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Biologicals

Biologicals Solutions and Regenerative Agriculture

Vixeran®

Innovation
powered by nature


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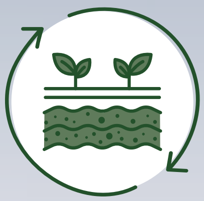
Biologicals' four benefits to Regenerative Agriculture



Healthier soils

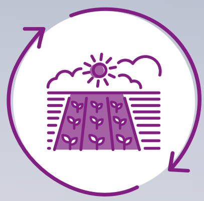
Biologicals can help improve the biochemical activity of the soil, contributing to its capacity to function as a vital living ecosystem that sustains the life of plants, animals, and humans.

Reduced greenhouse gas emissions

The integration of biological inputs in crop management can help contain emissions through a more efficient use of resources and an increase in productivity.

Better water management

Biologicals for water use efficiency help farmers optimize the use of agricultural water, making the most of this precious resource.



Increased farm productivity and profitability

Biologicals can help crops be more productive and face the abiotic and biotic stresses that jeopardize their yield and quality, therefore protecting farmers' incomes and limiting the expansion of agricultural land.

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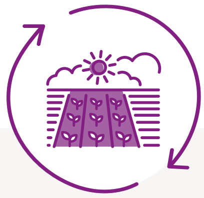


Biologicals Solutions for Regenerative Agriculture: VIXERAN ®

Summary

Rethinking Agriculture

The availability of food for the whole world depends, directly or indirectly, on agricultural production.
The increase in crop productivity achieved over the last century has alleviated poverty and malnutrition around the world, and, at the same time, has made it possible to limit the conversion of habitable land for agricultural purposes to feed a growing population.
However, this success was only temporary. The combined effects of global warming, scarcity of resources and population growth, which reached 8 billion in 2022, now make it necessary to **rethink the way we produce food.**
Guaranteeing enough healthy food for the entire world population, and, at the same time, limiting the consumption of resources and safeguarding the health of plants, soil and ecosystems: this is the challenge that modern agriculture is facing, a challenge that requires a rigorous approach and globally coordinated measures.
To drive change, the United Nations

END HUNGER, ACHIEVE FOOD SECURITY AND IMPROVED NUTRITION AND PROMOTE SUSTAINABLE AGRICULTURE

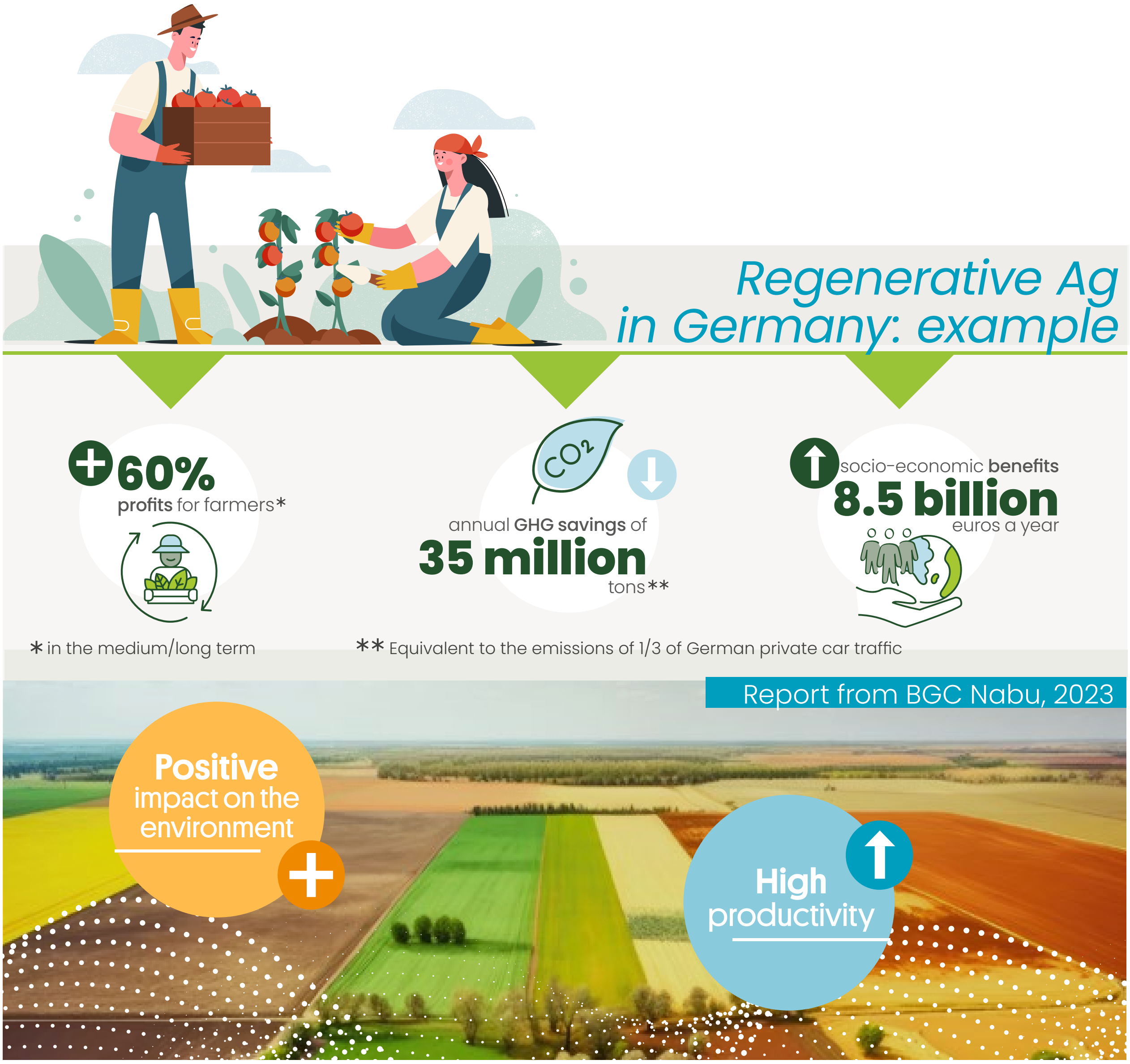
has dedicated a goal of the Sustainable Development Goals (UN-SDGs) to food production, number 2, which aims to "end hunger, achieve food security and improved nutrition and promote sustainable agriculture".
However, as a confirmation of the central role that agriculture occupies in our society, and its transversal impacts, the goals connected to the production of food among the UN-SDGs are the majority, and are distributed among objectives of an environmental, social and economic nature.
In this complex and interconnected panorama, **all the players in the food chain will have to find effective and innovative solutions to face the challenge that awaits us.**
Solutions leveraging both on the imperative of ecosystems conservation and on the answers provided by scientific innovation.

