PREMIER TECH

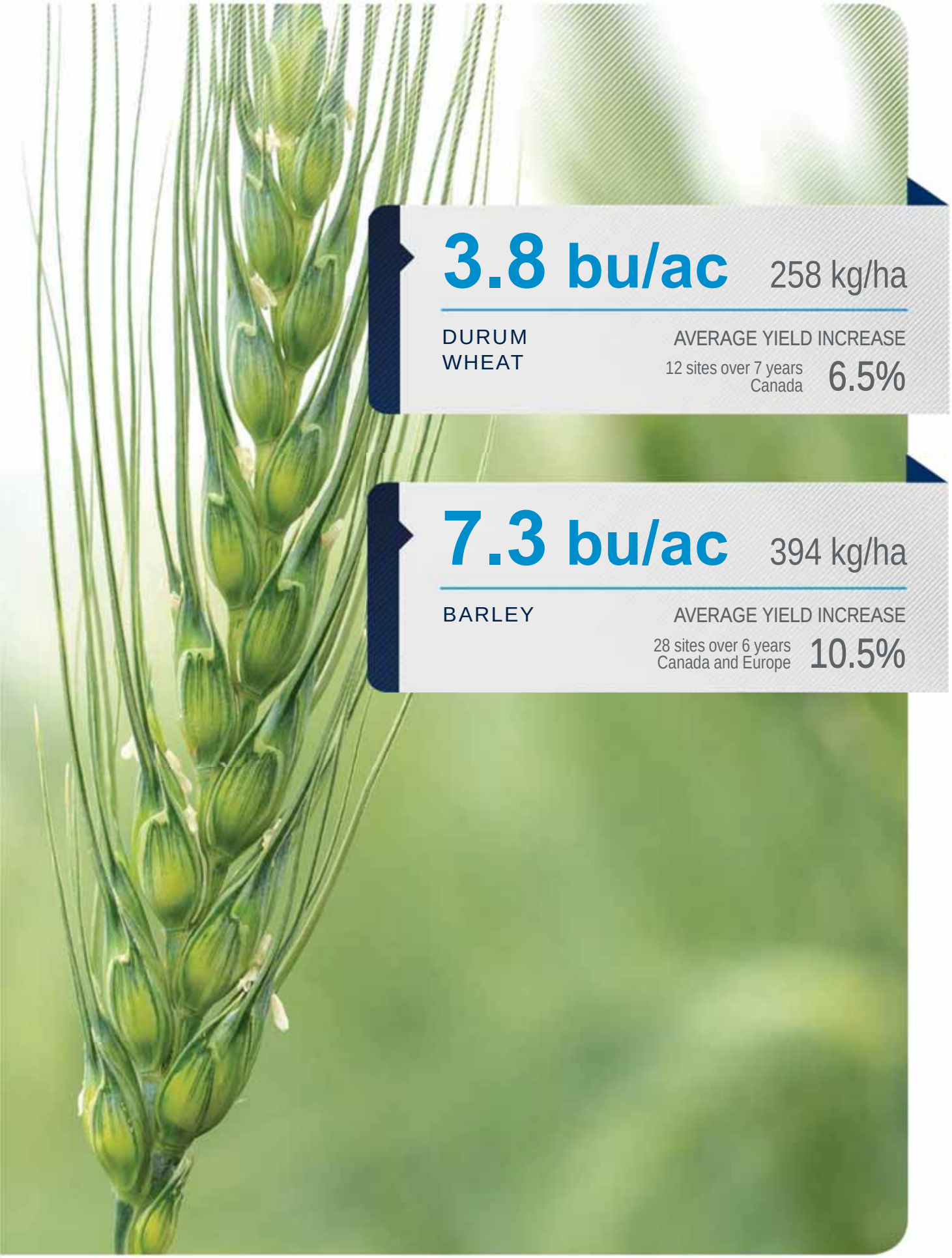
CONTENTS

2020 EDITION

PREMIER TECH

CEREALS

DURUM WHEAT & BARLEY



3.8 bu/ac 258 kg/ha

DURUM WHEAT

AVERAGE YIELD INCREASE

12 sites over 7 years
Canada

6.5%

7.3 bu/ac 394 kg/ha

BARLEY

AVERAGE YIELD INCREASE

28 sites over 6 years
Canada and Europe

10.5%

Durum wheat split field with AGTIV® vs untreated.
More uniform field, head and spikes almost all out on the right.

Young wheat plants whose root systems show better growth with AGTIV® and the plants are stronger with more leaves. Better nitrogen absorption through the more developed root system.

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SUMMARY – MYCORRHIZAL INOCULANT

► GROWER SPLIT FIELDS

Table 1. **Average yield increase with AGTIV® mycorrhizal inoculant in Canada and Europe (37 sites, 2012 to 2019).**

Number of sites	Average increase (%)
37	8.4%

Table 2. **Average yield increase with AGTIV® mycorrhizal inoculant in Western Canada (2012 to 2018).**

Number of sites	Average increase (bu/ac)	Average increase (kg/ha)	Average increase (%)
12	3.8	258	6.5%

Table 3. **Average yield increase with AGTIV® mycorrhizal inoculant in FRANCE, Europe (2014 to 2019).**

Number of sites	Average increase (bu/ac)	Average increase (kg/ha)	Average increase (%)
25	9.1	615	9.2%

EFFICACY REPORT
2019 – MYCORRHIZAL INOCULANT

DURUM WHEAT

► PLOT TRIAL

Research partner: Eurofins Agroscience Services

Research site: Beauce, France

Treatments : a) Untreated;
b) AGTIV® FIELD CROPS • Powder*.

Experimental design: 8 replicated plots per treatment in randomized complete block design

Wheat variety: Anvergur

Previous crop: Sugar beet

Seeding details: Seeded on November 15th at 300 seeds/m^2 with 15 cm row spacing.

*Products applied according to manufacturer's recommended rate.

Table 1. **Summary of wheat yield per treatment.**

Treatment	Yield[1] (bu/ac)	Yield[1] (t/ha)
Untreated	142.8 [a]	9.6 [a]
AGTIV® FIELD CROPS • Powder	155.2 [b]	10.4 [b]

[1] Yields with same letter are not statistically different following a Tukey HSD test at p≤0.05

Plot operational notes and rain fall.

- Fertilization:
  - N:P+S at 450 kg/ha (19-02-18)
  - Ammonitrate at 290 kg/ha (19-03-18)
- Pesticides:
  - Atlantis Pro (19-03-21)
  - Priori Xtra (19-04-21)
  - Bofix and Chardol (19-04-23)
  - Rubric 125 SC (19-05-15)
  - Prosaro (19-05-29)
- Harvested on July 25th 2019.

