sweden

The Kingdom of Sweden is a Nordic country located on the Scandinavian Peninsula in Northern Europe. It has 3,218 km of coastline along the Baltic Sea, the Gulf of Bothnia, the Kattegat Sea, and the Skagerrak Strait. Sweden has 2,233 km of land boundaries; 1,619 km borders Norway to the west, and 614 km borders Finland to the northeast; it is connected to Denmark by the Öresund Bridge in the south. Sweden is the 55th largest geographical country in the world, with a total area of 450,295 sq km, comprised of 410,335 sq km of dry land and 39,960 sq km of water. In terms of size, the size of Sweden is slightly larger than the state of California, USA. Only 5.93% of Sweden's land is identified as arable land with an additional 0.01% with permanent crops (C.I.A., 2010). The terrain of Sweden is mostly flat or gently rolling lowlands, but there are mountains in the west, mostly along the borders of Norway. Sweden's climate is generally temperate in the south with cold, cloudy winters and cool, partly cloudy summers; the northern parts of Sweden lie within the Arctic Circle and those areas usually experiences subarctic conditions with long, cold winters (U.S.D.O.S. 2009).

The population of Sweden is estimated to be 9,059,651 people, making it the 88th most populous nation in the world. The ethnic composition of Sweden is a majority of Swedes as well as Finnish and indigenous Sami minorities. Foreign-born or first-generation immigrants to Sweden include: Finns, Yugoslavs, Danes, Norwegians, Greeks, and Turks. About 87% of the population identifies as Lutheran while the other 13% include Roman Catholic, Orthodox,

Baptist, Muslim, Jewish, and Buddhist (C.I.A., 2010). Sweden's population density is primarily concentrated in the southern half of the country. About 85% of the population lives in urban areas. The capital of Sweden is Stockholm, being also the largest city in the country with a population of about 2 million in the metropolitan area (U.S.D.O.S. 2009).

The Kingdom of Sweden is a limited constitutional monarchy with a parliamentary system of government. The Swedish Parliament (Riksdag) has its origins in the Viking era tribal courts (Ting) when kings were elected. The Riksdag became a permanent Swedish institution during the 15th century. The current monarch is King Carl XVI Gustaf (Bernadotte) who ascended to the throne on September 15, 1973. His authority is only symbolic and representational. The primary executive authority resides with the Cabinet, made up of a prime minister and 22 ministers who run the governmental departments. This current "Alliance" government, led by Prime Minister Fredrik Reinfeldt, came to power in September 2006. Sweden has three levels of government: national, regional, and local. There is also a European level, which has become increasing in importance since Sweden joined the European Union on January 1, 1995. Elections are held every four years (U.S.D.O.S. 2009). Sweden is also a member of the Organization for Economic Co-operation and Development (OECD).

Swedes enjoy a highly successful developed economy. The 2009 estimate for the Gross Domestic Product (GDP) for Sweden is \$333.2 billion USD, ranking it as the 35th in the world, but with a declining growth rate of -4.9%. Sweden's GDP per capita is about \$36,800 USD, making the Swedes as the 28th most affluent nation in the world. Sweden's GDP is derived from 1.6% agriculture, 26.6% industry, and 71.8% services. Sweden was ranked Number 1 in terms of Democracy Index, scoring the highest ranking in the categories of: electoral process and pluralism, government functionality, political participation, and civil liberties, and scoring the

third highest ranking in political culture (The Economist, 2008). The United Nations' Human Development Index ranks Sweden 7th for its very high human development (H.D.R., 2009). This worldwide recognition for such a high standard of living is what drew this author to investigate Sweden as the topic for this exercise.

Sustainability in Sweden

The Swedish Ministry for the Environment is responsible for identifying and establishing the country's vision for sustainable development. The Swedish Government has been working for more than a decade to incorporate sustainable development into its government policy. *"As of January 1, 2003, the Instrument of Government states that the public sector is to promote sustainable development designed to ensure a sound environment for current and future generations."* They executed this strategy with a large number of sweeping bills and communications dealing with energy, construction, education, consumerism, climate, and technology. With the same passion for progressive government, they moved quickly so that their actions match their stated objectives (M.O.E., 2006).

Sweden views itself playing an active international role in leading the global policy on the issues of sustainable development. The goal is to achieve an international policy for equitable and sustainable global development (M.O.E., 2006). Such vision is expressed as follows:

1. Sustainable development must be directed with a long-term vision of balance between social, economic and environmental benefits and consequences.
2. Sustainable development requires direction in resource utilization that depends on the ability to use, create and invest in Sweden's natural resources, existing and future buildings and infrastructures, and the Swedish population, including their health, expertise and creativity.

