The plant breeding industry is a major contributor to more sustainable agriculture and food production.

This is the conclusion from an independent review by ADAS of the scientific literature relating to key EU food and forage crops for the 10-year period 2005 to 2015.

The challenges of global population growth, climate change and pressure on finite natural resources demand a sustainable intensification solution – this means producing more output per unit of resource and balancing that productivity gain with reduced environmental impact.

Plant breeding companies develop crop varieties with higher yields, better quality, improved resource use efficiency and reduced environmental impact.

In the report ADAS shows how innovation in plant breeding provides the essential platform for more sustainable agriculture and food production.

The main focus of modern commercial breeding programmes is to increase and protect marketable crop yields, increasing production from the same amount of land with more efficient use of inputs and reduced greenhouse gas emissions per tonne of output – key requirements of sustainable intensification.

Alongside selection for physical yield, the development of varieties with improved standing ability, better end-use quality and enhanced pest and disease resistance brings reduced harvest losses and wastage in the supply chain.

Public/private research partnerships are vital to this success. The plant breeding industry works collaboratively with the academic research community on the strategic R&D and pre-breeding activities that pave the way for the breeding achievements described in the ADAS report. The companies then bring this to market through the crop varieties developed and commercialised in their breeding programmes.

The ADAS study demonstrates how plant breeders contribute to improved sustainability in our farming systems – through improved pest and disease resistance, more efficient land use and soil conservation, better nutrient and input use efficiency, and improved resilience to a changing climate.

How plant breeding contributes to sustainable agriculture

**Increasing productivity**
- Physical yield
- Pest and disease resistance
- End-use quality

**Improving resource use efficiency**
- Land use
- Water use
- Fertiliser and chemical inputs
- Energy consumption

More output per unit of resource and environmental impact = SUSTAINABLE INTENSIFICATION

**Reducing negative environmental effects**
- Soil health
- GHG emissions
- Climate resilience
- Water quality
Stronger, more durable disease resistance

Plant breeders strive to identify, understand and introduce disease resistance genes as the first line of defence for the crop, reducing harvest losses and protecting yield potential. All commercial UK sugar beet varieties now carry rhizomania resistance genes, major progress has been made in understanding the genetics of yellow rust resistance and Septoria tritici in wheat and deploying new durable genetic defences, and new varieties of oilseed rape have been launched with better resistance to light leaf spot and canker.

More physical yield

Plant breeding gains have added 0.5t/ha/decade to national wheat yields over the past 50 years and 0.5t/ha/decade to oilseed rape since 1980. Genetic gain in new varieties developed by breeding companies has produced annual increases of 0.1t/ha in forage maize and sugar beet over the past 30-40 years.

Preventing loss to pest attack

Varieties resistant to pests have reduced harvest losses. Breeding companies have succeeded in commercialising varieties with resistance to orange wheat blossom midge, turnip yellows virus in oilseed rape and beet cyst nematode in sugar beet. Work is underway to introduce aphid resistance in cereals, stem nematode resistance in field beans, and European corn borer resistance in maize.

Higher crop yields mean better performance

Plant breeding companies develop varieties with higher yield potential, more durable pest and disease resistance, and market-relevant end-use quality, making plant breeding the single biggest contributor to productivity gains in our major crops.
Promoting more efficient resource use

Specific breeding targets to increase resource use efficiency have focused on improving plant uptake and use of resources, principally water and nutrients such as Nitrogen and Phosphorus.

Quality adapted to market needs

Improved milling and malting quality are key selection criteria in wheat and barley, with associated benefits for reduced wastage and enhanced processing efficiency. Breeders have also improved digestibility in oats, introduced healthier oil profiles in oilseed rape, and reduced anti-nutritional factors in pulses, and increased starch and energy content in forage crops.

Better standing ability

Varieties that stand better protect their yield potential, making standing ability an important breeding objective for most crops. Breeding success has come from identifying height genes and developing molecular markers to improve selection for optimal height, stem strength and rooting.

Reducing the negative environmental effects of food production

Using higher yielding varieties to increase productivity on existing farmland leaves uncultivated land for biodiversity. Crop varieties with improved resilience to climate extremes such as flooding, drought, frost and heat stress can help mitigate the effects of climate change for crop production. Innovation in plant breeding has led to wheat with better rooting and new herbage crops that can improve soil structure. Selection for improved pest/disease resistance and resource use efficiency can improve water quality by allowing reduced pesticide or fertiliser applications.
The following table, featured in the ADAS report, shows how plant breeding helps meet sustainability objectives in major crops. Blue boxes denote breeding advances already brought to market by plant breeding companies Green boxes relate to areas of plant breeding where research is in the pipeline or where further R&D investment is required to realise potential genetic gains through commercial crop varieties.

<table>
<thead>
<tr>
<th>Trait</th>
<th>Wheat</th>
<th>Barley</th>
<th>Oats</th>
<th>Oilseed rape</th>
<th>Field Beans</th>
<th>Field Peas</th>
<th>Forage Maize</th>
<th>Herbage</th>
<th>Sugar beet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase harvestable yield</td>
<td>Increase by 0.7t/ha decade since 1980</td>
<td>92% increase in W.B and 87% in S.B since 1982</td>
<td>Improve harvest index and no. grain per sq. metre</td>
<td>0.5t/ha increase per decade since 1980</td>
<td>Little increase seen in last 10 years</td>
<td>Little increase seen in last 10 years</td>
<td>Focus on dry matter and starch yield</td>
<td>Focus on dry matter yield</td>
<td>Faster increase than any UK arable crop since 1980</td>
</tr>
<tr>
<td>End use quality</td>
<td>Bread making quality</td>
<td>Low β-glucan levels, low β-amylase</td>
<td>Naked oats, oil content</td>
<td>Decrease glucosinolate and fibre</td>
<td>Reduce tannins, amino acid content</td>
<td>Digestibility, energy content</td>
<td>Sugar content</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resistance to disease</td>
<td>Eyespot, Septoria, rust</td>
<td>Mildew, rust, Rhyhchosporium, Ramularia, Net blotch</td>
<td>Rust, mildew</td>
<td>Light leaf spot, stem canker</td>
<td>Leaf and pod spot</td>
<td>Pea wilt, Downy mildew</td>
<td>Eyespot</td>
<td>Mildew, Rhynchosporium, rust</td>
<td>Rhizomania</td>
</tr>
<tr>
<td>Resistance to pests</td>
<td>Orange wheat blossom midge</td>
<td>Little work</td>
<td>Little work</td>
<td>Turnip Yellows Virus</td>
<td>Stem nematode resistance</td>
<td>Little work carried out</td>
<td>Corn borer resistance</td>
<td>Little work</td>
<td>Beet cyst nematode tolerance</td>
</tr>
<tr>
<td>Adaption to env. extremes</td>
<td>Drought traits identified</td>
<td>Little work</td>
<td>Little work</td>
<td>Little work</td>
<td>Traits identified</td>
<td>Traits identified</td>
<td>QTLs found</td>
<td>Drought tolerant</td>
<td>Traits identified</td>
</tr>
</tbody>
</table>

Impact in market place

Work in progress/development required

Read the full ADAS report – Review of the objectives of modern plant breeding and their relation to agricultural sustainability, June 2015 – by visiting www.bspb.co.uk