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College of Agriculture,
Food & Rural Enterprise

The Green Challenge

"Sustainability in Horticulture"

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Contents

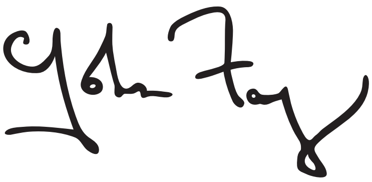
Foreword

Sustainable development is a concept which has an increasing importance to all areas of work within the horticulture sector in Northern Ireland. During the next 10 years, a range of sustainable challenges will impact on the sector, namely the effects of climate change, energy consumption and the use of finite resources. To meet these challenges will require the adoption of new ideas and technologies to ensure we develop a long term sustainable sector.

CAFRE is committed to assisting the horticulture sector to meet these challenges and we currently are evaluating a range of sustainable systems/technologies within our campuses, e.g. renewable energy for heating, rain water harvesting and using peat reduced growing mediums.

This booklet highlights the use of current and future technology systems which are being evaluated, not only here at CAFRE, but also with our partners in the wider horticulture sector.

I trust the booklet is useful for you. Please make contact with relevant CAFRE staff for further information on the technologies and their potential to make a positive change to your business.



John Fay
CAFRE Director

Sustainable technologies in horticulture at Greenmount Campus

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The Horticulture Development Centre (HDC), Greenmount Campus, is a centre equipped with glasshouses, polythene tunnels and standing out areas which is representative of a small nursery. It is used to deliver education, training, knowledge and technology programmes to those entering and within the industry.

As the horticulture industry faces increasing challenges with regard to climate change, issues of limiting resources and economic pressures, HDC is used to demonstrate sustainable and renewable energy technologies.

Sustainable technologies demonstrated include:

- Small scale in vessel composter*
- Reduced peat composts*
- Mustard crop for weed control
- Biodegradable pots*
- Rain water harvesting*
- Precision irrigation

(*See the following sections).

A) Small scale in-vessel composter and peat reduced growing medium
The agriculture and horticulture sector in Northern Ireland produces over 15.4 million tonnes of biodegradable waste per year (DoE, 2003). Under the Landfill Directive (1999/31/EC) which aims to prevent, as far as possible the negative effects of landfill of waste on both the environment and human health, targets have been set to reduce the amount of biodegradable municipal waste going to landfill. Government waste minimisation initiatives are exploring alternative disposal methods for this type of waste.

Windrow and in-vessel composting are examples of methods used for the breakdown of biodegradable waste providing a valuable resource. In composting, bacteria and other micro organisms act in the presence of oxygen to destroy plant pathogens and decompose biodegradable waste into composts which are high in plant nutrients.

Fig. 1 Horticulture green waste ready for composting

There are a number of different systems of in-vessel composting available such as a vertical aerobic system with forced aeration and a rotating drum system in an enclosed container. In the latter (demonstrated at Greenmount Campus), the rotation of the drum exposes more of the surface area of the material to air and oxygen speeding up the composting process. The enclosed container provides a controlled environment ensuring any pathogens are killed. In addition, the composting process can be monitored and regulated producing a more consistent final product. A consistent final product is essential if it is to be used commercially for horticulture purposes e.g. as components of growing mediums, landscape mulching and source of plant nutrients.

Trials carried out in the UK, including Northern Ireland (at local nurseries and at Greenmount Campus) have shown that composted green waste (made from hedge and plant clippings etc.) in combination with bark, can replace at least 25% peat in the growing medium for bedding and hardy nursery stock species (Fig. 1). Similarly composted spent mushroom could substitute 20% of peat requirement in a growing medium for bedding plants. These substitutes also supply valuable nutrients to the growing plants (Table 1, Fig. 2).

Fig. 2 Bedding plant species in various peat reduced growing medium

The reduction of peat in a growing medium goes towards achieving the UK government's targets of a 40% reduction of the total market (3.4 million cubic metres peat used in growing media and soil improvers) to be supplied by non peat materials by 2005 and a 90% reduction by 2010 (Defra, 2005). The former target has been exceeded, (Horticulture Trade Association, 2007).

Table 1 An example of water extractable nutrients (excluding micronutrients) from composted spent mushroom substrate (CSMS), 20% CSMS mixed with 80% peat, and green compost in comparison with a commercially available bedding mix.

	pH	Conductivity µ S/cm	Total N percent	P mg/kg	K mg/kg	Ca mg/kg	Mg mg/kg
Composted SMS phase III	7.3	3,680	2.31	105	3,689	3,992	510
20% composted SMS & 80% peat mix	5.8	872	1.60	215	1,149	755	173
Green compost	6.7	1600	1.45	130	3,102	676	477
Commercial bedding mix	5.8	341	1.26	218	430	100	129

B) Biodegradable pots

It is estimated that 500 million plastic pots are used annually (BBC, 2008) and their disposal is becoming an ever increasing problem. Whilst some pots are reused, most end up in landfill sites. As the majority of plastic pots used are made from different types of plastics of varying sizes, colours and shapes, their disposal and recycling is difficult and very expensive.

Manufacturers of packaging have to comply with legislation such as 'Producer Responsibility Obligations Regulations 2007' and the anticipated legislation on 'Reduction of Impact of the Packaging'. The High Court test case ruling (McCarthy 2001) also classified pots as a packaging product making it the responsibility of the producer to find ways of dealing with the disposal of pots.

Technology that considers the end life of the plastic product at the design and development stage is slowly becoming available. These pots when made from standardised degradable material could easily be recycled on a commercial scale.

Aside from recyclable plastics, bio degradable pots are being developed for the propagation and the growing-on stage. These containers will decompose when planted into the soil or when composted after use.

At the propagation stage, biodegradable modules (Fig. 3) which can easily decompose can be used. These modules can be used for either seed or cutting raised material and the young plants can be transplanted directly without removing the modules and damaging the root systems.

Fig. 3 Rooting plant cuttings in biodegradable modules

Containers for the growing-on stage are made from materials such as coir, corn starch, *Miscanthus* and paper (Fig. 4). These containers would be suitable for crops which require a short growing cycle, for example bedding plants and herbs. So far, some pots have been designed to be placed into the soil together with the plants and break down in the soil with time. There are other types of pots which have to be removed and composted separately using a composting process.

Investigations at Greenmount Campus have shown that the plants perform equally well in these biodegradable pots as in the standard pots. Issues such as pot longevity (pots becoming less rigid over time or may become externally overcome by growth of saprophytic fungi Fig. 5), difficulty with handling, presentation at the point of sale and the compostibility of these pots needs to be further evaluated.

