The Plant Biologicals Cluster in Southern Scandinavia

An analysis of key players, growth potential and policy recommendations

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IRISgroup

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Preface

An expected world population of 11 billion people by the end of the 21st century will require a significant increase in global food production and challenge the agricultural sector as we know it.

The introduction of chemical fertilisers, pesticides and new high-yield crop breeds in the 1950s and 1960s was a successful way to increase crop production. However, the use of chemical products is subject to growing societal concerns due to the risks to human health and the environment. Accordingly, the EU "Farm to Fork" strategy outlines a 50% reduction of chemical pesticides by 2030.

A key question arises as to whether yield per hectare farmland can be increased while reducing chemical products in the agricultural sector.

Biotechnology is believed to be a part of the solution. Biopesticides and bio-fertilisers can complement and, in some cases, replace agro-chemicals.

A recent impact study on the future of crop protection concludes that biocontrol products have a very positive impact on crop yield and biodiversity.[1] Precision agriculture technologies have also created new opportunities to reduce environmental impact and increase yield through automated crop monitoring and spatially adapted management.

But more research, development and testing are needed to unfold the full potential of plant biologicals.

Southern Scandinavia is home to several leading academic institutions prominent in this area of research as well as headquarters or R&D activities for a number of globally leading biotech companies. The region has the potential to become a globally significant technology hub, test bed and showcase for plant biologicals.

The purpose of this publication is to describe and display the size, scientific strongholds and dynamics of the plant biologicals cluster in Southern Scandinavia as well as its potentials and barriers to growth.

The publication is prepared by IRIS Group for the Plant Biologicals Network in the spring 2021. The Plant Biologicals Network is a non-profit membership-based collaboration between key players in the field of plant biologicals located in Southern Scandinavia. The analysis is based on desk research, bibliometrics and interviews with biotech companies, universities and national authorities in Denmark and Sweden.

[1] European Parliamentary Research Service (2020): "The future of crop protection in Europe".

Plant biologicals and the Southern Scandinavian cluster

What are plant biologicals?

Plant biologicals are biological alternatives to chemical protection and stimuli of crops. In contrast to their chemical counterparts, biologicals are derived from living organisms. Plant biologicals can be grouped into three categories based on the way they are developed:

- **Macrobials** are insects like mites, spiders, bugs, ladybirds and wasps. They are nature's own predators against plant pests.
- **Microbials** are microorganisms like bacteria, fungi and vira. They are developed and produced biotechnologically.
- **Naturally derived products** are botanicals and other natural substances like plant extracts and proteins. They occur naturally, e.g. in composting processes.

Plant biologicals can lead to stimulation of plant growth (biostimulants), pest control (biocontrol agents), soil health improvement and enhancement of plant nutrient uptake (biofertilisers).

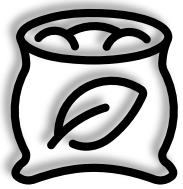
Historically, plant biologicals are not new to the agricultural sector. Naturally derived products and experiments with insects to protect crops have been part of farming for centuries. But biotechnology and increased knowledge of the modes of action of biologicals have developed the field significantly during the last decade. Today, the rate of introduction of new biological products has exceeded that of conventional plant protection products worldwide.[2] Nonetheless, less than 5% of plant protection products currently sold worldwide are biocontrol agents.[3]

Even with advances in technology and increasing investment in R&D, biologicals deliver lower levels of control and more variable performance than their chemical counterparts. There seems to be a consensus that biologicals will not replace chemical crop protection products in the short term, but with more knowledge and development it will be possible that they will be able to replace some pesticides or complement others. Plant biologicals a part of a solution to create a more healthy, biodiverse and self-sustaining farm environment, and provide a more holistic approach for growers in balance with the local ecosystems.

[2] Phillips McDougall (2018): "Evolution of the Crop Protection Industry since 1960".
[3] Buckwell, A., De Wachter, E., Nadeu, E., Williams, A. (2020): "Crop Protection & the EU Food System. Where are they going?"

Macrobials
are used as biocontrol agents.

Microbials
serve as biostimulants, biocontrol agents and biofertilisers.



Naturally derived products
are used as biostimulants.

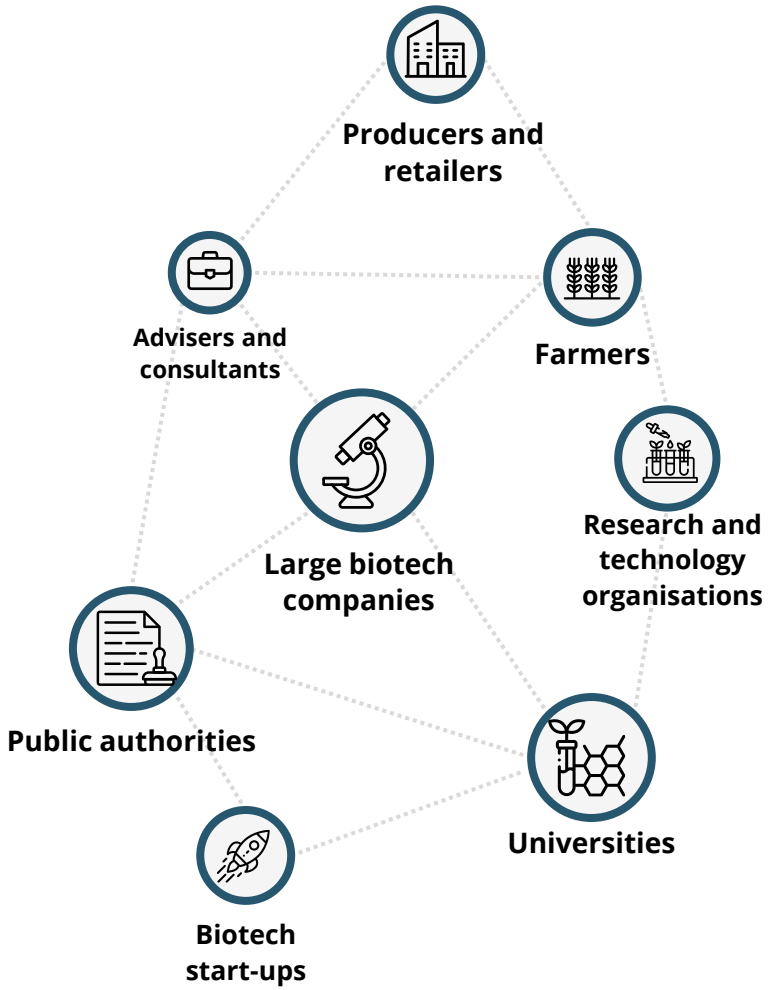
The Southern Scandinavian cluster at a glance

