Limagrain

LIMAGRAIN AND GMOs IN 10 QUESTIONS

February 2021

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Limagrain

1. Genetically Modified Organisms (GMOs): what are we talking about exactly?
2. How can genetically modified plants contribute to meeting agricultural challenges?
3. What is Limagrain's approach on the subject of GMOs?
4. Why are more and more farmers using GMOs?
5. Why do we primarily find GMOs tolerant to herbicides and resistant to insects on the market?
6. Why are there no GMOs found in vegetables?
7. Is there a possibility that some insects may develop resistance to GM plants tolerant to insects?
8. What is the risk that weeds may become resistant to herbicides?
9. More generally, what is known about GMO risks related to the environment?
10. What is known about GMO risks related to health?

A SUMMARY ASSESSMENT OF GMOs

1. GENETICALLY MODIFIED ORGANISMS (GMOs): WHAT ARE WE TALKING ABOUT EXACTLY?

MAN HAS LEARNED HOW TO ISOLATE AND DETERMINE THE MOLECULAR STRUCTURE OF GENES, MODIFY THEM AS NEEDED, AND REINTRODUCE THEM INTO AN ORGANISM, WHICH THEN BECOMES A GENETICALLY MODIFIED ORGANISM.

For example:

THE EUROPEAN UNION DEFINES A GMO AS

" AN ORGANISM, WITH THE EXCEPTION OF HUMAN BEINGS, IN WHICH THE GENETIC MATERIAL HAS BEEN ALTERED IN A WAY THAT DOES NOT OCCUR NATURALLY BY MATING AND/OR NATURAL RECOMBINATION " (1)

(1) See note page 17

that is, an organism whose genetic heritage has been modified in a way other than by natural hereditary transmission mechanisms, and whose progeny includes foreign germplasm.

This modification of germplasm is the result of technological and scientific advances.

IN THE FIELD OF HEALTH CARE,
it is referred to as gene therapy.

FOR PLANTS, THIS TECHNIQUE, KNOWN AS TRANSGENESIS, IS USED TO PROVIDE THE GENETICALLY MODIFIED PLANT WITH A NEW TRAIT,

for example, through the addition of one or several genes of interest, so that it has the desired trait (increased tolerance to drought, tolerance to insect pests, better nutritional qualities, etc.).

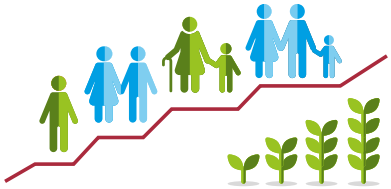
It is important to realize however that in nature, modifications of the genome are taking place all the time in all living organisms. These modifications are what has driven evolution and resulted in genetic diversity.

Breeders work primarily to study and understand this diversity and then make use of nature's work to direct breeding towards human needs in response to new challenges.

2. HOW CAN GENETICALLY MODIFIED PLANTS CONTRIBUTE TO MEETING AGRICULTURAL CHALLENGES?

SINCE THE INVENTION OF AGRICULTURE AND LIVESTOCK BREEDING, HUMAN COMMUNITIES HAVE ALWAYS SOUGHT TO SELECT PRODUCTS BEST SUITED TO THEIR FOOD NEEDS.

GMOs REPRESENT ONE OF THE SOLUTIONS AVAILABLE THAT CAN HELP MEET THE CHALLENGES FACING AGRICULTURE IN THE FUTURE.



IN LIGHT OF A CONSTANTLY INCREASING GLOBAL POPULATION, NEW HEALTH AND ENVIRONMENTAL REQUIREMENTS

as well as the need to ensure that farmers continue to earn a living, agriculture must evolve at a faster pace to find suitable responses.

GMOs CONTRIBUTE TO PRODUCING «MORE» AND «BETTER» :

- By improving productivity and crop yields
ON AVERAGE AROUND DE + 10 À + 15 %,
- while also optimizing acreage,

183 MILLION HECTARES SAVED
between 1996 and 2016

- reducing pesticide use (in the order of 671,000 tonnes between 1996 and 2016),

- and increasing farmer income.

