Digital Technology in Agriculture

science & technology in action
www.sta.ie
13th edition

Introduction

From the early tools of the first farmers to the invention of the plough and the tractor, technology has been used to continually improve farming techniques and improve outputs. New and innovative technologies are emerging that will further increase ***crop yields*** and ***reproductive efficiency*** in animal production, reduce the impact of farming on the environment and much more. In this lesson we will look at some of the most exciting technologies being used in agriculture and explore the future of agriculture in Ireland and globally.

Benefits of technology in agriculture

- Technology can help improve crop yields.
- New technologies can help reduce the amount of water, pesticides and fertilisers used in crop cultivation.
- Digital technologies can help improve reproductive efficiency in animal production, leading to higher outputs in dairy and meat production (beef, lamb, pigs etc.).
- Technology helps reduce the impact of farming on the environment e.g. by lowering fertiliser run-off to water ways.
- Technology makes the working conditions safer for farmers.
- Digital technology improves efficiency in work practices on farms, reduces labour costs and increases output, providing lower costs to both the farmer and the consumer.

Emerging technologies

Many new and emerging technologies will revolutionise farming in Ireland. These include the use of advanced ***sensors*** for data collection, further development of ***precision agriculture***, expanded use of robotics and automation and greater use of ***biotechnology*** and ***bioengineering*** in farming.

Sensors

A sensor is an electronic device that detects or measures a change in the physical environment (such as temperature or light intensity), converts this measurement into a signal and usually sends that information to a computer or mobile app. Your mobile phone, for example, may have motion sensors, pressure sensors (on the screen), light sensors, ***GPS*** (Global Positioning System) and much more. Below are some examples of sensor technologies used today on Irish farms.

GPS & GIS Sensors

GPS, or Global Positioning System, is a technology widely used to help identify one's exact position and speed. GPS satellites orbiting the Earth continuously transmit their own location and the exact time. Using the signals from three or four satellites a GPS receiver (as used in some smart phones) calculates its own position. ***GIS*** (Geographic Information Systems) is a similar technology which maps the surface of the Earth and can be used to monitor crop growth.

Using these technologies in precision agriculture farmers can vary the sowing rate, fertiliser application, pesticide use etc. to suit different fields or even parts of a field. GPS may also play be used in automated farming, in which driverless vehicles are used to harvest crops. GPS also facilitates more accurate soil sampling and better farm planning. It allows farmers work when there is poor visibility — at night or during fog.

Biometrics

Biometrics may be used to monitor the health and status of animals and crops. Biometric sensors can measure animal temperature, activity, ***rumination***, fertility, milk yield and more. Sensors on crops can measure their ***dry matter*** content, ripeness and fertiliser requirements. For example, the ***MooMonitor+*** is an Irish sensor system for dairy cows, developed by the Kerry based company DairyMaster, which allows farmers to monitor the fertility, rumination, feeding habits and general health of their cows.

Machinery sensors

Sensors fitted to farm machinery provide farmers with ***real-time data***. Sensors on tractors can monitor performance, prevent breakdowns and to improve safety. Sensors on harvesting equipment can measure properties such as dry matter (DM), starch, sugar or protein content. Milking machines can actively measure milk yield, fat content and non-fat components of milk for each cow and send the information to the farmer.

Soil & weather sensors

New soil sensor technology provides farmers with accurate and immediate data on the soil conditions. Sensors can measure the water content, ***pH***, ***soil fertility***, and temperature. Using this information the farmer can optimise the use of water, fertiliser and ***lime***. Sensors can also actively measure the weather conditions (temperature, rain fall, wind speed & direction) on a farm and record past conditions.

Drone technology

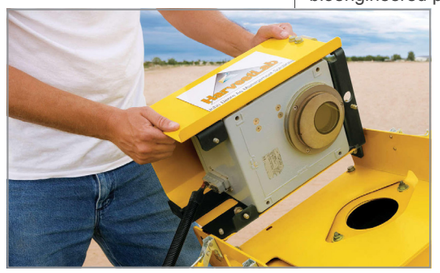
Drones can be used to obtain high resolution images of fields, indicating plant size, crop height and density, water needs, weed or pest infestation etc. In the future they may be used or to herd animals or to precisely administer ***herbicides*** or fertiliser to crops.

'Big Data' and the 'Internet of Things'

Sensors generate a huge amount of data which needs to be stored (at least temporarily), analysed and communicated in a concise way. Most such data is stored in the '***cloud***' and is potentially available to other farmers. Important information can be obtained by combining the data from several farms, for example, in relation to pest and disease control.

The '***Internet of Things***' involves devices connected to the internet. For example, sensors in a fridge could send data to a ***microcomputer*** which would then 'decide' if you needed to buy milk and send you a message or indeed order it for you!

This emerging technology could, for example, open or close gates when a specific animal (who may require attention) approaches it, or order more feed when supplies are low.



Precision agriculture

Using precise biometrics and GPS the farmer can apply appropriate treatment not just to fields but to different parts of a field as required.