The plant biologicals cluster in Southern Scandinavia consists of approx. 60 companies, four universities, a handful of specialised advisers, as well as research and technology organisations.

The core of the cluster is microbiological and biotechnological R&D at the universities and biotech companies. But farmers and producers and retailers of plant biologicals are also an important part of the ecosystem. Thus, the cluster represents stakeholders covering the entire value chain from research and development, test, manufacturing and lastly the users of plant biologicals. Finally, a smooth cooperation with agricultural and environmental authorities are important in a heavy regulated area like plant protection products.

This broad scope characterises the cluster in Southern Scandinavia. The fact that Novozymes, Bayer, FMC, Chr. Hansen and Syngenta are all members of a plant biologicals network while competing in the same field indicates the cooperative spirit of the cluster.

The figure to the right illustrates the inter-relationships of the cluster, and the box presents key players, who are described in more detail on the following pages.



Key players

Large biotech companies

- BASF (sales office)
- Bayer (sales and regional tests)
- Chr. Hansen (R&D)
- FMC (R&D)
- Novozymes (R&D)
- Syngenta (sales and regional tests)

Biotech start-ups

- BioPhero
- Healthycrop.world
- Plantcarb
- YooNoon

Universities

- Aarhus University
- Lund University
- Swedish University of Agricultural Sciences
- University of Copenhagen

Research and/or technology organisations

- AgroLab
- Danish Technological Institute

Public Authorities

- Danish Agricultural Agency
- Danish Environmental Protection Agency
- Swedish Board of Agriculture

Advisers and interest groups

- BJ Agro
- Danish Crop Protection Association
- Gullviks
- HortiAdvice
- SEGES

Producers and retailers of plant biologicals

- Binab Bio-Innovation
- Borregaard BioPlant
- DLF Seeds
- ECOstyle
- EWH Bioproduction
- Lindesro
- MariboHilleshög

Farmers

- Ingleby Farms
- Lantmännen BioAgri
- Spendor Plant

A core of internationally leading biotech companies

The plant biologicals cluster of Southern Scandinavia is relatively young. But at its core, large well-established biotech companies are leading the research in commercial plant biologicals.

Not only traditional developers of chemical plant protection products like BASF, Bayer, FMC and Syngenta are active in the field of biologicals. Also Chr. Hansen and Novozymes have added biological plant health and protection solutions to their areas of business during the last decade.

Six large biotech companies are present in the cluster. Chr. Hansen, FMC and Novozymes have R&D activities in Copenhagen related to plant biologicals, and BASF, Bayer and Syngenta have sales offices and conduct regional tests of plant biologicals in Denmark.

The large biotech companies focus on enzymes and microbes such as bacteria, which makes this area of plant biologicals the most prominent in the Southern Scandinavian cluster. R&D activities are focused on both biostimulants, biocontrol agents and biofertilisers.

The global market for microbial biocontrol agents is concentrated and highly dominated by internationally leading biotech companies of whom a fair share are part of the Southern Scandinavian cluster.

In the global biocontrol market, companies are not only competing based on product quality and promotion; they are also focused on strategic moves to gain larger market shares. New product launches, partnerships

and acquisitions are the major strategies adopted by the leading companies in the market.

Partnerships and acquisitions have also shaped the plant biologicals cluster in Southern Scandinavia. In 2013, the acquisition of the Danish agrichemical company Cheminova and a partnership with Chr. Hansen paved the way for the American agricultural sciences company FMC to place its European innovation center in Copenhagen. Likewise, Novozymes entered the plant biologicals market by acquiring agro-bioscience companies in the USA.

The time to market for biotechnological products is long and expensive. In the last decades, Southern Scandinavia has developed a thriving ecosystem supporting entrepreneurship within medical biotech, but start-ups with industrial and agricultural biosolutions do not enjoy a similar ecosystem with venture capital, dedicated accelerator programmes, etc. Thus, biotech start-ups are rare. The mapping of companies in the Southern Scandinavian cluster only revealed a few university spin-offs; the most successful start-up being BioPhero that was spun off from the Technical University of Denmark in 2016. BioPhero has developed a biotech-based fermentation technology to mass produce pheromones for pest control at a low price.

> *Plant Health is a strategic ambition, a lighthouse, for Chr. Hansen. For over a century, we have developed our technology platform and understanding of good bacteria, which is highly relevant in the agricultural sector.*
>
> - Chr. Hansen

> *FMC chose Copenhagen as location for its European Innovation Center, which is our global R&D center for biologicals, because of the strong biological ecosystem in food and biotech.*
>
> - FMC

> *Our BioAg business is a collaboration between our microbial R&D in North Carolina and the enzyme research in Denmark.*
>
> - Novozymes

> *Denmark and Sweden represent an interesting environment for testing plant biologicals. Institutions like SEGES, Danish Technological Institute and AgroLab have skills and expertise in this area.*
>
> - Bayer

Four universities specialised in the field

The plant biologicals cluster includes two Danish and two Swedish universities – all with a long history in plant science.

The historic importance of agriculture in Denmark and the southern part of Sweden gave birth to early academic interest in plant growth and yield optimisation.

