

INNOVATION YIELDS RESULTS



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One of the steps in the process of genetically engineering a plant is transformation and then multiplying the transformed cells in sterile tissue culture. Above are soybeans growing in the petri dish after transformation. By the year 2050, the United Nations estimates that the world population will reach 9.3 billion. As the population increases, so will the demand for food, fuel and animal feed to raise livestock. To match this growth curve, agricultural production will have to double in 40 years.

Global trends

The challenge is finding a way to expand the food supply to meet demand and do so in a sustainable manner. At the moment, approximately one-third of the world's harvest is lost due to weeds, plant pests or diseases. Furthermore, the ratio of arable land to population is declining and for the first time in history more people are living in urban areas than in the countryside. Per capita food consumption is also on the rise.

The difficulty of increasing agricultural production is also compounded by the use of limited resources. Expansion of land under cultivation may damage natural habitats and threatens biodiversity. Water use has tripled over the last five decades, with demand for fresh water increasing as well. Agriculture accounts for 70 percent of fresh-water withdrawals and water scarcity is a constraint to agriculture in many areas of the world.

BASF understands the scope and scale of these global trends and is developing new and innovative solutions to help feed the growing world. One solution is plant biotechnology. A source of vast, largely untapped potential, this rapidly growing field of research involves the discovery and development of plants that contain desirable traits. The genes are transferred into plants in a deliberate method called transformation that produces the desired characteristics, resulting in crops that offer benefits for farmers, consumers and the environment. Plant biotechnology is a natural progression of conventional plant breeding and allows for a more precise method that can utilize additional sources of variation to create plants with desirable traits.



above:

Rush hour traffic, a daily reminder of increasing urbanization and the need for more food, feed and fuel provided by agriculture.







above:

Biotechnology helps farmers provide more and better crops while using less resources. Drought tolerant traits conserve water. Herbicide tolerant plants facilitate no-till farming. Yield and stress traits in crops such as rice mean higher productivity and greater food security.

The growth of plant biotechnology

The advantages of biotechnology are numerous, from increasing agricultural yields and improving nutrition to providing plants optimized as renewable resources. Biotechnology supports farmers in producing more with less input. Crops that are herbicide tolerant facilitate no-till farming, which reduces the use of fossil fuels from tractors, reduces the loss of soil carbon and also lowers carbon dioxide emissions. The increased agricultural productivity of biotech crops can also save land and reduce deforestation while overcoming problems with drought, weeds and diseases.

The adaptation of biotechnology crops has taken root rapidly throughout the globe, increasing agricultural productivity. According to the 2013 International Service for the Acquisition of Agri-Biotech Applications Report (ISAAA) in 1996 1.7 million hectares of biotech crops were planted, and 16 years later in 2012, 170.3 million hectares of biotech crops had been planted, a 100-fold increase. As of 2012, genetically modified plants were being cultivated in 28 countries throughout the world, including Argentina, Brazil, Canada, China, India, Spain and the United States.

Biotech crops from 1996 to 2011 increased total crop production throughout the world by \$98.2 billion. In addition, biotech crops reduced carbon dioxide emissions by 23 billion kilograms. As a result of increased yields, biotech crops also saved 108.7 million hectares of land.

BASF Plant Science, where innovation yields results

BASF, The Chemical Company, is the world's leading chemical company. Its portfolio ranges from chemicals, plastics, performance products and crop protection products to oil and gas. We combine economic success, social responsibility and environmental protection. Through science and innovation we enable our customers in almost all industries to meet the current and future needs of society. Our products and system solutions contribute to conserving resources, ensuring healthy food and nutrition and helping to improve the quality of life. We have summed up this contribution in our corporate purpose: We create chemistry for a sustainable future.

BASF Plant Science – a BASF group company – is one of the world's leading companies providing innovative plant biotechnology solutions for agriculture. Today, approximately 800 employees are helping farmers meet the growing demand for improved agricultural productivity and healthier nutrition. BASF Plant Science is where **Innovation Yields Results** and has developed an unparalleled gene discovery platform focusing on key crops such as corn, soybean and rice. Our strategy is driven by three growth pillars:

yield and stress, herbicide tolerance and fungal resistance. These three pillars offer BASF great opportunity in leading edge innovation areas where we can provide sustainable solutions for the future.

Acting jointly with leading partners in the seed industry, BASF Plant Science is commercializing its products. Current projects include higher yielding row crops, the first genetically modified drought tolerant corn, herbicide tolerant soybeans and fungal resistance for both corn and soybeans. In addition, BASF Plant Science is working in the area of nutrition, providing higher content of specific Omega-3's (EPA/DHA) in oil crops for preventing cardiovascular diseases.