3. Sustainable development demands a holistic approach to the needs and problems of society of the nation and of the world. Activities must be designed that mutually reinforce the economic, social and environmental health. This approach involves insight that a healthy economy includes social justice and environmental protection. Additionally, what is good for the population and the environment also benefits the economy.
4. Sustainable development commands that society respect human rights, democratic values and equality for all to participate. Collaborative initiatives are needed at the regional, national, EU and global levels (M.O.E., 2006).

Sweden is proud of its very long tradition of local development work in rural areas. A local sustainability definition can be found in the following: "There is an established development model whereby people come together at a local level, get organized, establish common goals and then, through methodical work, realize their ideas and visions." (Thorner, 2009).

Sweden has mandated a rural development policy that includes a support network and financial stimulus from the Swedish Rural Development Programme [*Sic*]. One such rural development project is aimed at combining rural development with environmental work, thus providing both financial and environmental benefits. "Focus on Nutrients" is an advisory project which began in 2001. "The goal is to reduce the leaching of nitrogen and plant protection products from farms into water courses, the sea and water catchment areas." The result to date has been successful both in terms of reducing farm substance run-off at the same time being financially successful farms (Thorner, 2009).

Historical Production Practices

In the early 19th century Sweden was an overwhelmingly agricultural country. However, trade was deregulated in 1846. The organizations, called guilds, which controlled the farms and agriculture lost their powers as a result of this deregulation. In the late 19th century and early 20th century Sweden was transformed by the industrial revolution with the booming production of iron and steel (Lambert, 2009).

In the 20th century, Sweden's agricultural had been controlled by an "iron triangle" of special interest farming organizations, politicians, and bureaucrats from the 1930s until 1990 when the Parliament voted for a new agricultural policy. Protectionists that feared importing food and grains would harm their prosperity. So they worked with the politicians and bureaucrats in order to place themselves in a position to control prices and restrict competition, which ultimately hurt the Swedish consumers. In the 1980s, a group of economists focused on this detrimental agricultural policy that exposed the "iron triangle". When the Parliament voted for change, it was to a freer price system coordinated by competition. Consequently food prices dropped somewhat. However, these changes gave way when the EU agricultural controls supervened.

The control of the "iron triangle" included historical production data on which to compare. While case studies have been written on Sweden's agriculture as it relates to energy use and sustainability (Jansen, 2000) historical records of production proved to lie beyond the research of this author. Therefore, a different approach was considered, instead investigating the traditional Swedish cuisine and seeking a horticultural perspective therein.

In Sweden and Norway, reindeer steak was and remains traditionally served with gravy and lingonberry sauce. The native lingonberry (*Vaccinium vitis-idaea* L.), referred to as "the red

gold of Sweden” (Persson 2000), is a signature of the Swedish cuisine. Lingonberry is of considerable economic importance to Sweden. Historically they exported a large amount of fresh and frozen lingonberries harvested from the wild. (Persson 2000)

Forest management has been heavily modified in the 20th century. Modern ground preparation methods in addition to application of fertilizer had replaced forest grazing. Large machinery now are used for logging replacing horses and those machine and practices altered the natural growing habitats of the lingonberries. (Gustavsson, 1999) For centuries people had picked and used wild grown lingonberries.

Current Production Practices

Today, the Swedish Board of Agriculture is the Government authority in agricultural and food policy. They are responsible for market regulation, providing support to farmers, agriculture environmental issues, phytosanitary issues and animal health, as well as agricultural, regional, and structural policy. The Board also handles direct aid and grant payments from the European Agricultural Guidance and Guarantee

Harvested quantities of certain open air products	2002 (tons)	2007 (tons)
Cauliflower	4,900	3,100
Cucumber	12,300	7,000
Iceberg lettuce	23,400	26,600
Onion	23,200	34,900
Carrot	84,800	89,400
Cabbage	13,400	15,200
Leek	2,600	3,100
Apple	18,000	21,000
Strawberry	9,800	13,300

Fund (EAGGF). Together with the Ministry of Agriculture, the Board also participates in EU committee work on a regular basis. (Jordsbruksverket, 2009) In the last 50 years, fundamental structural changes have resulted in a sharp decline in the number of Swedish farms, but at the same time the farms have grown larger. Farmers have become more and more specialized in specific areas such as cereal grains, dairy or the raising swine and bovine animals, by investing

heavily in machinery and equipment for such productions. Agriculture employment figures for 2007 were 177,600 full-time and part-time workers. This includes agriculture and horticulture employees, as well as farm buildings and machinery maintenance personnel. Agriculture provides approximately 1.5% of the total employment in Sweden (S.A.B., 2009),

Current Swedish agriculture crop production is dominated by cereal grains, mostly barley, oats and wheat, as well as by grassland. Approximately 40% of arable land is sown with cereal grains. Yields are greatest in the plain districts in the south, while the northern fields produce the lowest yield per hectare. The differing climate conditions throughout the country also clarify crop distribution.