In Denmark, the Department of Plant and Environmental Sciences at the University of Copenhagen dates back to 1858. In Sweden, the University of Agricultural Sciences (SLU) was founded on the basis of the former agricultural, forestry and veterinary university colleges, some dating back as far as 1775.

Today, the four universities are at the forefront of research in plant microbiology and genetics.

While SLU, Lund University and the University of Copenhagen are focused on fundamental plant biology and engineering of microorganisms, Aarhus University is also active in testing plant biologicals.

50 years of systematic field trials has turned Denmark into a flagship for test and demonstration of plant protection products, stimulants and fertilisers. These activities also engage research and technology organisations like the Danish Technological Institute and the private company AgroLab.

Finally, SEGES is an important part of the cluster with its long history in bridging university research and field trials with practical farming. SEGES constitutes the leading agricultural knowledge and innovation centre in Denmark.

Aarhus University

About 40 researchers across three departments carry out research related to plant biologicals.

The Department of Agroecology has a group focusing on plant diseases and pests. At the Department of Molecular Biology and Genetics, a large group investigates the molecular genetics and mechanisms of plants. The Department of Environmental Science has expertise in a number of specific areas within microbial ecology.

Lund University

The Department of Biology includes a research group in Plant Biology (13 researchers) and a Pheromone Group (15 researchers).

In addition, Lund has a strong interdisciplinary Centre for Environmental and Climate Science with activities in agroecology.

A major research area is how plants and beneficial microorganisms interact with each other, and how this interaction is shaped by the genetics of the plant.

Swedish University of Agricultural Sciences

SLU has several locations in Sweden. In the southern part of the country, the Alnarp Campus is home to the Department of Plant Protection Biology, the Department of Biosystems and Technology and a Centre for Biological Control. Around 50 researchers do research related to plant biologicals at SLU, of which 15 work at Alnarp.

Strong research in concepts and modelling focusing on the understanding and sustainable use and management of biological resources.

University of Copenhagen

More than 50 researchers work with plant biologicals at the Department of Plant and Environmental Sciences.

The department focuses on basic research in understanding how microorganisms in soil and plants interact, why they react and under which circumstances. Research groups focus on e.g. insect microbial interactions, plant protection, pathology and biological control.

Benchmarking research output and quality against other leading universities

To get a picture of the research impact from the cluster, we have benchmarked the four Southern Scandinavian universities against eight world leading universities within the fields of plant and agricultural research.

A bibliometric analysis can indicate the size, quality and collaboration patterns of an academic institution by counting its number of scientific publications and analysing the rating of journals in which they are published.

Universities included in the analysis:

1. Aarhus University (Denmark)
2. University of Copenhagen (Denmark)
3. Lund University (Sweden)
4. Swedish University of Agricultural Sciences (Sweden)
5. Wageningen University & Research (Netherlands)
6. University of Reading (UK)
7. ETH Zürich – Swiss Federal Institute of Technology (Switzerland)
8. University of California at Davis (USA)
9. Cornell University (USA)
10. University of São Paulo (Brazil)
11. ICAR – Indian Agricultural Research Institute (India)
12. China Agricultural University (China)

When combined, output from Scandinavian universities sizes that of large agricultural universities

Counting the number of publications in a research field is a way of analysing the size of the field and productivity of the researchers within that field. In this analysis, the fields investigated are Plant Science, Soil Science and Agronomy and Crop Sciences.

In the figure below, the bars show the number of scientific articles, reviews and conference papers published in the period 2016-2020 by researchers affiliated with the 12 benchmarked institutions. The bullets show the share of these publications (within Plant Science, Soil Science and Agronomy and Crop Sciences) of all publications registered from the institutions.

The four universities in the Southern Scandinavian cluster (green bars) are individually in the lower end when measuring scientific output compared to large universities with a clear agricultural profile like China Agricultural University and Wageningen. But if the publications from the four Scandinavian universities are combined, the cluster actually matches the publication volume of the large and specialised universities.[4]

[4] The number of publications cannot simply be multiplied, because co-publications will count twice. Adjusting for co-publications results in a combined scholarly output of 4,186.