3. WHAT IS LIMAGRAIN'S APPROACH ON THE SUBJECT OF GMOs?

As a seed company, Limagrain works on genetically modified plants

WITH THE CONVICTION THAT THEY ARE ONE OF THE SOLUTIONS TO MEETING MAJOR AGRICULTURAL CHALLENGES, BOTH TODAY AND TOMORROW.

As an international group, we are developing this activity in countries where it is authorized, in strict compliance with their laws and regulations.

Plant biotechnology (which includes GMOs) represents around

14%

OF LIMAGRAIN'S SEED R&D INVESTMENT.

It is in line with the idea that the various technologies available to the different types of agriculture complement one another, whether they are conventional, organic, or genetically modified. Limagrain believes their complementary nature is fundamental and that it will help in meeting the expectations of consumers, farmers, and citizens.

SINCE 2012, LIMAGRAIN HAS BEEN A MEMBER OF ETS (EXCELLENCE THROUGH STEWARDSHIP)

EXCELLENCE THROUGH STEWARDSHIP®

an international organization that (through external and independent audits) recognizes the adoption of quality management and administration systems responsible for the entire life cycle of agricultural products resulting from biotechnologies, from their discovery in the lab right up to their distribution.

BY TAKING PART IN THIS PROGRAM THAT GOES BEYOND THE REGULATIONS IN EFFECT, LIMAGRAIN HAS DEMONSTRATED ITS COMMITMENT TO THE RESPONSIBLE MANAGEMENT OF GMOs.

4. WHY ARE MORE AND MORE FARMERS USING GMOs?

WHEN FARMERS USE GMOs (AND THEY HAVE ADOPTED THEM QUICKLY), THEY DO SO BECAUSE THEY FIND THAT THESE PLANTS HAVE GREATER CAPABILITIES IN TERMS OF HERBICIDE TOLERANCE, RESISTANCE TO INSECTS, YIELD, QUALITY AND RELIABILITY, WHICH TOGETHER PROVIDE THEM WITH A HIGHER AND MORE CONSISTENT INCOME.

In particular, by reducing the number of passes made in the fields, there is a reduction in farmers' work time, which gives them the opportunity to farm an even larger area and as a result increase their income.

TODAY, MANY FARMERS ARE USING GMOs.

In 2019,
17 MILLION FARMERS
CULTIVATED
GM varieties of soybean, corn, cotton and canola in close to
30 COUNTRIES,
over a total acreage of
190 MILLION HECTARES.

SOYBEAN is the main genetically modified crop with 48% of global acreage, followed by **CORN.**

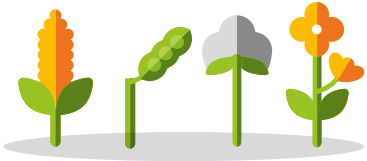
THE 5 LEADING COUNTRIES

growing genetically modified plants are
THE UNITED STATES, BRAZIL, ARGENTINA, CANADA, AND INDIA.
Paraguay is not far behind and China will soon be a significant player in this regard.

5. WHY DO WE PRIMARILY FIND GMOs TOLERANT TO HERBICIDES AND RESISTANT TO INSECTS ON THE MARKET?

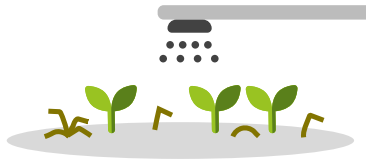
A very large part of the market today involves GMOs tolerant to herbicides and resistant to insects,

PRIMARILY FOR 4 CROPS: CORN, SOYBEANS, COTTON, AND OILSEED RAPE.



TOLERANCE TO HERBICIDES

enables using a non-selective herbicide which the plant can tolerate as the herbicide eliminates weeds growing around it.



RESISTANCE TO INSECTS,

for its part, allows plants to defend themselves against certain crop pests, while respecting the environment, and without affecting other insects, which represents a real alternative to some insecticide treatments.