Year	Month	Precipitation (mm)
2018	November	96.7
	December	57.9
2019	January	41.2
	February	34.3
	March	77.5
	April	30.8
	May	79.2
	June	70.7
	TOTAL	**488.3**

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EFFICACY REPORT
2018 – MYCORRHIZAL INOCULANT

DURUM WHEAT

► PLOT TRIAL

Research partner: Wheatland Conservation Area

Research site: Swift Current (SK), Canada

Treatments: a) Untreated;
b) AGTIV® FIELD CROPS • Granular*.

Experimental design: 4 replicated plots per treatment in randomized complete block design

Wheat variety: Precision durum

Previous crop: Canola stubble

Seeding details: Seeded with fabro plot drill & Atomjet knife openers on May 13th 2018 at 115 lb/ac on 20 m² plots with 9 in row spacing

*Granular product applied according to manufacturer's recommended rate.

Table 1. **Summary of Wheat yields per treatment.**

Treatment	Yield (bu/ac)	Yield (kg/ha)
Untreated	12.0	806
AGTIV® FIELD CROPS • Granular	13.3	894

Plot operational notes and rain fall.

- Fertilized with
  - 58 lb/ac 21-0-0-24
  - 67 lb/ac 11-52-0
  - 111 lb/ac 46-0-0
- Pre-seeding burn off with Clean Start
- Combined on August 9th 2018.

Month	Precipitation (mm)
May	8.8
June	23.6
July	15.1
August	28.3
TOTAL	**75.8**

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EFFICACY REPORT
SUMMARY – MYCORRHIZAL INOCULANT

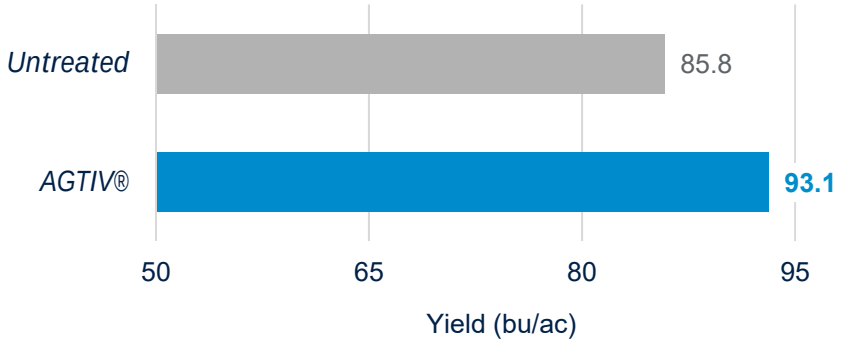
BARLEY

► GROWER SPLIT FIELDS

Table 1. **Average yield increase with AGTIV® mycorrhizal inoculant in Canada (2012 to 2016).**

Number of sites	Average increase (bu/ac)	Average increase (kg/ha)	Average increase (%)
26	7.0	377	10.6%

Figure 1. **Average yield increase with AGTIV® mycorrhizal inoculant in Canada and Europe (28 sites, 2012 to 2017).**



Barley plants have an increased root mass on the right with AGTIV®, which leads to enhanced plant health and growth.

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EFFICACY REPORT
2019 – MYCORRHIZAL INOCULANT

FIBRE FLAX

► PLOT TRIAL

Research partner: Antédis

Research site: Bourbourg, North department, France

Treatments : a) Untreated;
b) AGTIV® FIELD CROPS • Powder*.

Experimental design: 9 replicated plots per treatment in randomized complete block design

Seeding details: Seeded April 26th at 2 000 seeds/m^2 16.5 cm row spacing.

*Product applied according to manufacturer's recommended rate.

Table 1. **Summary of flax marketable yield (whole and fiber) per treatment**

Treatment	Yield [1]		Fiber yield	
	(kg/ha)	(lb/ac)	(kg/ha)	(lb/ac)
Untreated	5490 [a]	4898 [a]	730 [a]	651 [a]
AGTIV® FIELD CROPS • Powder	6390 [b]	5701 [b]	856 [b]	764 [b]

[1] Yields followed by different letters are significantly different (Tukey's test HSD at p≤0.05).

Plot operational notes and rain fall

- Pesticides:
  - Patton M (19-04-26)
  - Lontrel + Oil (19-05-22)
  - Nissodium (19-05-31)
- Harvested October 15th, 2019.

Month	Precipitations (mm)
April	3.8
May	47
June	66.6
July	33.2
August	25.4
September	69.6
October	60.6
TOTAL	**306.2**

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PREMIER TECH

Making a difference, this is what we are all about at Premier Tech. One team driven by a shared passion to deliver solutions that will better the lives of people, businesses and communities.

At Premier Tech, People and Technologies connect in lasting, transformative ways, giving life to products and services that help feed, protect and improve our world.

We are committed to creating sustainable solutions that help bring beautiful gardens to life, increase crop yields, improve the efficiency of manufacturing facilities, treat and recycle water, and much more as we keep innovating.

We are Premier Tech

PEOPLE AND TECHNOLOGIES
MAKING A DIFFERENCE

95 years OF PASSION

DRIVING CHANGES TO MAKE A DIFFERENCE

IN 5 BUSINESSES

OUR BRANDS

AGTIV

PROMIX wilson

C-I-L ALASKAN

CHRONOS

Ecoflo®

Ecoprocess™

OUR DESIRE TO INNOVATE IS DRIVEN BY THE TECHNOLOGIES WE MASTER

At Premier Tech, innovation is in everything we do. Every day, we invest the time and energy necessary to master the science and technology behind the products we offer. This knowledge allows us to connect our technologies with real market needs, creating products that are relevant today — and for years to come.

Here, we not only seek to create new products, we redefine the very process of innovation to deliver upon our ambitions. It's no longer only about delivering transformative solutions, it's about pushing our technologies forward to bring meaningful solutions to life. Ones that can truly make a difference for our clients.

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INNOVATION

AN INTEGRAL PART OF PREMIER TECH COLLECTIVE DNA

At Premier Tech, Innovation goes beyond the concept of research and development. More than a process leading to the creation of new products, it is a **state of mind that is strongly embedded in our corporate DNA**. Always seeking to **create unique and addictive experiences** for our clients, we simply never cease to push the boundaries of our abilities, competencies and technological platforms.

Creativity is a mix of knowledge, expertise and passion for unprecedented efficient solutions. Innovation, Research & Development and biological active ingredients have combined forces to put commercial offers to the agricultural market.

