Acadian Plant Health
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Soil Health Study
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Introduction

Acadian Plant Health (APH), a division of Acadian Seaplants Limited, is a Canadian company and global success story. APH is the largest independent marine plant research and development, harvesting, cultivation, and extraction company in the world. Our global footprint is significant with operations in five countries and over 400 employees, the majority of whom are in Canada. We harvest seaweed and create innovative extracts with beneficial compounds for use in agriculture, as well as collaborate extensively with researchers to document and improve the effectiveness of our products for farmers and agriculture. We also participate extensively in regional and global coalitions and collaborate with other like-minded groups on regenerative agriculture, soil health and climate change in order to better understand how our company and its products can contribute to environmental sustainability. This brief provides detail to supplement our company's February 13, 2024 testimony to the Committee on how our seaweed extracts contribute to soil health, and ultimately regenerative agriculture and sustainability.

Global soil health, agriculture under increasing pressure

There are numerous projections about the amount of additional food that will be needed for the growing global population in coming decades. The general consensus is that global agriculture production has to be increased by about 60-70 percent to meet the increased food demand in 2050. At the same time, the UN Food and Agriculture Organization (FAO) projects that 90 per cent of the Earth's topsoil will be at risk by 2050, pointing out that the equivalent of one soccer field of earth erodes every five seconds, and that it takes approximately a thousand years to create a few centimeters of topsoil.

While soil health and the environmental sustainability of farming in Canada are positive in global terms even as areas for improvement are identified, in many areas around the world pressures on land and water resources are limiting the productivity of key agricultural systems. Those pressures include rapid population growth, urbanization, growing wealth and consequent changes in consumption patterns. This is occurring at the same time that farming around the world is affected by extreme weather events associated with climate change, land degradation and biodiversity loss.

To take one example, abiotic stresses such as drought are also expected to increase with climate change and other factors. The FAO notes that the percentage of the planet affected by drought has more than doubled in the last 40 years and in the same timespan droughts have affected more people worldwide than any other natural hazard. Climate change is exacerbating drought in many parts of the world, increasing its frequency, severity and duration, with the IPCC (Intergovernmental Panel on Climate Change) stating that climate change is already affecting food security through increasing temperatures, changing precipitation patterns, and greater frequency of some extreme events.

A recent global survey of 800 farmers from Bayer reported that 71 per cent believe that climate change has significantly affected their farms with 45 per cent having experienced very high temperatures and eight in ten expecting future yield losses. On average, these farmers estimated that their incomes had decreased by 15.7 per cent due to climate change in the past two years. Other effects reported by farmers in the survey include changes from one weather extreme to another in a short space of time, change to the date when seasons start or end, very strong winds, very low temperatures, and long periods of low temperature.

Role of regenerative agriculture and innovation

In an era where climate change threatens global food security, APH believes that the agricultural sector is undergoing a transformation. Farmers, policymakers, and industry leaders are increasingly addressing the challenges posed by a changing climate by integrating three key pillars—increasing productivity, enhancing resilience to climate change, and reducing greenhouse gas emissions. This multifaceted approach aims to create a more sustainable and efficient agricultural system that can adapt to the challenges posed by a warming planet.

Agriculture's potential in meeting these challenges is not to be undersold, as it has been estimated that global soils have the potential to absorb approximately 20% of anthropogenic carbon emissions through beneficial management practices like zero-till and cover cropping. While Canada's domestic performance in sequestering carbon in agricultural soils is uneven and in need of improvement overall, some regions are nevertheless a model for the world of what can be achieved, with agricultural soils in Canada having removed more than 6 Mt CO_2e in 2018 (the most recent year for which soil sequestration data was reported separately).

To achieve this and other improvements to environmental sustainability while increasing food supplies, innovation is needed. APH is able to contribute substantially to this need via biostimulants, which are a group of substances that stimulate plant growth, boost nutrient uptake, and enhance overall plant health, and at the same time improve soil health and securing global food supplies against severe weather events.