Fig. 4 Cyclamen in biodegradable pots

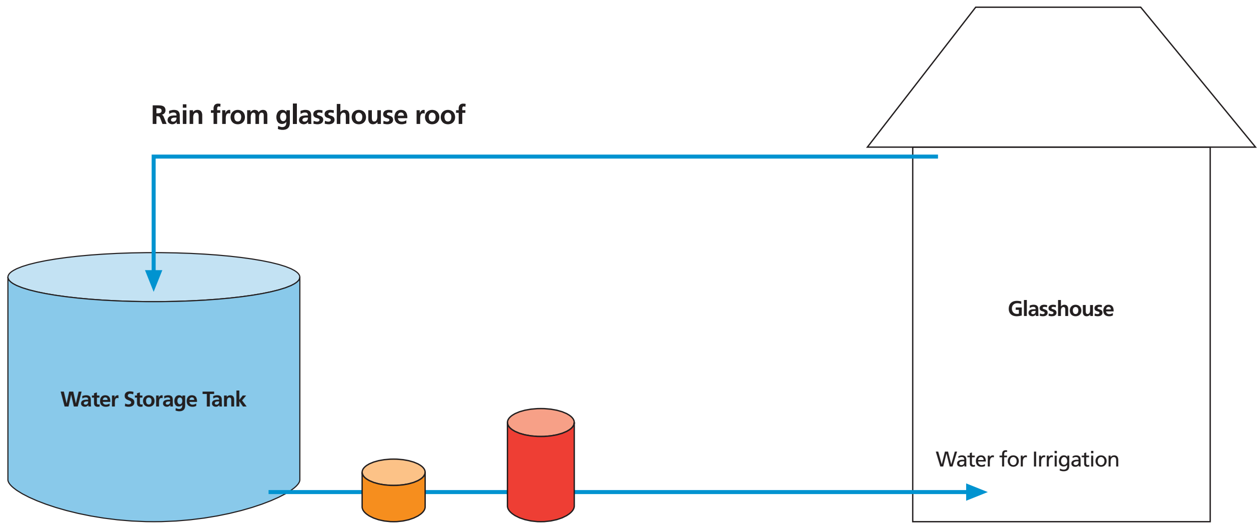
Fig. 5 Saprophytic fungi on surface of biodegradable pot

C) Rain water recycling

In anticipation of increased water charges, including charging for bore-well water and European Union water regulations promoting sustainable water use (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000), there was a need to consider rain water harvesting i.e. rain water collection from the place it falls.

A rainwater collection facility consists of the collection of rain from the roof to a storage tank, a pump to take water through a slow sand filter to remove any detritus with a further pump to transfer clean water for irrigation.

Fig. 6 Schematic diagram of rain water harvesting



A rain water harvesting system was installed at Greenmount Campus in 2008 to collect rain from a 2000 m^2 glasshouse (Fig. 6, Fig. 7) This provides a potential annual rainfall collection of 1700 m^3 (annual rainfall of 850 mm/year) which is in excess of that required for irrigation within this glasshouse.

Fig. 7 Rain water harvesting installation at HDC, Greenmount Campus

Analysis of the rain water harvested showed it to be ideally suited for irrigation. If the rain water is to be used for drinking water, or bathing, additional treatment and purification systems are required.

The potential payback for a rain water harvesting system is estimated to be around 8 years.

Sustainable best practice in horticulture at Greenmount Campus

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There are many sustainable best practices that can be adopted in a horticulture business in order to achieve a balance between available resources and care for the environment. A number of these are carried out at the Horticulture Development Centre (HDC), Greenmount Campus. These practices when adopted in nurseries will contribute toward achieving accreditations e.g. Assured Produce Scheme, LEAF (Linking Environment and Farming), BOPP (British Ornamental Plant Producers Certification Scheme), which enable growers to supply retailers who demand these qualifications.

Some of the best practices adopted at HDC are:
- Integrated pest management*
- Safe use and disposal of chemicals
- Prevention of pollution of ground water
- Water recirculation using ebb and flood systems
- Waste management*

(*See the following sections).

A) Integrated Pest Management

One of the biggest problems in the commercial production of crops is the outbreak of pests. Even when spray programmes are carried out strictly according to schedule, there can still be occasions when an outbreak can occur when certain pests become resistant to the specified chemicals e.g. aphid species to pirimicarb and pyrethroid or when certain chemicals are no longer approved for use e.g. aldicarb. An alternative method is the use of Integrated Pest Management (IPM).

The use of IPM is not something new and it has been with us for many years but its implementation requires commitment. IPM is the working together of cultural, biological and chemical control. By this integrated approach the reliance on chemicals is reduced and the control of pests found to be more effective.

i) Cultural control

The biggest cultural control is prevention. When production factors for example, temperature, humidity, nutrient and moisture are all optimum the plant thrives and becomes less prone to pest and diseases. These cultural methods are practised at HDC.

- There is a minimum of 5 percent ventilation in glasshouses to allow for air movement and minimise condensation on the leaves. Moist air promotes fungal diseases such as *Botrytis* and mildew. Air movement is further enhanced by using circulation fans.

- Humidity is further reduced by active ventilation where a low level of pipe heat is provided in conjunction with a level of ventilation. The optimum level is calculated by the environmental computer.
- Where appropriate, leaf wetness is minimised by adopting an 'ebb and flood' system or a trickle tape system where plants are watered from the base of the plants rather than by an overhead watering system.
- The standard of hygiene is kept high. Old compost and rubbish can harbour pests; therefore cleaning out between crops is essential.

ii) Biological control
In commercial horticulture crop production a large number of plants of the same species are grown together under a standard environmental condition. This monoculture system is the norm upsetting the natural balance between pests and predators (Fig. 1). In most cases pest species become more dominant.

Fig. 1 Sticky traps to trap pests for identification. (Yellow for white flies and blue for thrips).

To mimic natural systems, biological control could be established by artificially introducing predator species into the controlled environment (Fig. 2). These predators have been tested rigorously under quarantine conditions for a number of years before being made available for commercial use. The predators range from insects to single cell organisms such as bacteria and in some cases viruses. These predator species are best introduced in small numbers at regular intervals giving time for a natural balance to occur between predators and pests. The majority of species used are not native and will therefore require specific conditions; e.g. warmer temperatures or a source of material to feed on when the level of pests are low. Hence, predators are mainly used under glasshouse conditions where temperatures are warmer or used outdoors during the summer months.

