

Sustainable Horticulture Crop Production in the Republic of Ireland

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I. Introduction

This country was chosen for research because it has fascinated me since I was a young child growing up. In the United States today stereotyping plays a big role in our culture. Since I can remember people have said that I must have some Irish in me, hence the fact that I have red hair; however, as far back as I can trace my heritage I don't have Irish in me at all. That doesn't obstruct my fascination with the beautiful picturesque landscape of Ireland. It has in some ways intrigued me to observe this country with a deeper understanding of their culture and sustainable horticultural production practices. Ireland consists of beautiful country sides that incorporate and preserve historical architecture and castles.

The Republic of Ireland is located in Western Europe at 53 00 N and 8 00 W. The country covers five-sixths of the island which is in the North Atlantic Ocean due west of Great Britain. The population currently contains around 4,203,200 persons of Irish descent who dwell on the 68,883 sq km land mass; the other 1,390 sq km of the country is inhabited by water. The language mainly used is English, but Irish (Gaelic or Gaeilge) is spoken in some areas more along the west coast of the island. The approximate population growth rate is at 1.12 percent based on a 2009 estimate. The entire coastline of Ireland stretches across 1,448 km. The climate is temperate maritime which is altered by the North Atlantic Current. The summers tend to be cool followed by moderate winters. After summer, a humid consistency rests among the island with a cloud cover nearly half of the time. The terrain is for the most part level to rolling plains inland surrounded by rugged hills and low mountainous landscapes with sea cliffs along the west coast of the island. The lowest geological elevation point is at 0 m on the Atlantic Ocean and 1,041 m at the highest point at the top of Carrauntoohil (C.I.A., 2010).

According to the Department of Foreign Affairs (DFA) the island which Ireland resides on has two separate legal jurisdictions. The sovereign independent state of Ireland comprises twenty-six counties resting on the south, east, west and north-west parts of the island. Northern Ireland however has the remaining six counties on the north-east side of the island which is under the jurisdiction of the United Kingdom. The capital of Ireland is Dublin and is found on the eastern coast of the island. The type of governmental system in the sovereign independent state is a Parliamentary republic which consists of three branches: executive, legislative and a judicial system.

The natural resources found in Ireland consist of: natural gas, peat, copper, lead, zinc, silver, barite, gypsum, limestone, and dolomite. The land use is broke down into three areas which are arable land (16.82%), permanent crops (0.03%) and other (83.15%). The amount of irrigated land in Ireland is currently unknown. One of the current issues dealing with Ireland's environment is agricultural runoff causing pollution in the lakes (C.I.A., 2010).

The labor force can be broken down into three catagories- 6 percent work in agriculture, 27 percent work in industry, and 67 percent work in services. Agriculture sectors represented 5 percent of Ireland's Gross Domestic Product (GDP) in 2002 while industry and services played a higher role. Agriculture is now being seen as a more limited sector due to the competition it has against the industry and services. Ireland's agriculture products consist of turnips, barley, potatoes, sugar beets, wheat, beef and dairy products. (C.I.A., 2010). The DFA researched how the combined agri-food and drink sector had exports of over €8 billion in 2006, and accounts for almost 9% of the GDP. They together directly employ approximately 166,000 Irish citizens. Out of the total land area which incorporates approximately 7 million ha, 5 million ha are utilized for agricultural purposes which include the forestry industry. Cattle-raising and dairying

contribute to a high portion of the agricultural industry. Cattle in Ireland as well as livestock products such as milk are at a higher demand that make up 76 percent of the total economic gross agricultural outputs. Ireland's main crops in 2006 were barley, wheat, potatoes and mushrooms (Department of Foreign Affairs, 2010). So, crop production is not a highly noticeable figure in the sector of the agricultural industry.

II. Sustainability, Defined

The first sustainable development strategy was published in 1997 and defined by Martin Cullen (Minister for the Environment and Local Government) as:

“to ensure that economy and society in Ireland can develop to their full potential within a well protected environment, without compromising the quality of that environment and with responsibility towards present and future generations and the wider international community” (Cullin, 2002).