We first structured our Innovation efforts and approach back in 1983, driven by the ambition of developing value-added products derived from peat moss through technological advances. Today, **more than 260 Premier Tech team members** are devoted full-time to mastering the technologies behind the next leading-edge solutions that will make a difference to our clients, helping them stand out in their marketplaces.

Driven by a collective Culture and rooted in Values which revolve around our tradition of Innovation, the entire Premier Tech team holds a restless ambition to shake up the status quo and shift industry paradigms. Through the current innovation program IPSO: Innovation in Products-Processes, Services and commercial Offers, we are **constantly challenging the way we do business and how we can improve everything we do**.

This mindset is key to how we operate on a daily basis. Contributing to the loyalty of our clients around the world, it sets the ground rules for how collaborating with Premier Tech turns out to be a contagious experience they are willing to share with others.

We deeply believe that in order to continue to be sustainable and grow our market share, it is essential to never let our innovative spirit rest — to keep pushing forward and eliminate any barriers on the path to bringing new technologies, products and services to life in the marketplace. With the agility to truly make a difference by tapping into our full potential, **we make a difference for our clients' profitability**, and ultimately ensure our continued relevance as a strategic partner.

CELEBRATING DECADES OF

35 years OF EXPERTISE IN ACTIVE INGREDIENTS

Established manufacturer and marketer, Premier Tech builds on innovation and collaboration with local partners and growers to offer reliable high-quality inoculants. Every day, in our labs, facilities, and in the field, highly experienced scientists, engineers, and specialists from various domains collaborate to maximize the outcomes of research and turn them into effective products making a difference on your bottom line.

PRODUCTION

In 2000, Premier Tech set up a world-first endomycorrhizal inoculum plant, developing a new mycoreactor process for industrial scale production. Backed by more than 35 years of expertise in active ingredients, Premier Tech constantly develops and innovates in terms of production of mycorrhizae, rhizobium and other active ingredients:

- ☑ No contamination through a strictly controlled and aseptic environment
- ☑ Large-scale manufacturing production
- ☑ Adapted quality control for each step of the production processes, ensuring consistent high-quality inoculum

PTAGTIV.COM/en/expertise

INNOVATION AND VALUE

FORMULATION

Premier Tech's know-how makes it possible to adapt formulations with multiple active ingredients, concentrations and carriers tailored to different crops and application methods. Because a quality inoculant makes all the difference, our proven formulations are based on these important elements:

- Carrier compatible with the active ingredients
- Formulations that guarantee active ingredient viability until use
- Quality control at several key points ensuring the performance of active ingredients
- Various formulations also tailored for organic production

APPLICATION

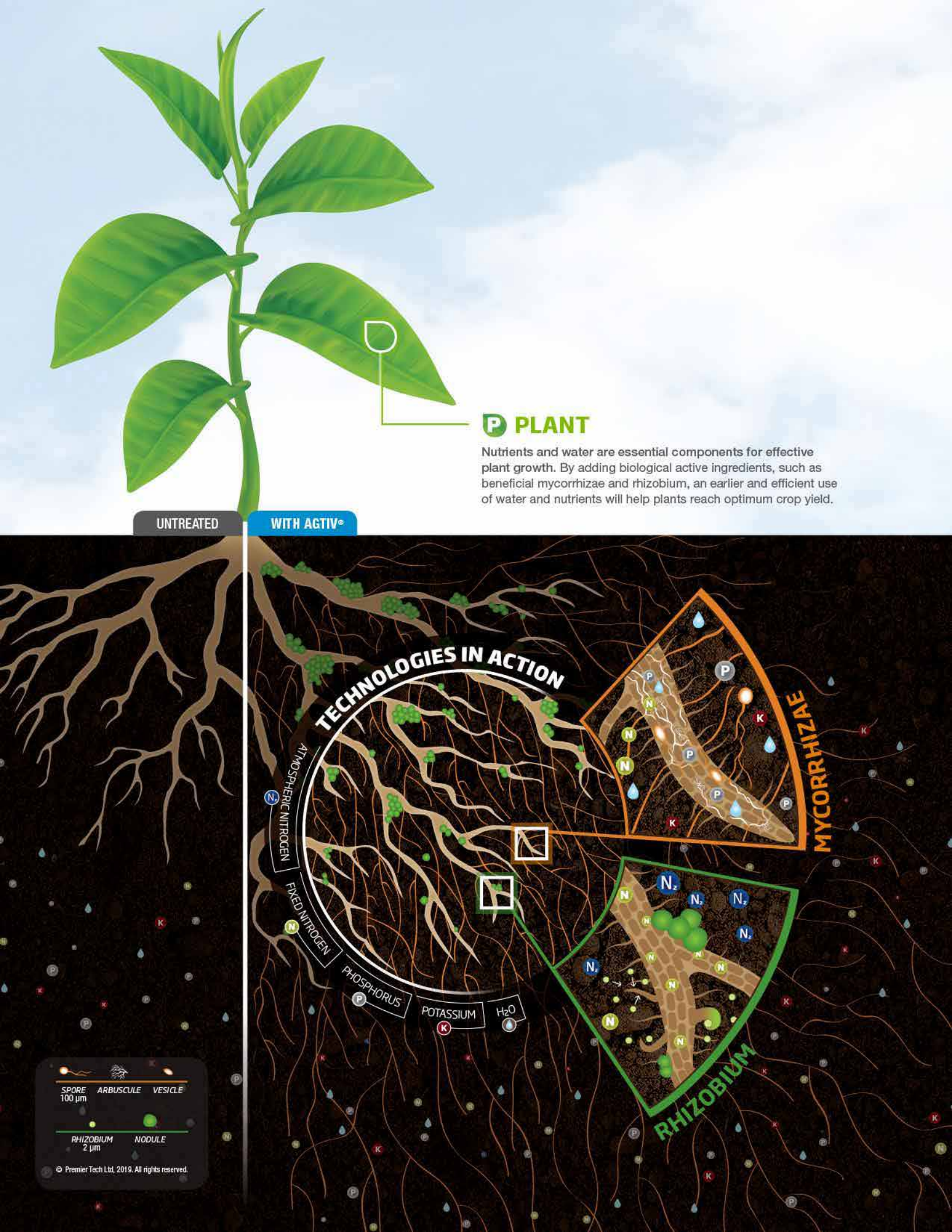
Caring about our clients' performance, each recommendation for product use takes into consideration validation by our field experts and by farmers themselves, which ensures:

- Effective application rates, at the right time and place, with the right inoculant
- Products adapted to growers' equipment
- Easy integration into farming practices
- Validation of compatibility with other agricultural inputs