Fig. 2 Biological predators used at HDC

Table 1 Biological predators used at HDC

Pest	Location	Control Predator
Whitefly	Glasshouse	*Encarsia formosa*
Aphids	Glasshouse and tunnel	*Aphidius colemani,* *Aphidoletes aphidimyza*
Two spotted mite	Glasshouse, tunnel and outdoor	*Amblyseius californicus* *Feltiella acarisuga* *Phytoseiulus persimilis*
Thrips	Glasshouse and tunnel	*Amblyseius cucumeris* *Orius laevigatus*
Leafminer	Glasshouse and tunnel	*Dacnusa sibirica* *Diglyphus isaea*
Caterpillar	Glasshouse and tunnel	*Trichogramma pupae* *Bacillus thuringiensis*
Sciarid Fly	Propagation under glasshouse and tunnel	*Hypoaspis aculeifer* *Hypoaspis miles* *Steinernema feltiae* *Atheta coriaria*

The above predators (Table 1) were found to be effective over time. However, time and effort are required to plan and implement their introduction. For example, in the control of white fly, the predator *Encarsia formosa* can be introduced to the crop as a preventative prior to the pest being found. If whitefly has been detected repeated weekly applications are needed.

iii) Chemical control

In an IPM system a small amount of carefully chosen approved chemicals are used when absolutely necessary. Chemicals are chosen based on their compatibility with the predators used, and timing is essential. Chemicals are applied at the appropriate stage of the life cycle of the pests and predators. To minimise harm to the predators, only affected plants are treated with the chemicals.

From our own experience at Greenmount Campus, we have found that IPM is a very effective strategy to control pests without extra cost. The additional cost of predators is compensated by the reduction in chemicals used. The added benefit in using an IPM system is from an environmental perspective. Less harmful chemicals are used throughout the supply chain; i.e. less chemicals in the environment with reduced exposure to both crops and those using the chemicals.

B) Waste management

The agriculture and horticulture industry in the UK produces a wide range of waste types ranging from plastic sheeting to waste chemicals and machinery oils (Defra, 2005).

Under Government legislation 'The Controlled Waste (Duty of Care) Regulations (Northern Ireland) 2002' we all have a duty of care in relation to the waste produced. To comply with this regulation waste must be stored securely. Transfer notice is required if the waste is passed on to a third party and this notice must kept for 2 years.

The Duty of Care Guidelines (DoE, 2008) provides the following recommendations:

i) Waste audit

A waste audit should be carried out at least on an annual basis. Types and quantities of waste, current methods of disposal and pollution potential should be identified. This was carried out at HDC (Table 2). From this audit recycling and disposal solutions can be put in place. The audit can also be used to identify where input resources could be saved with the avoidance of waste initially.

Fig. 3 Waste to be segregated

Table 2 Waste audit at the Horticulture Development Centre, Greenmount Campus.

Waste identified	Quantity produced per year	Storage method	Current method of disposal	Future method Of disposal
Organic e.g. prunings, dead plant material, used composts	10 m^3	Compost trailer, bulk storage bay	Certified composting contractor	Onsite composting
Plastic e.g. tunnel covering, pallet wrapping	40 m^3	Specific bins	Certified recycling contractor	Not identified
Pots: used pots & trays	6 m^3	Separate pallet boxes	Return to suppliers, save for reuse after washing	Sterilise and reuse. Use biodegradable pots and trays.
Empty chemical containers (compressed)	200 litres	Supplied drum	Certified contractor	Not identified
Paper	120 litres	Dry collection sacks	Recycle contractor	Composting
Cardboard	4 m^3	Dry collection cage	Recycle contractor	Composting
Glass (Horticulture)	25 kg	Specific bins	Landfill	Not identified
Wood pallets	100 pallets	Clean storage area	Return pallet system / recycle contractor	Processed on site

ii) Training
All staff have to be trained to deal with waste. This includes how the materials are segregated, their destinations and some materials have to be cleaned before being sent for recycling.

iii) Storage
Providing a storage area within a nursery with easy access to all will help to segregate the waste into discreet groups alleviating the problem of mess. Following discussion with local authorised disposal contactors different skips or bins can be provided for items such as waste packaging and plastics for ease of disposal. Segregation also identifies materials which have potential value, e.g. metals.

In summary the best method to deal with waste is to follow the best practice of:

- Avoidance - avoid waste production - plan better.
- Reduction - reduce the volume produced.
- Reuse - reuse where possible.
- Recycle - identify opportunities in recycling.
- Dispose - dispose of waste in an environmentally positive way.

Record keeping not only helps keep track of waste but also helps to comply with legislation.

Further help and advice in dealing with waste is available from the following websites:

- www.ni-environment.gov.uk
- www.wakeuptowaste.org
- www.netregs.gov.uk
- www.envirowise.gov.uk
- www.wrap.org.uk

Evaluating renewable energy technologies at Greenmount Campus

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The majority of energy used in commercial and amenity horticulture, is derived from fossil fuels. With increasing pressure on world stocks of this diminishing resource and rising energy prices, sustainable alternatives to conventional energy production need to be considered. In addition the Climate Change Act 2008 has committed the UK to reduce greenhouse gas emissions by 80% on 1990 levels by 2050.

For heat production, biomass and solar heating systems are now available for use in place of oil and gas systems, and renewable electricity can be produced from wind turbines. These systems are currently being evaluated at CAFRE to examine both the cost/profit implications and the effect on reducing CO_2 emissions.

Northern Ireland has a renewable energy target of 12% electricity consumption from indigenous sources by 2012 (of which 15% should be from non-wind sources) with an aspirational target in the NI Sustainable Development Strategy (SDS) of 40% by 2025.

A) Evaluating a small scale wind turbine at Greenmount Campus

Wind energy as an abundant natural resource, is a non-polluting clean and sustainable source of power. The UK has one of Europe's windiest climates and wind energy can be expected to be an important element in achieving the UK Governments commitment to reduce CO_2 emissions to 12.5% below 1990 levels by 2010.
When considering whether a wind turbine would be a suitable technology to adopt at each location, there are a number of points to be considered:

- Is the average annual wind speed at the location sufficient to drive a turbine fast enough for prolonged periods to generate economic levels of electricity?
- Can the power used match the production to a significant extent? Greatest returns are achieved from power used on your unit.
- Is there good access to the site and will ground conditions allow a suitable base to be installed?
- Where is the nearest point for connection to the grid and what will this connection cost?
- What size of turbine is best suited to your needs?
- How long will it take for a turbine to payback the installation cost?

In order to demonstrate the use of a small wind turbine within a horticultural setting, a 5kW (Iskra) wind turbine was installed at the Horticulture Development Centre (HDC), Greenmount Campus in October 2007 (Fig. 1)

The turbine is mounted on a free-standing 12 metre tower and has a blade diameter of 5.4 metres. The electricity generation from the turbine is connected to and

operated in parallel with the Northern Ireland Electricity (NIE) network.
Each make and type of wind turbine will have a power curve specific to the model. The power curve will indicate how much electricity will be generated at a given wind speed. The power curve for the 5kW Iskra turbine is illustrated in Fig. 2.

The cut-in speed of this turbine (i.e. the minimum wind speed at which it will generate electricity) is 3 m/s. At this wind speed, about 0.21 kW per hour of electricity is generated. At a wind speed of 8 m/s, 2.39 kW of electricity per hour will be generated. (Table 1).

From the power curve data (Fig. 2) it was estimated that the turbine at HDC would generate approximately 8700 kWh per annum based on an annual average wind speed of 5.4 m/s, (from available wind maps for the site). This equates to a saving in electricity cost of approximately £1000 per annum @£0.11/kWh.