Cullin also states in the review, assessment and future action of making Ireland's development sustainable illustrates another definition of sustainable development as:

“Sustainable development is about getting the balance right between the economy, social issues and the environment so that we, as well as people in other parts of the world, are able to enjoy economic prosperity, social progress and a high quality environment – both now and in the future. It's about getting these

three elements working together for a better overall quality of life, instead of gains in one area being offset by losses in another” (Cullin, 2002).

Sustainability relating to the agricultural sector in a more in depth perspective is portrayed by Cullin as:

“... changing agricultural practices, resulting in substantial increases in animal and farm productivity, a greater degree of specialization and a greater concentration of intensive agricultural practices; in certain cases, increases in livestock numbers have had implications for waste management, water pollution and soil erosion” (Cullin, 2002).

The Republic of Ireland is currently working on establishing an education system for the future that will target a knowledgeable strategy called Education for Sustainable Development (ESD).

According to Hain (Secretary of State for Northern Ireland) sustainable development/sustainability is:

“Development which meets the needs of the present without compromising the ability of future generations to meet their own needs” (Hain, 2006).

This definition that Hain points out seems a bit vague and seems to not really pinpoint anything specifically. However, it examines the fact that we need to live off of what we have already, and use those resources efficiently and effectively in order to leave enough behind for future

generations to live off of. In his writing he also talks about sustainable consumption and production. He strives to examine the goals and necessities on this topic and describes the purpose to be able to accomplish more with less waste. Hain explains that people will need to become more aware of this topic and the trouble it may cause them and the environment if people don't start acting now. He states his claim that "the aim of this is to ensure that resources are conserved and wastage minimized during the manufacture, distribution and usage of all goods and services" (Hain, 2006).

III. Historical Production Practices

The potato was introduced to Ireland in 1590s. Because the crop was not mentioned in the Bible, it was not favored among the people due to superstitions the Protestants and Catholics in had. The Catholics dealt with this situation in a different way than did the Protestant. They would plant the potato seed and sprinkle holy water on the potato seeds on Good Friday. Eventually potatoes became the main source of food for Ireland and helped the Irish survive when other crops failed. The moist soil that persists in Ireland was able to bear the fruit even when other crops were unable to produce adequate yields. Irish families were able to make a higher profit on their crops because they were able to feed their families potatoes which provided a major food source for them. In 1845 however, the crop became infested with potato blight, (*Phytophthora infestans*) and by 1851 around one million Irish had died and around the same amount emigrated the mainland to countries such as the United States and England. With lack of knowledge on fungicides at the time they were unable to control this disease outbreak. Ever since this historical Irish Potato Famine occurred, they began practicing biodiversity amongst their country (Wilson 113-114).

During the beginning of the nineteenth century farmer's in Ireland seemed to move toward animal husbandry versus tillage cultivation. This was because prices were more favorable for animal commodities compared to grain and other commercial crops produced around this time. Some farmer's during this time had cultivated plots of 0.4047 hectares or less, and mainly produced potatoes for a means to survive by practicing traditional "lazy bed" production methods, and operators of holdings over two hundred statute acres whose fields were largely used for grazing and hay production (Huttman 354). The "lazy bed" practice involves building up parallel banks of soil that are up to 2.5 meters wide with narrow drainage channels one to three feet wide running in between the banks. Huttman also explains that when the Potato Famine hit Ireland it had not only a drastic affect on the population, but also led to Legislative restrictions against the subdivision of holdings facilitated primogeniture and basically forced the Irish workers to find work elsewhere due to the holdings converting from cultivation to grazing space for the cattle leading to a lack of employment" (Huttman 355). Since the work force wasn't at a prevailing state an accelerating use for horses came into play for crop cultivation. This is where other means of crop production came into play as Ireland faced harder challenges to meet the needs of their citizens.

Farmer's in the 1860s as well as later years, would have commercial seed available to them, but the quality of the seed was not reliable in any way. (Huttman, 1972) In the 1890s the commercial seed production process became more, but not sufficiently reliable.