IN ORDER TO UNDERSTAND WHY THE GMO MARKET HAS FOCUSED ON THESE 4 CROPS AND 2 TRAITS,
it is necessary to look at how regulatory constraints have evolved over the past 30 years.

Prior to the development of GMOs in the 1990s, many research projects were studying a very large number of crops and functionalities such as resistance to biotic and abiotic stress, nutrient content, shelf life, resistance to viruses and diseases, etc.

NEXT...

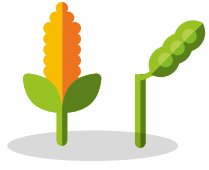
5 WHY DO WE PRIMARILY FIND GMOs TOLERANT TO HERBICIDES AND RESISTANT TO INSECTS ON THE MARKET?

GMOs had potential applications for these diverse crops and goals, but the projects did not result in products brought to market.

Guided by the goal of protecting consumers and the environment, the regulations implemented in various countries in the world led to very high costs for certifications to release them to market. To understand the order of magnitude, it required approximately

100
MILLIONS D'EUROS
PER PROPRIETARY VARIETY FILE
for a product to be certified worldwide

Little by little, only very large markets where such high costs could be recouped were targeted by products based on GM technology.



This meant that GM product lines were concentrated in the most widespread crops in the world – such as the most dominant, corn and soybeans – and focused on traits that could be universally expressed, such as tolerance to herbicides and resistance to certain insects (which is not the case for other agronomic traits* that solve less widespread problems, given the variability of pedoclimatic conditions and crops in the various zones throughout the world).

*the gene(s) providing the plant with a desired characteristic (examples: high tolerance to drought, resistance to a virus, fungus...)

6. 6.WHY ARE THERE NO GMOs FOUND IN VEGETABLES?

TODAY, THERE IS A GM SUMMER SQUASH

(WITH SMALL-SCALE DISTRIBUTION)

AND A GM TOMATO IN THE UNITED STATES

(WHICH HAS NOW DISAPPEARED FROM THE MARKET)

AS WELL AS AN EGGPLANT RESISTANT TO INSECTS IN BANGLADESH

In terms of fruit, there is a virus-resistant papaya in Hawaii and Arctic apples that do not brown, in the fresh produce, ready-to-eat market

AS EXPLAINED IN QUESTION 5,

The technology could also have resolved other problems in vegetable crops. Many other products were ready but were never brought to market.

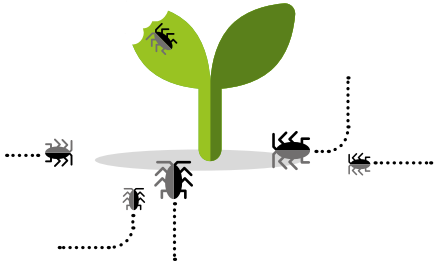
THIS LIMITED APPLICATION CAN ALSO BE EXPLAINED AS AN EFFECT OF THE REGULATORY COSTS FOR RELEASE TO MARKET CERTIFICATION.

Vegetable seed markets are in fact very diversified and segmented. Individually they are very small and there is no way to recoup the regulatory costs for this size of market.

IT IS ALSO IMPORTANT TO NOTE THAT GM VEGETABLES HAVE BEEN NEGATIVELY AFFECTED BY THE FACT THAT CONSUMERS HAVE NOT ACCEPTED THEM.

This problem of acceptance by society, even though it is based on unjustified fears, is exacerbated by the fact that vegetables are consumed directly by consumers, without any industrial processing. As a result, these products have had trouble finding a market.

7. IS THERE A POSSIBILITY THAT SOME INSECTS MAY DEVELOP RESISTANCE TO GM PLANTS TOLERANT TO INSECTS?



JUST AS INSECTS CAN DEVELOP RESISTANCE TO INSECTICIDES, IT IS POSSIBLE FOR INSECTS TO DEVELOP RESISTANCE TO BT* PROTEINS PRODUCED BY GM PLANTS.

It should be noted that this problem is already present in the United States, South Africa, and especially in Brazil and Argentina.