With the inclusion of Renewable Obligation Certificates (ROCs) gained from renewable electricity generation, this will add a further income of £285.

The estimated CO_2 reduction will be approximately 4 tonnes per annum, which is 7% of the total CO_2 generated from electricity used by the HDC.

Fig. 1 Iskra wind turbine at the Horticulture Development Centre, Greenmount Campus

Fig. 2 Annual Output (MWhr) from a 5 kW ISKRA wind turbine

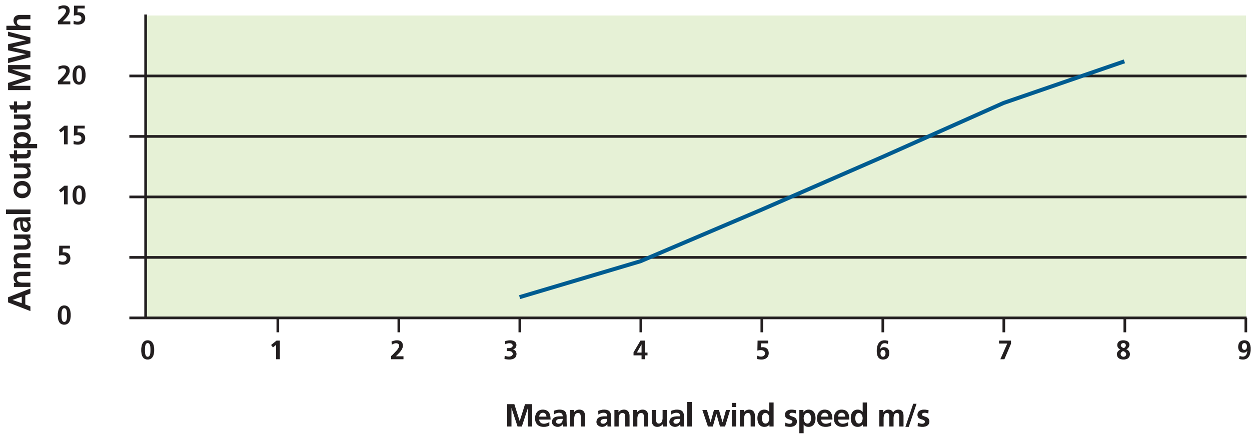


Table 1 Anticipated power generation from a 5 kW ISKRA wind turbine at different wind speeds (Iskra technical data sheet)

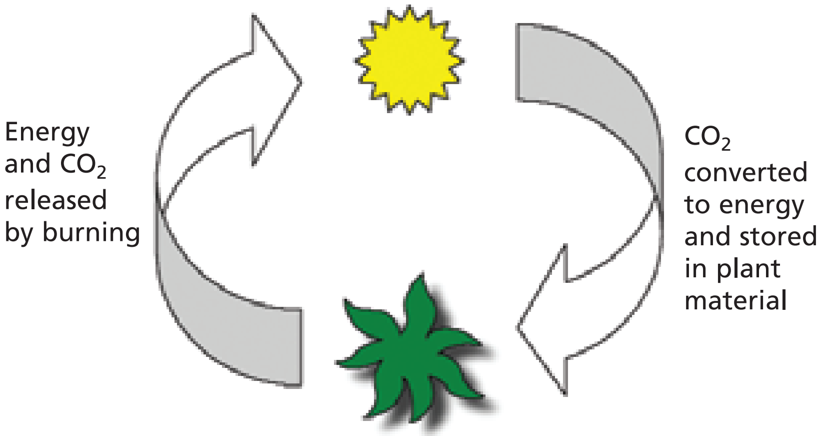
Annual mean wind speed m/s	Hourly kWh	Daily kWh	Annual MWh
3	0.2	5.04	1.8
4	0.5	13.0	4.8
5	1.0	23.9	8.7
6	1.5	36.0	13.2
7	2.0	47.5	17.4
8	2.4	57.4	20.9

The payback period for small scale wind turbines depends predominantly on the wind speed and on the ability to utilise the power generated on-site. The value of electricity generated which displaces purchased power equals the cost price of the electricity plus the value of the ROC. For the majority of the period recorded this amounted to 11 p/kWh plus 3.27 p/kWh for the ROC. The return from electricity spilled to the grid was much lower at 4.5 p/kWh plus 3.27p/kWh for the ROC. It is anticipated that the payback for the wind turbine will be 10 - 15 years.

B) Biomass and solar panels at Greenmount Campus

What is Biomass?
The term biomass covers a wide range of fuels and technologies used to produce renewable energy. Biomass covers crops grown specifically for energy, and many other by-products and organic wastes which have arisen originally from photosynthetic activity. These are non-fossil renewable forms of fuel such as wood, grasses, crops, agricultural and municipal wastes which can be burned to provide heat and power. Liquid biofuels can also be derived from biomass crops such as oilseed rape.

When plant material is burned for energy, carbon dioxide is released. However, as plants absorb carbon dioxide during their life cycle, the net emissions of carbon dioxide are zero. As a result, burning wood is regarded as carbon neutral.



Benefits of Biomass
There are many environmental economic and social benefits of using biomass instead of fossil fuels to produce our heat and electricity.

(i) As energy production from biomass is regarded as carbon neutral, considerable savings can be made in greenhouse gas emissions which are believed to cause global warming
(ii) Biomass fuels are home produced. All our fossil fuels are imported. Utilising locally produced biomass reduces our dependence on imports.
(iii) Being an indigenous fuel supply removes the risk of political supply problems giving greater security of supply
(iv) Development of the biomass industry offers opportunities in employment especially in rural areas. Jobs will be created in a range of areas such as fuel supply, installation, engineering and maintenance.
(v) Biomass is sustainable and renewable, avoiding the depletion of our natural resources. Energy crops offer a different environment to pasture land and can increase biodiversity.
(vi) Useful bioenergy can be generated from resources that were previously regarded as wastes such as forestry thinnings and wood waste from sawmills. Crops such as SRC willow can be used for bioremediation of wastes prior to burning. Heat and electricity can be generated from agricultural and food wastes, while simultaneously dealing with a waste disposal issue.

Biomass feedstocks
Sources of biomass split into two main areas, energy crops and organic residues. Energy crops are grown for the primary purpose of being burned or converted into a product which can be used as a fuel. They include trees for timber and their thinnings, short rotation coppice (SRC) willow, miscanthus - elephant grass, cereals for burning and oilseeds for biodiesel.

Organic residues such as animal manures, spent mushroom compost, wood wastes and vegetable wastes in some cases can be burned to produce energy but can also can be used to fuel anaerobic digestion (AD) systems to produce biogas. In future, if the economic climate was correct, crops such as grass or maize may be grown to fuel AD systems. Table 2 shows the relative calorific values of various types of biomass fuels along with some fossil fuels for comparison.