In the late 18th century to the mid 19th century the Irish had used the Rundale system (a.k.a. ridge and furrow pattern) in which the lands were divided into infields and outfields. The infields were provided with continuous fresh farm manure and were cropped at all times. McCourt states that in some infields they grew crops continuously for thirty years or more

without leaving the land fallow for any part of it. The outfields were mainly the less arable lands that were farmed with a continuous two year rotation. Outfields would receive little to no fresh manure and would be planted with a less valuable crop such as oats grown for two years and then the land would lay fallow for two years. During those two years they would use the outfields as grazing areas for livestock until it was time to sow another crop (McCourt, 1955).

During the 1960s and 1970s in Ireland, poly tunnels were often used to allow for an increase in temperature during the winter season as well as a wind break for the crops. However, they were unaware of the potential structural failure that would later arise due to the lack of knowledge of framing the tunnels correctly. They had used wood as the framework and had to deal with the failure which became the result. Many problems had arisen as well dealing with the poly tunnels such as: lack of environmental control, low and high temperatures fluctuating, high humidity at night, unsuitable ventilation, and a deficiency of CO₂ during the day (Robinson, 1991).

During the 1970s-1980s they started testing the use of double and single-clad polythene greenhouses using tomato crops to produce an early crop before the typical growing season. They were testing the differences between the two and were trying to see which one was more cost effective. The research shows that the double cladding presented a greater than thirty percent fuel saving, whereas, the single cladding presents a much less percentage of fuel saving. However, the tomato crops in the experiment showed a decrease in total crop yield due to the high humidity rate. Although, this was overcome with a proper installation of a dehumidification system that results in only a two percent decrease of the total fuel savings. Development of a microprocessor controller has been currently researched to maintain heating and ventilation systems to sustain peak responses towards influential conditions (Maher and O'Flaherty, 1980).

Another method used in the 1970s and 1980s was hydroponics. Research done by Morgan and Tan examined greenhouse lettuce production at high densities in hydroponics. They came up with advantages by using this type of method which resulted in energy cost reduction, high plant quality, reduced labor, crops planted year round, reduction in plant diseases, water conservation, controlling nutrient supply, elimination of high soluble salts (Morgan and Tan, 2009).

IV. Current Production Statistics

As stated earlier, the DFA, which examines the combined agri-food and drink sector has had exports of over €8 billion in 2006, accounts for almost 9% of GDP, and directly employs 166,000 Irish residents. The total land area of approximately 7 million ha, 5 of those million ha are used for agricultural purposes which includes the forestry industry. Cattle-raising and dairying contribute to a high portion of the agricultural industry. Cattle in Ireland as well as livestock products such as milk are at a higher demand that make up 76 percent of the total economic gross agricultural outputs. Ireland's main crops observed in 2006 that the DFA list are barley (*Hordeum vulgare L.*), wheat (*Triticum aestivum L. emend Fiori et Paol*), potatoes (*Solanum tuberosum L.*) and mushrooms (*Agaricus bisporus*) (Department of Foreign Affairs, 2010). The total area of cultivated crops is as follows: barley occupies 167,000 ha, wheat at 87,500 ha, potatoes at 12,100 ha, maize (*Zea mays L. (partim)*) at 20,200 ha, and oilseed rape (*Brassica napus L. ssp. oleifera*) (Rape oil is extracted from the plant seeds in oil mills and then processed into biodiesel in manufacturing plants) at 5,100 ha (See Figures 1-4 for details). These five crops previously listed do not have any forms of commercially cultivated genetically modifications (Teagasc, 2010). According to a study by Central Statistics Office (CSO) in 2008,

the total area cultivated as barley is at 181,200 ha; wheat at 104,900 ha; potatoes at 12,000 ha, and the last one listed is oat (*Avena sativa* L.) at 23,300 ha (Central Statistics Office Ireland, 2009 (b)).

V. Current Production Practices

Currently there are 130,000 farmers that reside in Ireland. The average farm size is 32 ha with approximately 50 percent of farms less than 20 ha (Teagasc, 2010). They still are harvesting potatoes as one of their main crops. They are reducing the chance of potato blight currently by using fungicides.