Established in 1998, BASF Plant Science is active around the globe, helping farmers meet the demand for greater productivity and healthier nutrition. An international research and technology business, BASF Plant Science is headquartered in Research Triangle Park, N.C. and operates numerous field site centers and research and development facilities across the globe. Besides Research Triangle Park, research and development (R&D) sites are in Ghent, Belgium, Berlin, Germany, Limburgerhof, Germany and St.-Jean-sur-Richelieu, Quebec, Canada. The company has built more than 80 partnerships with universities, research institutes and other plant biotechnology businesses.

Innovation is the company's DNA. It drives us forward, spurring the company's success and the success of partners. As specialists in gene discovery and integration, BASF Plant Science has developed breakthroughs that lead to superior crop performance. The company has the widest knowledge of yield and stress genes and their functions in the plant biotechnology field. Jointly with BASF Crop Protection, Plant Science is researching and developing new herbicide tolerant traits. With a novel discovery approach, we strive to develop new traits to protect plants from aggressive fungal diseases. This enables BASF Plant Science to help its partners develop the traits that will contribute to the much-needed sustainable intensification of global agricultural output.

Through industry-leading technology platforms, BASF Plant Science analyzes up to 10,000 gene sequences each year to understand the role each plays in the metabolic process of plants. The most beneficial genes are then incorporated into crop plants through the process of genetic engineering. The resulting biotech crops make farming more consistent and cost-effective while reducing the amount of environmental, material and energy resources that are needed.





above:

BASF Plant Science has a deep understanding of plant biology and physiology and combined with cutting edge molecular biology techniques enables us to identify and develop high value traits that will increase agricultural productivity.



above:

BASF has succeeded in genetically optimizing canola plants to make them capable of producing unsaturated omega-3 fatty acids. These fatty acids have a positive effect on human health because they lower the risk of cardiovascular disease. Shown is a microscopic view of a canola flower petal with pollen.

below:

Scientists analyze corn plants in the greenhouse. The plants are grown under controlled environmental conditions and exposed to specific stresses, such as drought.

Building on a key technology for the future

BASF Plant Science specializes in the development of yield and quality traits in crops like corn, canola, soybeans, rice, sugarcane, and sugar beet. Employees across the globe provide a depth and breadth of expertise and technical leadership that furthers the company's powerful research and development platforms.

In the U.S., the global headquarters house the executive management team and business functions as well as a research and development group focused on yield and stress traits, herbicide tolerance and fungal resistance projects. Our Berlin, Germany site provides innovative methods of metabolic profiling for gene function analysis. In Quebec, Canada, our site is a leader in the development of genetic markers for plants and animals. In Ghent, Belgium, we are a leader in trait discovery and development with a uniquely applied genomics platform. A fully automated greenhouse at CropDesign tests more than 100,000 rice plants per year.

By understanding genetic functions, BASF Plant Science can continue to develop plants with commercially useful and beneficial traits in its strategic focus areas of yield and stress, herbicide tolerance and fungal resistance.



Partners and projects that produce success

BASF Plant Science is The Trait Technology Partner for leading companies in the seed and food industries. The company's work focuses primarily on research and development, and through strategic partnerships with companies such as Monsanto, Bayer CropScience, and Cargill, the developed products are commercialized.

Cargill collaboration: Cargill, a global leader in food, agriculture, financial and industry products, and BASF Plant Science are working together to develop a new, cost-effective source of EPA/DHA Omega-3 fatty acids in canola oil. This new source of EPA/DHA Omega-3 fatty acids in canola will enable food and nutritional supplement manufacturers to create a diverse array of products for global consumers that deliver the health benefits of EPA/DHA Omega-3 fatty acids. (see photo, inside front cover)

BASF Plant Science has already identified the genes that, when introduced into canola, consistently produce high levels of EPA/DHA Omega-3 fatty acids in canola oil. Scientifically proven to prevent heart disease when consumed in specified quantities, EPA/DHA Omega-3 fatty acids may also lead to improvements in brain health and provide protection from inflammatory and cognitive disorders. The EPA/DHA canola oil from this collaboration is expected to launch by the end of the decade.

CTC collaboration: CTC, one of the leading Brazilian sugarcane breeding companies, collaborates with BASF Plant Science on improving productivity for Brazilian sugarcane growers by increasing yields and making sugarcane more tolerant to drought. CTC is very actively integrated into the sugar and ethanol value chain in Brazil,has full access to the sugarcane market and brings extensive knowledge in breeding and producing sugarcane elite varieties. BASF contributes plant biotech know-how and its most promising genes to the collaboration. Greenhouse and field trials will be conducted by CTC in Brazil.

Embrapa collaboration: Embrapa, one of Brazil's leading public agricultural research institutions, is collaborating with BASF Crop Protection and Plant Science to develop a herbicide-tolerant soybean system. This innovative system will provide easier, more efficient weed control to optimize productivity for farmers.