What is Regenerative Agriculture?

We define regenerative agriculture as an **outcome-based** approach, that is to say, oriented towards obtaining specific agronomic and ecological results. Some of these objectives are:

At the same time, we identify **principles and practices** that are functional to achieving these goals. According to the principles of regenerative agriculture, **traditional practices** such as minimal or no-tillage, the use of cover crops, or crop rotation meet with **innovative solutions and technologies** in accordance with the specific needs of crops and land, to tailor an approach that is simultaneously beneficial to humans, the environment and the entire value chain.

This strategy supports the UN-SDG Objective n.2 in its promotion of a "sustainable agriculture", with the idea that **only by safeguarding the well-being of the environment and of the crops themselves it is possible to obtain results that are sustainable in the long term from an economic, social and environmental point of view**.



The role of Biologicals in Regenerative Agriculture

Regenerative agriculture requires rethinking not only the way of cultivating the land, but also the systemic agronomic strategy and the use of external inputs for crop nutrition and protection. The latter are still considered, but managed in the principle of **precision application**: administered in a targeted way, minimizing waste, and leveraging on the most innovative technologies to optimize treatments on the basis of the single crop or area.

In this context, an important help is provided by **Biologicals**, innovative products that **valorize the action of molecules and organisms present in nature** with the aim of improving crop performance and soil quality. These solutions are designed on the basis of a **deep knowledge of the chemical and biological mechanisms underlying the physiology of plants** and their interactions with the environment, to ensure their **health and productivity** while respecting ecosystems.

Biologicals are made up of three main categories: **biostimulants, biocontrol, and nutrient use efficiency**

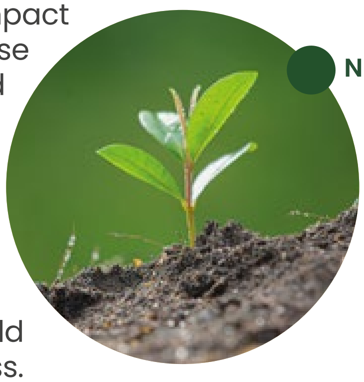
products. Biostimulants improve the natural physiological processes of crops to increase their **quality, resilience to climatic stress and efficiency in the use of resources**, also benefiting the **microbial activity of the soil**. Biocontrol help plants to face and overcome the pitfalls posed by **weeds or parasites**. **Nutrient use efficiency products** – considered biostimulants or biofertilizers in some markets – improve macro- and micronutrient availability and uptake to promote growth, increase resilience or enhance yield.