SERVICE

The AGTIV® experience combines highly effective value-added products and the access to a team of field experts dedicated to supporting your growth. From our management team and research project managers to our field specialists, our multidisciplinary team is listening to growers' needs to continuously improve our products and level of service:

- Technical support for product application, equipment compatibility and field demonstration
- Proud promoter of science education and knowledge sharing
- Partnership with agriculture retailers throughout Canada, the United States and Europe


PLANT
Nutrients and water are essential components for effective plant growth. By adding biological active ingredients, such as beneficial mycorrhizae and rhizobium, an earlier and efficient use of water and nutrients will help plants reach optimum crop yield.
UNTREATED
WITH AGTIV®
TECHNOLOGIES IN ACTION
ATMOSPHERIC NITROGEN
FIXED NITROGEN
PHOSPHORUS
POTASSIUM
H2O
MYCORRHIZAE
RHIZOBIUM
SPORE
100 µm
ARBUSCULE
VESICLE
RHIZOBIUM
2 µm
NODULE
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BIOLOGICAL ACTIVE INGREDIENTS

Backed by more than 35 years of expertise in biological active ingredients, Premier Tech masters a unique large-scale manufacturing process that meets the highest quality control standards, allowing you to fully benefit from the highly effective inoculants of our AGTIV® agricultural product line. For stronger growth through better plant resistance to stresses, **higher yields** and superior **crop quality**, you can count on AGTIV®.

M MYCORRHIZAE

PTB297 Technology, *Glomus intraradices*

Mycorrhizae are beneficial associations between a mycorrhizal fungus and roots. The mycorrhizal spores germinate in the soil and produce filaments (hyphae) which will enter into root cells. This association will allow the formation of an intra and extra-radical network of filaments that will explore the soil and access more nutrients and water, and transfer them to the plant.

- EXPAND ROOT SYSTEM GROWTH
- ENHANCE NUTRIENT & WATER UPTAKE
- INCREASE TOLERANCE TO STRESSES
- IMPROVE SOIL STRUCTURE

+ R RHIZOBIUM

PTB160 Technology (pulses), *Rhizobium leguminosarum* biovar *viciae*

PTB162 Technology (soybean), *Bradyrhizobium japonicum*

Mesorhizobium ciceri (chickpea)

Rhizobium bacteria live and thrive in symbiosis in root nodules produced by the plant. They are responsible for fixing the atmospheric nitrogen and making it available for the plant.

- FIX NITROGEN & MAKE IT AVAILABLE TO THE PLANT

= TRIPARTITE SYMBIOSIS

Tripartite symbiosis is the biological interaction between Mycorrhizae, Rhizobium and the Plant.

By enhancing root system growth and creating a network of filaments, mycorrhizae help plants to uptake more nutrients, such as phosphorus, and increase the nodulation process for the rhizobium.

- INCREASE PROPAGATION OF RHIZOBIUM TO OTHER ROOTS
- HELP FEED THE PLANT
- ENHANCE PHOTOSYNTHESIS

To learn more about the tripartite symbiosis

PTAGTIV.COM/**en/tripartite**

MYCORRHIZAE
EFFICACY – VERSATILITY – COLLABORATION

Why use Premier Tech's mycorrhizae?

Mycorrhizal fungi have existed since the first plants appeared on dry land more than 450 million years ago. AM (Arbuscular Mycorrhizae) symbiosis applies to over 80% of all plants and plays a major role in plant nutrition and productivity. "Over the last 35 years, numerous scientific studies have clearly highlighted the fundamental role that mycorrhizal fungi play in natural eco-systems, and in those managed by man." [A]

How does the technology work? Mycorrhizae develop a network that explores the soil and accesses more nutrients and water to transfer to the plant. The beneficial alliance between mycorrhizal fungi and roots accelerates root development and stimulates plant growth.

Absorption capacity

Premier Tech's mycorrhizal technology makes P more available in the soil, and actively absorbs and transfers it via its filament network (hyphae) directly to the root. The filaments in the soil also have the ability to absorb water and elements such as Cu, Zn, B, Fe, Mn which are important in nodule formation and grain filling.

Mycorrhizae have been shown to improve soil structure by releasing a "biological glue" called glomalin and to increase the presence of other beneficial micro-organisms in the root environment.

"Although mycorrhizal fungi do not fix nitrogen, they transfer energy, in the form of liquid carbon to associative nitrogen fixers." [B]

"Mycorrhiza deliver sunlight energy packaged as liquid carbon to a vast array of soil microbes involved in plant nutrition and disease suppression." [C]

"The absorptive area of mycorrhizal hyphae is approximately 10 times more efficient than that of root hairs and about 100 times more efficient than that of roots." [D]

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Efficient P uptake and transfer

Thonar et al. (2010)[E] compared three species of AMF and observed "*Glomus intraradices*, *Glomus claroideum* and *Gigaspora margarita* were able to take up and deliver P to the plants from maximal distances of 10, 6 and 1 cm from the roots, respectively. *Glomus intraradices* most rapidly colonized the available substrate and transported significant amounts of P towards the roots."

Cavagnaro et al. (2005)[F] found that "*Glomus intraradices* was found to be one of the arbuscular mycorrhizal fungi that was able to control nutrient uptake amounts by individual hyphae depending on differing phosphorus levels in the surrounding soils."

Collaborating Species

The mycorrhizal species used in Premier Tech products (*Glomus intraradices*) is among the most 'collaborative' species in various articles.

"According to the article by Kiers et al. (2011)[G], it has been shown that the different species of mycorrhizae are not equally effective when it comes to transferring nutrients from the soil to the plant. Under controlled conditions, certain species of mycorrhizae have been shown to be more 'cooperative' and to transfer most of the phosphorus absorbed from the soil to the root, while other mycorrhizae species use it or store it as reserve.

"[…] Moreover, when host plants were colonized with three AM fungal species, the RNA of the cooperative species (*G. intraradices*) was again significantly more present than that of the two less-cooperative species (*G. aggregatum* and *G. custos*)" [B]. "This illustrates key differences in fungal strategies, with *G. intraradices* being a 'collaborator' and *G. aggregatum* a less-cooperative 'hoarder'." [G]

Glomus intraradices' versatility in different conditions

There are more than 200 species of AMF (Arbuscular Mycorrhizae Fungi) and Premier Tech offers a versatile species. Selected more than 35 years ago, it has been tested continuously under various conditions and has performed well in a range of soil pH from 5.2 to 8.1.

"*G. intraradices* has turned out to be a "great fungus" in several surveys, and field trials so far has shown it to be equal or superior to mixtures of other fungi." [H]

Indigenous Populations

Some articles demonstrate that mycorrhizal populations in agricultural soils are highly heterogeneous or not sufficient to have the desired beneficial effect.