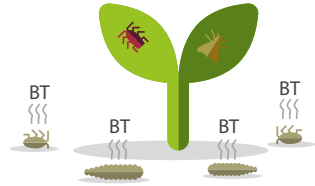
*The resistance gene Bt (Bacillus thuringiensis, bacteria that has a gene coding for an insecticide protein) is found in nature. When introduced into a plant, it allows the plant to produce a protein that blocks the development of targeted insects by itself. For example, when introduced into corn, it will block the development of corn borer larva, an insect pest in corn.

IN NATURE, THIS TYPE OF SITUATION OCCURS WHEN THERE ARE REPEATED USES OF THE SAME INSECTICIDE MOLECULE AT THE SAME PLACE ON THE SAME POPULATION OVER TIME

as a result, under the pressure of natural selection caused by the application of insecticide, insect populations may evolve naturally. It is this phenomenon, clearly identified by biologists, that may lead to resistant populations – similar to what happens with antibiotics – and which must therefore be anticipated.

For this reason, during certifications for bringing GM products resistant to insects to market, regulators request that farmers using them establish refuge areas – in which there are no plants producing the Bt protein – so that populations of susceptible insects continue to subsist, in order to reduce the probability that resistant insects proliferate. These kinds of regulatory measures have not, for the moment, been implemented in Argentina or Brazil.

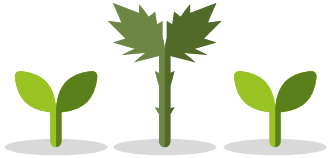
However, at the interprofessional level (for example, within the framework of the ETS - Excellence Through Stewardship program), there are efforts to implement best practices for managing insect resistance (raising farmer awareness, crop rotation, refuge areas, etc.) for all of the regions concerned.



IT SHOULD ALSO BE NOTED THAT GM **PLANTS RESISTANT TO INSECTS DO NOT ELIMINATE ALL THE INSECTS IN A FIELD**

but only those targeted by Bt proteins. Only larvae susceptible to the Bt protein and that eat these Bt plants will be affected. A comparison between fields with GM plants resistant to insects and conventional fields subject to insecticide spraying shows that there are in fact a greater number of useful insects in fields with GM plants.

8. WHAT IS THE RISK THAT WEEDS MAY BECOME RESISTANT TO HERBICIDES?



ARE INVOLVED OR NOT, ALL AGRONOMISTS HAVE ALWAYS KNOWN THAT THE REPEATED USE OF THE SAME HERBICIDE ON THE SAME PLOT WILL INEVITABLY RESULT IN THE RISK THAT RESISTANCE TO THAT HERBICIDE WILL APPEAR AT SOME POINT.

IN SOME REGIONS OF THE WORLD, SUCH AS THE UNITED STATES, BRAZIL, AND ARGENTINA,

farmers, due to familiarity and convenience, have generally used resistance to glyphosate in their main crops (corn / soybeans / cotton) in rotation (in the American Midwest, for example), continuously on their farms at a large scale over time. Inevitably, non-GM plants resistant to glyphosate have appeared in these regions.

However, even though regulators put mechanisms in place to reduce the risk with regard to insects, no measures were envisionned for the use of GM plants tolerant to herbicides.

Limagrain has learned from this American experience. The use of tolerance to glyphosate in the corn / soybeans / cotton cropping system in the Midwest confirms that it is important to analyze the impacts of the innovations proposed, not only individually crop by crop, but especially as part of a cropping system, that is, depending on the way in which crops are used in relation to each other by the farmer on the farm.

FOR LIMAGRAIN, THIS MEANS THAT IT IS ESSENTIAL TO PROVIDE THE BEST SUPPORT FOR OUR CUSTOMER FARMERS IN THE SUSTAINABLE USE OF PROPOSED INNOVATIONS.

It also involves reminding them that there is a clear need for crop rotation, which allows for different herbicides to be used over the years and almost completely eliminates the risk that resistance may appear.

