Farming Fundamentals

A guide for food, nutrition, & health professionals




BAYER

In 1900, much of the world's population was farmers.

Today in developed countries, only a small part of the population are farmers or ranchers. With many of us several generations removed from the farm, we may not have much first-hand knowledge or experience in agriculture. Farming practices and agricultural innovations continuously evolve, and this evolution helps farmers increase efficiency while reducing the amount of natural resources - water, land, and energy - necessary to provide the diverse range of foods we eat, fuel we use, and fiber for our clothing, furniture, and more. This resource serves as a brief introduction to many of the practices used by researchers, plant breeders, farmers and many others who work together to achieve a common goal: sustainably producing enough quality food for the growing world.

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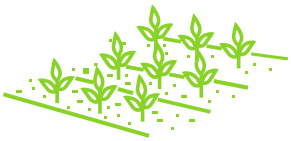
Environmental Sustainability

Limited Farmland

Acres per Person

1



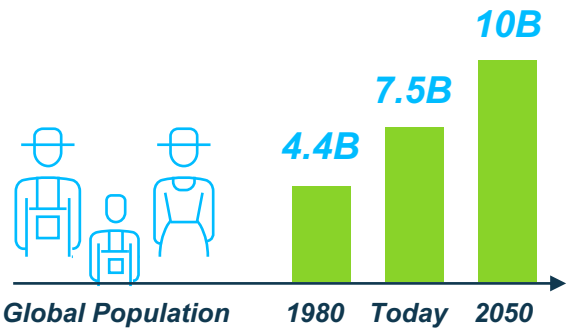
1961

Acres per Person

<1/3

2050

Rising Population



Changing Economies and Diet

50%
*More food, feed & biofuel needed**

70%
*More meat in developing nations needed**

1/3
of all food gets lost

**By 2050*

Changing Climate

Water availability issues

Increasingly unpredictable weather

Plant health
(with pressures from disease and insects)

Using Natural Resources More Efficiently

In order to provide people with food for a healthy, nutritious diet, we must begin with a healthy, nutrient-rich planet. As the planet's population increases, farmers need to use natural resources more efficiently, producing food on less land with fewer inputs. Every aspect of our climate – including temperature, sunlight, rain, and wind – is important to agriculture. Farmers know how much agriculture depends on the climate, especially considering the distinct challenges and opportunities found in each unique area of the world. Agriculture can help address climate change through two major initiatives – reducing carbon emissions and capturing carbon by securing it where it naturally benefits plants and the soil.

Soil Health

Soil covers most of the world's total land surface, but only about 11 percent of Earth's soils are considered healthy enough to be perfectly suitable for farming.[1] It is a complex ecosystem made up of air, water, beneficial bacteria and fungi, nutrients from decaying plants, organic matter and minerals. There are three basic types of soil particles, categorized by size: sand, silt and clay. Most soils include a combination of all three particle types.

Healthy soils not only produce more food, but they also retain water during drought, filter pollutants, prevent flooding, absorb greenhouse gases and support a rich diversity of life. A better understanding of this important ecosystem can also help us unlock the secrets of producing healthier crops more sustainably. Soil forms the foundation for our ability to grow food, but by some

estimates, nearly half of the topsoil on the planet has been lost in the past 150 years. Since it can take thousands of years to create a small layer of topsoil after erosion, protecting the soil we have is critical. Keeping soil healthy is important to support our future food supply, and soil management is the key to sustainable agriculture.

Conservation Tillage

Farmers till their land to help control weeds. There are different types of tillage and some are more beneficial for leaving precious top soil intact. Conservation tillage is any method of soil cultivation that leaves the previous year's crop residue on the surface of the field. Low-till and no-till practices allow root systems and residues on the surface of the ground to naturally decompose, which builds more topsoil to minimize erosion, improves water absorption into the field, improves soil's ability to store carbon, helps manage weeds, and reduces tractor emissions due to fewer passes over the field. Unlike other practices that disrupted the soil structure and left topsoil exposed, modern soil management, enabled by innovations like genetically modified crops and biologicals, is focused on preserving the soil to keep it healthy and productive. Low-tillage farming practices and integrated weed management programs can help preserve soil organic matter, nutrients and moisture and reduce erosion. They also cut down fuel and energy use and costs.

Plowing destroys the *soil structure* and reduces its ability to hold water.[2]

A healthy soil can hold up to

20 *times its weight*

in water while recycling nutrients that plants use to make our food.[4]

Cover Crops

After farmers harvest their main crop, they sometimes plant a different crop, such as a grass or a legume, or a combination of seeds, which covers the field until the next growing season. Having a cover crop in place instead of an open or bare field increases nutrient-rich organic matter in the soil, improves its capacity to hold water, and enhances fertile topsoil. Cover crops also create habitat for wildlife and can attract pollinators and other beneficial insects.

It can take the Earth

2,000 years

to make 10 centimeters of fertile soil from bedrock.

Every year, we lose around

24 billion tons

of fertile soil globally.[3]

Crop Rotation

Crop rotation is when farmers plant different crops in a single field. For example, last year a farmer may have planted 50 acres of soybeans, and this year, he or she is devoting that same 50 acres to corn. This practice can break disease and pest cycles and can assist in building organic matter.

With sustainable soil management, we have the potential to produce up to

58%

more food.[5]

References

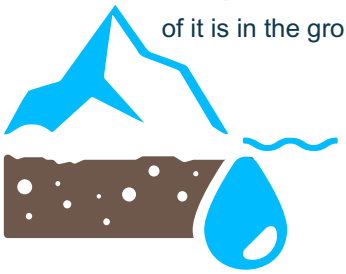
1 **FAO.** bit.ly/38vcqb4
2 **USDA.** bit.ly/2waz36r
3 **Nature** Conservancy. bit.ly/2SqC77k
4 **USDA.** bit.ly/39BNjnm
5 **FAO.** bit.ly/2HqxWlC

Water

As the global population continues to rapidly grow, the demand for clean, fresh water is growing with it. Only three percent of the water on Earth is fresh water, and most of this is frozen in glaciers and polar ice caps. In fact, just 0.5 percent of global water supplies are available for practical uses. Even without accounting for shifting weather patterns driving regional droughts, demand for fresh water for agricultural, industrial and municipal use is predicted to increase by 50 percent globally between 2000 and 2030.

Finding drinking water is not as easy as it seems.

2/3 of the Earth's fresh water supply is trapped inside glaciers, while only *30%* of it is in the ground.[1]



Water is vital to agriculture and our global food supply. We must all be vigilant in protecting our water supply by minimizing its use and keeping it safe. Innovations in agriculture help ensure that we have water that is safe to drink and available to grow our crops.

It takes about *3,000 liters of water* to produce the daily food needs of a single person.[1]

The agriculture community is working to protect our water supplies. From digital farming tools that reduce pesticide use to new gene editing techniques that can breed crops that use water more efficiently, innovation in agriculture will help ensure that our water supply stays safe and abundant.