In the Republic of Ireland mushrooms have played an important role in the agricultural industry. The production of *Agaricus bisporus* has been a huge success and has provided economic support towards small farms. They are considered to be the single most important food crop in Ireland and conduct a net value of €124 million. An approximate value of €95 million contribute towards exporting around 70 percent of their crop. The industry has a satellite grower system from which it is based off of. The growers from there are transferred to the central compost companies in which they are capable of getting in supplies of spawned compost. The companies from there use the appropriate measures to grade and market the completed finished product. The mushroom industry is made up of mostly family managed businesses which incorporate around three to five polythene tunnels. According to CALU, 70 percent or more mushroom growers have established contracts with these central marketing groups to expand their businesses (CALU 2009).

A growing practice that Robinson describes that took place in the early 1990s was that of producing mushrooms (*Agaricus bisporus*) in plastic tunnels. The specific kind of mushroom is

not listed in the article and is just referred to as *Agaricus bisporus*. “In this practice the specialist composters provided small-scale producers with plastic bags holding 25 kg of spawned compost. These bags are cropped throughout the year in structures consisting of an inner steel framework covered by a white plastic sheet (to provide good light reflection within the house), 125-230 mm of fiberglass insulation with an outer sheet of heavy gauge (200 microns) black plastic” (Robinson, 1991). Robinson explains that cooling and dehumidification of these tunnels is accomplished by using heat pumps. Another method which is also used is to cool the tunnels is by using ground water at 9-10°C that is taken from a borehole using a submersible pump in the well.

Barley grain in Ireland is used for animal feed and also used as a raw material for the production of distilled alcohol and beer. It currently is grown out in the field occupying approximately 167,000 hectares. It is either sown in the winter which is around September and harvested in late July, or sown in the spring between February and April and harvested mid to late August. They have been running into some problems while growing barley with an increase in susceptibility to fungal diseases such as: rhynchosporium, head blight, mildew, and net blotch. Other problems they are currently dealing with in the production of barley is weed control and the need to match the fertilizer input with the yield potential for the crop (Teagasc, 2010).

The main crop potatoes are sown in between March and April and harvested in between September and October. There are currently three varieties of potatoes grown in Ireland which account for around seventy percent of the Irish potato production which are: British Queen, Kerr's Pink, and Rooster. Rooster is considered to be between forty and forty-five percent of the main crop production (Teagasc, 2010).

VI. Integration of Historical and Current Production Practices; Ranked Strategies

The current top five crops in the Republic of Ireland are ranked from highest economic value to lowest: barley, mushrooms, cereals, other fresh vegetables and potatoes. The top five lowest economic valued crops will be ranked from lowest greatest: sugar beet, oats, fresh fruits, other crops and wheat (See Table 1 below). The following order of most important crops in Ireland is listed from highest to lowest as: turnips, barley, potatoes, sugar beets, wheat; beef, dairy products (C.I.A., 2010). Ireland's historical crop production practices dealing with potatoes were not sustainable due to the fact of limited biodiversity on their farms. Without creating a suitable environment for their crop they eventually ended up with no crops available to them, and either had to emigrate elsewhere or ended up dying. Now they control that issue by using fungicides and utilizing biotechnology and plant breeding practices to creating biodiversity among plant varieties above that were lacking in the past. They are also becoming more sustainable by creating new and improved ideologies dealing with how to create a sustainable landscape for their country. Also, by trying to educate and create a strategy for the younger generations to avoid any future problems with their country becoming unsustainable. They have broadened their horizons and now export crops around the world to create a larger economic growth for their country as a whole. For instance, they now export mushrooms at a large rate and is one of their highest marketable crops they have using them as a food source as well being sold as a compost product.