Biostimulants

Biocontrol

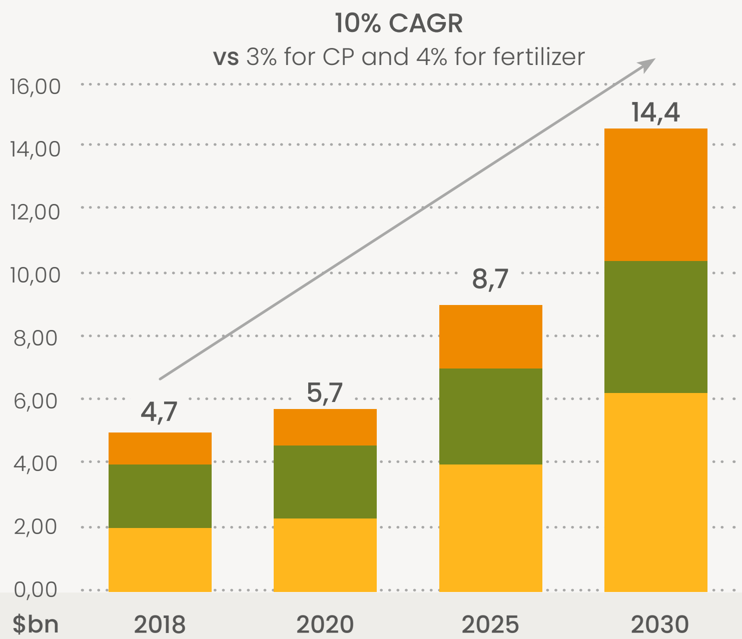
Biologicals are not born as alternative solutions to traditional inputs, but to be used in synergy with them and to optimize their use. In particular, Biostimulants improve the health and nutrition status of plants; by doing so, they allow crops to better react to adverse climatic events, or, depending on the type of product, to make the best use of the available resources, minimizing the waste of nutrients.

Products in the Biocontrol category, on the other hand, exploit molecules and substances present in nature to implement highly targeted, specific and low-impact crop defense strategies. An example is the use of pheromones, chemical substances used by parasites for signals between individuals, used to alter reproductive behavior in areas of agricultural interest without harm to the surrounding environment. Lastly, nutrient use efficiency products can effectively support fertilization, by helping plants optimize the nutrients at their disposal and prevent yield reductions that may be caused by nutrient loss.



Nutrient Use Efficiency

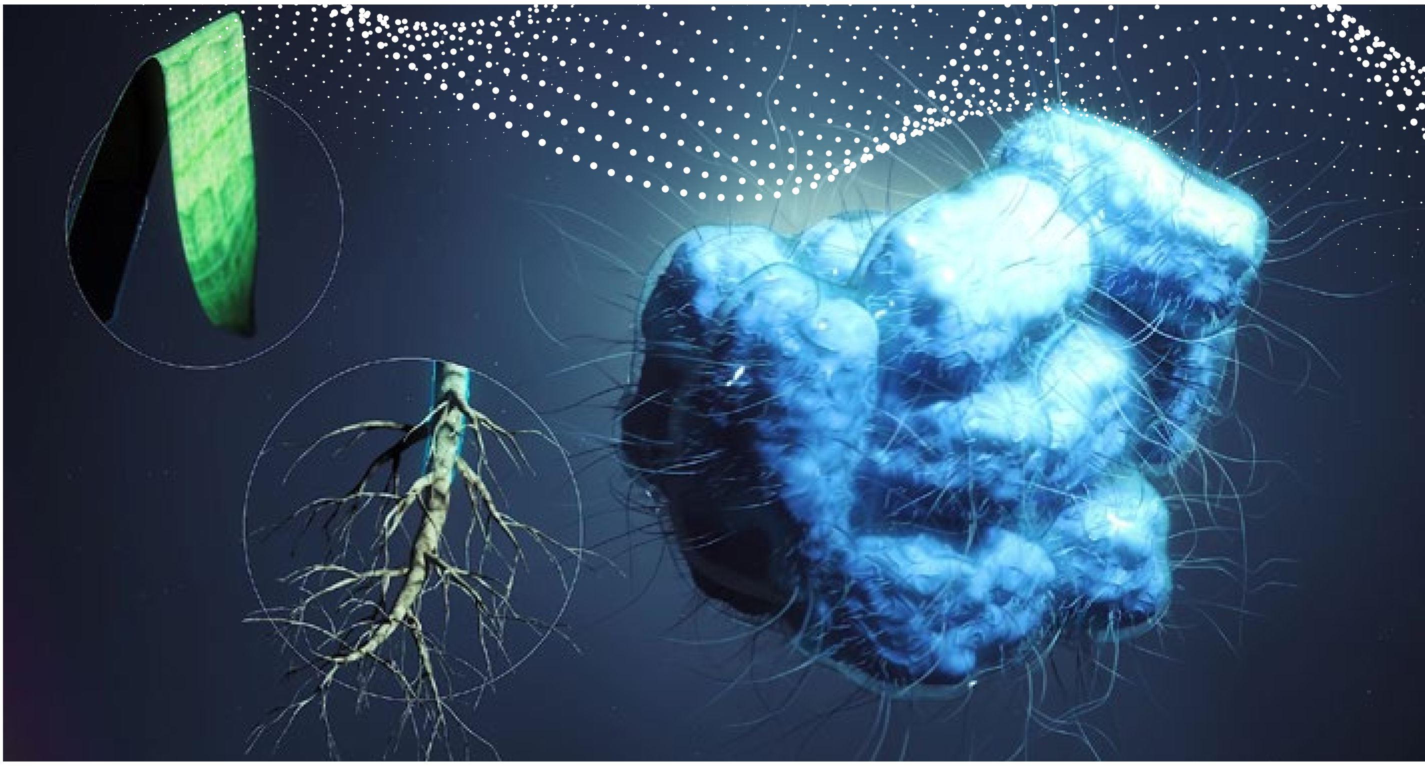
Market perspectives reflect farmers' increasing interest in Biologicals.