2/3 of the world's population is projected to face water scarcity by *2025* according to the United Nations.[2]

References

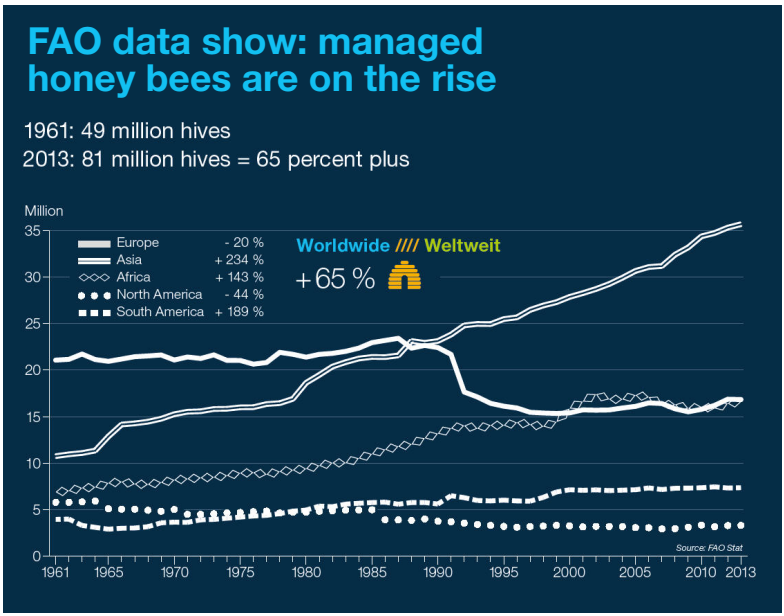
1 **USGS.** on.doi.gov/2Hr84WQ
2 **United Nations.** bit.ly/2OWDatk

Protecting Pollinators

Pollinators transfer pollen, in part, for nearly 90 percent of world's wild flowering plant species and 80 percent of flowering crops. They are critical for not only food supplies, but also other components of a functioning ecosystem. Pollinators as a group contribute to 35 percent of global crop production volume and affect yield and/or quality for more than three-quarters of the leading global food crops. It is estimated that five to eight percent of current global crop production is directly attributable to animal pollination. Pollinators are critical for many of the fruits, nuts and vegetables that we enjoy in healthy diets. Without them, many of these foods would be in short supply.

Honey Bees

Honey bees, largely *Apis mellifera*, the western honey bee or European honey bee (native to Europe, Middle East and Africa), play an important role in pollinating many nutritious foods like almonds, blueberries, melons and cherries. This bee is the most important managed bee species and accounts for approximately $15 billion of the U.S. economy. In Europe, it is estimated that pollinators contribute at least 22 billion euros each year to the European agriculture industry.



Agriculture, nutritious foods, and worldwide food security depend on honey bee health. Most people are surprised to learn that honey bee colonies have increased by 45 to 65 percent worldwide over the past 50 years. Annual surveys conducted by the United States

A Tiny Parasite Is One Of The Biggest Threats To Honey Bee Health Today

Department of Agriculture (USDA) show that the number of honey bee colonies in the U.S. has trended upward over the past decade and in 2016 reached its highest level in 20 years.

Stress Factors on Honey Bee Health

Bee health is a complex issue and most scientists agree that bees are affected by a variety of factors. Generally, these complex issues fit in four major topics – pests and disease, hive management, lack of forage and nutrition, and incidental pesticide exposure. Researchers are exploring many ways to help protect bee health, but there is much work yet to be done.

Fortunately, there are many groups working to protect and improve the health of honey bees, including universities, industry, government, beekeepers, farmers, and consumers. Programs to help honey bees range from protecting against parasites and diseases to increasing the amount of available food and forage that can sustain bee colonies wherever they may be. Many backyard bee enthusiasts are doing their part by planting a variety of bee-friendly plants around their homes and gardens.

Protecting Habitat

Farmers, ranchers, and landowners play an important role in establishing pollinator habitat, which provides forage and nutrition. Providing high quality monarch breeding and foraging habitat also provides benefits to many other species of pollinators including honey bees, native bees, and native songbirds.

For more information:

Honey Bee Health Coalition - bit.ly/2HB0Z6d

Bayer Bee Care - bit.ly/2SJ2Tqh

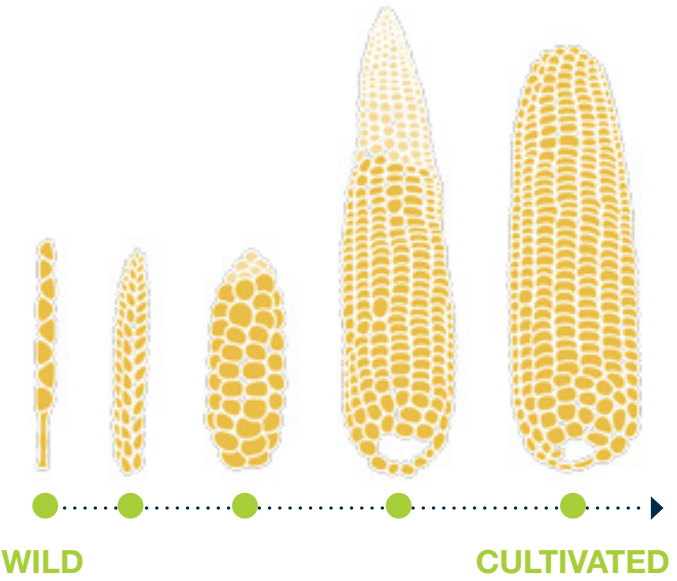
Varroa mites originate from Asia. They spread to Europe in the 1970s, invaded North American bee colonies in the late 1980s, and beekeeping has never been the same since. The Varroa mite is the “single most detrimental pest of honey bees,” according to the USDA. This parasite weakens bees and transmits diseases that can wipe out entire colonies. Beekeepers try to control the mite with insecticides, but effective control is difficult to achieve.

Plant Breeding

The History Of Plant Breeding

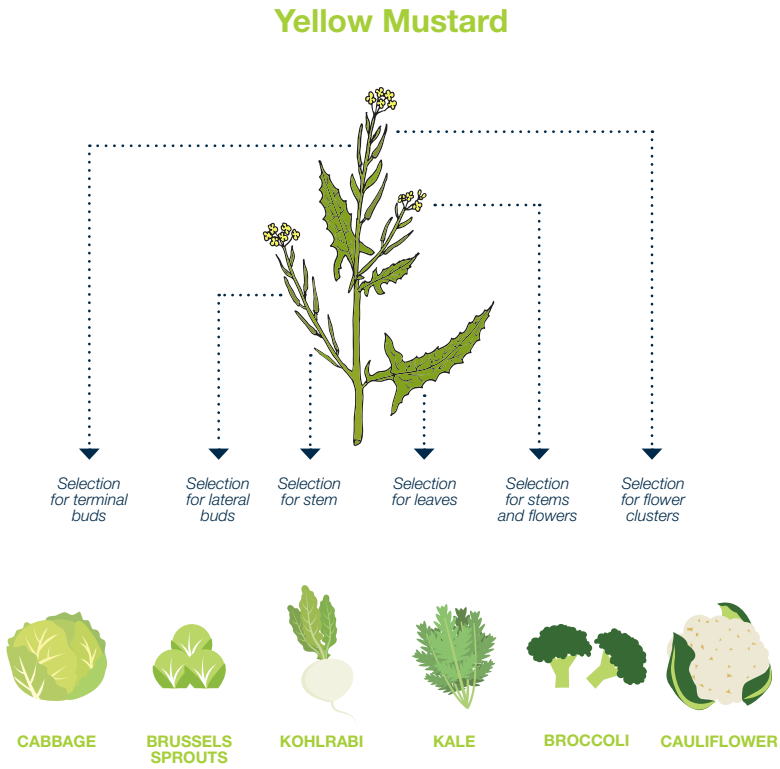
For more than 10,000 years, farmers have intentionally changed the genetic makeup of crops. Today, plant breeding is used to farm in a way that requires less land, water and energy, uses nutrients efficiently, preserves natural habitats, conserves farmlands, provides a variety of healthy, nutritious options, and helps reduce food loss and waste.