The potential of seaweed-based biostimulants

According to the United Nations Global Compact, seaweed has the potential to help address some of the world's most pressing challenges, enriching soils, complementing terrestrial fertilizers by boosting plant nutrition, and helping restore ocean biodiversity, as well as having potential to mitigate climate change through atmospheric carbon dioxide removal. Seaweed, a seemingly simple marine plant, is actually a diverse group of algae that can be found in oceans worldwide and play a critical role in marine ecosystems. It has the potential to address many of the United Nations Sustainability Development Goals and connects the land and the ocean, creating a symbiotic relationship between a blue economy on the ocean and a green economy on land.

The use of seaweeds in agriculture dates back thousands of years. During ancient Roman times, plant seedlings were mulched with seaweed to promote their growth. In the coastal area of Europe, farmers

incorporated seaweeds in the soil or used them as a compost. Seaweed has evolved a set of highly unique biological properties as part of its ability to survive in some of the world's most stressful conditions. This helps it thrive in variable salinity and withstand temperatures ranging from below freezing to the extreme heat of summer months. It can also survive exposure to the air as tides rise and fall, and it takes up limited nutrients without the advantage of terrestrial plant root systems.

By the middle part of the 20th century, 18 countries had developed their seaweed resources for fertilizers. By 1950, a liquid product was developed which could be considered the first step of the seaweed extract industry with respect to agricultural applications. APH's company founder, Louis Deveau of Acadian Seaplants Ltd., started to commercialize seaweed extracts in 1992. In the intertidal waters of Canada and other regions of the North Atlantic, *Ascophyllum nodosum* seaweed thrives in some of the harshest growing conditions on earth. Its resilience to rapid fluctuations inspired APH scientists to extract its elements in their most active form and apply these resilient qualities to biostimulant technologies for agriculture on land.

Today's science and technology enables us to understand and isolate the specific molecules involved. Known as seaweed-based biostimulants, our *Ascophyllum nodosum* extracts modify the physiological processes in plants that enable them to effectively mitigate abiotic stress. APH's *Ascophyllum nodosum* extracts are manufactured through a proprietary process that ensures stability and consistency, helping crops grow stronger roots, improve nutrient efficiency, resist drought, and remain healthy in the face of other abiotic stresses like salinity or excessive heat. Innovative formulations are applied through foliar spray, soil drenches, seed treatments, or incorporated into fertilizers for agricultural use.

What makes APH products unique

Our proprietary alkaline extraction process liberates more pure and active compounds from the *Ascophyllum nodosum* so more of their natural properties are maintained, improving the strength of the plant receiving the application of the extract. Seaweed extracts' biochemical composition is complex, so understanding their mechanism of action is intricate. Partnering with the National Research Council of Canada, we have identified a 'biochemical fingerprint' for our products using nuclear magnetic resonance (NMR) technology. This fingerprint shows that our products are biochemically unique and consistent in quality.

Our extracts help plants to take up and use the nutrients they need more efficiently. Our extracts' bioactive compounds help the plant to attract and absorb nutrients in the soil through chelation and even help plants to use fertilizer more effectively since more of it ends up in the plant. This all results in enhanced growth, fueled by a suite of genes that are responsible for growth, metabolism and stress response under limited nutrient conditions.

Our *Ascophyllum nodosum* extracts are scientifically shown to modify the physiological processes in plants and have a unique and consistent biochemical composition, with the highest concentration of stress-mitigating compounds. These include:

- Organic acids that help plants produce energy and encourage the production of new compounds, boosting plant production;
- Oligosaccharides which elicit plant abiotic defense mechanisms to help keep plants healthy;
- Betaines that help plants adjust water levels, salt and other substances within cells, help protect chlorophyll and better mitigate abiotic stress;
- Mannitol that protects and adjusts the amount of water in plant cells in times of water-related stresses;
- Alginic acid which helps chelate nutrients, making them more available to plants; and,
- Fucose-containing polysaccharides which increase antioxidant levels and help protect plants from stress in general.