Along the lines of revisiting the analyzes of the historical and current production practices of the Republic of Ireland (see Table 2), it is essential to discuss these strategic methods to fit the needs of creating a sustainable prospective future. In order to vary between these strategies, they have been ranked for their overall sustainability and potential. As

illustrated in Table 3, the strategies are ranked for sustainability and implementation potential with five being the most and one being the least. The sum of these two numbers provide the total overall sustainability of that production practice. The top five sustainable production practices from highest ranked to lowest are: Diversification, Polythene Tunnels, Open Field Production, Polytunnels, and Integrated Pest Management (IPM). The five lowest sustainable production practices from lowest to highest ranked are: “Lazy Bed” method, Rundale System, hydroponics, crop rotation, and seed production and double-clad polythene greenhouses (ranked equally). Diversification has the highest rank due to the ability of using native crops in the area which will reduce the potential for disease and pest outbreaks that will later need to be controlled. The polythene tunnels were ranked second due to the fact that the agricultural economy growing mushrooms in these tunnels is at its highest rate. The third highest rank is the open field production which is ranked higher due to the fact of limiting the use of structures that may not be affordable to smaller farms. The two lowest ranked strategies were the lazy bed method and the Rundale system which both were previously used and resulted in failures of crops and outbreaks of diseases. The third lowest ranked strategy was the use of hydroponics. It does produce sustainable outcomes in the end, but the training and building of the structure would be a major limiting factor as well as the cost of the entire process. Crop rotation would be the fourth lowest ranked strategy because if this were to occur the smaller farms would lose a crop for that season, thus reducing their families annual income and food source.

VII. Finalized Sustainable Development Strategy

In developing a final sustainable strategy there has to be more diversification implemented into the entire landscape of Ireland. If this occurs there will be less disease outbreaks and pest problems that arise. This will reduce the need for IPM practices on farms and

reduced inputs of unnecessary applications of harmful insecticides. The polythene tunnels should be included in this final sustainable development strategy because it has brought forth an economic increase for Ireland as a whole. Although, there needs to be more research documented on this subject relating to cost and labor of production compared to growing out in the field. This will help examine if the polythene tunnels are necessary in the horticultural field and if it is an economically feasible method to choose. The open-field production should continue being implemented due to the low cost of development and easy access to arable fields. However, IPM practices should be taken in order to preserve these crops and a training program should be implemented to allow all farmers to practice safe pesticide practices without introducing harmful chemicals on their crops. Cover crops should be used to help improve soil quality and fertility on the farms, and to reduce disease and pest outbreaks as well.

Potato Blight (*Phytophthora infestans*) soon led to the Potato Famine and was unable to be controlled due to lack of knowledge about fungicides, crop diversity, and crop rotations.

What also needs to be researched are varieties of crops such as barley that could be resistant to the potential disease outbreaks it is currently facing in the open field production. The research should be dealing with seed production and breeding techniques. If there are any improvements in these topics currently discussed it should provide a more sustainable environment for the Republic of Ireland.

VIII. Future Sustainable Controlled-Environment Production Facility

A future sustainable controlled-environment production facility would be using polytunnels for early heated crop production. This would be implemented to increase the growing season for crops such as tomatoes. These polytunnels could allow for various crops to

be grown before the typical growing season starts. This would give them a head start to the season and allow for an time period where they could increase their price of the crop not usually available at that time. The polytunnels are not as expensive to produce compared to other various greenhouses such as: glass greenhouses, single-clad polythene greenhouse and double-clad polythene greenhouses. The location of this facility would be in south eastern Ireland due to the amount of arable land and livestock manure availability. The experiments to be tested will be the use of tomatoes, cucumbers, and strawberries. The experiments will consist of measurement by using a sensory evaluation, growth rate, vegetable/fruit weight, plant fresh weight, and compared overall to an open field growth environment to examine the benefits/disadvantages of using polytunnels. The production schedules will start three weeks before the typical growing season (in the open field) for each crop. The plants will be sown and data will be recorded throughout each test with measurements of the criteria listed above. At harvest dates the plants will be removed from the testing sites and the data will be recorded. Each crop will have separate sensory evaluation tests that consist of blind taste testing subjects (persons) and will evaluate the following: appearance, taste, texture, and if the test subject would buy this product or not. The trouble with this experiment will be the ability to harvest the individual crops in different environments at the same time for the test subjects to compare the two. If this problem occurs we will be able to confirm that by growing these specific crops in polytunnels it creates an earlier more beneficial start in the growing season compared to crops grown in the natural open field environment. However, the experiment would not be completed due to insufficient knowledge comparing the two in a sensory evaluation test, and having the test subjects decide between the individual crops in different environmental settings. The duration of this experiment will continue for three years and start three weeks before the open-field growing

season begins. If the data is not efficient the first year, the experiment shall be retested in the same matter, but start at the beginning of the typical open field growing season.