By using the data from, for example, the ***HarvestLab*** a cereal farmer can adjust the sowing rate, fertiliser requirements, crop density and other factors for the following growing season. Such practices can help minimise the impact of agricultural on the environment and reduce the run-off from fertiliser and other chemicals.

Robotics and automation

The future of farming will likely be in automation, using robotic and self-driving machinery to sow, fertilise and harvest crops or manage animals. Already, automated or robotic milking machines are in use in Ireland and over 50% of all new milking machines installed in the EU are automated.

Robotic milking has a number of advantages. There is more consistency, reduced labour costs, the possibility of increased milking frequency (three times a day) and better overall herd management. Automated feeders are also in use in Ireland right now, adjusting the feed amount to milk yield, live weight gain, stage of pregnancy and other factors detected by biometric sensors.

In crop production driverless tractors, utilising GPS, GIS, soil, water and biometric sensor data, can work day and night and provide greater precision than the farmer. Robots can be used to harvest fruit automatically and are already being used in vineyards around the world.

While robots and automated machinery may improve efficiency, there are some disadvantages. Can you think of any?

Biotechnology & Bioengineering

Biotechnology is the controlled and deliberate manipulation of biological systems (whether living cells or cell components) for the efficient manufacture or processing of useful products. These biological systems often utilise genetically engineering (bioengineering) — the alteration and manipulation of the ***genes*** within organisms. Such ***genetically modified*** (GM) crops may have greater yields or to have resistance to certain diseases or herbicides. GM crops are widely used in the US.

Animals can be bioengineered to increase milk or meat outputs or to produce milk with higher protein, or fat levels, zero ***lactose*** or to reduce their methane output. Indeed, meat may not come from animals in the future at all; synthetic or cultured meat is already being produced but is not for sale commercially yet. To date, most of the genetic manipulation of animals has been through selective breeding but advances in ***genomics*** have led to increased accuracy in this area.

Genetic engineering is a controversial area and currently GM crops may not be grown for human consumption in the EU. However, with higher demands on agriculture to produce food for a growing population, bioengineered plants may become more widespread.

Conclusion

The human population is expected to reach 10 billion by 2050 and this will place enormous pressure of the farmers to produce enough food for them. We may well see more widespread use of semi-automatic vertical farms, which save space and reduce harvesting and transport costs.

The increasing role of digital technology in agriculture farmers brings with it both challenges and opportunities.

Agriculture and Food Development Authority

Teagasc is Ireland's agricultural and food development authority supporting science-based innovation in the agri-food sector and the wider bioeconomy. It delivers six programmes:

- Animal and Grassland Research and Innovation Programme
- Crops, Environment and Land Use Programme
- Rural Economy and Development Programme
- Food Programme
- Education Programme
- Advisory Programme

Teagasc employs over 120 scientists and 120 technicians in research, 30 specialist staff, and over 320 advisers/teachers in education and advisory roles. In total, over 1,200 staff are employed at over fifty locations throughout the country.

The research carried out by Teagasc is essential to the development of competitive and sustainable agricultural and food industries.

You can find out more about the work of Teagasc at **www.teagasc.ie**

Find this and other lessons on www.sta.ie

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Syllabus References

The main syllabus references for the lesson are:

Leaving Certificate Technology

- Introduction to robotic control: classification of robots by structure; applications (p. 29)
- Control; Programmable Devices: control using computers or other programmable devices. (p. 29)

Leaving Certificate Agricultural Science

- Physical properties of soils… Chemical properties of soils. (p. 1)
- Measurement of output of grassland in terms of total weight, dry matter, meat and milk. (p. 3)

Leaving Certificate Geography

- The use of satellite images and statistical information in the study of changing agricultural land use. (p. 20)

Science and Technology in Action is also widely used by **Transition Year** classes.

Learning Outcomes

On completion of this lesson, students should be able to:

- Describe and discuss the benefits of digital technology to agriculture
- Outline examples of sensor technology currently available to Irish farmers and describe briefly how they can benefit both the farmer and the consumer
- Discuss how GPS and GIS technologies can contribute to enhanced farming techniques
- Describe what is meant by 'precision agriculture' and how it can aid in both crop and animal production.

General Learning Points

These are additional relevant points which are used to extend knowledge and facilitate discussion.

- Crop yields are dependent on the growing conditions on the farm - soil, fertiliser, water, weather etc.
- Careful management of farms is necessary to minimise the effects on the wider environment of changed land use, fertilisers, pesticides and plant and animal waste.
- Emerging technologies can help increase food production and reduce the impact of agriculture on the environment.
- Precision agriculture is the term used to describe farming in which digital technology and the data collected in the process, are used to improve agricultural output.
- The 'Internet of Things' involves the interconnection of everyday devices with one another and with the Internet.
- Future agriculture will involve wider application of electronic control systems and robotics..