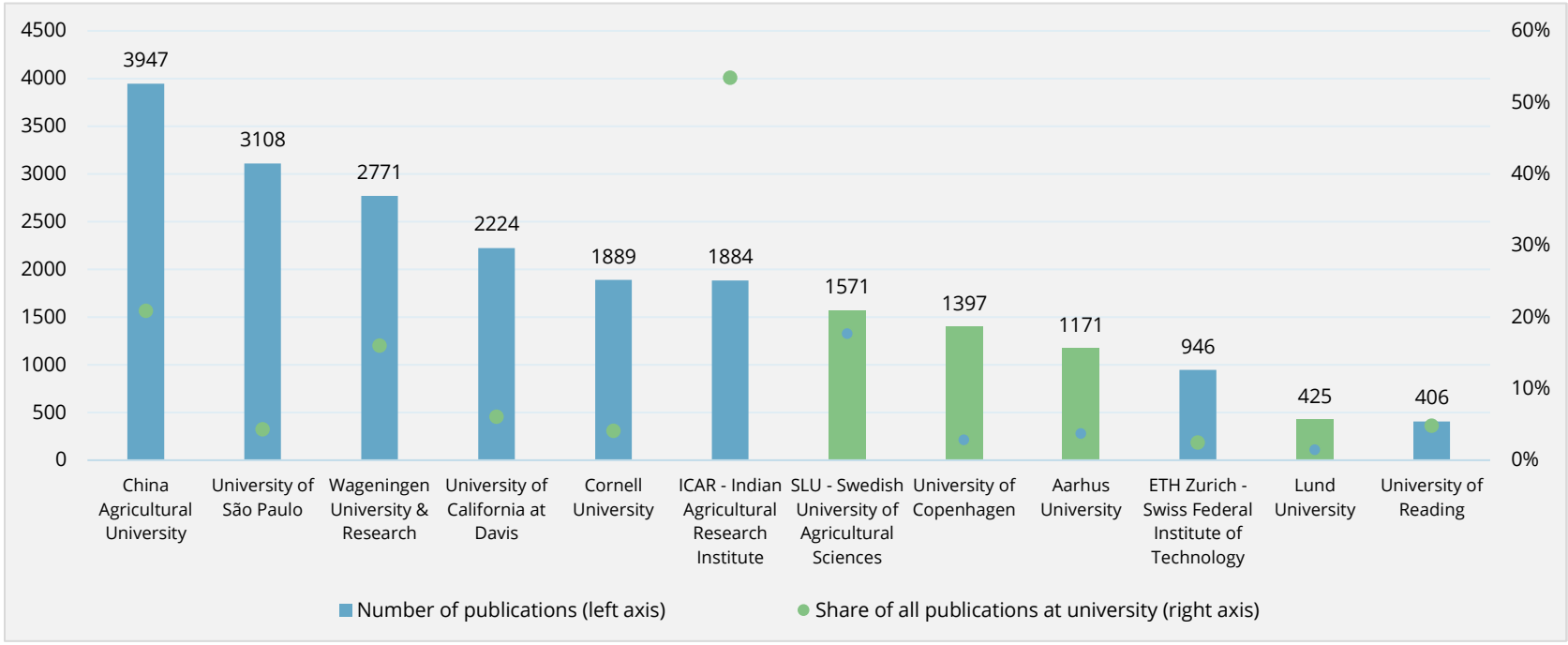
Bibliometric approach

Bibliometrics deploys statistical methods to analyse books, articles and other publications. In this analysis, the method is used to analyse the number and quality of scientific articles, reviews and conference papers from the four universities of the cluster and eight benchmark universities.

The bibliometric analysis is based on data from SciVal. It is important to note that "plant biologicals" does not exist as an autonomous subject area in SciVal. Thus, the bibliometric analysis is based on three subject areas: Plant Sciences, Soil Sciences and Agronomy and Crop Sciences.

This approach might exclude some areas of research within plant biologicals such as Environmental Microbiology and Microbial Ecology, while, on the other hand, including areas of Plant and Soil Sciences that are beyond the scope of plant biologicals.

Publications in Plant Science, Soil Science and Agronomy and Crop Sciences (2016-2020)



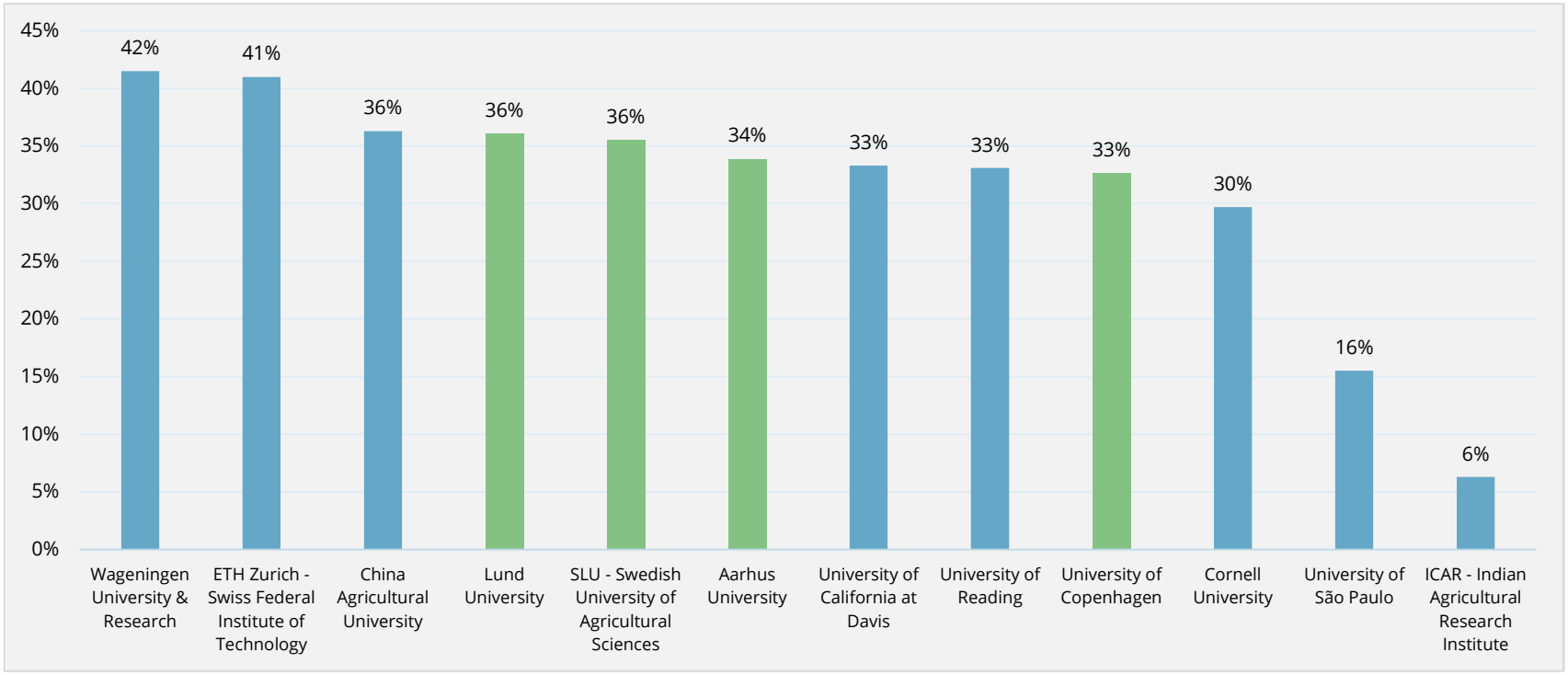
Source: IRIS Group based on data from SciVal.