For thousands of years, humans have used traditional breeding methods to grow more of the foods needed to maintain a balanced diet. With phenotypic selection, choosing parent plants based on their observable characteristics, farmers were able to select what traits they found valuable (like flavor, texture and survivability) and continued to select and improve that trait for several hundred generations.



The corn we eat today is a great example of this. Its ancestor is teosinte. Over 10,000 years ago, this grass plant produced dozens of small ears of corn averaging 5-12 kernels. Teosinte has been selectively bred throughout history and crossed with other grass varieties to produce fewer ears with larger numbers of kernels. Today, modern hybrid corn has less ears per plant, and each ear averages 400-600 seeds. Almost every fruit, vegetable and grain that is commercially available today has been altered by human hands, including organic and heirloom seeds.

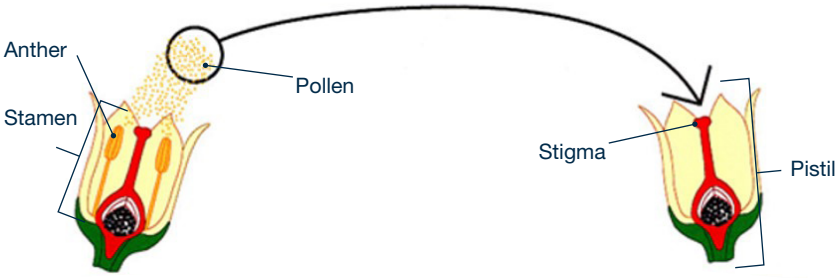
Many of the vegetables you see in the produce aisle today were bred from the same plant families. For example, the family Brassicaceae, or the Mustard Family, includes *Brassica oleracea,* better known as Wild Mustard. This plant species was modified through breeding to create modern day kale, cabbage, broccoli, Brussels sprouts, cauliflower, collard greens, kohlrabi and even canola.



Traditional Plant Breeding

How

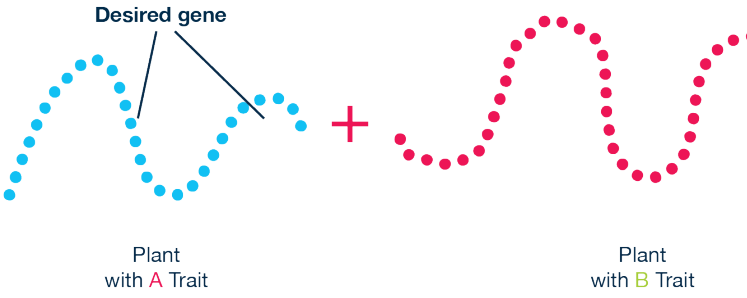
Plant breeding is the act of crossing two plants to produce offspring that, ideally, shares the best characteristics, or traits, of the two parent plants. Female plants are pollinated with pollen from the male plant.



Male **Female**

With traditional breeding, plant scientists can introduce a desirable trait from a parent to offspring, but there is a good chance that other traits will be transferred as well, since hundreds of genes are being crossed. Those additional traits may be desirable, or they might not. There is a lot of trial and error involved. It can take many generations of breeding plants to produce the seed that delivers a desirable trait without other unwanted traits.

Beginning in 10,000 BC: Plant Breeding



Mapping of the genome has allowed scientists to be much more precise in breeding techniques — they can identify which genes result in desirable traits, like yield potential, drought tolerance, or insect resistance, and introduce those traits into seeds. This more precise science allows plant breeders to develop crops with specific beneficial traits and without undesirable traits, such as those that would reduce food production. This also increases the speed in developing new varieties.

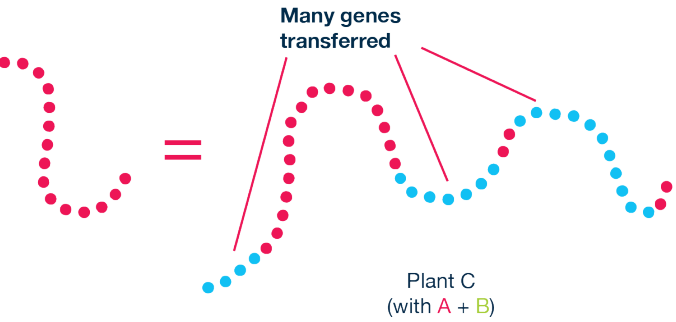
For example, plant scientists are using information gained from mapping the genome of peppers to reduce the impact of blight, which is a widespread and devastating pepper disease. By incorporating blight resistance from a donor pepper into a broad range of pepper types, peppers will be more resistant to blight. This will increase productivity and potentially reduce fungicide applications.

Why

Plant breeding enables innovation that helps farmers grow vegetables with characteristics that consumers want while maintaining produce freshness from farm to consumer. Just as our ancestors did before us, today's plant breeders focus on developing fruit and vegetable varieties that have the best flavor, appearance, and size, so that farmers and consumers will enjoy them.

To learn more, visit:

Conventional Plant Breeding - bit.ly/37u98nj



Plant Biotechnology

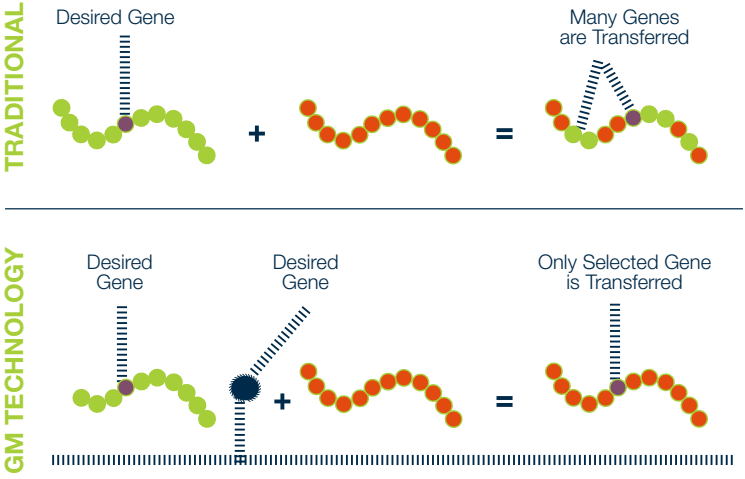
Biotechnology, or genetic engineering, was developed as a method more than 30 years ago. In the 1980s, researchers discovered a way to copy the gene for a desired trait and insert it into plants, creating new opportunities to develop crops that benefit farmers and consumers alike. Genetically modified (GM) crops have specific traits that help them grow and thrive in today's changing environment. Many products in industries like medicine, scientific research, and agriculture are made from genetically modified organisms, or GMOs. Insulin, laundry detergent, and many types of cheese are just a few examples of genetically modified products.