As many companies in the food chain are committing to regenerative agriculture for sustainable commodity sourcing, Biologicals can be an important tool in the farmers' toolbox to meet the demands of an increasingly sustainability-demanding market and become chosen partners of a sustainable food chain.

VIXERAN® for Regenerative Agriculture

*Based on the Nitrogen-Fixing bacteria Azotobacter salinestris strain CECT9690, **VIXERAN® is able to capture atmospheric nitrogen and transform it into a form that is readily accessible to all crop plants.** This innovative solution provides an alternative & complementary solution in nitrogen fertilization crops program which helps reduce the overall carbon footprint of agricultural practices, making the food chain more sustainable.*



The Nitrogen cycle

Nitrogen (chemical symbol N) **is the main element in proteins and nucleic acids and is essential for growth and development of all living beings**. It constitutes also the 80% of the air we breathe, but as a stable and unreactive form (N2) that **cannot be directly absorbed by most organisms**. Plants, that rely on nitrogen for their nourishment, make no exception. Therefore, before it can be used as a nutrient, **the nitrogen molecule in the air needs to be transformed into a chemical species that plants can absorb and process**.

This process can happen in the atmosphere, when nitrogen molecules are exposed to the high energy of lightning strikes in the presence of oxygen, but it mostly takes place into the soil thanks to the action of **specific bacteria that are able to "break" the stable and unreactive nitrogen molecule**. Additionally, it is possible to reproduce these processes by means of the so-called **Haber-Bosch procedure, the main industrial method for the production of ammonia**. This process, converting nitrogen into biologically usable compounds such as urea, ammonia (NH4+), or nitrate ion (NO3-), is **at the basis of modern synthetic fertilizers**.

Once plants absorb the now-bioavailable nitrogen from the soil, they use it to synthesize proteins and other essential biomolecules. When they are harvested, nitrogen is transferred to animals and humans through consumption, and eventually returns to the soil as organic matter. Then, microorganisms decompose this organic matter, re-converting the nitrogen of complex biomolecules into the simple ammonium and nitrate ions that can be taken up again by plant roots. To complete the nitrogen cycle, other bacteria can finally convert nitrate back into atmospheric nitrogen. **However, the cycle is not a closed system, as some inherent nitrogen losses can occur into water bodies** (leaching, runoff), **and the atmosphere** (volatilization). Moreover, under certain conditions, another gaseous product can be released - **nitrous oxide (N2O)**, an intermediary product of denitrification. Therefore, anthropic interventions in the nitrogen cycle through the use of nitrogen fertilizers, although practically indispensable to grow crops successfully, require a certain attention in order to minimize input-output imbalances.

When examining the overall carbon footprint of food production, the use of nitrogen fertilizers is a critical component. Plus, using an excess of this nutrient to secure yield leads to significant environmental issues. Enhancing the efficiency of fertilizer use, to reduce waste and minimize environmental impacts, is a challenge that agriculture needs to face in order to become more sustainable.