Table 2 Relative Calorific Values of Fuels (Biomass Energy Centre)

Fuel	Energy density by mass volume GJ/tonne
Log Wood Stacked air dry 20%MC	15
Wood Chip 15% MC	15.2
Wood Pellets	18
Grain	16
Miscanthus (bale)	17
Coal (lignite to anthracite)	20-30
Oil	42
Natural gas	54

There is now a wide range of technologies and equipment with proven capability to produce energy from biomass which will reduce the level of carbon released to the atmosphere when energy is produced. However, it is important to carefully calculate the costs and potential payback when considering your own particular situation.

Biomass Boiler Running Costs

Table 3 Biomass fuel savings for each 5,000 litres oil

		Oil prices (p/l)			
		35p	40p	45p	50p
12.7 t woodchip (20%MC)	@ £ 80/t	734	984	1234	1484
10.5 t wood pellet	@ £128/t	406	656	906	1156
11.5 t wheat	@ £130/t	255	505	755	1005
11.5 t wheat	@ £ 90/t	715	965	1215	1465

Environmental Benefit

In addition each of these biomass systems would result in a reduction of 13.4 tonnes of CO_2 for each 5000 litres of oil compared to 28sec home heating oil.

Payback on capital cost of Installation

While running costs of biomass systems are considerably lower than for fossil fuels (table 3), biomass boilers are more expensive than conventional oil condensing boilers of similar efficiency. Each individual situation will be different. When sizing a biomass boiler for a particular application, it is important to know the regular heat load required. As biomass boilers run most efficiently above 50% capacity, a smaller biomass boiler is normally installed than would often be the case with an oil boiler. The assistance of an experienced biomass practitioner is recommended.

Sustainable Energy Unit at HDC

CAFRE have recently installed a sustainable energy unit which combines two renewable energy technologies. The unit, made up of a 320kW biomass boiler integrated with ten 2.5m^2 solar thermal panels, was commissioned at the Horticulture Development Centre (HDC) at Greenmount Campus in November, 2008.

Solar energy will be used to pre-heat water before the main biomass boiler. During the summer months, as very little heating is used, the solar element of the unit will provide sufficient heat for the needs of the glasshouse complex. In the winter, the biomass boiler will shoulder the majority of the energy provision. The average consumption of heating oil in the HDC during the six years from 2000 to 2005 was approximately 70,000 litres.

Fig. 3 320kW Biomass boiler at HDC.

Based on an oil price of £0.50 per litre, the annual fuel bill is approximately £35,000.

Each year we anticipate the following savings
- 200 tonnes of CO_2
- 50% saving in fuel costs
- 85% reduction in the use of fossil fuels

The potential payback for the sustainable energy unit is approximately, 5 to 8 years.

Energy saving opportunities in horticulture

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Introduction
Getting the best price for fuel is often the main focus when a business wants to reduce energy costs. However, this approach only delivers limited short term savings. For long term sustainable savings a business must consider reducing fundamental energy consumption. To do this the following issues need to be considered:

- Is fuel being converted to useable energy in the most efficient way?
- Are you using the most cost effective fuel type?
- Can you reduce the amount of energy you need in the primary process?

This paper considers these issues for some of the main energy uses in horticulture.

Heating
Heating accounts for the biggest proportion of energy use in horticulture. The intrinsic thermal inefficiency of horticultural structures means that heating use can be over 10 times that found in commercial buildings and so is therefore very important.

Hot water based systems
A modern condensing boiler can have an efficiency approaching 90% but older boilers can easily be operating at 75% or below. With the potential for savings as much as 25% the payback on a new boiler or refurbishment can be very rapid.

Insulating pipes is not exciting but the savings can be! One meter of 100mm pipe carrying water at 80°C can lose 300W of heat. This could be costing you £1/week, possibly £2/week if you use high priced oil for heating.

Remember to check the integrity of old pipe insulation; is it thick enough? Is it dry? - wet / loose fitting insulation can be virtually useless.

Control at the point of use
Mixing valves are notorious for internal leaks - they allow hot water to pass even when they are fully closed. So check that if you only need 30°C heating water in your system, that is what is being provided. In a typical greenhouse, if pipe temperatures are 10°C more than needed because of a leaking valve for a period of only1 hour every day, it could be costing as much as £40-£60 extra per Hectare per week. Savings accrued by avoiding this will quickly pay for a new set of seals and even a completely new mixing valve.

Warm air systems
Direct fired warm air heaters i.e. those that have no flue, are the most efficient way of converting fuel into heat at the point of use - their efficiency is in the high 90% level. But the fuels you can use have to be clean and so your choice is limited - kerosene & gas are the common alternatives. With direct heating you must beware of a build up of flue gasses in your building and the effect they can have on plants and people.

The distribution of heat with warm air systems can also be poor so consider using additional air movement fans to avoid hot / cold spots. Indirect / flued warm air heaters can burn any fuel and gas oil is commonly used. However, their efficiency is less than unflued systems; typically around 80%.

The most cost effective fuel
When assessing the true cost of a fuel you need to look further than the headline unit cost. The cost per kWh of heat energy delivered into the building / greenhouse is what matters. A large mains gas fired boiler with uninsulated distribution pipes and an old mixing valve could have an overall efficiency of 50%, nearly doubling the effective cost of the fuel compared with a direct acting unflued system. Also don't forget the maintenance costs. A direct fired blown air heater using kerosene working at 90% efficiency might not be so expensive to run after all.

Electricity may appear expensive for heating but it is 100% efficient at the point of use. It can be the most cost effective energy source to heat small spaces such as offices and canteens. The table overleaf helps to compare different fuels but takes no account of the conversion efficiency as it varies so much from one application to another.

Energy content of different fuels:

Fuel Type	Units of purchase	kWh per unit of purchase
Electricity	kWh	1
Mains Gas	kWh	1
LPG	Litres	7.4
Kerosene	Litres	10.3
Gas Oil	Litres	10.8
Heavy Fuel Oil	Litres	11.8
Coal	Tonnes	7,444*

*highly dependent on the specific type

Reduce the amount of heat required
There are two key points to consider here:
- Air leakage
- Insulation

Air leakage
Holes & gaps cause expensive heat leakage. These can be in form of:
- Slipped panes of glass
- Badly fitting doors
- Old louvres that do not close properly

Good maintenance is the key to avoiding this area of heat loss.

Greenhouse Insulation
Transparent secondary cladding on side walls which still allow some light to penetrate e.g. thin plastic sheet or even bubble wrap, is often used. It may be simple and not 'pretty' but it is effective.

Temporary roof screens can reduce heat loss by 30% whilst in place but the benefits of this solution need to be balanced against the consequences of a reduction in light reaching the plants. Alternatively, permanent (moveable) screens can be opened during daylight hours but closed overnight so that energy is saved with minimal light loss. Depending on the type of crop grown these can save 10-30% of the annual fuel consumption. Their capital cost is in the order of £5/m^2.