A great share of publications in prestigious journals

An indicator of the quality of a scientific paper is the journal in which it is published. Some journals are more cited than others and consequently perceived as more prestigious.

The figure below shows the share of publications from the 12 benchmarked research institutions that are published in the 10% most-cited journals within Plant Science, Soil Science and Agronomy and Crop Sciences. 9 of the 12 institutions publish at least one third of their papers in highly cited journals. The Scandinavian universities are well-positioned in this group of leading research institutions, only significantly succeeded by Wageningen and ETH Zürich.

Share of publications in top 10% journals (2016-2020)



Source: IRIS Group based on data from SciVal.

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Close collaboration between universities and industry

A thriving ecosystem is characterised by well-established ties between its stakeholders. In a knowledge-intensive and research-based cluster, close relations and collaboration between universities and industry are important.

The interviews conducted with industrial players and the four universities in the cluster uncovered a high level of collaboration in the young cluster. The researchers across universities and departments are generally well-connected to each other and engage in joint research projects. The table to the right – displaying the share of publications co-authored with another research institution – shows that most co-publications include members of the cluster. For example, 14% of all publications from Aarhus University included a researcher from the University of Copenhagen.

Academic-corporate collaboration is prevalent too – especially in the cases of Aarhus University and the University of Copenhagen – as shown in the figure to the right. 7% of all publications from Aarhus University were co-authored with an industrial partner.[5] None of the institutions included in the benchmark analysis show a similar level of industry collaboration.

The large companies with R&D activities in Denmark engage in research and technology projects with Aarhus University and the University of Copenhagen. However, not much cross-border collaboration between companies located in Denmark and the Swedish universities was detected from the interviews. The Swedish academic-corporate collaborations usually include Swedish corporates like MariboHilleshög and Lantmännen.

A great deal of collaboration also involves farmers. SEGES constitutes an important link between agricultural R&D and farming in practice. Scandinavian farmers are known to be agile and willing to change. The interviewees emphasise the unique tradition for – and knowledge about – testing agricultural products as well as the easy access to farmers.

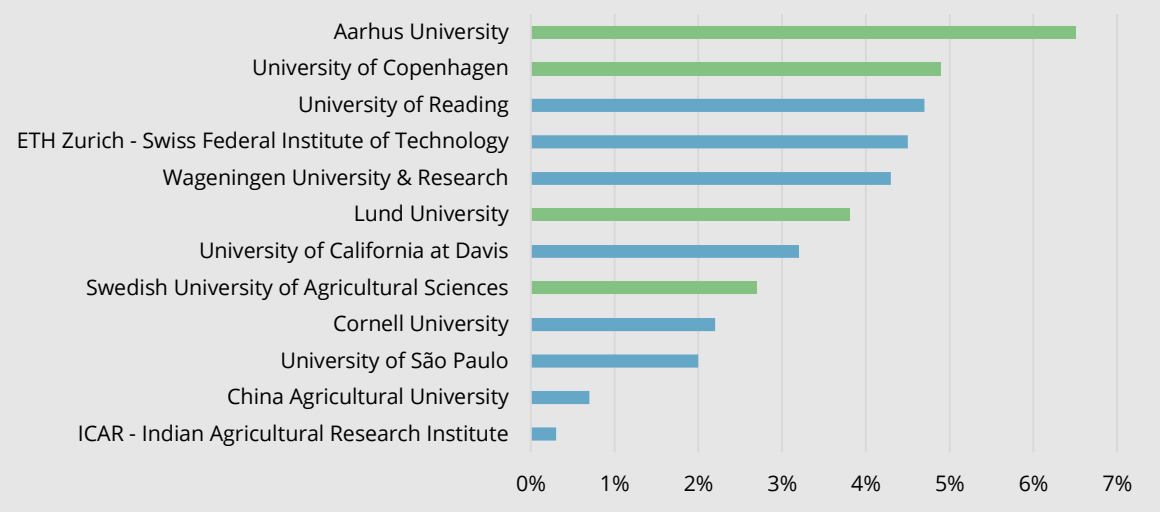
A national agricultural test regime in Denmark (Landsforsøgene®) is led by SEGES and operated by the Danish Technological Institute. It involves local advisers and consultants and enjoys a high level of trust among farmers. Today, plant biologicals only constitute a small share of the tested products. A lack of standards for testing biologicals is evident and is an important area for future collaboration in the cluster (see page 18).

[5] *Danish Technological Institute counts as an industrial partner in the bibliometric database.*

Top 5 academic collaborators by share of co-publications (%) (2017-2020)

AARHUS UNIVERSITET		LUND UNIVERSITY		Swedish University of Agricultural Sciences		UNIVERSITY OF COPENHAGEN	
14%	University of Copenhagen	15%	SLU	8%	Umeå University	11%	Aarhus University
5%	SLU	11%	University of Copenhagen	4%	Lund University	4%	SLU
4%	Aalborg University	4%	University of Helsinki	4%	Aarhus University	3%	Technical University of Denmark
3%	Wageningen University & Research	4%	Stockholm University	4%	Stockholm University	3%	Lund University
3%	China Agricultural University	4%	Uppsala University	3%	Czech Academy of Sciences	3%	Wageningen University & Research

Academic-corporate collaboration (%) (2016-2020)



Source: IRIS Group based on data from SciVal.

Growth potential for plant biologicals in a global market

A fast growing market led by microbial biocontrol agents

The future of plant biologicals is predicted to be promising.

The development of pest resistance to traditional plant protection products and the damage to the environment due to the overuse of chemicals are fostering a demand for biological products that can be applied solely or in combination with synthetic products.

