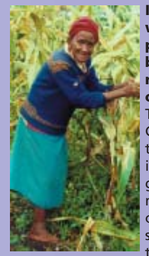
Sustainable agriculture in a changing world

Current global food production exceeds nutritional demand. However, it is estimated that to meet the needs of our expanding population, food production will have to double in the next 50 years. This must be achieved using the principles of sustainable agriculture.

In the developed world excess production comes with a significant cost to the environment. In the UK the government is promoting a shift in agricultural practice towards stewardship of the environment. Coupled with increased competition in global markets and a change in agricultural subsidies, this presents a major challenge for UK farmers. Scientific research institutes such as the John Innes Centre will play a vital role in helping farmers meet these new demands, not only in sustainability, but also in the production of novel and valuable agricultural commodities.



In the developing world food production is far below the nutritional needs of the populace. The John Innes Centre is working together with international research groups to identify and meet the challenges of sustainable food security for all. We are tackling key issues for sustainable food production in developing nations, such as important diseases in cassava, maize, rice and banana, improving varieties of rice and millet, and studying alternative management strategies for insect pests. We are also identifying ways of sharing John Innes Centre knowledge and resources more widely with scientists from developing countries, to help them meet their own demands for sustainable agriculture.

Symptoms of Maize Streak Virus

Sustainable agriculture

New tools for a sustainable future

There are many exciting opportunities in plant sciences that will help our society meet the challenges of sustainable development. Research institutes such as the John Innes Centre are playing a crucial role in producing the technological advances that are essential for sustainable development. The new science of genomics provides many ways of achieving these technological advances, including genetic modification of plants and fast, directed methods of selecting plants with favourable characteristics.

Genetic modification is an important tool in our efforts to meet the needs of UK and developing world agriculture. Despite much research, there is no evidence to suggest that GMOs are detrimental to human health. Indeed, there is vast potential for genetic modification of plants to enhance human health and to tackle major environmental issues. It is important to balance the perceived dangers of GMOs with their value as part of advanced breeding strategies to provide new crops for a more sustainable form of agriculture.

The John Innes Centre (JIC) is an independent research centre for plant and microbial sciences, grant aided by the Biotechnology and Biological Sciences Research Council (BBSRC) and is located on the Norwich Research Park, UK. JIC carries out fundamental, strategic and applied research to understand how plants and micro organisms function at the molecular, cellular and organism levels, from field trials to macromolecular studies. JIC participates in and directs collaborative research and plays a major role in the UK and internationally in training students and scientists.

Employing over 800 staff with an annual budget of over £22M, the JIC is a modern state of the art international centre of excellence. The extensive and diverse research programme is structured in six departments, Crop Genetics, Biological Chemistry, Cell and Developmental Biology, Metabolic Biology, Disease and Stress Biology.

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JOHN INNES CENTRE

Sustainable agriculture

Sustainable agriculture

Sustainable development attempts to supply the needs of people living today and secure the needs of future generations with minimal impact on the environment.

Within this framework **sustainable agriculture** describes the challenge of preserving fragile resources: soil, water, atmosphere, biodiversity and ecosystems, while supplying industrial raw materials and the nutritional needs of an expanding population.

Sustainable agriculture can only be achieved through a multifaceted approach involving changes in farming practice, changes in government policy and scientific developments.

The John Innes Centre is committed to this agriculture of the future and is undertaking scientific research that will:

- **REDUCE POLLUTION**
- **IMPROVE SUSTAINABLE PRODUCTIVITY**
- **PROVIDE RENEWABLE RAW MATERIALS**
- **SAFEGUARD BIODIVERSITY OF CROP PLANTS**

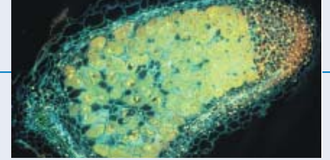
Sustainable agriculture

REDUCING POLLUTION

Fertilisers used in agriculture wash into our water systems causing algal blooms and human health risks. Fertilisers also account for nearly 50% of the energy needs of agriculture.

In place of fertilisers, legumes (peas and beans) acquire key nutrients through symbiotic interactions with micro-organisms. Hence legumes are used in rotation with other crops to improve soil fertility without the need for fertiliser applications.

Can symbiotic interactions be exploited more widely to reduce requirements for fertiliser in agriculture? At the John Innes Centre we are analysing the basic mechanisms in both the plant and the micro-organisms that are required to establish these symbiotic interactions. This work could improve the usefulness of legumes as rotation crops, but may also allow the transfer of these symbiotic interactions to crop plants that lack them. **Ultimately this work may reduce agricultural reliance on fertilisers**.