Figure 1: Area of barley under cultivation in Ireland from 2000-2006 (Teagasc, 2010)

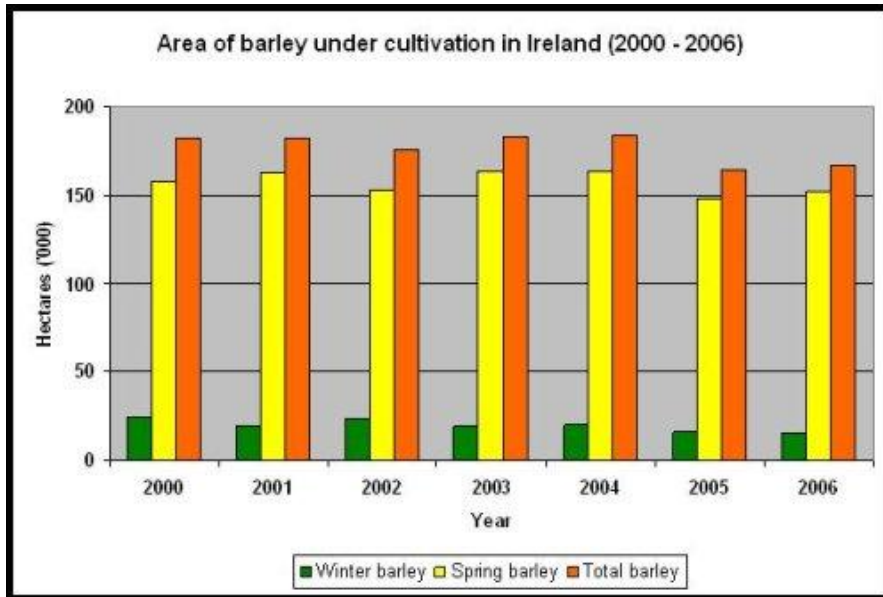


Figure 2: Area of wheat under the cultivation in Ireland from 2000-2006 (Teagasc, 2010)

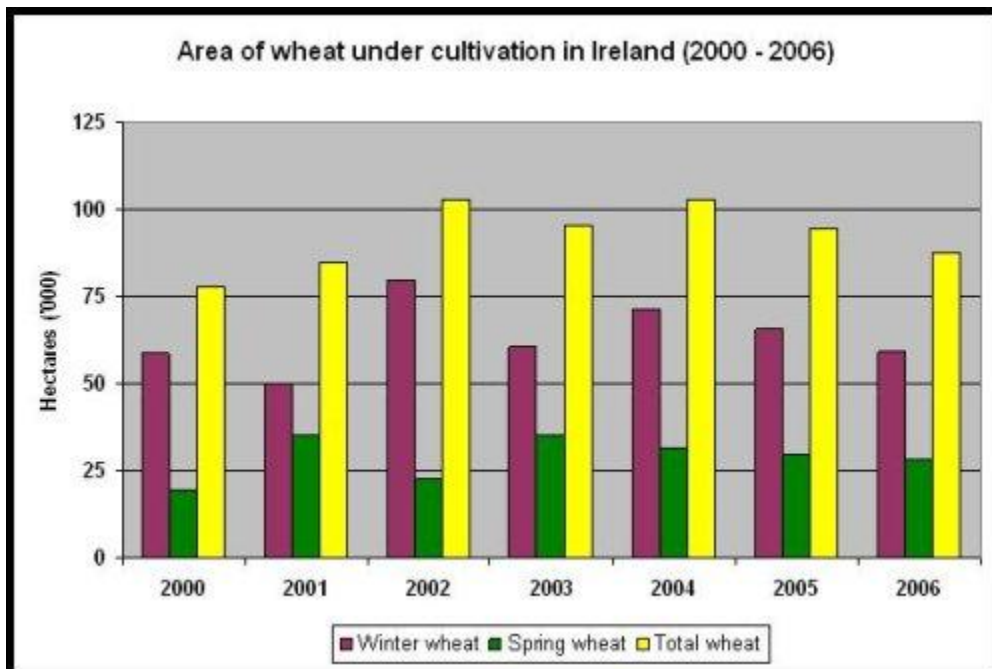


Figure 3: Area of potato under cultivation in Ireland from 2000-2006 (Teagasc, 2010)