9. MORE GENERALLY, WHAT IS KNOWN ABOUT GMO RISKS RELATED TO THE ENVIRONMENT?

THE POTENTIAL RISKS THAT GM CROPS MAY POSE TO THE ENVIRONMENT ARE OFTEN THE SUBJECT OF RELATIVELY RATIONAL AND SUBSTANTIAL DEBATES, IN EUROPE AND IN FRANCE IN PARTICULAR.

It should be noted that before a GM plant can be grown commercially in the European Union, the European Food Safety Authority (EFSA) subjects it to a risk analysis with regard to its cultivation.

Many studies and publications have analyzed potential risks and whether they have materialized.

A META-ANALYSIS PUBLISHED IN 2014
based on
147 studies conducted
over **20 YEARS,**
PRESENTS AN OVERALL POSITIVE ASSESSMENT OF THE IMPACT THE USE OF GM PLANTS HAS HAD ON THE ENVIRONMENT.

These impacts include:

A SAVINGS OF ACREAGE USED OF
183 MILLION HA
between 1996 and 2016.
Because GM crops provide a better yield of around **22%,** they allow for producing more on less acreage,

AN OVERALL REDUCTION OF PESTICIDE USE:
- 37%
over the last twenty years,
WHICH CORRESPONDS TO A DECREASE **OF AROUND 671,000 TONNES OF PESTICIDES**

NEXT...

9. MORE GENERALLY, WHAT IS KNOWN ABOUT GMO RISKS RELATED TO THE ENVIRONMENT?

A REDUCTION IN THE NUMBER OF PASSES MACHINES MAKE IN THE FIELD, RESULTING IN A SIGNIFICANT DECREASE IN GREENHOUSE GAS EMISSIONS AND LESS SOIL EROSION.

The issue is also often raised concerning the risk of cross fertilization between GM plants and related or neighboring non-GM plants. Whether it involves a GM or conventional variety, cross fertilization between two fields with the same crop is possible. Any field grown in normal conditions more or less pollinates the neighboring fields... and is pollinated by them.

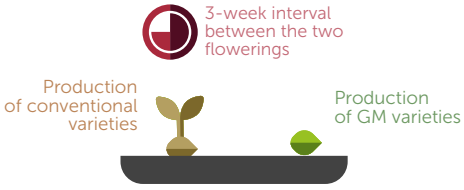
THIS IS NATURAL.
GM PLANTS DO NOT HAVE A GREATER ABILITY TO SPREAD THAN OTHER PLANTS. AND REMEMBER THAT CROPS DO NOT ALL CROSS AMONG EACH OTHER.

Limagrain has implemented the means necessary to reduce any pollination and even goes beyond what the regulations require. There are several solutions to limit such pollination during GM crop production. .

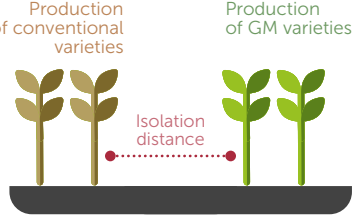
NEXT...

9. MORE GENERALLY, WHAT IS KNOWN ABOUT GMO RISKS RELATED TO THE ENVIRONMENT?

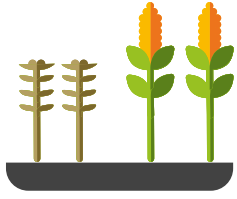
SOLUTIONS TO LIMIT THE RISKS OF POLLINATION DURING GM CROP PRODUCTION:



INTERVALS IN SOWING TIMES
so that two neighboring fields do not flower at the same time.



ISOLATION DISTANCE
between fields greater than the distance required by the regulations.



POSSIBLE CORN CROP BORDER ZONES CALLED «BUFFERS»
surrounding the fields, intended to protect them from pollen emitted from another field

MACHINE CLEANING
before and after any operations conducted in the fields during flowering and harvest.

SEED PRODUCTION TECHNICIANS SHOULD PAY ATTENTION
to the fields during flowering.

CHECKING SEED PRODUCTION
Validated by the Limagrain Quality Assurance department; ISO17025 certified laboratories inspect for the adventitious presence of GMOs in seed production.