The first genetically engineered crop was created by nature at least *8,000 years ago.*

Sweet potatoes have been found to genetically modify themselves using bacteria called *Agrobacterium*, sometimes referred to as 'nature's genetic engineer.[6]

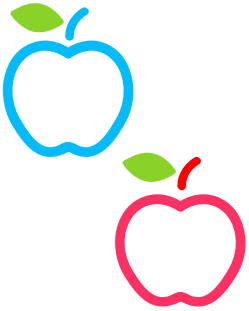
How

Genetic engineering allows plant breeders to take a desirable trait found in nature and transfer it from one plant or organism to another plant. Some examples of desirable traits commonly transferred include resistance to insects and disease and tolerance to herbicides that allow farmers to better control weeds.



There is *no nutritional difference*

between non-GMO and their GMO counterpart, unless the GM crops' nutritional content has been purposefully modified to increase essential vitamins, for example.[1]



GMOs Commercially Available

GMOs are imported, grown and/or field tested in more than 60 countries. Currently, there are 10 commercially available GMO crops in the U.S., with many others in development.

Corn

Soybean

Cotton

Alfalfa

Potato

Sugar Beets

Canola

Papaya

Squash

Apple

Why

If you're wondering why farmers choose to grow GM crops, it helps to consider the challenges they face every day: limited arable land, crop loss from weeds, insects, disease, and the effects of climate change such as drought, just to name a few. GM crops can better cope with weeds, insects, diseases and extreme weather.

Both small and large farms can realize the benefits of GM crops. These crops give farmers access to the best varieties available, which is particularly important in poor growing areas. Fewer inputs and increased productivity can add up to greater cost-savings and a higher return for all farms, regardless of size.

Safety of GM Crops

Since becoming available in the 1990s, not a single food safety or health issue associated with genetically modified crop use has been recorded.[2] Government regulators and every major scientific body that has reviewed the safety of GM foods over the past 20 years has come to the same conclusion: these crops are safe for human health, animals and the environment.

Farmers and scientists are also consumers - in addition to valuing stewardship of the land, they want safe foods for their families and communities. Each new GM seed undergoes years of testing to ensure that it brings value to farmers and is as safe as its non-GM counterpart. On average, it takes 13 years and costs $130 million to bring a GM seed to market.

Genetically modified foods are

just as safe

as conventionally grown food according to the UN Food and Agricultural Organization (FAO), the World Health Organization (WHO), the European Food Safety Authority (EFSA) and the U.S. National Academies of Science.[2, 3, 4]

The U.S. National Academies of Science reviewed more than

900 studies

conducted over 20 years and concluded that genetically modified crops are safe to eat and have not caused increases in cancer, obesity, gastrointestinal illnesses, kidney disease, autism or allergies.[2]

Benefits of GM Crops

Improving Productivity and Sustainability

// More efficient use of water than some conventional crops

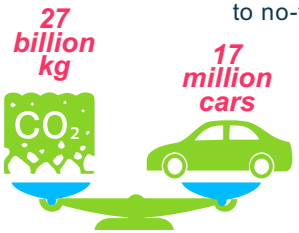
// Drought tolerance

// Herbicide tolerance allows farmers to use conservation tillage practices

// Insect-resistance allows farmers to spray less and decrease equipment trips across a field

27 billion kilograms

of CO_2 was captured in soils in 2016 (equal to nearly 17 million cars), thanks to no-till farming practices – which rely on the use of genetically engineered crops.[5]



Fighting Pests and Disease

The papaya ringspot virus was a significant threat on the islands of Hawaii in the 1990s. Scientists saved the papaya by inserting genes from the virus into the papaya genome, which created a virus resistant version. The GM papaya today looks and tastes the same, and has the same nutritional value, as non-GM papayas. In Bangladesh, genetically modified brinjal (eggplant) that are naturally resistant to the destructive fruit and shoot borer pest allow farmers to use less pesticides, which is safer for the farmer and saves money and time.

Like the papaya and the brinjal, scientists are developing many crops that look and taste the same as their non-GMO counterparts, but are resistant to insects and plant-specific diseases that can impact a farmer's harvest.

Conserving Natural Habitats

GM crops help farmers around the world make the most of their land by allowing them to grow more food without expanding the land they farm. This has a positive effect on biodiversity, encouraging many species of plants and animals to continue to thrive even as our human population grows.

The increased productivity of genetically modified crops has saved

183 million ha

of natural habitats from 1996-2016 equivalent to the *size of South Africa.*[5]

GMO crops increase productivity, protect biodiversity, reduce the need for chemical insecticides, facilitate the adoption of no-till and conservation tillage systems, enable adaptation to the effects of climate change and help farmers of all sizes to grow crops more profitably.

Genetically modified crops allow farmers more choice and flexibility in identifying varieties that can thrive on their farms. Consumers, in turn, have access to the variety and supply of foods they want that, without genetic modification, might not otherwise be available.

References

1 **GMOAnswers.com.** bit.ly/2UYFHY5

2 **NAS report, Genetically Engineered Crops: Experiences and Prospects.** bit.ly/38sYkHv

3 **WHO.** bit.ly/2HuX9Lv

4 **FAO.** bit.ly/39GxADD

5 **PG Economics. 2018.** bit.ly/39B2jle

6 **PNAS report.** The Genome of Cultivated Sweet Potato: An Example of a Naturally Transgenic Crop. 2015. bit.ly/2HnAb94

Genetically modified crops can help

reduce poverty and hunger

among smallholder farmers in developing nations.[5]

Where to learn more about GMOs:

GMOAnswers.com

biofortified.org

GeneticLiteracyProject.org

BIO.org

Gene Editing

Gene editing refers to a category of plant breeding tools (e.g. CRISPR, RNAi) which are the latest breeding innovations. Gene editing can generate the types of variations that are similar to, or indistinguishable from, the types of variations introduced by traditional breeding or mutagenesis, methods that have a long history of being used safely to develop new varieties.

Gene editing technology also has the potential to help solve problems that can't be addressed with other breeding technologies or biotechnology, like creating resistance to the citrus greening disease that is destroying the U.S. orange tree population.

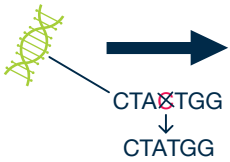
Both human and plant health are benefiting from increased genetic research. DNA is like an encyclopedia of information – and increasingly, scientists can identify the exact page, the exact paragraph, and even the exact word they want to study. Scientists have been able to pinpoint distinct connections between health attributes and genetic code with incredible accuracy. With this knowledge, they can use gene editing tools to make corrections or improvements to specific areas of the genome.

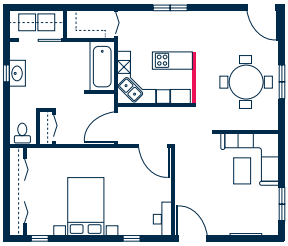
In medicine, gene editing technologies are being studied for the potential to edit the gene defects that cause sickle cell anemia, cancer and other diseases. In agriculture, gene editing can protect plant life too. Gene editing tools help plant scientists identify positive characteristics like drought tolerance or remove unfavorable characteristics like vulnerability to disease – so that plants are resilient and have a better chance of survival.

How

DNA is the biological “blueprint” for all living things. And similar to how an architect uses a blueprint to make changes to a house, gene editing tools allow plant breeders to make specific and targeted improvements to a plant’s genome blueprint.