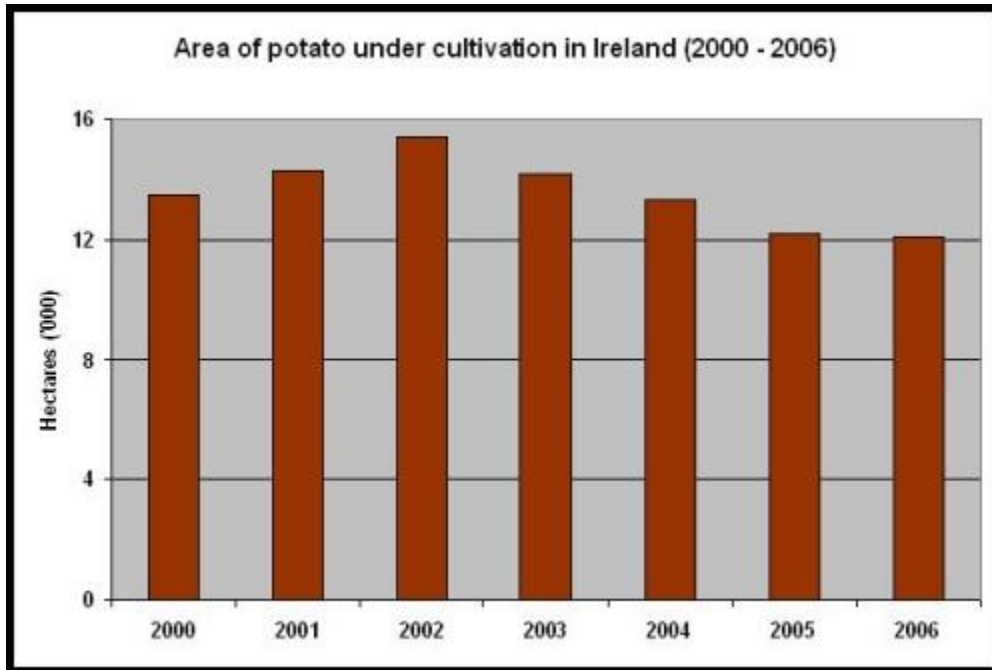


Figure 4: Area of maize under cultivation in Ireland from 2000-2006 (Teagasc, 2010)



Table 1: Value at Current Prices for Output, Input and Income in Agriculture by Statistic and Year (Central Statistics Office Ireland, 2009 (b))

	2006	2007	2008	2009
All crops (Euro Million)	1,453.90	1,595.40	1,608.20	1,380.10
All cereals (Euro Million)	159.7	241.8	200	95.9
Crops- Barley (Euro Million)	85.1	137.7	117.5	-
Crops- Wheat (Euro Million)	61.8	83.5	72.2	-
Crops- Oats (Euro Million)	12.8	20.6	10.3	-
Crops- Potatoes (Euro Million)	113	109.2	74.4	-
Crops- Sugar Beet (Euro Million)	0	0	0	0
Crops- Mushrooms (Euro Million)	99.9	99.6	102.8	-
Crops- Other Fresh Vegetables (Euro Million)	89	93.8	93.7	-
Crops- Fresh Fruit (Euro Million)	40.8	33	33.2	-
Crops- Turf (Euro Million)	35.9	32.8	33.2	-
Crops- Other Crops (Euro Million)	53.7	62.7	62.8	-
Crops- Forage Plants (Euro Million)	861.8	922.5	1,008.10	857.1
Goods Output at Producer Prices (Euro Million)	5,238.40	5,701.40	5,826.60	4,727.00

Table 2: Historic Irish horticulture production and their respective sustainability components.