Agriculture Crop Production, total harvest	2007 (1,000 tons)
Cereals, total	5,057
– Wheat	2,256
– Rye	137
– Oats	890
– Other	335
Grassland	4,154
Ware potatoes	535
Starch potatoes	254
Oilseeds	229
Sugar beet	2,138

Northern crop production is primarily comprised of forage and coarse grains. Bread grain is mainly grown in the south and central plain districts of Sweden. Oilseed production, mostly rapeseed and colza, is also grown in the south and central areas. Potatoes are cultivated throughout all of Sweden, while sugar beets are only grown in the southernmost region of the country (S.B.A., 2009).

In terms of Swedish horticulture crops, fruit, vegetables, berries and decorative plants are all professionally

Harvested quantities of certain greenhouse products	2002 (tons)	2007 (tons)
Tomatoes	22,800	16,400
Cucumbers	22,900	31,300
Herbs	22,600	22,900

cultivated in greenhouses as well as outdoors, mainly in the south areas of Sweden. In 2005, horticultural production was generated at about 2,600 enterprises throughout Sweden. Roughly

75% of those businesses were open air cultivation on 12,560 hectares. 1,000 enterprises had greenhouse cultivation on a total area of 300 hectares (S.B.A., 2009).

With regard to the author's interest, the lingonberry is further examined here. For centuries people had picked and used wild grown lingonberries. With the changes in forest management, in addition to variation in fruit quality in the wild stands, and the fluctuations in annual yield motivated and accelerated the domestication and cultivation of lingonberries. Plant breeding based on wild growing material was researched since 1978 and resulted in the propagation of several cultivars including 'Sanna', 'Sussi', 'Linnéa' and 'Ida', which were chosen for commercial production. (Gustavsson, 1999)

The lingonberry is an evergreen dwarf-shrub, belonging to the Ericaceae family. Lingonberry is very common in the northern temperate, boreal and subarctic regions of Sweden, growing mainly on acid soils in bogs, heath and coniferous forests. The lingonberry is propagated by seed, stem cuttings and rhizomes, its rhizomes being the means by which the plants spreads itself. The red berries of the plant measure 0.5 to 1 cm in size, can be eaten fresh, though they are quite tart even though they actually have a large amount of sugar, contain a rich content of benzoic acid, and are used for producing jam, as well as juice, liqueur, yogurt and ice cream. (Persson 2000) Lingonberries typically produce fruit twice a year, though some varieties can have three fruit seasons. The first season in the spring is generally very small and essentially useless. The second season yields the majority of the fruit production. Lingonberries thrive in areas with a short growing season, cool summers, regular and moderate precipitation, and reliable winter snow cover. (Penhallegon, 2006)

Sweden is the largest producer of wild lingonberries. About 10% of the total available wild production is harvested. The current harvest in Sweden can vary from 20,000 tons to as

little as 4,000 tons annually, depending on weather conditions. The majority of Swedish lingonberry production is for domestic consumption but exports of this prized product can vary from 30% to 80% of its commercial harvest. The Swedish domestic lingonberry consumption is about 1 kg per capita. Roughly 2,500 to 3,000 metric tons are used by Swedish commercial jam producers. (Penhallegon, 2006)

While the native wild growth of lingonberries remained as the majority source of fruit production, the threat to growth habit forced the search for alternative growth habits. This included further studies of the plant. With the changes in forest management, in addition to variation in fruit quality in the wild stands, and the fluctuations in annual yield motivated and accelerated the domestication and cultivation of lingonberries. The wild lingonberry, is found across the northern hemisphere in each of the Scandinavian countries as well as Alaska, and Canada. The wild plant is generally short, 7 to 15 cm tall, and produces fruit on a single bloom. Domesticated lingonberries are plants that grow to 20 to 30 cm tall, blooming at least twice, producing more fruit than the wild variety. (Penhallegon, 2006)

The cultivation of lingonberries has increased the potential for the production of a reliable supply of large quantities of quality fruit for commercial processing. (Penhallegon, 2006) A healthy lingonberry planting can be expected to be productive for 20 plus years. Yields from commercial fields of 5 to 8 year-old plants in Sweden produce 2.5 to 8.9 tons per hectare.