Nitrogen optimization is key to a sustainable food production

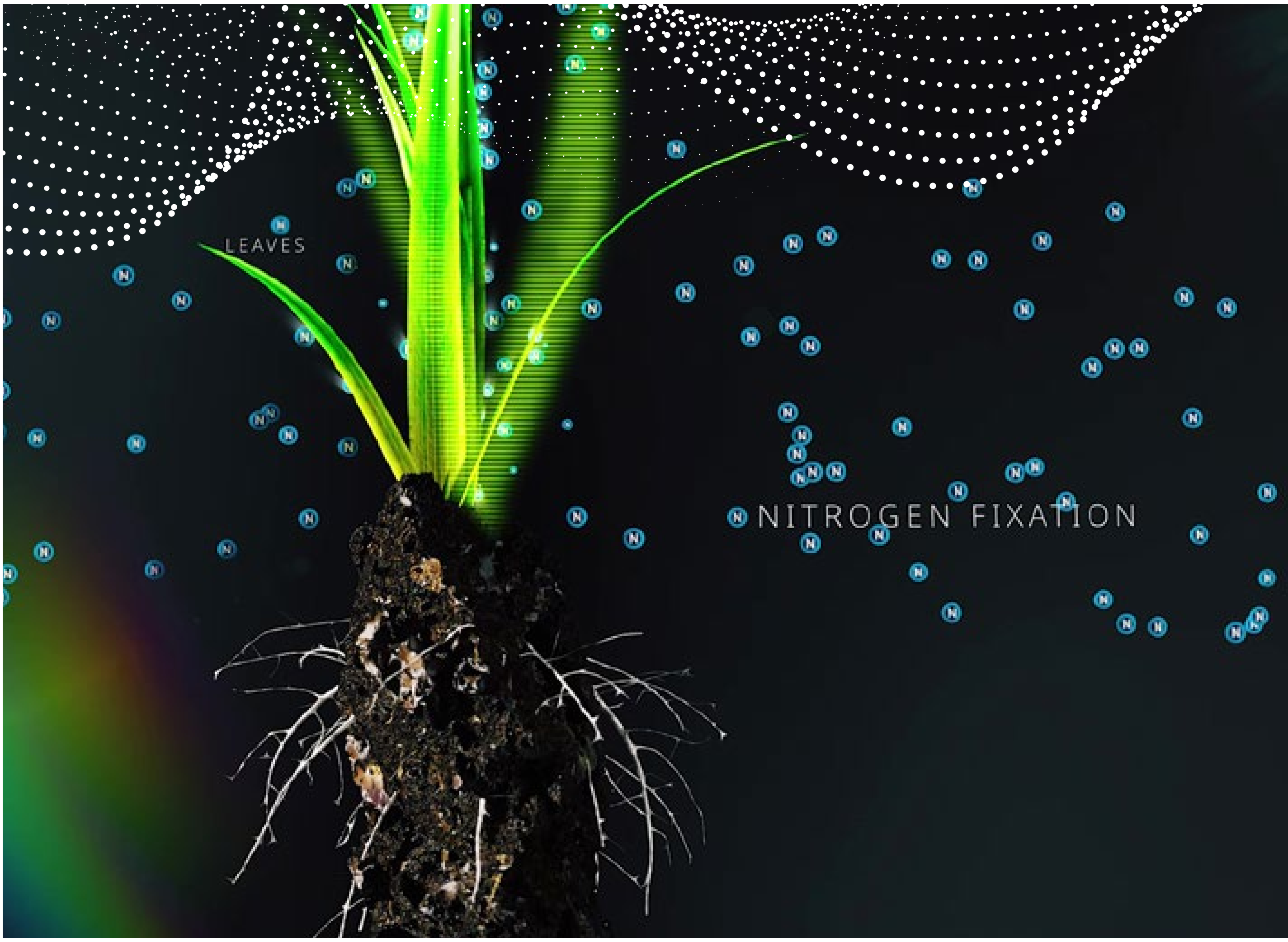
The global agri-food system heavily relies on synthetic nitrogen fertilization, to the extent that it was estimated (Smil, 2004) that **around 40% of the global population on the year 2000 were dependent on food production from synthetic fertilizers**. However, the efficiency of its use is an important weak link within the food chain: a recent study (Kanter, 2020) showed that **the nutrient use efficiency of crops for human and animal feed averages 43% globally**, meaning that more than half of applied nitrogen fertilizer is lost into the environment.
Moreover, the large use of nitrogen fertilizers poses important environmental challenges. **In 2018, the supply chain of synthetic nitrogen fertilizer was estimated to be responsible for 2.1% of global GHG emissions, a percentage that raises to 10.6% when considering agricultural emissions alone** (Menegat, 2022). The manufacturing phase accounts for about 1/3 of these emissions, due to the inherent energy-intensity of the industrial process and the still large use of fossil fuels in the production. The in-field emissions, accounting for the remaining 2/3, are mainly due to GHG-emitting microbial processes during the nitrogen cycle. The above-mentioned **nitrous oxide** is **a greenhouse gas with a global warming potential 265 times greater than that of carbon dioxide**, and its release is strongly dependent, among other factors, from the total input of nitrogen to the soil.
In addition to the energy and emissions aspects, the excess use of nitrogen fertilizers in agriculture has led to other significant issues. Over-application of nitrogen-based fertilizers results in the **leaching of nitrates into groundwater**, causing contamination that poses risks to human health and aquatic ecosystems. Runoff from agricultural fields carries these nutrients into rivers and lakes, leading to **eutrophication**, which disrupts aquatic life