Even though our products are used on over 100 crops in 80 countries, the adoption of plant biostimulants like seaweed extracts remains low, utilizing only a fraction of their potential, and APH products are considered to be in an early stage of commercialization. While some of the largest crop input companies in the world are beginning to incorporate plant biostimulants into their products, most growers do not understand the benefits of our extracts or how they contribute to sustainable agricultural practices. Progress toward our goal to achieve broad recognition in agriculture will improve sustainability, soil health, and our company's ability to grow and create jobs in Atlantic Canada and around the globe.

Impacts of seaweed extracts on soil health and climate change

What sets APH apart is our commitment to research and documenting our products' performance through publicly available trial results, as well as our commitment to collaborations with scientists and universities. Through a well-established body of evidence, scientists have been able to document that seaweed extracts have a large potential role in agriculture. Our seaweed extracts contribute to soil health in the following ways, all supported by research.

- Increased growth of arbuscular mycorrhizal fungi
- Enhanced plant-microbe symbiosis
- Optimized nutrient availability
- Increased nodulation on the roots (allows legume plants to use nitrogen from the atmosphere)
- Increased soil aggregation and improved soil structure
- A well-developed microbiome overall, which can help out-compete pathogens, allowing for better crop establishment, which can lead to improved yields
- Enhance plants' ability to absorb carbon dioxide during photosynthesis and convert it into carbohydrates, which they use to grow leaves, stems and roots
- Promoting carbon content in soil through the development of healthier soil and increased root biomass

Among the latest of the peer-reviewed articles highlighted in the next section, a key study demonstrates an increase in mycorrhizal fungi when our technology is applied, while other recent research shows increased root and shoot biomass, leading to more organic matter in soils. Increases in fungi and soil organic matter are both key indicators for soil health and contribute to regenerative agriculture. Only

healthy soil can grow healthy plants and good soil has microbes, which help with plants' nutrient uptake, growth, and stress tolerance.

Our extracts also contribute to climate change mitigation through carbon accumulation in the regrowth of the seaweed we harvest, as one of seaweed's notable abilities is to absorb large amounts of carbon dioxide from the atmosphere through photosynthesis, capturing carbon 20 times faster than trees. Understanding just how much CO2 has been absorbed in seaweed beds was a recent research area for APH and results show that 362 kg of CO2 is absorbed for every ton of the seaweed that APH harvests. As it regrows each year, carbon is absorbed once again creating a continuous regenerative cycle that holds very large potential to deliver on global climate goals.

Recent research highlights from scientific collaborations

Much of APH's success in seaweed biostimulants is a result of the high priority we have placed on research and development, which has followed on our founder's pioneering efforts in the 1980s. APH made the decision to heavily invest in research and development to truly decipher the impacts of their seaweed extracts on plants and the root/soil environment. In 2020, we created the Acadian Open Academy, which is a scientific advisory board of twelve experts from eight countries who are working to validate, enhance, and contribute to a new wave of technology that compliments seaweed extract.

Among the many topics being discussed at the Acadian Open Academy is the role of biostimulants in improved fertilizer management practices given its ability to increase the efficiency of the fertilizer, while still contributing as a sustainable, green product. Significant efforts have gone into studying this, and we've seen that APH biostimulants not only improve nutrient levels in the plant but also affect metabolic processes within the plant that allows it to maintain growth and productivity even under reduced nutrient inputs.

Via the Acadian Open Academy, we've also partnered with an international plant research company to understand the genetic mode of action toward improved commercialization. An additional project involving the same product is underway as part of our university research collaborations with the goal of understanding its effects on beneficial soil microbial populations.

These partnerships enable us to have strong, independent, third-party validated data to support the benefits and mode of action behind our new products. Recent research highlights include:

A recent study published in Nature Scientific Reports found that APH's seaweed extract improved growth and symbiosis of AMF through multiple mechanisms. The results suggest that *Ascophyllum nodosum* extract enhances mycorrhization through both direct stimulation of arbuscular mycorrhizal fungus growth and through stimulation of the plant's accommodation of the symbiont, together promoting the establishment of this agriculturally vital plant–microbe symbiosis. This is an important result as it contributes to the growing body of evidence that APH products broadly influence the structure and activity of microbial communities in the rhizosphere, increasing rhizosphere activity, biodiversity, and metabolic activity.