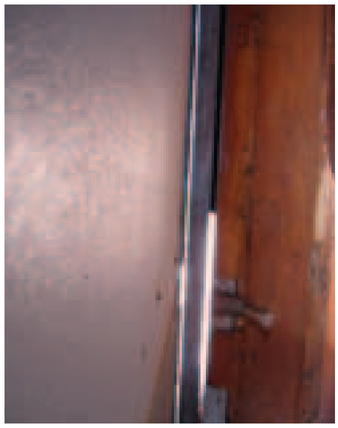
Refrigeration - getting the best out of what you have

Simple maintenance
The condenser on a refrigeration system ejects transferred heat to the atmosphere and must be clean and well ventilated with fresh ambient air to work efficiently. Far too often we see them installed for convenience rather than good performance, with bad airflows and low levels of maintenance. Anything that reduces their ability to reject heat will increase energy use, so -

- Clean the cooling fins - but be gentle. High pressure air or water can easily bend the fins
- Ensure free access to cool ambient air
- Avoid recirculation of warm air
- Locate on the north side of buildings to shelter from the sun


The evaporator is the coil that delivers cooling to your packhouse or crop store. Similar rules apply to these as discussed above for condensers.

- Make sure they are clean
- Ensure free flow of chilled air away from the evaporator
- Avoid recirculation of chilled air
- Keep an eye out for ice forming on them and have an effective defrost system.



Reduce heat gain
Essentially dealing with the heat gain of a refrigerated building is the same as dealing with the heat loss of a heated one. Issues are:

- Air leakage
- Insulation

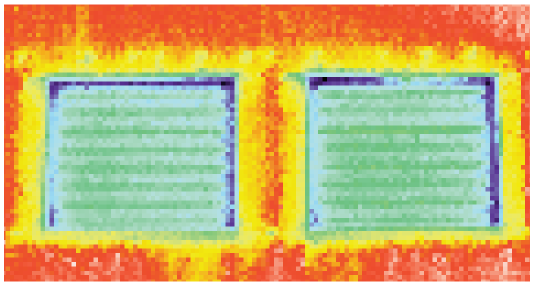
Air leakage
Focus points should be:

- Badly fitting doors
- Old louvres that do not close properly
- Building structural and cladding joints.

Insulated curtains over doors can be very effective if attention to detail is paid when they are fitted. For sealing curtains -

- Sides - Velcro strips make a good seal.
- Floor - A wide overlap onto the floor weighed down with anything to hand - bricks, scaffolding pole,
- Top - this is the most difficult part to seal. At the very least a pelmet over both the inside and outside surfaces of the curtain will help.

In some cases it may be possible to fit an insulated curtain even when the store is full. If not, consider heavy plastic sheeting taped in place. We have also seen wooden frames fitted on the inside of stores to which plastic sheeting is stapled each year; not as good as an insulated curtain but still better than nothing at all. At the very least get some wide, heavy duty duct tape and apply it all around the door/door frame joints.



Often we see older stores that have been modified over the years with louvers that are no longer used. Ideally they should be completely sealed and insulated using spray-on foam or something similar.

There is often a reluctance to seal louvers permanently just in case they may be needed in the future. In this case, box them in using insulation board and seal all the joints using spray foam. This way the box can always be cut off to reveal louvers in the future if required. The same goes for unused doors. Duct tape and a can of spray foam will improve things even if it may look a bit 'agricultural'.

Insulation
Current guidelines for insulation levels are for a U-value of $0.3 W/m^{2} {}^{\circ}C$ or better. In practice this means approximately 75mm of spray on urethane foam or composite panel. Many older stores will only have 50mm. Better insulation will also help to improve the quality of the crop in store by keeping conditions more stable and avoiding condensation.

Spray-on foam insulation can be applied as top up insulation to existing stores. It has the added benefit of sealing any gaps in the building structure thereby reducing air leakage. In most long-term stores and pack houses this is very cost effective.

Conclusion
Energy prices have been very volatile over the past 2 years, in some areas reaching an all time high but more recently falling back to more reasonable levels. In the longer term it might be expected that energy will gradually become more expensive because of dwindling fossil fuel resources and increasing taxes with greater governmental concern about greenhouse gas emissions.

Taking the longer term view, growers should consider lower energy and lower carbon systems for their greenhouse and other use. This will deliver sustainable and competitive businesses which will fair better against imports from countries with more favourable climates.

In tackling this issue, growers should firstly concentrate on waste and fuel use efficiency. Evidence shows that many businesses use more energy than they need to, to provide the environmental conditions that they require. When investing, growers should remember to add fuel efficiency to their list of requirements and factor-in likely cost increases in the future.

Having dealt with waste, alternative energy systems should be considered. Growers should monitor the changing face of renewable fuel economics from the point of capital, running costs, fuel availability, taxes and incentives. Many technologies are on the cusp of economic adoption but care has to be taken to ensure that rational choices are made and that the energy infrastructure chosen is practical and sustainable in the longer term.

Sustainable practices in ornamental horticulture in Australia and New Zealand

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Australia and New Zealand are vastly different in their size, population and climate but the major industries in both are agriculture and horticulture. The Australian horticulture industry was worth 13 billion Australian dollars (£6.5 billion) in 2006/2007 and mainly supplied the domestic market. In New Zealand horticulture was worth $5.2 billion New Zealand dollars (£4.0 billion) with at least 45% for the export market.

As both countries rely heavily on their natural resources of land and water both have had to make major changes to the challenges of sustainability to guarantee their long-term future. Challenges include water availability, rapid urban expansion, production costs, consumption of raw materials, eco verification programmes and 'towards zero' waste policy. What is evident from both countries is the way in which sustainable factors of environment, social and economic are integrated into the overall management of their businesses.

The horticulture industry in both countries operates at a professional level whereby specialised organisations exist within the industry, for example Horticulture Australia Ltd (HAL), to provide major funding. Both countries have a strict bio security operation recognised worldwide which restricts the movement of plant material both internally between states and regions and also restricts imports from other countries. The system also has the added benefit in providing market control and statistical data.

Within each state or region, grower associations operate to provide industry communication and cooperation. Bench-marking, management programmes (resource use efficiency plans) and accreditation (insurance) schemes are also included in their services.

Efforts to adopt sustainability practices in businesses in Australia and New Zealand occur throughout the whole of the supply chain. Businesses assess and consider not only the financial performance but also the environment and social impact of their activities. To achieve this sustainable factors are identified and evaluated with suppliers, staff, regulators and customers.

Issues on sustainability in Australia and New Zealand are similar to issues facing our horticulture industry in Northern Ireland and much can be learned from them.

Water management
Water in Australia is a scarce commodity with low and inconsistent rainfall. The horticulture and agriculture industries are very reliant on water for crop production. Following at least four years of severe drought the industry has had to adapt quickly to the use of recycled water supply. To contrast with the Northern Ireland conditions, water is plentiful but may eventually be costly when water charges are brought in.