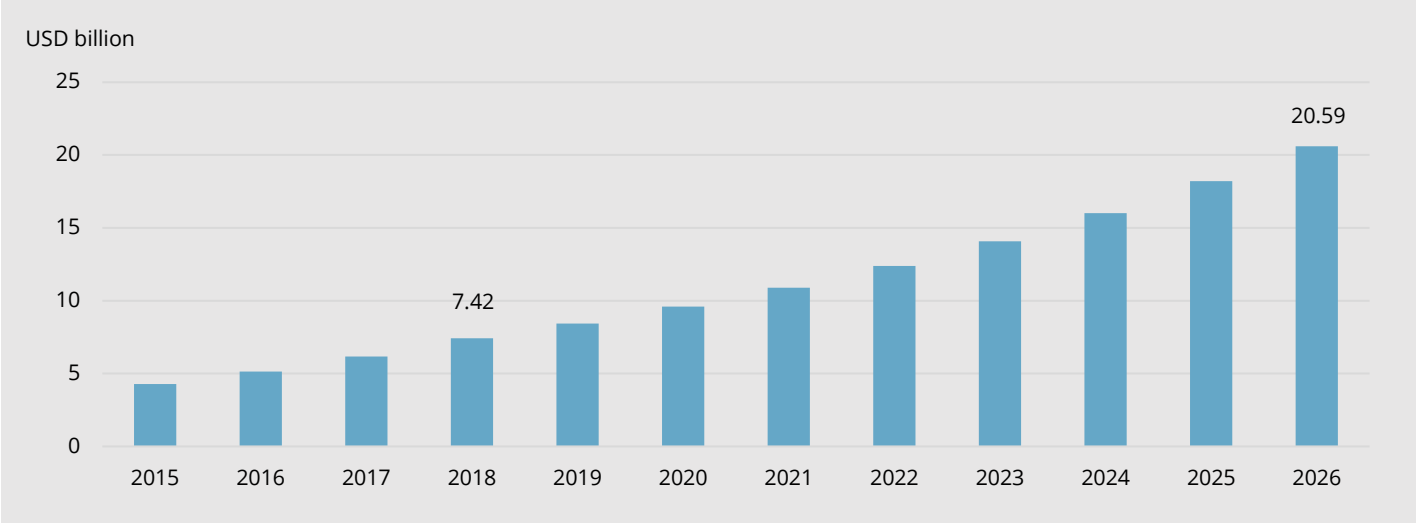
According to Fortune Business Insights, the size of the global plant biologicals market is expected to grow from 7.42 billion USD in 2018 to 20.59 billion USD by the end of 2026. That is a compound annual growth rate of 13.68% (see top figure to the right).

The figure below shows the market share of the three types of biologicals; biocontrols, biostimulants and biofertilisers. Biocontrol agents accounted for more than half of the market size (51.8%) in 2018, and according to the interviewees, biocontrols are expected to keep or even increase its market share in the years to come.

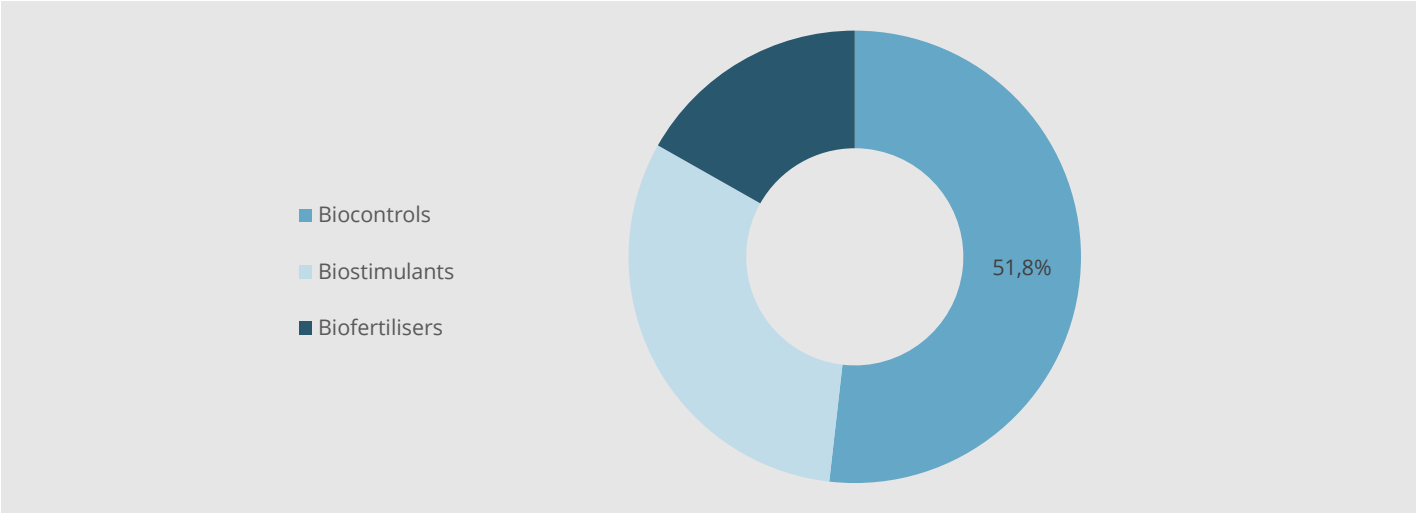
The microbial segment dominates the market across types of biologicals (biocontrols, biostimulants and biofertilisers). As evident from the description of the players in Southern Scandinavia, the cluster is mainly tapping into this large market of microbial plant biologicals.

In the interviews, the corporate stakeholders in the cluster all expressed high expectations to the global market potential of plant biologicals. Chr. Hansen has appointed the area as a strategic lighthouse, which by the company's definition is a new business area of strategic importance with a minimum revenue potential of 100 million EUR per year.

Global plant biologicals market size (2015-2026)



Global plant biologicals market share for types (2018)



Source: Fortune Business Insights.