APH products are also documented to improve plant growth as shown in a recent article published in the Canadian Journal of Plant Science, which found that metabolic activities of soil microbes increased following APH's seaweed extract applications and that APH's seaweed extract applications increased strawberry root and shoot growth, berry yield and rhizosphere microbial diversity and physiological activity.

A study published in the National Library of Medicine and supported by NSERC built on previous experiments that demonstrated positive effect of APH extract of *Ascophyllum nodosum* extract on plant stress-resistance. The study measured soybean response to drought stress with thermal imaging over a 5-day stress-recovery trial. *Ascophyllum nodosum* extract-treated plants showed better survival of treated plants compared to control, demonstrating the ability of APH seaweed extract to improve resistance of soybean plants to water stress.

An article published in Microbial Biotechnology used a commercially available *Ascophyllum nodosum* extract to test its effect on bacterial and fungal communities of rhizospheric soils and roots of pepper and tomato plants in greenhouse trials. The researchers conducted two independent trials to determine microbial community structure changes and found that productivity parameters of root, shoot and fruit biomass were positively and significantly influenced by the *Ascophyllum nodosum* extract amendment. They also identified an important area of further research to confirm the effect of APH products on other microorganisms most strongly correlated with crop yield increases, which has the potential to further enhance crop yield in sustainable agro-ecosystems.

APH extracts are also documented to improve the ability of legumes to fix atmospheric nitrogen via symbiotic relationships with soil microorganisms. A study on alfalfa demonstrated this effect by measuring the effects of the seaweed *Ascophyllum nodosum* extracts on nitrogen fixing nodules and growth of alfalfa plants under greenhouse conditions. The researchers noted that while *Ascophyllum nodosum* extract was already known to stimulate both root nodulation and growth of alfalfa, the additional research confirmed that *Ascophyllum nodosum* extract is likely to contain compound(s) that promote the legume–rhizobia symbiotic relationship and plant signaling, and that these should be further studied.

An article in Journal of Applied Phycology explored the sustainability of seaweed harvests in Nova Scotia and New Brunswick, evaluating the impact of over 25 years of commercial harvesting of *Ascophyllum nodosum* by comparing the biomass and height of the seaweed in the late 1990s to the late 2010s over a broad spatial scale. There was no significant decrease in the biomass of *A. nodosum* in either province, with biomass increasing in some regions of New Brunswick during that period. The article concluded that the current management and harvest of *A. nodosum* in eastern Canada are sustainable and that additional measurement is desirable to document this as changes occur in environmental conditions.

Highlights of further research

APH is always investing in R&D, but a particular area of focus has been to further establish the role of our seaweed extracts to support more efficient fertilizer nutrient uptake. When applied to plants or seeds in

specific formulations, these extracts have the capacity to modify the physiological processes in plants in a way that provides potential benefits to emergence, crop development and stress response.

Over the past several years, APH has conducted nine different trials looking at the effect of our seaweed extracts in reduced nitrogen situations. Effects of APH product application were measured across trials involving a standard fertility program and a reduced fertility program where APH seaweed extracts were added to each scenario. The trials showed consistently improved yield regardless of the fertility program when APH technology was applied, but with the surprising result of similar yields to the standard fertility program when APH extracts were applied to the reduced fertility program.

Initial results were able to track the bioactive compounds in APH seaweed extracts such as polysaccharides, alginates, mannitol, amino acids, organic acid and betaines. There is evidence of the chelation of nutrients when these compounds are present, resulting in an improved rooting system for better up take of nutrients, improved stress tolerance, soil health and even enhanced nitrogen uptake and movement.