Student Activities

1. Create a poster summarising the use of digital technology in agriculture.
2. Investigate the history of the Global Positioning System (GPS) and plans for its future.
3. Find out more about Geographical Information Systems (GIS) and explore some uses of the technology.
4. Discuss the advantages and disadvantages of automated farming equipment.
5. Debate the pros and cons of genetic engineering in farm animals and crops.
6. Create a presentation on vertical farming. Will it solve the Earth's food crisis?
7. Carry out a company profile on DairyMaster, summarising their history, products and market.
8. Create a presentation on synthetic meat products and discuss their advantages and disadvantages.
9. Research the challenges facing the further implementation of digital technology in Irish agriculture.
10. Invent new ideas for sensor technology on farm machinery to improve efficiency or safety.
11. Devise a new application for connected devices (The Internet of Things) that could be used on Irish farms or in the home.

True/False Questions

a) Precision farming uses sensor technology and automated vehicles to improve yields. **T F**
b) The MooMonitor is used to measure crop yields during harvesting. **T F**
c) GPS is a system for mapping the Earth's surface. **T F**
d) Genetic engineering is the manipulation of genetic information in an organism. **T F**
e) Crop yield is not affected by fertiliser use. **T F**
f) Farming can have a negative impact on the environment. **T F**
g) Biometric sensors can help detect fertility in cows. **T F**
h) Automated and self driving farm machinery can only work during the day. **T F**
i) Agricultural drones are used for aerial photography on farms. **T F**
j) Crop yield is not dependent on the soil it is growing in. **T F**
k) Genetic engineering of animals is banned in the US. **T F**

Check your answers to these questions on www.sta.ie.

Examination Questions

Leaving Certificate Agricultural Science (HL) 2017, Q. 5 c

Reproductive efficiency is an important target in a beef-rearing enterprise.

(i) Explain the term reproductive efficiency
(ii) Describe three factors affecting reproductive efficiency.

Leaving Certificate Agricultural Science (HL) 2011, Q. 3

(a) Describe four grassland management practices used to achieve high quality silage.
(b) Explain why a young animal should receive colostrum in the first day of life. List three benefits of colostrum to the young animal.
(c) Outline the main features of strip-grazing. Give two advantages and two disadvantages of strip grazing in the feeding of fodder roots to sheep.

Leaving Certificate Agricultural Science (OL) 2011, Q. 11

(a) Parasites are a common occurrence in agriculture. What is a parasite? Give an example of a parasite of a named crop or livestock that you have studied. State one way to get rid of the parasite you have named.
(b) With the aid of a labelled diagram, describe the life cycle of a named insect.
(c) Describe the cultivation of a cereal or a root crop under the following headings:
  (i) Soil suitability
  (ii) Sowing – date and method
  (iii) Fertilizer used
  (iv) Control of pests
  (v) Harvesting – method and time
  (vi) Yield per hectare.

Leaving Certificate Agricultural Science (OL) 2016, Q. 6 a

Weeds, pests and diseases in crops may be controlled by direct and indirect methods.

(i) What is meant by indirect control?
(ii) Describe three methods of indirect control commonly used in Irish agriculture.

Leaving Certificate Physics (OL) 2004, Q. 12 b

Give two reasons why the telecommunications industry uses optical fibres instead of copper conductors to transmit signals. Explain how a signal is transmitted along an optical fibre. An optical fibre has an outer less dense layer of glass. What is the role of this layer of glass?

An optical fibre is manufactured using glass of refractive index of 1.5. Calculate the speed of light travelling through the optical fibre.
(speed of light in air = 3.0×10^8 m s^{-1})

Did You Know?

- The first fully automated lettuce farm is due to open in Japan in 2017, producing 30,000 heads of lecture every day. The farm uses a wide variety of sensors to detect the soil conditions on the farm, monitor water levels, temperature etc. and automated robots to sow the seed and harvest the crop. The farm is a vertical farm and uses LED lighting to increase the growth rate in the plants. The "farm" will have minimal impact on the environment but will have a staff of humans at hand should anything go wrong.
- Commercial vertical farms are already in operation in the UIS, Canada, Uk and elsewhere. See Youtube video: https://www.youtube.com/watch?v=-_tvJtUHnmU

Biographical Note

Dr Edmond 'Ned' Harty

Edmond Harty, from Co. Kerry, is the CEO of DairyMaster — a large company specialising in the production of milking machines, automated devices and biometric sensors for the dairy industry.

He studied mechanical engineeing in the University of Limerick and in 1998 he worked with Dairymaster while researching milking performance for his PhD studies in UCD.

He has filed over forty patents for devices he has invented, mainly relating to the dairy industry.

In 2012 he received the award of International and overall *Ernst and Young Entrepreneur of the Year*.

Revise The Terms

Can you recall the meaning of the following terms?
Revising terminology is a powerful aid to recall and retention.

bioengineering, biotechnology, cloud, crop yield, drones, dry matter, genes, genetically modified, genomics, GIS, GPS, HarvestLab, herbicide, Internet of Things, lactose, lime, Microcomputer, MooMonitor+, pH, precision agriculture, real-time data, reproductive efficiency, rumination, soil fertility.

Check the Glossary of terms for this lesson on www.sta.ie