In nursery stock production, all run-off water from the sites is utilised. Run-offs from hard surface areas which have been designed using drainage materials, and from down pipes on buildings are collected in large ponds or reservoir areas. In most cases the water collected is treated before being used in irrigation systems. Treatment is in the form of sand filters, UV or chemical treatment.

In field production, basic sprinkler systems and trickle tape is used. Precision water systems using electromagnetic induction technology to assess soil constraints and their suitability for irrigation are used with decision support tools and simulation models. These have been implemented for high value crops such as fruit, nut and wine production.

Fig.1 Water collection and storage areas

Plant selection
With government pressure on the use of water the retail horticulture industry has seen major decline in sales. Growers have had to react quickly to change. Plant selection has been towards native species which have evolved over time in response to climate, soil conditions, rainfall patterns, drought and frost. Growers lead the way in educating the consumers on the benefits of these species in their use for the retail, flower and foliage industries. Breeding programmes have been implemented to select and breed using native plant materials to provide for future plants, which are more sustainable in a changing climate.

Using Peat
Australia has only a very limited source of peat mostly found in the state of Victoria. Compared to the UK, Australian compost manufactures have to rely on non-peat sources. The main products used in the industry are coir and pine bark. Coir comes from an imported source from neighbouring countries such as Malaysia. Pine bark is a waste material from the forestry industry. *Pinus radiata* is widely planted throughout Australia for timber production. The species grows quickly and the compost industry utilises the waste bark available from the processing of timber. Pine bark is supplied in many grades from large particle sizes for larger pot production to composted materials for propagation. Coir is mainly used at the propagation stage.

Other non-peat alternatives are also used, for example rice husks and green compost from tree prunings. However these are still only in the investigation stage within nursery production.

Waste Management

a) Plastic pot recycling

Within the nursery sector a major pot manufacturer has realised the potential in post customer pot recycling by manufacturing plastic pots from recyclable polypropylene. The problem with recycling of used plastic pots and labels has been the fact that they are dirty. The manufacturers have invested in a technology to collect, clean and recycle the pots back into polypropylene for reuse in the making of new plastic pots.

b) Bio pots

The landscape industry in Australia is a growing market and to help speed up planting, aid root development and reduce pot collection, bio pots have become popular alternatives in major roadside and industrial plantings. Plants in their biopots are planted directly into the soil and as these biopots are made of biodegradable materials, they decompose naturally as the plants establish.

Fig. 2 Biodegradable pots for landscape plant species

Growers who supply the retail market, as opposed to the landscape market, are also looking at the use of bio pots. These are currently sourced in China, have a longer life span and compost only by the means of breaking up. So far trials carried out by the growers have been successful and some growers are moving 100% of their production to bio pots.

Aside from using bio pots for the retail sector growers are moving over to the use of bio degradable pots in the propagation stage. With the strict bio security laws which operate within Australian and New Zealand horticulture, all nurseries produce their own propagation materials. Propagation has moved away from tube stock and tray production to biodegradable cell pots. These enable direct stick cuttings but it is at the potting on stage where growers have found the benefit. The use of biodegradable pots mean that plant material does not need to be separated from each other as found in tray systems or cleaned as found in tube stock. Establishment percentage is higher due to less root disturbances and the cell pots operated effectively within potting machines with tray uniformity.

c) Composting

Composting of biodegradable waste materials has only been carried out by local government institutes and larger compost manufactures. Within the landscape sector the composting of tree and shrub prunings is just developing by specialised operators. Within the local government for example Botanic gardens operate in-vessel composting at specialised nurseries. Vertical in-vessel (VCU) technology which provides a fully enclosed aerobic system whereby vertical orientation provides aeration by natural convection is used to compost a range of materials from green compost to manure based materials from large event centres and city zoos. The final product is used not only as a mulch where it is extremely useful for moisture retention but as a mix with pine bark for special plant mixes.

d) Sterilising

In two of the nurseries visited steam sterilisation was used to sterilise compost and to sterilise old used plastic pots and trays. The systems used steam boilers and an enclosed sealed framework. One of the nurseries based in a large horticulture area shared the facility with other nurseries. The sterilising system enabled the nurseries to reuse waste compost but also cut down labour costs of washing pots and trays which would be reused.

e) Tray return system

Within the state of Victoria a large vegetable plug grower has introduced a tray return system. This supplier who supplies 260 million plugs per year operates a robot controlled production system using a standardised tray size through out the total system including in final transport. As many vegetable growers operate a scheduled planting system the tray is returned. To match the standardised tray system manufactures also developed the standardised size in their planting machines.

Future issues with the use of herbicides

Growers in Australia and New Zealand (who are looking to export their products) are concerned about the possibility of new EU legislations limiting the availability of plant protection products (herbicides and pesticides). The industry is therefore looking at alternative products that may be of benefit. For example, nursery stock growers have started using bio oil (oil made from natural products) for weed control. Also, the oil derived from pine species is used on the top of pots to control annual weed species and has been found to be effective.

Design of protective structures

New outdoor structures are now being developed for pot plant and nursery stock production. The use of retractable roof structures enables the grower to utilise their natural climate by completely retracting the roof when the environment is favourable.

Fig. 3 Greenhouse, with retractable roof

Conclusion

The practice in sustainability is the making of all human activities balance with the demands on the earth's ecosystems. Everything carried out on a daily basis affects the environment, the economy and the community around us. The horticulture industries in Australia and New Zealand have embraced sustainability as a positive new journey in their long-term planning. Those involved in the industry must be ready to work together, with constructive communication and co-operation to implement environmental sustainability strategies into the daily inputs of their production systems. The use of sustainable management tools will have an impact in achieving a balance between financial and environmental resources.

Sustainability is a positive change. It's our future.

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Securing your horticultural future through research

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Since 1986, growers of all horticultural crops in England, Scotland and Wales have been paying a statutory levy (calculated on turnover) to the Horticultural Development Council (HDC) for the sole purpose of funding near market research and development to address high priority issues. With government having withdrawn funds for this type of research in the 1980s, it was deemed necessary that the industry should fund this itself.

Why should the industry fund its own R&D?
A quick glance at some of the world's leading companies provides a very good argument for doing so. The 2006 Booz Allen Global Innovation Study revealed that the world's thousand largest R&D (Research and Development) spenders (including Ford, Pfizer, Microsoft, Toyota etc) spent £203 billion on R&D in 2005. For these most successful companies, spending on R&D is vital to drive forward their businesses. Their individual R&D spending increased between 2000 and 2005. However, the proportion of sales dropped because their revenues and profits rose at a faster rate.