North America and Europe are the largest markets for plant biologicals

Today, North America and Europe are the two largest markets for plant biologicals. Cumulatively, the two regions account for approx. 60% of the global plant biologicals market.[6]

The figures below show regional market sizes by types of biologicals. Europe is a leading market for plant biologicals. However, the billion-dollar biocontrol market is led by North America with around 37% share of the biological control market.[7]

Despite academic and commercial expertise in developing biocontrol agents, less biocontrol products are available to European farmers, because it is expensive to develop in Europe, and because the European market for plant protection products is strictly regulated to protect human health and the environment.

The registration and market entry of a biological plant protection product in Europe lasts up to seven years and costs about 1 million EUR.[8] Thus, many products are launched in other regions, where costs are lower and the time to market is shorter.

South America is an example of a fast-growing market for all types of plant biologicals due to its huge agricultural sector and less restrictive regulation. Regulation issues are discussed in more detail on page 19.

[6] Fortune Business Insights
[7] Mordor Intelligence

[8] Azizbekyan, R. R. (2018): "Biological Preparations for the Protection of Agricultural Plants (Review)".

Biocontrol market: Market size by region, 2020

Source: Mordor Intelligence.

Biostimulant market: Market size by region, 2021-26

Source: Mordor Intelligence.

Biofertilisers market: Market size by region, 2019

Source: Mordor Intelligence.

Challenges and policy recommendations

To fulfil the growth potential, more knowledge on biologicals is needed

Challenges

The interviews and foresight studies included in this analysis point unambiguously towards a great growth potential for plant biologicals.

However, the effectiveness of the plant biologicals available to farmers today is more volatile than that of traditional agrochemicals. Biologicals are more complex than their chemical counterparts, because they interact with the microorganisms of the crops and soil when applied, causing a less predictable mode of action. More research is needed to improve our understanding of how microorganisms in soil and plants interact, why they react and under which circumstances.

For now, plant biologicals are primarily used in protected cropping systems, such as greenhouses, where temperature, humidity and irrigation can be controlled. Often, the biological choice is also more expensive, which further limits its use to high value crops like berries, fruits and ornamental plants. In arable systems with low value crops, a narrower supply of plant biologicals is available.

The interviewees believe that we will witness continuous improvements in biologicals in the years to come. Plant biologicals are still young and more complex than agrochemicals, but equipped with sensor technology, data and AI, we might witness a much faster development of reliable products in the future. In the area of early-stage modelling and concept development, the cluster possesses great capabilities at the four universities.

When developing and testing biologicals, several of the interviewees emphasised the importance of including farmers. Today, biologicals are seen by farmers as less efficient and reliable than synthetic products. Farmers need to gain experience with these types of products to build trust and acquire knowledge. In this regard, the agricultural company Ingleby Farms is pioneering. With the stated goal to be carbon neutral and free from synthetic pesticides in 2030, Ingleby Farms works across four continents to develop sustainable farming suited to local environments.

To fulfil the growth potential, more knowledge and research on biologicals is needed – not only in the early developmental stage, but all the way to the farmers and their host crops.

Actions

Better options for academic-corporate and international collaboration

To improve our understanding of how plant biologicals work, the universities and R&D heavy companies in the cluster need to join forces. According to the stakeholders, the Innovation Fund Denmark is important for the level of collaboration achieved in Denmark. However, options to include international collaborators are limited.

The Plant Biologicals Network should encourage the Innovation Fund Denmark and Vinnova in Sweden to formulate joint calls on plant biologicals, for example as part of the coming mission on climate and eco-friendly agriculture.

An inclusive and transparent communication towards farmers

Farmers are risk adverse, and alternative growing methods should have at least as reliable and adequate level of control as the known practice.

In parallel with the development of biological products, the Plant Biologicals Network should engage more end users (farmers) in network activities. Also, SEGES should consider highlighting biologicals in the national tests “Landsforsøgene®”, as this annual public-cation is the main decision support tool for farmers.

At a later stage, when more biologicals are available, support schemes provided by national authorities should be considered in order to remove the risk from farmers.

Lack of standards and unified infrastructure for test of biologicals

Challenges

Because plant biologicals are young products, standard procedures or protocols for testing them have not yet been developed. Biological products are more complex to use than their chemical counterparts, because they react depending on the local environment (weather, soil pH, etc.).

Today, biologicals are tested the same way as traditional pesticides and stimulants. But there is a need to develop a test regime dedicated to biologicals, as they are fundamentally different in the way they work. A reliable test system for plant biologicals is essential to prove efficiency and provide application manuals for farmers.

In the coming years, a standardised test system for biostimulants is expected in Denmark. The aim is to test biostimulants available today and provide an impartial documentation of effects. Such documentation is called for by farmers and retailers and will be required when a new EU Fertiliser regulation becomes effective in July 2022.

Testing biocontrol solutions is, however, more complex and requires a complete infrastructure to support tests from lab to field. The universities and research and technology organisations in the Southern Scandinavian cluster each possess capabilities and facilities to support tests of plant protection products. But standards and protocols for testing need to be developed and acknowledged.

Actions

A common strategy to build and link infrastructure for tests

The universities in the cluster are all strong in plant microbiology and to a large extent possess the infrastructural framework for testing biologicals from lab to field. But the infrastructure to support tests of biologicals could be improved, if the universities and the research and technology organisations agree on a common strategy for future investments. Such a strategy would help the cluster develop a strong and aligned infrastructure for test and demonstration based on complementary focus areas.

Development of standards and protocols

With a strategy in place, the universities and research and technology organisations should pioneer standards and protocols for testing biologicals. This is not an easy task, but if successful such a Southern Scandinavian testbed is likely to attract international biotech companies to test in Denmark and Sweden.

The development of standards and protocols will require a grant of about 7 million EUR, according to one of the interviewed researchers.

A transparent and accessible platform for companies

Facilities, prices, methods, etc. should be transparent and displayed as a united platform. Such a platform would showcase the Southern Scandinavian cluster as a testbed of united infrastructures easily accessible for companies interested in testing biological products.