International sustainability collaboration and leadership

APH's Acadian Plant Health is advancing its commitment to meet the needs of a growing population while protecting the environment via several international collaborations and memberships in key initiatives. Highlights include:

- APH is a member of the "4 per 1000" Initiative, named for the theoretical calculation that an increase of 0.4% of carbon in soil every year will help stop the increase of anthropogenic CO2 emissions. The global initiative is a public and private collaboration that aims to show that agriculture, and in particular agricultural soils, can provide concrete solutions to the challenge of climate change while at the same time meeting the challenge of food security by implementing practices adapted to local conditions. It has a global footprint of more than 400 members from government bodies, development banks, universities, foundations, agriculture groups, NGOs and for-profit companies.
- APH joined the Global Seaweed Coalition, whose aim is to facilitate the emergence of an international seaweed sector with global safety standards grounded in science, as well as responsible and sustainable seaweed harvesting, cultivation and extraction. APH is working within the Coalition membership to establish a seaweed industry that provides safe products, safe working conditions and environmental protection as it grows and provides a safe and sustainable food source for an increasing global population.
- APH is a community member of GLOBALG.A.P., which develops consumer requirements into Good Agricultural Practices and advances the principles of safe, socially and environmentally responsible farming practices through collaboration and dialogue. More than 430 organizations support the GLOBALG.A.P. vision and mission, with more than 200,000 producers now under GLOBALG.A.P. certification worldwide.
- APH partnered with World Farmers' Organisation (WFO) in a docuseries showcasing the critical role of soil health and regenerative agriculture that was screened at COP28 in December 2023. The collaboration aims to inspire a positive change by promoting farmers' best practices to

mitigate and adapt to climate change. The WFO represents over 1.2 billion farmers worldwide and was the driving force behind this series of films that highlight the efforts that farmers and food producers are making to secure the future for farming.

- APH is a member of the United Nations Global Compact initiative, which is a voluntary leadership platform for the development, implementation, and disclosure of responsible business practices. With more than 18,000 companies and 3,800 non-business signatories based in over 160 countries, the UN Global Compact is the world's largest corporate sustainability initiative.

Roles for government

All levels of government in Canada can help support this success story through greater recognition in programming of the emerging market in biostimulants and the vast and underexplored opportunities they present for sustainable agriculture. While the Canadian regulatory framework is among the more favorable in the world towards plant biostimulants, the time it takes for the review and approval of innovative products is long, delaying their adoption and use. Financial support could also be provided for early adopter farmers who help explore the full potential of biostimulants for the soil and broader environment, as well as aid in the dissemination of information about improved nutrient uptake and other agronomic benefits to producers. These are the themes that APH will be focusing on in our interactions with both federal and provincial governments to support and encourage the broad adoption of seaweed based biostimulants into Canada's sustainable agriculture strategy.

Conclusion

- Seaweed extracts have numerous benefits for sustainable plant production, and specifically soil health. Numerous published research trials have documented that APH's seaweed extracts, which are a category of biostimulants, make it possible for terrestrial plants to benefit from the unique biological properties of *Ascophyllum nodosum,* which has evolved the ability to survive in some of the most stressful conditions for plant growth on earth.
- The particular benefits to soil health of APH's seaweed extracts include increases in beneficial soil microorganisms, enhanced symbiotic interactions between plants and microorganisms, and the promotion of more organic matter in soils through enhanced root and overall plant growth.
- Seaweed extracts contribute to sustainability overall by helping to keep plants alive and growing during drought, temperature extremes, and other abiotic stresses. This key feature of our seaweed extracts will become even more important as growing conditions fluctuate with a changing climate. Optimized nutrient uptake is also expected to be of increasing interest as fertilizer use efficiency receives greater attention globally.
- Acadian Plant Health, a Canadian success story, is leading the way in the research, production and promotion of seaweed-based biostimulants. APH's numerous strengths include research and development, scientific collaborations leading to publicly available performance results, sustainable seaweed harvests, and the positioning of Canada as a leader in an emerging biostimulant market that is expected to grow exponentially.

- Results to date are significant, evidence is growing, and this sector is worthy of much greater attention from all relevant groups including scientists, agronomists, farmers, input organizations and government.