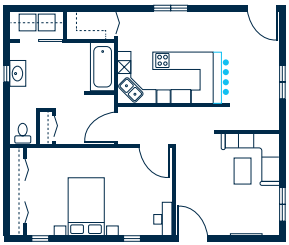
Deletion
Loss of Function





Just like strategically removing a wall can improve a house by creating more open space, gene editing tools can make deletions in the DNA blueprint, or genome, to improve a plant.

Replacement
Change in Function



Gene editing tools can also make replacements in the DNA blueprint enabling new traits, like replacing a table and chairs with a kitchen bar, creating a new seating arrangement.

Why

Gene editing enables plant scientists to make targeted improvements within a plant's DNA that offer new solutions and benefits to consumers and farmers that support agricultural practices around the world.

Today's consumers want healthy food options that are grown using fewer natural resources. Gene editing has the potential to deliver plant health and nutrition improvements to food crops so farmers can more efficiently and sustainably grow the types of foods that consumers want.

For example, it can be used to:

// Enable a beneficial characteristic such as drought tolerance or improved nutrition

// Deactivate an unfavorable characteristic such as disease vulnerability

// Break a genetic link between beneficial and unfavorable characteristics, such as between disease resistance and drought sensitivity

Plant scientists across the public and private sector around the world are evaluating gene editing tools against some of agriculture's toughest problems. From concepts that aim to curb food waste or fight environmental challenges that are being exacerbated by climate change – to products that could improve the nutritional value of food crops or alleviate food allergy concerns for some of those affected – the possibilities are only beginning to take shape.

Want to know more?

Innovature - Nourishing Tomorrow - bit.ly/2kNcEmd

The Center for Food Integrity - Downloadable Engagement Guide to Help Communicate about Gene Editing - bit.ly/2rievU2

Best Food Facts: What is CRISPR Technology Video Series bit.ly/2UmwPZi

Integrated Pest Management

The Crop Protection Toolbox

The Food and Agriculture Organization of the United Nations estimates that as much as 40 percent of the world's potential harvests are lost to damaging insects, weeds, fungi and plant diseases each year. These pests, which rob plants of water, sunlight and nutrients, can have a devastating impact on food production. Farmers around the world make multiple decisions each season on how best to protect their crops. Fortunately, advances in agriculture provide them with a variety of solutions.

Crop protection solutions help farmers produce more food on less land to help meet rising demand, while also preserving vital natural resources. A farmer's crop may compete with up to 30,000 different weeds, 10,000 species of insect pests, 3,000 types of nematodes, and 50,000 plant diseases caused by bacteria, fungi and viruses.[1] For example, plant-infesting fungi and their toxins can be detrimental to our health if we don't fight them. With the world expected to exceed 9 billion people by 2050, farmers need effective tools that can help them grow more food, even as the amount of farmland per person continues to shrink.

There is no singular approach to crop protection. Farmers today have a diverse toolbox at their disposal to minimize damage from pests, including state-of-the-art chemical and biological products, advanced data analytics, and precision technologies. While these tools are individually powerful, combining them in an agronomic approach tailored to farmers' specific challenges enhances their effectiveness while minimizing the environmental impact of agriculture.

References

1 **CropLife International.** bit.ly/3bALf0x

For more information about crop protection:

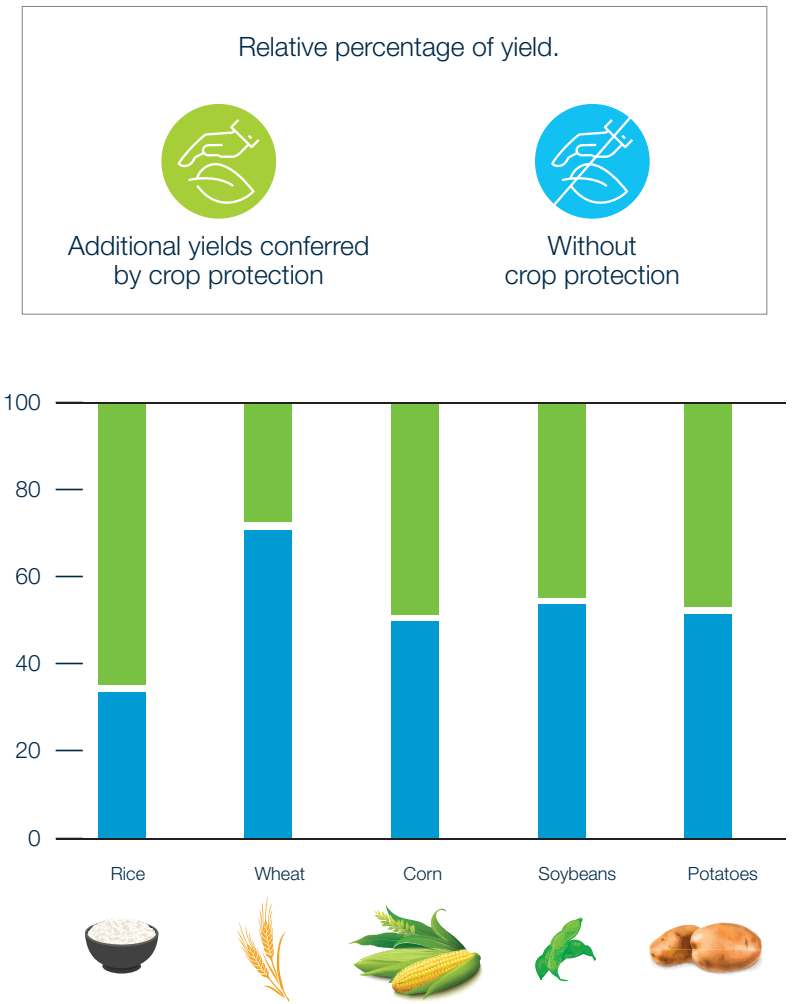
The Crop Protection Toolbox - bit.ly/3bAn1U9

Innovation in Agriculture - bit.ly/2vxkppK

Crop Life International - Croplife.org

Crop Protection Products Safeguard Harvest Yields

Disease pathogens, pests and weeds represent a significant threat to major field crops.



Source: Oerke, Bonn University, in Journal of Argricultural Sciences 144/2006

Pesticides

Up until a few decades ago, the crop protection toolbox consisted of farm families trying to protect their livelihood by manually pulling weeds. The other method of protection was tilling the soil. While effective, researchers later determined that tillage degraded soil health, leading to more erosion and releasing greenhouse gases that contribute to climate change. The ability to control these weeds, through tillage, could come with a great cost to human health, productivity, and the environment.

Today, farmers rely on a group of chemicals called pesticides to help in the field. This includes herbicides to manage weeds, insecticides to manage insects, and fungicides to prevent infection by fungal diseases. Most farmers depend on these solutions to effectively control different types of pests while also preserving the environment.

How is The Safety of Pesticides Ensured?

The registration of crop protection products is designed to protect human health and the environment. Regulatory agencies require nearly 100 safety studies before allowing a product to be placed on the market. All studies submitted to a regulatory agency are conducted according to internationally recognized standards (Good Laboratory Practices) and audited, which ensures that the tests are conducted properly, and the results are reliable. Major regulatory agencies around the world – including the U.S. Environmental Protection Agency (EPA) and the European Food Safety Authority – review all the safety data required for registration to conclude products can be used safely when label directions are followed. Products are then regularly re-evaluated with the latest data and scientific knowledge to ensure continued safe use.