A survey conducted by Hamel et al. (2008)[I] reported low biodiversity and occurrence of AM fungi in cultivated soils of Saskatchewan. The survey was conducted for 3 years. Dai, M. et al. (2013)[J] noticed that the relative abundance as well as diversity of AM fungal communities is lower in cropland soils of the prairies compared to the roadsides environments which favors diversity.

The recommendation of Premier Tech, approved by Agriculture Canada, to add a mycorrhizal inoculant at the time of seeding stands on 4 points:

- ✓ **The right mycorrhizae for the plant**
  at least 80% of plants can be colonized with *Glomus intraradices*, a collaborative species
- ✓ **Available in the right place**
  on or close to the seed in order to trigger the symbiosis quickly
- ✓ **In the right quantity**
  the proven and registered mycorrhizal rate
- ✓ **At the right time**
  at seeding time to trigger the symbiosis quickly after seed germination

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Quick colonizer

It has been shown that plants favour certain species according to their effectiveness.

"We show that order of arrival can influence the abundance of AMF species colonizing a host. These priority effect can have important implications for AMF ecology and the use of fungal inoculant in sustainable agriculture." [K]

Duan et al. (2011)[L] using our *Glomus intraradices* isolate (DAOM181602) with *G. margarita* (WFVAM 21), wrote "Furthermore, *G. margarita* developed slowly compared with G. intraradices when they were inoculated separately and it seems likely that the latter fungus dominated the symbiosis with medic when both fungi were inoculated together." He adds "The positive effect of *G. intraradices* was probably enhanced by its ability to colonize quickly and it may well have contributed a much larger fraction of fungal biomass than *G. margarita*, when both were inoculated together". In conclusion, he writes "When inoculated together *G. intraradices* may have dominated the activity of symbiosis, both in terms of rapidity of early colonization and functionality, including tolerance to disturbance."

Drought resistance

Mycorrhizae increase tolerance to various environmental stresses (diseases, drought, compaction, salinity, etc.), and play a major role in the soil particle aggregation process and contribute to improving soil structure which leads to better water penetration, better aeration, less erosion and leaching.

Benjamin Jayne and Martin Quigley of the University of Denver mentioned that "[…] our meta-analysis reveals a quantifiable corroboration of the commonly held view that, under water-deficit conditions, plants colonized by mycorrhizal fungi have better growth and reproductive response than those that are not." [K] "Most measures of growth are augmented by the symbiosis when plants are subjected to water stress; […]." [M]

It has been found that plants with AMF association display greater hydraulic conductivity in roots and reduced transpiration rate under drought stress. This may be due to their capacity to regulate their ABA levels (abscisic acid – a plant hormone) better and faster than non-AM plants. This establishes a greater balance between leaf transpiration and root water movement in drought situations and drought recovery.[N]

A. Fortin J. A, 2009. Mycorrhizae The new green revolution. Ed. MultiMondes. pp.140.
B. Jones, C. E. 2009. Mycorrhizal fungi -powerhouse of the soil. Evergreen Farming 8:4-5.
C. Jones, C. E. 2014. Nitrogen: the double-edge sword. Amazing Carbon. pp. 8.
D. Jones, C. E. 2009. *loc. cit.*
E. Thonar, C. et al. 2011. Traits related to differences in function among three arbuscular mycorrhizal fungi. Plant Soil. 339: 231 – 245.
F. Cavagnaro, T et al. 2005. Functional diversity in arbuscular mycorrhizas: exploitation of soil patches with different phosphate enrichment differs among fungal species. Plant, Cell and Environment 28: 642 – 650.
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M. Jayne B., Quigley M. 2013. Influence of arbuscular mycorrhiza on growth and reproductive response of plants under water deficit: a meta-analysis. Mycorrhiza 2014. 24:109-119.
N. Aroca et al. 2008. Mycorrhizal and non-mycorrhizal Lactuca sativa plants exhibit contrasting responses to exogenous ABA during drought stress and recovery. Journal of Experimental Botany, Vol. 59, No. 8, pp. 2029-2041. In: Raviv M. 2010. The use of mycorrhiza in organically-grown crops under semi arid conditions: a review of benefits, constraints and future challenges. Symbiosis 2010. 52-65-74.

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RHIZOBIUM

FERTILITY – PRODUCTIVITY – COLLABORATION

Why is rhizobium important?

Peas, lentils and soybeans play a big role in a crop rotation by promoting nitrogen fixation (the conversion of nitrogen gas to plant-available ammonium) and returning some nitrogen to the soil. However, these crops can't take all the credit: because it's only possible thanks to a symbiotic relationship between select legumes and rhizobium bacteria.

These bacteria can't fix nitrogen on their own. To do so, they need to colonize the root of a host plant. As in all symbiotic relationships, both the rhizobium and the pulse or soybean plant get something of value from the relationship. For the legume, it is a readily available form of nitrogen (ammonium) as well as important amino acids. The rhizobium get three things in return:

1. **A Home** – the bacteria inhabit the nodules formed by the plant
2. **Food / energy** – provided in the form carbohydrates (heterotrophic bacteria cannot create their own food through photosynthesis)
3. **Oxygen** – which is necessary for respiration

Roots of the rhizobium relationship

Approximately 20%[A] of all legumes form mutualistic relationships with rhizobium. Soybean, peas, clover, lentils and faba beans are among them. Interestingly, Rhizobium species are very plant specific. Pulses form relationships with a rhizobium called *Rhizobium leguminosarum*, while soybeans engage with another member of the family called *Bradyrhizobium japonicum*.

When a rhizobium and a host legume are present, the plant makes the rhizobium aware of its presence by sending out a chemical signal (via flavonoids and isoflavonoids) from the root. This attracts the rhizobium bacteria, which responds by sending out signals of its own, known as Nod factors.[B]

How does the technology work? Rhizobium are a bacteria that live and thrive in symbiosis in root nodules produced by the plant. These nodules house the bacteria responsible for fixing the atmospheric nitrogen and makes it available for the plant.

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Nodule formation & nitrogen fixation

The bacteria start the "invasion process" by penetrating the root-hair wall and enter the plant cells. This primes a gene within the plant that initiates the root nodulation. Within these nodules, the rhizobium differentiate into a non-motile form, which go to work fixing the raw atmospheric nitrogen (N_2) into plant accessible ammonium. They achieve this by producing nitrogenase enzyme, which starts the conversion process, consuming a great deal of energy. Maximum N-fixation is reached when the plant is sufficiently nodulated.