Unlike many of the multi-national companies included in the Booz Allen survey, most of the small and medium sized enterprises that operate in the horticultural industry are not large enough to fund their own large scale robust research projects. However, legislative and technical changes create an enormous challenge for such businesses and without some form of R&D, they will find it difficult to meet these challenges and survive. Collective research through a statutory levy therefore offers a solution to the horticulture industry.

How does the HDC operate?
The HDC administers the collection and use of a horticultural levy on behalf of the horticultural industry to ensure that the research needs of all sectors of the industry are catered for. The total income from the levy in 2008/09 was £5.2 million. This total is divided up into individual funds for seven different crop sectors which include Field Vegetables, Protected Crops (both edible and ornamental), Hardy Nursery Stock, Bulbs & Outdoor Flowers, Soft Fruit, Tree Fruit and Mushrooms. Levy payers are asked to state their crop interests and their levy money is apportioned to different sectors accordingly and annual budgets are drawn up for each. Some funds are also retained for research work on areas of common interest to all sectors. In the past, a small proportion of this has been used for promotional activities.

To direct how the funds are spent, HDC organises a panel of experts for each sector, which meets regularly each year. Levy paying members are elected to serve on all panels. These members are drawn from growing businesses that represent a diverse range of interests in each sector in terms of crops grown, business type and geographical location. In addition, some invited members are co-opted onto panels to provide scientific and agronomic guidance and expertise. Each panel is managed and directed by a full time technical manager employed by HDC. The manager works on behalf of the industry to develop and co-ordinate research projects with scientific contractors, who are commissioned to undertake the research on behalf of the HDC.

The HDC board has developed R&D strategic themes, which include 'Reducing costs of production', 'Minimising the impact on the environment', 'Sustainable crop protection' and 'Meeting the needs of the customer'. Within these themes, each sector panel identifies their own particular research requirements and produces a 'research strategy' which is shared with the scientific contractor communities and used to initiate a continuing programme of research projects. In addition to the function of the sector panels, HDC openly invites its levy paying members to inform the panels and technical managers of their research requirements.

What has HDC been delivering to its levy payers?
The results of all HDC funded projects are made available to all levy payers on its dedicated website, complemented by a weekly email message and monthly magazine which are sent to all members. In addition, HDC employs full time communication managers to organise the successful dissemination of research results. This is achieved through a range of activities which include the production of factsheets, wallcharts, grower guides, computer programmes, DVDs and the organisation of conferences, study tours and other events for growers. Specifically, HDC has delivered a vast amount for each of its crop sectors in the past year:

Field Vegetable growers have recently benefited from the production of a Brassica Crop Walkers' Guide and a factsheet on controlling volunteer potatoes in field grown crops. New work is currently being targeted at developing new weed control programmes and working on red beet 'root malformation' disorder.

Protected Crops growers have been provided with a series of pest & disease and IPM workshops, factsheets on energy saving in Poinsettia and spray application, a plant care DVD & calendar for retailers to train staff in plant handling, energy training courses on humidity, thermal screens and energy management and most recently a Herb Crop Walkers' Guide.

Hardy Nursery Stock growers have received Pest & Disease control wallcharts, along with factsheets on handling imported plants, managing your own trials and sterilising pots for re-use. Workshops and seminars on integrated crop management and research on roses have also been delivered.

Cut Flower growers have benefited from four cut flower handling factsheets and a best practice DVD.

Soft Fruit growers have been delivered a new Strawberry Feed Calculator and complementary factsheet, new factsheets on controlling strawberry blossom weevil and powdery mildew, new Bush and Cane Fruit Crop Walkers' Guides and recently benefited from a conference outlining the results of the last year's HDC funded research on soft fruit. Work is ongoing to deliver a new Health & Safety DVD for soft fruit growers.

Tree Fruit growers have been delivered DVDs on harvesting and store management and wallcharts on monitoring pear orchards and storage management regimes. Work is ongoing to produce a revised electronic 'Best Practice Guide' for apple growers.

Mushroom growers have received factsheets on Virus x, spawn running, dry bubble and cobweb.

Cross panel work
HDC funds a large amount of work which delivers to all sectors. Most notable is the pesticide work it undertakes through a full time technical manager who works solely on behalf of grower members to maintain a suitable armoury of pesticides to provide sustainable crop protection. HDC works closely with the government's Pesticide Safety Directorate as well as agrochemical companies to secure the release of new Specific Off-Label Approvals, which allow agrochemicals to be used on minor horticultural crops, which would not otherwise be available. In addition, close collaboration with bodies in other EC member states secures the availability of agrochemical products to UK growers through mutual recognition and similar mechanisms.

HDC is also currently engaged in development work on biopesticides, biobeds for pesticide disposal, energy saving and carbon footprints, biodiversity and biocontrol, waste and water management.

Benefits to growers in Northern Ireland

Historically, the statutory levy on growers in England, Scotland and Wales has not applied to growers in Northern Ireland, so that the results and output from the research have never been available. However, changes to the levy board structure took place in April 2008, when the HDC was incorporated into a new joint levy board with other agricultural sectors, which is called the Agricultural and Horticultural Development Board. As part of this larger organisation, HDC is now known as the Horticultural Development Company.

The opportunity exists for growers in Northern Ireland to be included in the new body and benefit from the research programme as other growers in the UK do. HDC staff have been repeatedly approached at trade shows by Northern Irish growers, seeking to procure HDC publications and research results. This information could be freely available to all in Northern Ireland in future. Like Wales and Scotland, the horticultural industry in Northern Ireland is currently only modest compared to England. Of the current £5.2 million levy collected, Welsh growers provide £13.7K and Scottish growers £228K in comparison to English growers who provide £4.94 million. Given that growers in Wales and Scotland receive exactly the same volume of information and results from their levy, it could be argued that they get a good return on their investment. Growers in Northern Ireland would benefit in the same way.

The Horticultural Trades Association

Michele Shirlow
Business Development Advisor for Northern Ireland

The Horticultural Trades Association (HTA) is a membership organisation that supports the Horticulture Industry. Its members include growers, landscapers and nursery retailers. The HTA provides access to a range of information, training and support tailored to your needs. Based in the UK, it now has a Business Development Advisor in Northern Ireland – please see contact details below.

Growers who are members of the HTA have access to Nursery Business Improvement Schemes and LEAN (subsidised), free advice lines, information, packaging waste workbooks and substantial discounts on insurance, materials and show fees. In addition, members have access to market information on production and sales trends for different plant categories. If you want to reduce costs in your business and keep abreast of the latest trends why not consider joining? Your HTA subscription can deliver value up to 10 times the cost of your subscription.

In addition to business benefits, you are able to access increased business opportunities through access to a wide range of other members.

Membership of HTA is also an excellent way to keep up to date on current issues such as new ways of selling plants, waste, logistics, policy issues and plant health.

To find out more go to www.the-hta.org.uk or contact your Business Development Advisor in Northern Ireland - Michele Shirlow Tel 0798 4029811, michele.shirlow@the-hta.org.uk.

Notes

Notes

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