Glyphosate

First introduced in the 1970s, glyphosate is an effective herbicide with a 40-year history of safe use. It is a breakthrough for agriculture, as it reduces the need for tilling fields, which decreases erosion and water loss to help keep soils healthy and reduce carbon emissions, and saves time and costs for farmers. Its widespread adoption coincided with the introduction of crops genetically modified to tolerate glyphosate, allowing farmers to target weeds while protecting valuable crops. Glyphosate works as part of an integrated weed management program that also includes

crop rotation, multiple effective herbicides and other practices. Today, glyphosate-based products are the most widely used weed control products in the world. This widespread adoption is due not only to the effectiveness and extensive economic and environmental benefits, but also due to the strong safety profile of these products.

Without glyphosate, yields in the EU for rapeseed, barley, wheat and maize could

decrease by

22%,

possibly impacting access to and cost of food.

Is Glyphosate Safe?

Glyphosate is one of the most studied herbicides in the world. Like all crop protection products, it is subject to rigorous testing and oversight by regulatory authorities. These authorities in the U.S., Europe, Canada, Japan, Australia, New Zealand, Korea, Brazil, and elsewhere routinely review all approved pesticide products and have consistently reaffirmed that glyphosate does not cause cancer. Evaluations spanning more than 40 years, and the overwhelming conclusion of experts and regulators worldwide, support the safety of glyphosate and glyphosate based-products.

In January 2020, the U.S. EPA again concluded that it “did not identify any human health risks from exposure to glyphosate.” This favorable conclusion was based on the agency’s expert scientific review and reaffirms that the extensive body of science continues to support the safety of herbicides containing glyphosate.

Glyphosate Promotes Biodiversity and Environmental Sustainability

The environmental safety profile of glyphosate has been well-documented, including its minimal risk to non-target animals, such as honey bees, monarch butterflies, amphibians and many other wildlife species[1,2]. Farmers use glyphosate to reduce the weeds competing with crops for nutrients, water, sunlight and space, resulting in more productive harvests while using less land. The use of glyphosate has allowed many farmers to reduce the need to till, which saves them time and money. This also allows organic material, nutrients and beneficial insects to build up in the soil. This build up helps protect soil fertility and reduce erosion and run-off, keeping moisture in the ground and available to crops. It leaves more crop residue (stems, leaves, seeds, pods, etc.) on the surface, providing a useful habitat for some animals. Low-till soils have a greater capacity to retain carbon dioxide and require fewer tractor trips across the field. Without glyphosate, globally, "there would be additional carbon emissions arising from increased fuel usage and decreased soil carbon sequestration, equal to the equivalent of adding 11.77 million cars to the roads.[3]"

Does Glyphosate Cause Cancer?

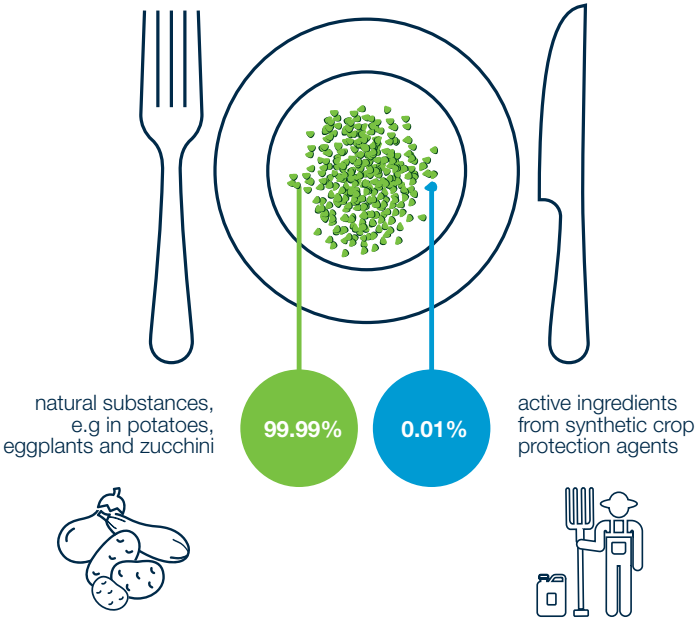
In March 2015, the International Agency for Research on Cancer (IARC), a sub-agency of the World Health Organization (WHO), classified glyphosate as "probably carcinogenic." IARC is one of four programs within WHO that has reviewed glyphosate, and the only one to have made such a finding. Regulatory authorities around the world have all reached conclusions contrary to this one outlier IARC report. Since the IARC report, regulatory authorities in the United States, Europe, Canada, Korea, Japan, New Zealand and Australia have publicly reaffirmed that glyphosate-based products are safe when used as directed and that glyphosate is not carcinogenic.

IARC is not a regulatory authority and conducted no independent studies. IARC is the same organization that determined beer, meat, cell phones and hot beverages cause cancer or are likely to cause cancer.

IARC's opinion is inconsistent with the overwhelming consensus of regulatory authorities and other experts around the world, who have assessed all the studies examined by IARC – and many more – and found that glyphosate presents no carcinogenic risk.

Almost all Potentially Toxic Substances in Food Have Natural Origins

Plants produce many toxins to defend themselves against competitors or pests.



Source: Ames 1990 et al., Dietary pesticides (99.99% all natural), Medical Sciences, 87–1990

References

1 **ECPA Infographic on glyphosate.** bit.ly/2OWCTqx

2 **Giesy et al. (2000).** Reviews of Environmental Contamination and Toxicology, vol 167. bit.ly/31XxlB7

3 **GM Crops Food.** 2017 Oct 2;8(4):216-228. doi: 10.1080/21645698.2017.1390637. Epub 2017 Dec 11 bit.ly/2vAiiRM

Learn more about glyphosate here:

Transparency in Crop Science - bit.ly/2UQ53ao

Environmental Protection Agency - bit.ly/2SpFACZ

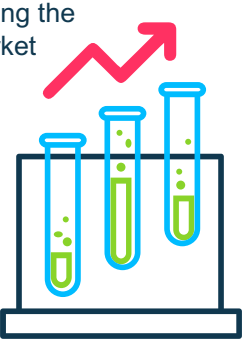
Status of Glyphosate in the EU - bit.ly/2OUaRvz

Biological Crop Protection

Biological crop protection has seen a dramatic rise in popularity in recent years. Inspired and developed from naturally occurring sources, biologicals have unique plant protection qualities that complement conventional chemical products and other farm practices. Biologicals are gaining increasing acceptance as a key part of crop protection because they offer unique ways of controlling pests and diseases and provide new resistance management options for farmers worldwide. Due to their recognized safety to people, wildlife and the environment, when used as directed, biologicals offer more choices for both farmers and consumers.

Biologicals are among the fastest growing market segments for crop protection with an annual growth rate of over

16%.[1]

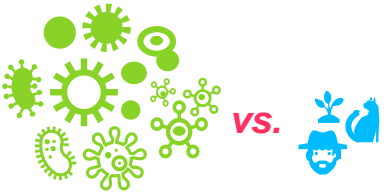


Biologicals work in many ways. They can fight pests directly, colonize the roots of plants to act as a barrier against pests or stimulate the plant to vigorously grow and defend itself. In addition to offering effective pest control, some biologicals act symbiotically with the crop to increase growth, improve nutrient uptake and prime the plant's natural defenses.