10. WHAT IS KNOWN ABOUT GMO RISKS RELATED TO HEALTH?

MANY DEBATES, RECEIVED IDEAS, AND STUDIES, WHICH ARE SOMETIMES CONTRADICTORY, HAVE BEEN DEVELOPED IN EUROPE, AND ESPECIALLY IN FRANCE, ON THE ISSUE OF GMOs AND THEIR IMPACT ON TOXICITY, ALLERGY RISKS, AND NUTRITIONAL QUALITY, OFTEN IN SPITE OF CERTAIN FACTS.

THE IMPACT OF GENETICALLY MODIFIED PLANTS ON HEALTH HAS BEEN EXAMINED JUST AS MUCH AS THE IMPACT ON THE ENVIRONMENT.

After close to 30 years since the first European directive on GMOs, no agricultural GM product intended for food has ever been officially reported as having secondary effects on health:

> no detectable toxic compounds

> no allergy risk

(if probability of allergenicity is predicted during a test prior to release to market, the GMO is not distributed)

> ... and no particular trouble for digestion

(GMOs are broken down during digestion, just like any other food).

TWO REPORTS CONDUCTED BY THE EUROPEAN COMMISSION IN 2000 AND 2010 CONCLUDED THAT

" the use of more precise technology and the strengthening of regulatory checks have probably made GMOs even safer than conventional plants and foods".

IN 2014

60 OPINIONS | **46** STUDIES

A compilation of more than 60 opinions from the European Food Safety Authority (EFSA) and 46 studies found in scientific journals, published in 2014 in the International Journal of Biotechnology, concluded that there was no health risk.

A SUMMARY ASSESSMENT OF GMOs

An assessment on the use of GM plants in their cropping system over a period of 20 years was conducted.
Overall, we should remember that contradictory studies can be found on the topic of GMOs and their impact on the environment and health. Some are incomplete and/or come from activists.
Only global studies – meta analyses – provide some perspective and present objective conclusions.
These studies show that generally, with 20 years of perspective, and in spite of certain situations such as the resistance to herbicides found in the American Midwest mentioned in question 8, GMOs have demonstrated their potential and have had, and continue to have, a positive impact.

TO FIND OUT MORE, VISIT:

https://www.youtube.com/watch?v=7TmcXYp8xu4

Link to Europabio

« Are GMOs good or bad? »

Sources used :

• 2019 ACTUAL International Service for the Acquisition of Agri-Biotech Applications.

• PG Economics studies: Farm income and production impacts of using GM crop Technology 1996-2016 and Environmental impacts of GM Crop use 1996–2016: Impacts on pesticide use and carbon emissions.

• PLOS 2014. The Public Library Of Science (PLOS) presents a meta-analysis of more than 147 research studies over the last twenty years, conducted by agricultural economists at Göttingen University in Germany.

• A compilation of more than 60 opinions by EFSA (European Food Safety Authority) and 46 studies found in scientific journals, published in 2014 in the International Journal of Biotechnology.

Notes

Directive 2001/18/CE includes 3 lists of techniques in the appendices:

- techniques resulting in GMOs: 1) recombinant nucleic acid techniques involving the formation of new combinations of genetic material by the insertion of nucleic acid molecules produced by whatever means outside an organism, into any virus, bacterial plasmid or other vector system and their incorporation into a host organism in which they do not naturally occur but in which they are capable of continued propagation; 2) techniques involving the direct introduction into an organism of heritable material prepared outside the organism including micro-injection, macro-injection and micro-encapsulation; 3) cell fusion (including protoplast fusion) or hybridisation techniques where live cells with new combinations of heritable genetic material are formed through the fusion of two or more cells by means of methods that do not occur naturally.

- techniques not involving genetic modification (that do not result in GMOs): 1) in vitro fertilization; 2) natural processes such as: conjugation, transduction, transformation; or 3) polyploidy induction.

- techniques involving genetic modification but outside the regulatory framework: 1) mutagenesis; 2) cell fusion (including the protoplast fusion) of plant cells of organisms which can exchange germplasm through traditional breeding methods.

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For any further information, please contact the Group's Regulatory Affairs department.