Integration of Historical and Current Production Practices; Ranked Strategies

The naturally grown wild lingonberry production has historically been so successful; it has been difficult to improve on that success in Sweden. Given that lingonberries thrive in areas with a short growing season, cool summers, regular and moderate precipitation, and reliable winter snow cover, (Penhallegon, 2006), the natural environment of Sweden provides a

potentially successful growing environment. But as the problems with weather, foresting and logging management, and the need for reliable standardized fruit, domestication and cultivation have become necessary. The fruit itself still requires a great deal of human labor for production and harvest. This benefits the sustainability of the production practices. Therefore, for reasons of economics, domesticated lingonberry production ranks higher than the harvesting of wild lingonberries. A more uniform fruit is preferred over variable size and quality the weather and genetic conditions that affect wild production

Finalized Sustainable Development Strategy

Strategizing for the agricultural industry of another country is monumental and overwhelming to begin with. Include in those considerations, ideas for a more sustainable production of a particular crop that had not yet realized its full potential of harvest, when grown in the wild, has presented even greater challenges. Recognition for the need for more productive, standardizing the quantity and quality of the fruit of the lingonberry is in order. But it must be addressed that the naturally grown wild lingonberry must be doing something right to have such successful production estimates.

In terms of other crops, domestication and cultivation of the lingonberry has been rather recent. A great deal of success in cultivated lingonberry production has taken place here in the U.S. This phenomenon is partially due to the attitude that much of Europe held that wild lingonberry harvest was only a fraction of wild lingonberries grown but left unharvested. This attitude has since changed but it gave the U.S. an advantage early in commercial cultivation of lingonberries. Determining the balance of the benefits of cultivation to the consequences environmentally is the challenge of this section.

So much of the studies on record to date have dealt with more basic issues of domestication of lingonberry production, especially propagation. Being able to grow viable plants that display the desired characteristics for large scale commercial production has been the researched focus. Standardizing the domesticated lingonberry has correctly investigated before publishing studies on alternative growth habits.

With the attention to the ideal needs of this crop, short growing season, cool summers, regular and moderate precipitation, and reliable winter snow cover (Penhallegon, 2006), how can production be made more sustainable for the future benefit of Sweden and its population? First I would look at the various cultivars that produce a third bloom and fruit season. Further study and standardization of this characteristic increases the productive potential of the crop. Increased productivity might reduce the need for more plants, and planting areas, in order to maintain economically productive supply and demand levels.

A more important area of investigation is in the forest and logging practices that have been destroying the wild lingonberry habitat. Investigation is in order that seek alternative measures allowing financially viable logging procedures that minimize lingonberry habitat destruction. Additionally, introducing domestically cultured lingonberry plant material back into a reclaimed habitat where it once grew wild is an area that must be examined. Given the plants' productive longevity and healthy self-propagation, minimal adverse impacts to the environment make this an possibly successful option.

The Swedish government and its people have committed to the program of sustainability. This author has seen enough evidence that would suggest that tackling the issue of sustainable lingonberry production will most likely be solved by Sweden.

Future Sustainable, Controlled-Environment Production Facility

This section looks at how to create an environment that closely mimics the optimum conditions that the lingonberry prefers, short growing season, cool summers, regular and moderate precipitation, and reliable winter snow cover, (Penhallegon, 2006). For a plant that has been so successful in the wild, how can such ideal conditions be recreated in a controlled, sustainable manner? I think it is possible to control certain parts of the environment in a sustainable manner. Suitable sustainable water sources could be designed. Additionally, temperature can be addressed in a sustainable manner, only so far as a more northerly location would provide potentially reliable cool summers as well as potentially reliable winter snow cover.

Again, the ideal possibility would be to reclaim the damaged north forest areas, formerly known for wild lingonberry production, that have been harmed by the logging industry. Introduction of domesticated cultivars of lingonberries that exhibit a more uniform fruit production. Provide irrigation alternatives in the event of insufficient precipitation. The final conditions would have to be left to nature. This scenario would appear to maximize the lingonberries characteristics and growth preferences as well as the temperate and terrain that Sweden offers.

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