The first product, Cultivance[®], will launch in the middle of this decade in Brazil and Argentina. Other South American countries, including Uruguay and Paraguay, are expected to develop this technology to meet the requirements of their individual countries.





above:

Healthy Brazilian sugarcane growing on a plantation in an arid environment. A soybean field planted in Cerrado area, Brazil.





above: Farmers discussing their sugarbeet yield. Corn thriving outside of Mindon, Iowa. **KWS collaboration:** KWS Saat AG, one of the world's leading plant breeding companies and the leader of commercial sugar beet breeding globally, is working jointly with BASF Plant Science to develop varieties which will enable farmers to increase their sugar beet yields significantly. In this collaboration KWS will contribute its outstanding germplasm portfolio and strong experience in sugar beet breeding, while BASF Plant Science utilizes its unique platform to identify and provides genes for higher yields.

Monsanto collaboration: BASF Plant Science is collaborating closely with Monsanto on a multitude of projects. Together, we are working on genetic traits that can improve the yield and stress tolerance of major crops such as corn and soybeans. The collaboration's first corn product, Genuity[®] DroughtGard[™] Hybrids, is the first genetically modified corn to provide increased drought tolerance and improved production in regions where water can be scarce. This drought tolerant corn system is designed to enhance yield stability when water is limited, providing farmers in tough environmental conditions with an opportunity to improve yield and consistency.

DroughtGard Hybrids demonstrated strong performance in 2012 Ground Breakers[®] trials, with commercially projected products showing a yield advantage of more than five bushels per acre over competitive hybrids in the Western Great Plains. Monsanto has introduced Genuity DroughtGard Hybrids in the Western Great Plains for the 2013 growing season. These hybrids combine germplasm selected for its drought tolerant characteristics through breeding, the drought tolerant biotechnology trait and agronomic recommendations. This is the first commercial product launch from the Monsanto and BASF Plant Science yield and stress collaboration.

BASF is also working with Monsanto to identify corn traits that improve yield performance and stability by enabling more effective use of nutrients, water and energy. In soybeans, BASF is working with Monsanto to develop higher yielding varieties. These products are designed to launch as multi-gene combinations that will maximize yield opportunity.

Rice Yield collaboration: BASF Plant Science and Bayer CropScience have joined forces in a non-exclusive long-term collaboration focused on developing higher yielding rice hybrids enhanced through plant biotechnology. These hybrid seeds will offer farmers significant yield increases over conventional hybrid rice varieties. The first new hybrid rice varieties developed through this collaboration are expected to launch by the turn of the next decade, enabling rice farmers to produce the crop under more sustainable conditions with higher yield and greater revenues.

Global goals: stewardship and sustainability

At BASF, sustainability and stewardship are areas of long-standing importance. They speak to the company's values and role as a global citizen: "We Create Chemistry for a sustainable future." We take our responsibilities seriously and demonstrate them by setting specific long-term global goals for the environment, the economy and the safety of our society and our employees. By setting specific, measurable goals, we maintain transparency and verifiable integrity.

BASF Plant Science is committed to the responsible management of its genetically optimized crop products through each stage of the life cycle – from product concept to discontinuation. As an integral part of responsible product stewardship, we are committed to excellence in all activities related to assuring strict adherence to all applicable regulations globally. BASF Plant Science conducts extensive safety assessment studies on all of its genetically optimized crop products to confirm safety to human and animal health as well as environmental safety. We will not commercialize a genetically optimized crop product until the relevant regulatory authorities have reviewed the safety data and verified the safety of the crop.

BASF also provides tools for our customers and partners that can help them analyze their operations and manage their sustainable outcomes. One example is AgBalance™, a scientific method developed by BASF, which is a holistic life-cycle assessment tool specifically designed for integrated agricultural operations. AgBalance assesses the sustainability of solutions and processes in agricultural production systems and provides a scientific basis for informed, fact-based decisions improving the sustainability of any given production system.

BASF's commitment to plant biotechnology

By 2025, the global market for plant biotechnology is estimated to be worth \$50 billion. As the global population and the need for food and fuel increases, the market value will continue to rise.

BASF views plant biotechnology as a critical element for future growth. It is an important component in overcoming the challenges of a growing world population seeking increased quantities of better quality and affordable food.

Collaborations with major seed companies will continue, enabling farmers to increase agricultural yields, save resources and energy, and provide better nutrition to people around the world.





above:

Matthias Meder, Vice President Stewardship and Regulatory and John Marhoul, Regional Manager Responsible Care North America, discuss the safety measures employed during the pollination process

Tony Cavender, Regional Quality Manager for North America, confirms labeling and tracking procedures during an inspection of the RTP greenhouse. By the end of 2012, BASF Plant Science invested a total of €1.5 billion in plant biotechnology research, tangible evidence of the company's commitment. Over the course of the following years, BASF Plant Science will continue its investment in plant biotechnology – a funding that will help us address the challenges of agriculture in the future.



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The newest generation of BASF employee scientists will inspire the innovations that yield results in the coming decades.

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www.basf.com/plantscience

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