Ammonium absorption / exchange of services

After the nodule formation, the plant converts the ammonium into amino acids which are exported throughout the plant. At this point, the plant releases the simple sugars and O_2 to the rhizobium bacteria, fulfilling its end of the bargain.

This last step is important, as the presence of free oxygen can stop nitrogen fixation, preventing ammonium (NH_3) synthesis and transfer to the plant. Fortunately, the rhizobium take the oxygen and bind it using a protein called leghemoglobin (was first discovered in legumes and is very similar to the hemoglobin found in human blood). Like blood, leghemoglobins appear red in the nodules, due to the presence of iron molecules.

Legume plants are known to have a lower phosphorus use efficiency. This is a problem, because the process of nitrogen fixation is very energy-intensive for pulse and soybean plants. For this reason, they consume more phosphorus (P) than other plants.

The increased demand can be alleviated thanks to another symbiotic association, the mycorrhizal symbiosis. Mycorrhizae are symbiotic fungi that colonize the roots of most plants, and dramatically improve the plant's ability to absorb phosphorus. The plant will photosynthesize 51%[C] more and grow faster, and the rhizobium will fix more nitrogen if more phosphorus is available. For this reason, having a healthy mycorrhizal association is of particular benefit to pulses and soybeans.

What modulates / influences nodulation?

- Successful infection depends on the competitiveness, specificity, infectivity and effectiveness of the rhizobia.[D]
- Infection rate & effectiveness of rhizobia are influenced by soil low N status and is a necessary requisite to trigger symbiosis.[E]
- Successful infection requires the bacteria to actively colonize root-hair tips (motility) and reach the Quorum sensing of the rhizobium.[F]
- N fixation relies on a cascade of effector molecules – events in multi-steps series of reactions and depend on effector availability, concentration and localization, synchronization, host specificity and environmental factors.

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PREMIER TECH

THE TRIPARTITE SYMBIOSIS
HELPS YOU GET BIGGER YIELD

How can the tripartite symbiosis improve crop productivity?

Each phase of the plant growth requires a lot of nutrients and energy to obtain higher yield. *"* […] *the tripartite interactions between legumes, AMF* [Arbuscular Mycorrhizal Fungi] *and rhizobia cause increases in legume productivity, and the N:P:C supply ratio as influenced by the tripartite symbiotic associations plays a fundamental role in controlling the legume's photosynthetic rate and biomass productivity."* [A]

How do the technologies work? Mycorrhizae develop a network that explores the soil and accesses more nutrients and water to transfer to the plant; rhizobium fixes nitrogen and makes it available to the plant. By working together, they influence positively the plant for increased yield.

Help feed the plant

N and P are major nutrients for the plant. *"Tripartite associations of host plants with both rhizobia and AMF* [Arbuscular Mycorrhizal Fungi] *benefit the host plant by increased P uptake through the mycorrhizal association balancing the high input of N through rhizobial N-fixation."* [A] In addition, mycorrhizae reach more water and nutrients needed by legumes such as B, Ca, Cu, Fe, K, Mn, Mo and Zn, key components for energy production.

Higher photosynthesis

When used in combination, mycorrhizae and rhizobium increase the photosynthetic rate by 51%[B]. *"The rate of photosynthesis increased substantially more than the C* [Carbon] *costs of the rhizobial and AM* [Arbuscular Mycorrhizal] *symbioses."* [B] The total increased sugar production by the plant far outweighs the cost to "house" the partners.

Better productivity

Better nutrient use efficiency and bigger biomass result in higher yield from each legume plant (harvest index). For example, *"*[…] *it has been found that pea plants coinoculated with Rhizobium leguminosarum and AMF* [Arbuscular Mycorrhizal Fungi] *has shown best results regarding plant height, plant dry mass, nodule fresh weight, number of seeds, seed weight, seed yield, number of root nodules, number of pods per plant, average pod weight and pod length* […]*".* [C]

PTAGTIV.COM/en/tripartite

A Koele et al. 2014. VFRC Report 2014/1, pp. 1-57.
B Kaschuk et al. 2009. Soil Biol. Biochem. 41:1233-1244.
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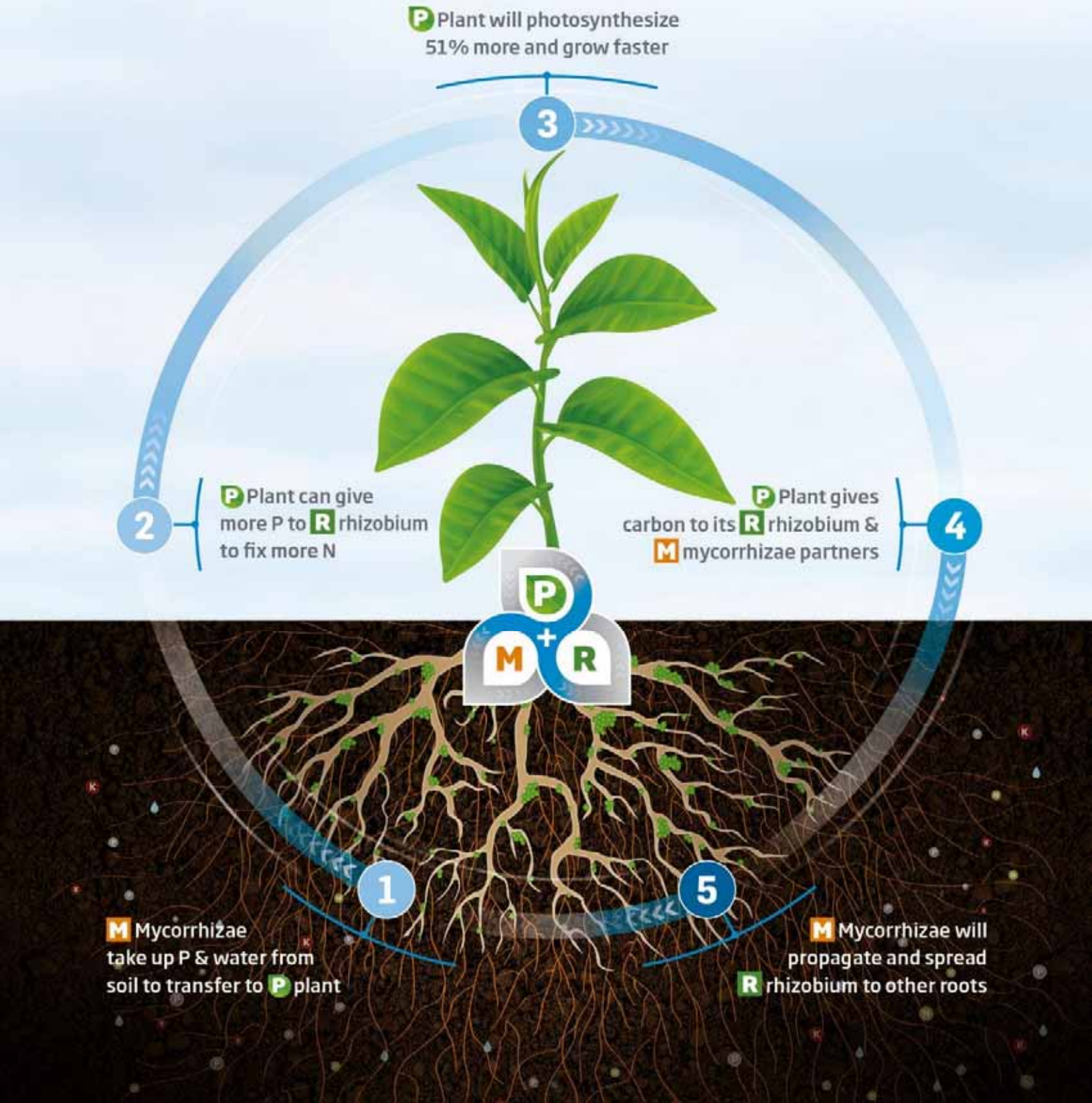
PREMIER TECH