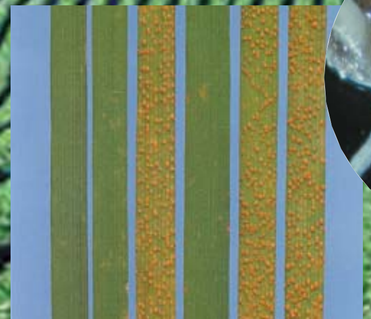
Pesticides used in agriculture may cause environmental degradation and human health risks.

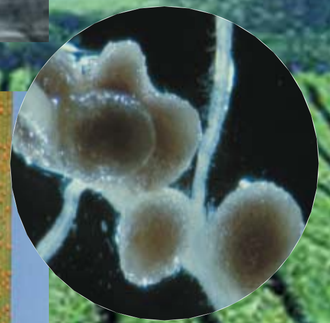
Natural defence mechanisms against a variety of organisms exist in plants. However, many crop species are susceptible to specific insect or pathogenic pests, that can cause considerable damage to the crop.

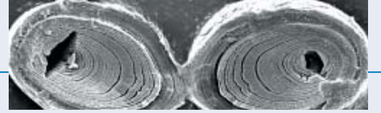
Can natural resistances be introduced or enhanced in crop plants, thus reducing the need for pesticide application? At the John Innes Centre we are studying how to utilise these natural defences to design improved disease resistance in crop plants. We also study alternative management strategies for insect pests that avoid or reduce the use of insecticides. **This work has the potential of greatly reducing chemical applications, while maintaining or increasing crop yield.**

Left: A mycorrhizal fungus inside a plant cell. This symbiotic interaction helps the plant take up vital nutrients from the soil, reducing the reliance on fertilisers.
Bottom Left: Resistant and susceptible lines of wheat infected with rust, a fungal pathogen that causes major crop losses in the UK.
Below: Nodules on alfalfa roots. Bacteria live inside the nodules and fix nitrogen from the atmosphere, making it available to the plant. This interaction can be used to naturally enrich the soil.

Right: Expression of Apx2, a gene induced under extreme conditions. Understanding how plants respond to stressful environmental conditions will allow scientists to develop plants more resilient to drought, salinity and increasing temperatures.
Far right: Oil rich crops such as oil seed rape have the potential for producing green fuels for the future and valuable commodities for the manufacturing industry.







IMPROVING SUSTAINABLE PRODUCTIVITY

Yields of many crop species are sub-optimal and variable.

Contributing to lower yields are features of the plants themselves such as poor seed-set, poor standing ability, long maturation times and poor adaptation to adverse environmental conditions.

Can crop plants be designed to give higher yields that are sustained over a wide range of environmental conditions? At the John Innes Centre we are studying many features of plants that could contribute to better-designed crops. We seek to understand the factors that control time of flowering, fertility, plant height and shape. Our research also shows why some plants are tolerant of climatic extremes such as heat, high light, drought and cold. **This work will result in crops that are better suited for agriculture in the UK, increasing yield without requiring additional inputs.**

PROVIDING RENEWABLE RAW MATERIALS

Fossil fuels provide over 95% of the raw material used by the manufacturing industry. This leads directly to climate change and massive waste disposal problems.

Plants are efficient, clean and renewable sources of raw materials that can be used to replace fossil fuels in the manufacture of many commodities, including plastics, valuable oils, detergents and lubricants. Plant derived products are often biodegradable.

Can we increase the use of plants for production of raw materials, and thus decrease dependence on fossil fuels? At the John Innes Centre we are studying how plants make valuable raw materials such as oils, starch and fibre. We want to know what controls the amount and the chemical diversity of these materials in plants. We are also investigating means of engineering plants to produce completely new materials that will provide novel industrial feedstocks. **This work contributes to a vision of crops as the "green factories" of the future.**

SAFEGUARDING THE BIODIVERSITY OF CROPS

Biodiversity is declining rapidly, and the wild ancestors of some of our important crops are being lost.

A wealth of valuable traits reside in the wild origins of modern crop plants. These traits, such as disease resistance, novel oils for industrial applications and features of plant architecture, can be bred into crop species to improve the value of crops in agriculture.

What is the best way of preserving the natural diversity of crop plants? At the John Innes Centre we have a number of important seed collections of wild crop species. As stewards of the biodiversity of crops we are committed to maintaining these collections for future generations. We are also undertaking research to identify useful features in these wild species and transfer them into crop plants, improving the usefulness or resilience of these crop species.