by depleting oxygen levels and promoting harmful algal blooms. In this complex scenario it is evident that, although **the use of externally supplied nitrogen is indispensable to ensure a stable food production** for our growing population, it necessitates a **responsible management and a careful optimization of its efficiency in order to minimize negative impacts on the environment**. Not by chance, **the improvement of nutrient use efficiency** through sustainable farming practices and innovative solutions like biologicals **is an important element in regenerative agriculture frameworks**.

VIXERAN®: Improving the yield in a more sustainable way

The strain of nitrogen-fixing bacteria in VIXERAN® is able to colonize leaves, roots and the rhizosphere of the plant. Since it performs its function directly within the plant tissues, no nutrients are leached, lost in the soil, or volatilized.

VIXERAN® is a biofertilizer based on bacteria of the ***Azotobacter salinestris*** species, microorganisms able to naturally **convert nitrogen from the air into a form readily usable by the plant as a nutrient**. VIXERAN® in particular employs the **strain CECT 9690**, unique for its properties of plant growth promotion: it is an **endophytic strain**, meaning that it is able to **colonize and live inside the**

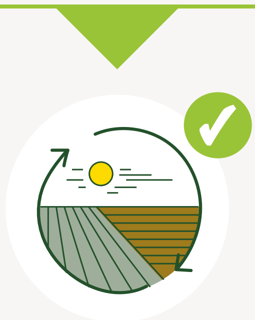


vegetation body of a plant, and it can also **attach to the surface of plant tissues** by means of surface-associated bacterial communities called biofilm. Once applied, bacteria not only colonize the **rhizosphere, the roots and leaves of the plant**, but it also transfers to new leaves after the treatment.

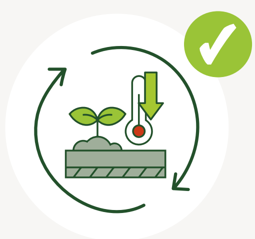
Within the plant tissues, Azotobacter is fed with the plant natural exudates and starts to process nitrogen molecules (N2) thanks to the **nitrogenase enzyme**, transforming them into ammonium ions (NH4+) that is readily absorbed by the plant. The plant-bacteria interaction is dynamic: **when crops do not require any more nitrogen, the fixed ammonium by Azotobacter is not absorbed anymore** - it is accumulated in plant tissues, deactivating Azotobacter nitrogenase temporarily.

When crops require nitrogen again, the accumulated ammonium fixed by bacteria is uptaken by the crops and the nitrogenase enzyme of Azotobacter salinestris strain CECT 9690 re-starts working.

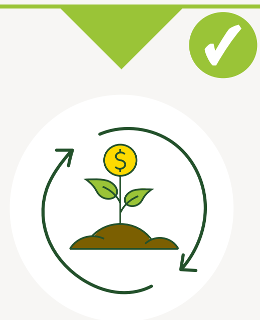
VIXERAN®, as a solution that enhances nutrients use efficiency, maximizing yield and minimizing problems related to excess use of nitrogen fertilizers, can greatly contribute to the Regenerative Agriculture outcomes linked to sustainable production increase:



Increase in the productivity of existing farmlands as it helps increase yield thanks to a beneficial microbial process that taps into a sustainable nitrogen supply



Reduction of the environmental impact of agricultural activities as it reduces the carbon footprint of the crop and the negative externalities due to excess use of fertilizers