TRIPARTITE SYMBIOSIS

BIOLOGICAL INTERACTIONS BETWEEN MYCORRHIZAE, RHIZOBIUM AND PLANTS

By enhancing root system growth and creating a network of filaments, mycorrhizae help plants to uptake more nutrients, such as phosphorus, and increase the nodulation process for the rhizobium.



THE CANOLA ROTATION INOCULANT

HELPS YOU COUNTER REDUCED YIELD AFTER CANOLA

What affects your soil biology?

Many crop practices (tillage, fallow land, flooding and crop rotation) contribute to decreasing the beneficial biology, such as mycorrhizal fungi population, in your agricultural soils. For example, it is well known that crops following *Brassicaceae* plants (canola and mustard), in a rotation generally tend to demonstrate reduced yield, compared to results when seeded after another crop. It can largely be explained by the relationship (or lack of relationship) between *Brassicaceae* and beneficial microorganisms, such as mycorrhizae[A]. Canola roots exude a toxic compound that reduces populations of those beneficial microorganisms in the soil. Furthermore, the "absence of a mycorrhizal host plant during the fallow period decreases mycorrhizal colonization potential for the succeeding crop and results in P deficiency symptoms in plants that are mycorrhizal dependent, such as corn, soybean, sunflower, and cotton." [B]

A. Gavito, M. E., Miller M. H., 1998. Changes in mycorrhizal development in maize induced by crop management practices. Plant Soil. 198: 185-192.
B. Ellis, J. R., 1998. Plant Nutrition. Post Flood Syndrome and Vesicular-Arbuscular Mycorrhizal Fungi. J. Prod. Agric., Vol. 11, no.2: 200-204.
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D. Jones, C. E. 2009. Mycorrhizal fungi - powerhouse of the soil. Evergreen Farming 8:4-5.
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Reach more nutrients and water

Sufficient nutrient and water uptake is critical for effective plant growth and ultimately to maximize your yield potential, especially for low mobility nutrients such as P and Zn.[C] By adding a mycorrhizal inoculant, the plant develops a secondary root system (mycorrhizal hyphae) allowing it a larger soil contact surface and thus better to access to nutrients and water. "The absorptive area of mycorrhizal hyphae is approximately 10 times more efficient than that of root hairs and about 100 times more efficient than that of roots." [D]

Ensure early P uptake

"Phosphorus plays a critical role in energy reactions in the plant [such as photosynthesis. Phosphorus is also a key component in building blocs for plant.] Deficits can influence essentially all energy requiring processes in plant metabolism. Phosphorus stress early in the growing season can restrict crop growth, which can carry through to reduce final crop yield." [E] Mycorrhizae make soil phosphorus (P) more available to the plant, and actively absorb and transfer it via the mycorrhizal filament network (hyphae) directly to the root.

Increase your yield potential

By introducing mycorrhizal inoculant close to the seed at seeding, you get the association working early with the full benefits of increased nutrient and water uptake when plants need them. Therefore, get more out of the fertilizer you have already invested into the crop.

PTAGTIV.COM/en/canola

PREMIER TECH

AGTIV® highly effective inoculants make a difference in the field by pushing crops' yield potential and increasing growers' net returns. Lead the way with Premier Tech's expertise for AGTIVated acres.

MYCORRHIZAE & RHIZOBIUM INOCULANTS

► Visit our website for product availability according to the territory and their eligibility for organic use : PTAGTIV.COM/**en/products**.

	ACTIVE INGREDIENT		ORGANIC	APPLICATION MODE: GRANULAR IN-FURROW	APPLICATION MODE: MIXING WITH SEEDS	APPLICATION MODE: LIQUID IN-FURROW	FORMULATION
PULSES (peas, lentils & faba beans)							
AGTIV® PULSES • Powder **F:** Powder (peat) **S:** 4.7 kg (10.3 lb) pail **C:** Peas & faba beans: **16 ha (40 acres)** – Lentils: **24 ha (60 acres)**	M	R	✓		●		
AGTIV® PULSES • Granular **F:** Granules (peat) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Peas, lentils & faba beans: Bag: **4 ha (10 acres)** – Tote bag: **80 ha (200 acres)**	M	R	✓	●			
AGTIV® RHIZO • Granular for PULSES **F:** Granules (peat) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Peas, lentils & faba beans: Bag: **4 ha (10 acres)** – Tote bag: **80 ha (200 acres)**		R	*	●			
N **AGTIV® RHIZO** • Liquid for PULSES **F:** Liquid **S:** 8 L (8 kg) bag-in-box **C:** Peas, lentils & faba beans: **32 ha (80 acres)**	C	R	✓			●	
SOYBEAN							
AGTIV® SOYBEAN • Powder **F:** Powder (peat) **S:** 4.7 kg (10.3 lb) pail **C:** Soybean: **16 ha (40 acres)**	M	R	✓		●		
AGTIV® SOYBEAN • Granular **F:** Granules (peat) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Soybean: Bag: **3.2 ha (8 acres)** – Tote bag: **64 ha (160 acres)**	M	R	*	●			
AGTIV® BRADY • Granular for SOYBEAN **F:** Granules (peat) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Soybean: Bag: **4 ha (10 acres)** – Tote bag: **80 ha (200 acres)**		R	*	●			
N **AGTIV® BRADY** • Liquid for SOYBEAN **F:** Liquid **S:** 11 L (11 kg) bag-in-box **C:** Soybean: **16 ha (40 acres)**	C	R	✓			●	
CHICKPEA							
AGTIV® CHICKPEA • Granular **F:** Granules (peat) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Chickpea: Bag: **3.2 ha (8 acres)** – Tote bag: **64 ha (160 acres)**	M	R	✓	●			
FORAGES							
AGTIV® FORAGES • Powder **F:** Powder (diatomaceous earth) **S:** 1.6 kg (3.5 lb) pail **C:** Alfalfa, mix forages & grass: **8 ha (20 acres)**	M		*		●		