At about

5 million trillion strong,

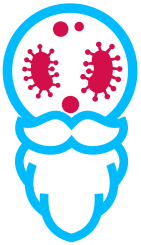
bacteria and related organisms vastly outnumber all other life-forms on Earth.[2]



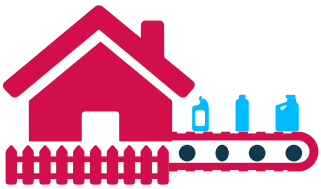
Bacteria have been around for at least

3.5 billion years,

making them the oldest known life-form on the planet.[2]



Biological products can be sourced from almost anywhere in the world, in gardens, tropical rainforests, on mountain ranges *and in your own backyard!*



References

1 **Agrow.** Biologicals 2018 An analysis of corporate, product and regulatory news in 2017/2018. bit.ly/2SLXgYr

2 **Discover Magazine.** bit.ly/38v35jA

For more information about microbes:

Agricultural Biologicals - bit.ly/39zf13X

Joyn Bio – joynbio.com

Digital Tools and Technology on the Farm

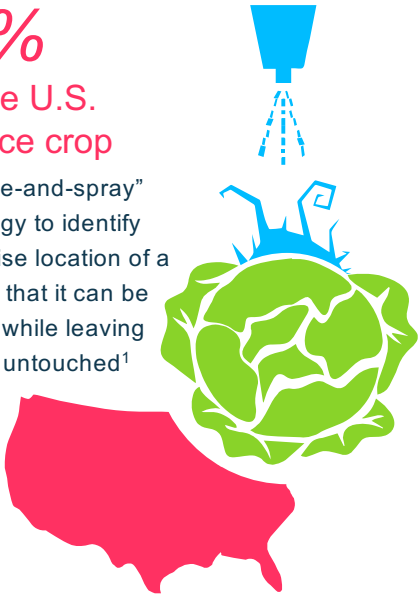
Digital Farming is Farmer Focused

The rise of digital farming technologies has opened a wealth of new data for farmers. Remote sensors, satellites and drones can monitor plant health, soil conditions, temperature, nitrogen utilization and much more - 24/7. This contributes to an overall improvement in decision making. Digital tools like drones and smart sprayers are maximizing efficiency for farmers, allowing for less wasted time and higher yield, all while using fewer resources. Artificial intelligence-based tools can analyze this overwhelming amount of data at high speeds and funnel it back to farmers in the form of useful insights, helping them make critical, timely and in-field decisions, even on the smallest footprint of land.

25%

of the U.S. lettuce crop

uses "see-and-spray" technology to identify the precise location of a weed so that it can be sprayed while leaving the crop untouched[1]



Since farmland varies in different areas, a "one-size-fits-all" management approach won't work for every farmer. The digital transformation of agriculture has the potential to benefit all farmers independent of size. Not all digital tools benefit all farmers equally.

However, they open the door for a more diverse offering of tailored solutions to bring the most possible benefit to each famer and, in turn, each field.

Even within a single farm, differences in soil, water, nutrients, vegetation and terrain create unique microclimates. Using data science, farmers have better insight into exactly where and at what rate a seed product or active ingredient should be applied. Using the right seed varieties and the right amount of fertilizers or crop protection products, applied at the right time, farmers can produce the maximum amount of food from every crop on every field, reducing the need to use more land. Combined with precision agriculture, these digital solutions help prevent the waste of resources, help improve farmers' bottom lines and minimize agriculture's impact on the environment.

Long before stress factors that endanger plants can be seen with the naked eye, they can be detected using

advanced *satellite imaging*

References

1 **Modern Agriculture.** bit.ly/3bAwXgu

For more information visit:

Bayer Data Science - bit.ly/39AVsIu

Farm Meets Table – Pioneering New Technology - bit.ly/2wjWPNB

Advancing Life

that's what we at Bayer are all about!

/// Why

Our Purpose - Science for a better life.

Our Focus - Health and Nutrition

/// What

Our Business Strategies

Pharmaceuticals // Consumer Health // Crop Science

Enabling Strategies

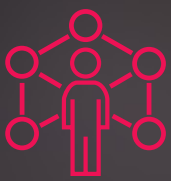
Customer Experience // Innovation // Digital

/// How

Our Values & Focus Behaviors

Customer Focus // Trust // Collaboration // Experimentation
Leadership // Integrity // Flexibility // Efficiency

Tackling two of the most pressing challenges of our time:
Health & Nutrition



Diverse, international focus with cross-border and cross-division **people development**

3

divisions:
Pharmaceuticals,
Crop Science,
Consumer Health

90

countries with
legal entities

~110k

employees worldwide in 2018

~€5.2bn

investment in R&D in 2018

€39.6bn

net sales in FY2018

Crop Science Division

/// Business Areas

Chemical & Biological Crop Protection // Seeds & Traits
Digital Technologies & Services // Environmental Science

~€14bn
generated in sales in 2018

>38K
employees 2018

€2,4bn
projected R&D budget 2019

>143
active countries in which business is performed with **>100K€** sales performance

We bring innovation to the market through a wide range of chemical, biological, and service-based agricultural solutions.

Living up to our responsibility and setting new standards in sustainability

Advancing a carbon-zero future for agriculture

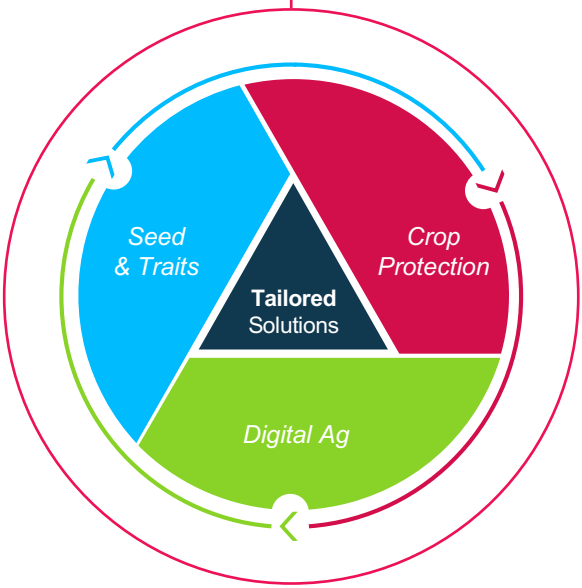
Reduction *in field* **greenhouse gases**
emitted per kg of crops produced

Produce better crops with fewer natural resources and inputs

30% **Reduction** *in* **impact** *on the environment*

Empowering smallholder farmers to access sustainable agricultural solutions

>100M **Smallholders benefit** *e.g. access to education, tailored solutions & partners*



Useful Terms

Agrobacterium
Agrobacterium is the soil microbe used in transformation that has the natural ability to put genes into plant cells. It is the truck that delivers genes to a plant cell, just like a truck delivers packages to your house.

Biofortification
The process in which the nutritional quality of food crops is improved through biological means, such as environmental plant breeding. Biofortification differs from conventional fortification in that it aims to increase nutrient levels in crops during plant growth rather than through manual means during processing of the crops (WHO).