Expensive and long time to market

Challenges

Microbial biocontrol solutions are expensive to develop, and the time to market is long. It requires a stable cash flow and deep insights into the legal frameworks to bring a biocontrol agent to the market. Consequently, starting up a business in this area is not easy, which is evident from the lack of start-ups found in the cluster.

The registration and market entry of a biocontrol product in the EU lasts up to seven years and costs about 1 million EUR.[9] Consequently, many plant biologicals are launched in other regions of the world before they reach European crops.

Biocontrol solutions are not recognised as a specific regulatory category and do, to a large extent, follow the same set of data requirements and approval processes as chemical pesticides. Registration of biocontrol solutions in the EU is complicated by a dual process. The European Food Safety Authority authorises active substances based on evaluations from so-called Rapporteur Member States, while products are authorised nationally in an (inter)zonal system. The evaluation of biocontrols is further challenged by the fact that only few Rapporteur Member States have experience with biological dossiers.

Denmark and the Netherlands are among the most popular EU Rapporteur Member States when it comes to evaluating biocontrol solutions. Consequently, applications from all member states are forwarded to the two countries, causing a long waiting list (currently up to three years).

A major challenge in the evaluation process are insufficient dossiers from applicants. As mentioned, biopesticides follow the same set of data requirements as chemical pesticides, including requirements that do not make sense to producers of plant biologicals. There is an urgent need for approval procedures and guidelines adapted to biocontrol solutions.

The long time to market and lengthy product approval in the EU result in repeated extensions of approvals of chemical pesticides in Europe, challenging the EU goal of a 50% reduction of chemical pesticides by 2030.

[9] Azizbekyan, R. R. (2018): "Biological Preparations for the Protection of Agricultural Plants (Review)".

Actions

An ecosystem to support start-ups

A strong ecosystem is important to foster new biotech companies. Start-ups focusing on plant biologicals should be incorporated in a broader strategic boost of an ecosystem for biosolutions, including accelerator facilities and venture capital.

Regulatory fast-track for low risk biological solutions

With the European Green Deal and Farm to Fork strategy, the current political momentum should be used to ensure that the EU has the frameworks in place for incentivising new biological innovations and facilitating a fast market access.

A fast-track system for low risk/minor use biological solutions should be implemented at the EU level (both in the approval of active substance and product authorization). A fast-track should include prior review by experienced Rapporteur Member States, new data requirements adapted to biologicals and clear guidance for applicants to make sure dossiers are sufficient.

Competencies for future evaluation and authorisation of biologicals

More Rapporteur Member States need to gain experience with the evaluation of biocontrol solutions in order to reduce the current waiting time and prepare for a future with an expected increase in applications.

In Denmark, the Environmental Protection Agency is currently looking into solutions for increasing the expertise needed to process evaluations of biocontrol solutions. In addition to hiring, a more agile system drawing on expertise at the universities could help reduce waiting time. However, being a public agency, the Environmental Protection Agency has limited options for arranging such consultant agreements.

Appendix – methodology and sources

Interviews
In total, 16 interviews were completed covering the key players of the cluster (see table to the right). All interviews were carried out online and followed a semi-structured interview guide.

Bibliometrics
Bibliometric data from the SciVal database, which contains research publications from more than 15,800 research institutions, was used to assess the relative scientific strongholds of the cluster. Bibliometrics deploys statistical methods to analyse books, articles and other publications. In this analysis, the method is used to analyse the number and quality of scientific articles, reviews and conference papers from the four universities of the cluster and eight benchmark universities. Data was exported 8 April 2021.

The selected indicators included:

- Number of publications.
- Publications in Top 10% Journal Percentiles by SNIP (%).
- Academic-Corporate Collaboration (%).

It is important to note that "plant biologicals" does not exist as an autonomous subject area in SciVal. Thus, the bibliometric analysis is based on three subject areas: Plant Sciences, Soil Sciences and Agronomy and Crop Sciences.

This approach might exclude some areas of research within plant biologicals such as Environmental Microbiology and Microbial Ecology, while on the other hand including areas of Plant and Soil Sciences that are beyond the scope of plant biologicals.

List of interviewees

Organisation	Name, title
AgroLab	• Martin Gejl, Owner
Bayer	• Niels Bjerre, Agricultural Affairs Manager
Chr. Hansen	• Kim Müller Christensen, Head of Plant Health • Lars Mølbak, R&D Manager • Jesper Packert Pedersen, Head of Public Affairs
Danish Agricultural Agency	• Nanna Karkov Ytting, Head of Section
Danish Environmental Protection Agency	• Inger Bergmann, Head of Unit • Vibeke Møller, Functional Manager • Birte Fonnesbech Vogel, PhD, Civil Engineering
Danish Technological Institute	• Mette Walter, Head of Section, Field Trials, Technology and Analysis
EWH Bioproduction	• Erik W. Hansen, CEO
FMC	• Bénédicte Flambard, Global Director • Lieselotte De Bruyne, Market Development Manager • Nina Jørgensen, Global Regulatory Manager • Eva Louise Holm Østergaard, Communications Manager
Ingleby Farms	• Mette Duedahl Høyer, Chief Production and Sustainability Officer
Lund University	• Allan Rasmusson, Professor
Novozymes	• Svend Kaj Petersen, Head of Technology Sourcing and External R&D • Jeanne Kjær, Senior Manager • Lise Christina Deleuran, Regulatory Expert • Peter Steen Mortensen, Director of Public Affairs • Kathrine Dose Stenild, Public Affairs Advisor
SEGES	• Troels Toft, Sector Director
Swedish University of Agricultural Sciences	• Erik Andreasson, Professor, Head of Resistance Biology Unit
Syngenta	• Carina Skovmøller, Head of Business Sustainability, Public Affairs & Press Nordics
University of Copenhagen	• Svend Christensen, Professor, Head of Department of Plant and Environmental Sciences
Aarhus University	• Carsten Suhr Jacobsen, Professor, Head of Department of Environmental Science

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