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	ACTIVE INGREDIENT		ORGANIC	APPLICATION MODE							FORMULATION
				IN-FURROW	SEED-PIECE TREATMENT AT THE WAREHOUSE	MIXING WITH SEEDS	INCORPORATION INTO GROWING MEDIA	TRANSPLANTING	SEED TREATMENT		
FIELD CROPS (cereals, flax & dry beans)											
AGTIV® FIELD CROPS – ○ • Powder **F:** Powder (peat) **S:** Case of 4 x 800 g (4 x 1.75 lb) pails **C:** Cereals, flax & dry beans: **32 ha (80 acres)** per case Alfalfa, mix forages & grass: **16 ha (40 acres)** per case	M		✓			●					
AGTIV® FIELD CROPS • Powder **F:** Powder (diatomaceous earth) **S:** 2 kg (4.4 lb) pail **C:** Cereals, flax & dry beans: **16 ha (40 acres)**	M		*			●					
AGTIV® FIELD CROPS • Granular **F:** Granules (zeolite) **S:** 18.2 kg (40 lb) bag – 364 kg (800 lb) tote bag **C:** Cereals, flax & dry beans: Bag: **3.2 ha (8 acres)** – Tote bag: **64 ha (160 acres)**	M		✓	●							
AGTIV® FIELD CROPS • Liquid **F:** Liquid (spores in suspension) **S:** Case of 2 x 950 ml (2 x 32 fl. oz) bottles **C:** Cereals, flax, beans & pulses: **16 ha (40 acres)** per case	M	C	✓	●							
POTATO											
AGTIV® POTATO • Liquid **F:** Liquid (spores in suspension) **S:** Case of 2 x 950 ml (2 x 32 fl. oz) bottles **C:** Potato: **8 ha (20 acres)** per case	M		✓	●	●						
GREEN PEAS											
AGTIV® SPECIALTY CROPS – PEA • Powder **F:** Powder (peat) **S:** 2.4 kg (5.3 lb) pail **C:** Green peas: **8 ha (20 acres)**	M	R	✓			●					
SPECIALTY CROPS											
AGTIV® SPECIALTY CROPS • Powder **F:** Powder (diatomaceous earth) **S:** Case of 4 x 500 g (4 x 1.1 lb) pails **C:** Vegetables, berries & garlic	M		*			●	●	●			
AGTIV® SPECIALTY CROPS • Granular **F:** Granules (peat) **S:** 10 kg (22 lb) pail **C:** Vegetables, herbs, berries & fruit trees	M		✓	●			●	●			
AGTIV® ON SEED™ **F:** Treated seeds **C:** Vegetables and fruits Ask your representative for more details.	M	B	*							●	

F: Formulation
S: Size
C: Crop/ Coverage

ACTIVE INGREDIENTS:

M MYCORRHIZAE
PTB297 Technology

B BACILLUS
PTB180 Technology

R RHIZOBIUM
PTB160 Technology (pulses)
PTB162 Technology (soybean)
Mesorhizobium ciceri (chickpea)

N New product

C Combo available

ORGANIC:

✓ For organic use

* Eligibility may vary depending on the territory. Contact us for more details.

TOOLS

Dedicated to offer technical support for product application, field demonstration, equipment and input compatibility, and to promote educational agronomic knowledge, Premier Tech provides various tools on PT**AGTIV**.COM.

EASY TO USE

For an easy integration in your farming practices, access:

- Labels, SDS, organic certificates
- Application videos, charts and rate calculators

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In addition, to ensure performance through efficient and precise application of its inoculants, Premier Tech recommends the use of approved equipment, such as the AGTIV® Liquid Injection Kit, endorsed by pay-back programs on selected AGTIV® products.

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EFFECTIVE

For the compatibility lists of our active ingredients with various agricultural inputs, such as:

- Pesticides
- Liquid fertilizers

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AGRONOMIC KNOWLEDGE

Access blog articles on various agronomic topics:

- Soil biology
- Plant health
- Active ingredients, etc.

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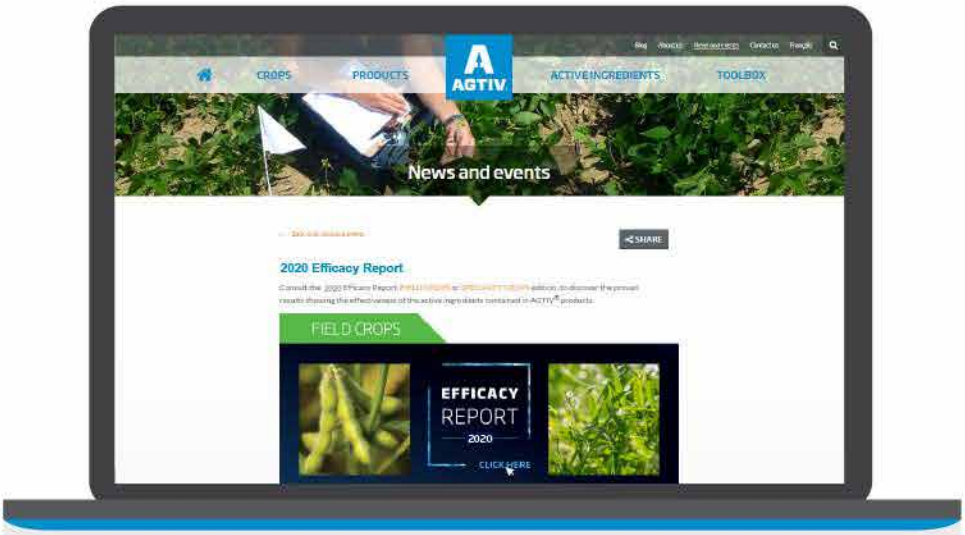

PROVEN RESULTS

Discover the third-party results proving the effectiveness of the active ingredients contained in AGTIV® products:

- ☑ Efficacy report
- ☑ Field observations

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