Biotechnology
At its simplest, biotechnology is technology based on biology. Biotechnology is the use of living systems and organisms to develop or make products. Commonly, crops enhanced with biotech are called GMOs.

Bt
Short for *Bacillus thuringiensis*; Bt is a bacterium found naturally in soil and is used in agriculture to control pests. Today, organic farmers and home gardeners spray it on their crops for insect control. It is also used in GMO crops, such as cotton and corn.

Conventional Agriculture
Conventional farming systems vary from farm to farm and from country to country. However, they share many characteristics, such as use of technological advances, pesticides and fertilizers, and sometimes GMOs, to enhance crop production.

Cover Crops
Crops such as a grass or a legume that are planted and left on the field until the next growing season to conserve and improve the soil by reducing erosion and nutrient management. Benefits may include weed suppression, increasing organic matter, improved nitrogen cycling, moisture conservation and reduced soil erosion. The crops may or may not be harvested for sale.

Crop Protection
Crop protection refers to a combination of tools a farmer can use to protect crops against disease, fungi, weeds, insects and/or weather damage. This can include use of pesticides (organic or synthetic), microbial products, plants that provide protection, such as by being improved through genetic modification or breeding, or agronomic practices.

Crop Rotation
Crop rotation is the practice of planting different crops on a planned basis. Farmers in the U.S. often rotate between corn and/or soybean. This offers benefits in soil health and pest management.

Drought/Heat/Stress Tolerant Crops
There are a number of crops that can withstand natural stress, like heat, wind, and water. This can be done through traditional breeding and/or genetic modification.

Fungicide
Fungicides are a type of pesticide used in plant protection to control fungi or fungal diseases. They work by either killing the fungus or inhibiting its growth. There are many types of fungicides available to control different types of fungi, including organic, microbial and synthetic products.

Gene
Every living thing - plants, humans and animals - has genes in its DNA that express specific characteristics, or traits.

Gene Editing
Gene editing technologies offer a way for scientists to make precise edits or deletions to specific plant genes to enhance beneficial or remove undesirable plant characteristics. Gene editing technologies could enable plant breeders to more effectively develop better varieties and provide the opportunity for improvements in plant biotechnology.

Useful Terms *continued*

Genotyping
Genotyping is profiling plants based on their genes/genetic makeup. An example of genotyping would be selecting a plant based on its yield potential, ability to resist insects, or ability to be drought tolerant.

Germplasm
Germplasm is every seed's library of genetics used in breeding to create new plant varieties.

GMO
A genetically modified organism is created by taking a beneficial trait, like insect or disease resistance, from one living thing and introducing it into another to help it thrive in its environment. GMOs are also commonly referred to as GM crops or products. GM crops are also referred to as biotechnology or genetically engineered, transgenic or bioengineered crops.

Herbicide
Herbicides are a type of pesticide that kills weeds that attempt to compete with a plant for sunlight, water and nutrients. There are many types of herbicides, the choice of which depends on the type of plant the farmer wants to control. Herbicides are available in both organic and synthetic forms.

Herbicide-Tolerant Crops
Herbicides control weeds that compete with the plant for sunlight, water and nutrients. Herbicide-tolerant crops allow the farmer to spray herbicide over the crop without damaging it.

Hybrid Plants
Hybrid plants are created by traditionally breeding together two different plants to create a new plant that has an added benefit. These plants create hybrid seeds.

Insect-Resistant Crops
Insect-resistant crops have genetics that protect the plant from insects. This can be done through traditional breeding and/or genetic modification.

Insecticide

Insecticides are a type of pesticide used to control insects. This includes organic, microbial, and synthetic products that can be used in home, garden, agricultural and commercial uses. There are many types available depending on the insects farmers want to control.

Irrigation

Irrigation is a method in which water is supplied manually to plants. In agriculture, it is used in areas that routinely have dry conditions or can be used during periods of inadequate rainfall to ensure plants receive enough moisture to remain healthy. There are many types of irrigation methods, including center pivot sprinklers, drip irrigation, furrow and rotation. Research continues to find ways to improve irrigation and water efficiency.

Microbes

Microbes - like fungi and bacteria - are organisms that live all around us. Some are in food - like yogurt - and aid in digestion. Like probiotics for the soil, they also aid plant growth, nutrient digestion, root growth, and protect against disease. Many of these microbes have distinct properties that can help control fungi, bacteria, nematodes, insects and weeds. They can also stimulate plant growth and yield by improving access to nutrients. Microbial products are made from microbes that can work alone or complement traditional methods of plant production.

No-Till Farming

No-till farming is the practice of not plowing soil before and after harvests that keeps leftover stalks and leaves in the field. No-till helps farmers improve soil to retain water, prevent erosion, and benefit soil health.

Organic Agriculture

Organic agriculture uses production practices that allow the use of natural pesticides and fertilizers, but generally disallows the use of synthetic pesticides and fertilizers. Food certified organic must meet specific production standards as defined by the country's recognized organic certifying body. In the case of the United States, the standards are determined by the U.S. Department of Agriculture (USDA) national organic program.

Useful Terms *continued*

Pesticides
Pesticides are used to help both home gardeners and farmers protect their plants from insects, weeds, and/or fungi. A pesticide is any substance or mixture of substances used to alter the life cycle of any pest. Pesticides can be naturally or synthetically produced. They can also be an organism, for example, Bt is used to control a number of pests and insects. Pesticides are also referred to as crop protection products.

Phenotyping
Phenotyping means to profile plants based on their observable characteristics, such as plant height, color, and texture.

Plant Biotechnology
At its simplest, plant biotechnology is technology based on biology. Plant biotechnology is inserting desirable traits from one organism into a plant. Biotechnology enables seeds for crops, such as corn, soybeans and cotton, to have greater resistance to disease, insects and drought.

Plant Breeding
Plant breeding is the act of bringing together two specific parent plants with desirable traits to produce a new offspring with those desirable traits. This is how we get new plant varieties and hybrids.

Plant Transformation
Plant transformation is the process of incorporating a new gene or trait into a plant using agrobacterium or other methods.

Precision Farming
The use of data analysis to help farmers improve crop production practices. Farmers analyze data to help them produce more on every square foot of every field, while using water, nutrients and fuel more efficiently.

Seed Treatment
Seed treatments generally refer to a biological and/or pesticide applied directly on the seed as coating. They are used to protect seeds, seedlings and plants from diseases, insects and other pests. They may also contain micronutrients to promote plant health and nutrient uptake. Seed treatments can be made of microbes or a synthetic compound.

Stacking
Stacked traits refer to the process of combining two or more genes of interest (desired traits) into a single plant, like insect resistance and herbicide tolerance in one seed (this can be done through traditional breeding or genetic modification).

Sustainable Agriculture
Sustainable agriculture is the long-term production of plant or animal products using farming techniques that protect the environment, public health, human communities and animal welfare year over year.

Tilling
The practice of plowing the field to loosen soil, manage weeds, and to remove remnants of past harvest. The practice of plowing soil before harvest to remove stalks, leaves and other residues from the field.

Trait
A trait is a distinguishing characteristic. In plants, that can include herbicide tolerance, drought tolerance, insect resistance, height, size, quality, etc. Root crop system type is also an example of plant traits.

Transgenic Crop
Transgenic crops are synonymous with GMO crops. Transgenic stands for transfer of genes. (UCSD).

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