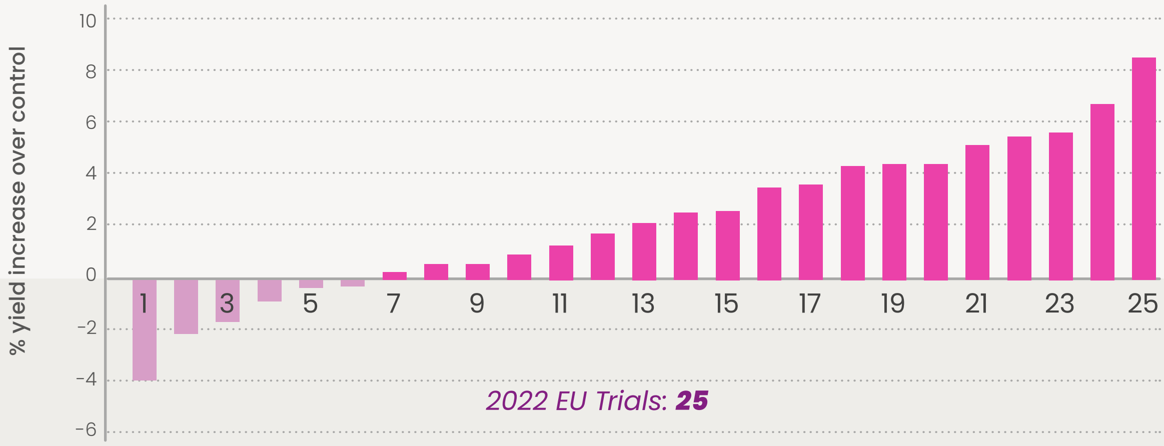


The protection of farmers' profit margins even in conditions where energy and nitrogen price fluctuations can cause a reduced availability of nitrogen inputs, Vixeran can help farmers preserve yields.

On the field

VIXERAN® complementary benefit in wheat

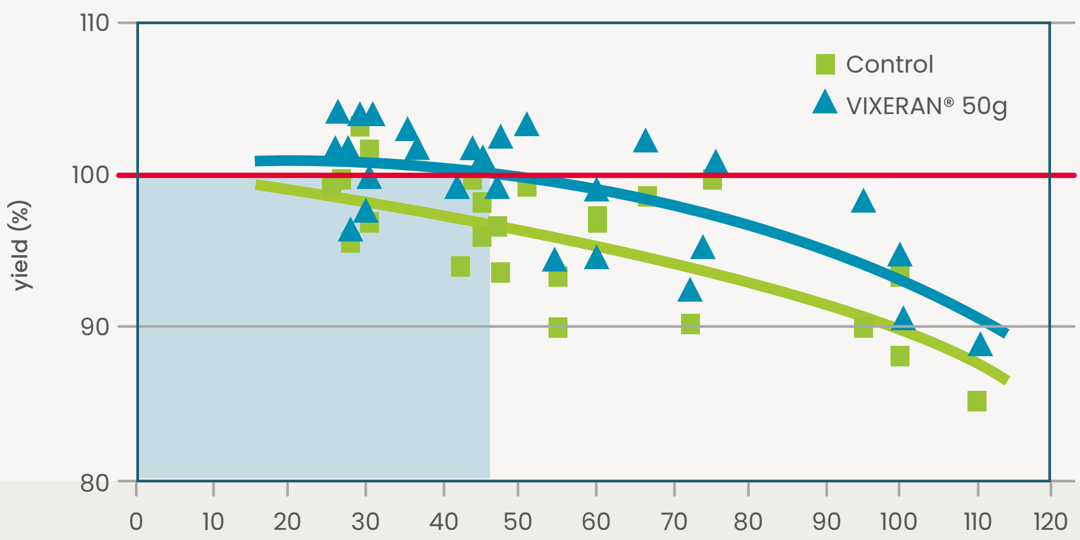
(100%fertiliser +/- VIXERAN®)



VIXERAN® complements Nitrogen inputs and allow yield increase when the crops is requiring more Nitrogen. Example of trials conducted across Europe in 2022 on Winter wheat adding VIXERAN® to the Farmer fertilization practice.

VIXERAN® complementary benefit in wheat

(Reduced N-Inputs vs 100% fertiliser)