Time Period	Sustainable Elements	Unsustainable Elements
Introduction of the Potato using the “lazy bed” planting technique: 1590s-1800	Potato was introduced and people were able to make a higher profit on their crops. They were able to feed their families potatoes which provided a larger food source.	Potato Blight (<i>Phytophthora infestans</i>) soon after lead to the Potato Famine and was unable to be controlled due to lack of knowledge about fungicides, crop diversity, and crop rotations.
Rundale System (a.k.a. ridge and furrow pattern): Primitive Plow-based tillage: Introduction of the more maneuverable swing-plow Late 1700s-1850s	Lead to improvements in the Rundale system by straightening and leveling out the Rundale strips which were approximately two hundred meters long.	Infields provided with continuous fresh farm manure and were cropped at all times. The outfields were mainly the less arable lands that were formed with a continuous two year rotation. Once the crop was harvested at the end of the second year they would let the land be fallow for two years and be used as grazing areas for livestock. Once the two years have passed a crop such as oats would be an example of what would be planted for the next two years. The primitive plowing technique was labor intensive and resulted in curved ridges. The Irish Potato Famine caused by the disease Potato Blight (<i>Phytophthora infestans</i>) occurred due to lack of plant diversity and fungicides available.
Seed Production: 1860s-1890s	Seed production process began.	Seeds were not reliable.
Polytunnels: 1960s-1970s	Research done on production with early heated tomato crops in polytunnels.	Wooden structural framework failed. There was a lack of environmental

		control, low and high temps. fluctuating, high humidity, unsuitable ventilation at night, and lack of CO ₂ during the day.
<p>Double & Single-Clad Polythene Greenhouses:</p> <p>Hydroponics:</p> <p>1970s-1980s</p>	<p>Double cladding results in >30% fuel saving expense.</p> <p>Development of a microprocessor controller to maintain heating and ventilation systems to sustain peak responses towards influential conditions.</p> <p>Greenhouse lettuce production resulting in energy cost reduction, high plant quality, reduced labor, crops planted year round, reduction in plant diseases, water conservation, controlling nutrient supply, elimination of high soluble salts.</p>	<p>Less tomato crop yields with double cladding due to humidity, but can be fixed resulting in a 2% increase for fuel expense.</p> <p>Chemicals implemented into the recirculating solution to control disease and pest outbreaks, knowledge needed to run the system.</p>
<p>Plastic Tunnels:</p> <p>1990s</p>	<p>Upgraded from the traditional system using wooden trays for mushroom crop production in concrete houses. Cooling and dehumidification is accomplished now by using heat pumps or by using ground water that is taken from a borehole using a submersible pump in the well. Limits environmental factors that could affect the crops.</p>	<p>More expensive than in the open fields.</p>
<p>Polythene Tunnels:</p> <p>Field Crops:</p> <p>1990s-Present</p>	<p>Used in growing <i>Agaricus bisporus</i> mushrooms which is the most important food crop in Ireland. Used as a mushroom compost as well as a food crop.</p> <p>Reducing potato blight by currently using fungicides and new cultivation techniques eliminating the “lazy bed” method.</p>	<p>Growing barley out in the field has resulted in an increase in susceptibility to fungal diseases such as:</p>

		rhynchosporium, head blight, mildew, and net blotch. Also weed control and fertilizer input needs to coincide with potential crop yields. Lack of IPM practices and essential crop rotations.
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Table 3: Strategic Ranking for Overall Sustainability of Production Practices.

Production Practice	Sustainability	Implementation Potential	Total Score
“Lazy Bed” Technique	0	0	0
Rundale System	0	0	0
Seed Production	3	1	4
Polytunnels	2	4	6
Double-clad Polythene Greenhouses	2	2	4
Hydroponics	1	1	2
Polythene tunnels	4	5	9
Open-Field Production	3	5	8
Crop Rotation	1	2	3
Integrated Pest Management (IPM)	3	2	5
Diversification	5	5	10

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