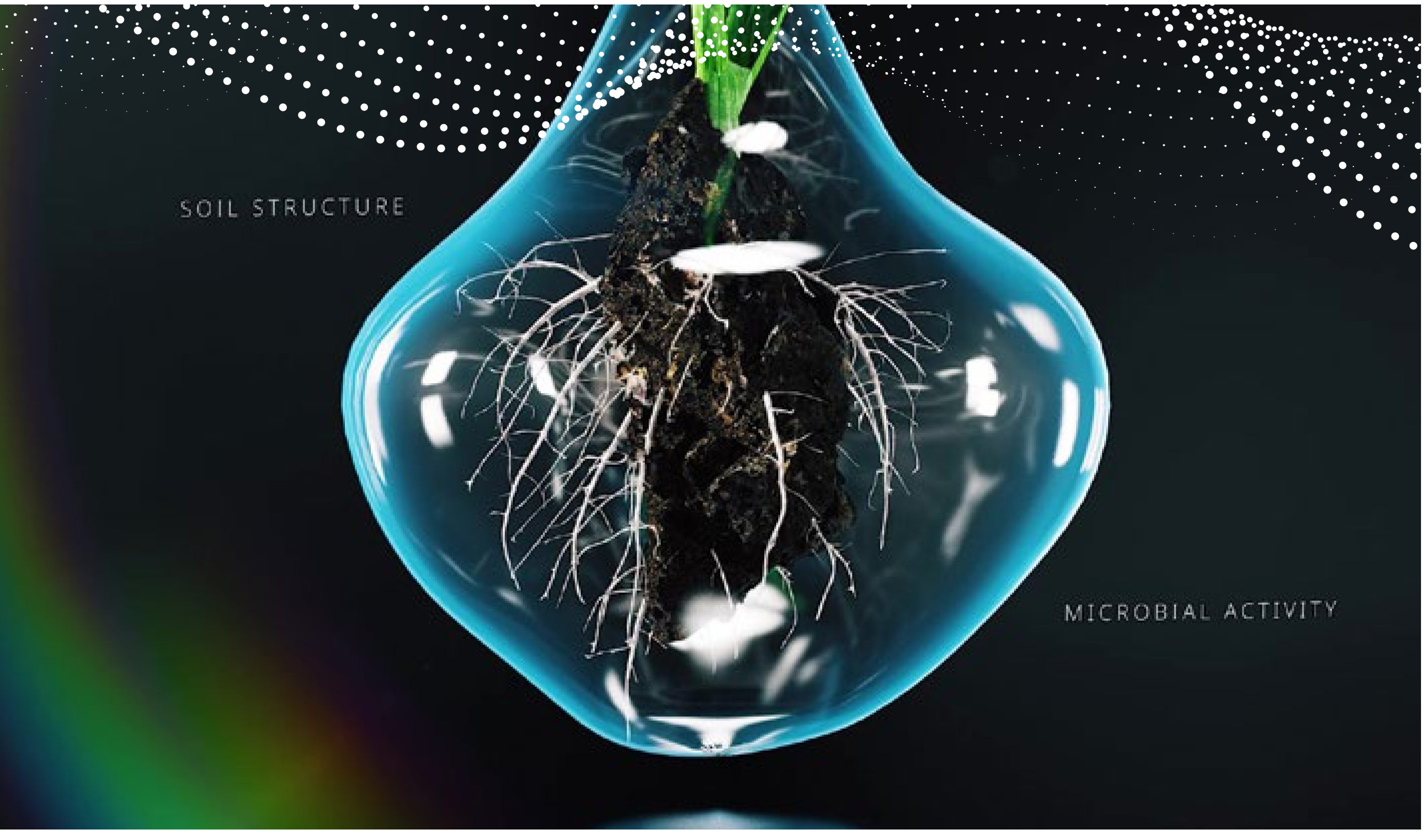
*Nitrogen reduction (kgN/ha)2022 EU Trials: **32***

VIXERAN® can also compensate the yield decrease of a reduction of Nitrogen inputs. This graph shows Nitrogen reduction on the axis on the impact on yield compare to the standard fertilization (100%) green curve. The blue curve shows the yield impact when the reduction of N inputs is associated with VIXERAN®.

Cultivating Sustainability

Sustainable practices and use of products such as biologicals are good enablers of regenerative agriculture, but this is still not enough! First and foremost, a culture of sustainability must be cultivated along the whole supply chain, leading to a deeper awareness of the issues that we are facing, their repercussions on a global scale, and what tools can be used to address them. In addition, biologicals such as VIXERAN®, although actually simple to use, require training and technical assistance for an optimal result configured on the precise needs of the customer.

For this reason, we devote ourselves to providing farmers frequent technical trainings on the use of Biologicals solutions in the framework of Regenerative Agriculture. From region to region, a special focus is put on the management of the local key crops and the main pain points for farmers, in order to close the knowledge gap that often hinders the adoption of new sustainable practices and products.
In addition, **we guarantee a system of continuous, widely distributed on-field support**, with a technical support team composed of experienced specialists in the field of Biologicals, competent in the agronomic field and, at the same time, **trusted advisors for customers from plantation to harvest**. These figures, combining excellent technical, commercial and human skills, have a strategic role in creating a link between the technology and its use, contributing to the goal of spreading Regenerative Agriculture practices, in order to create strategies that combine environmental and economic sustainability while respecting margins.



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