MICROBIALS

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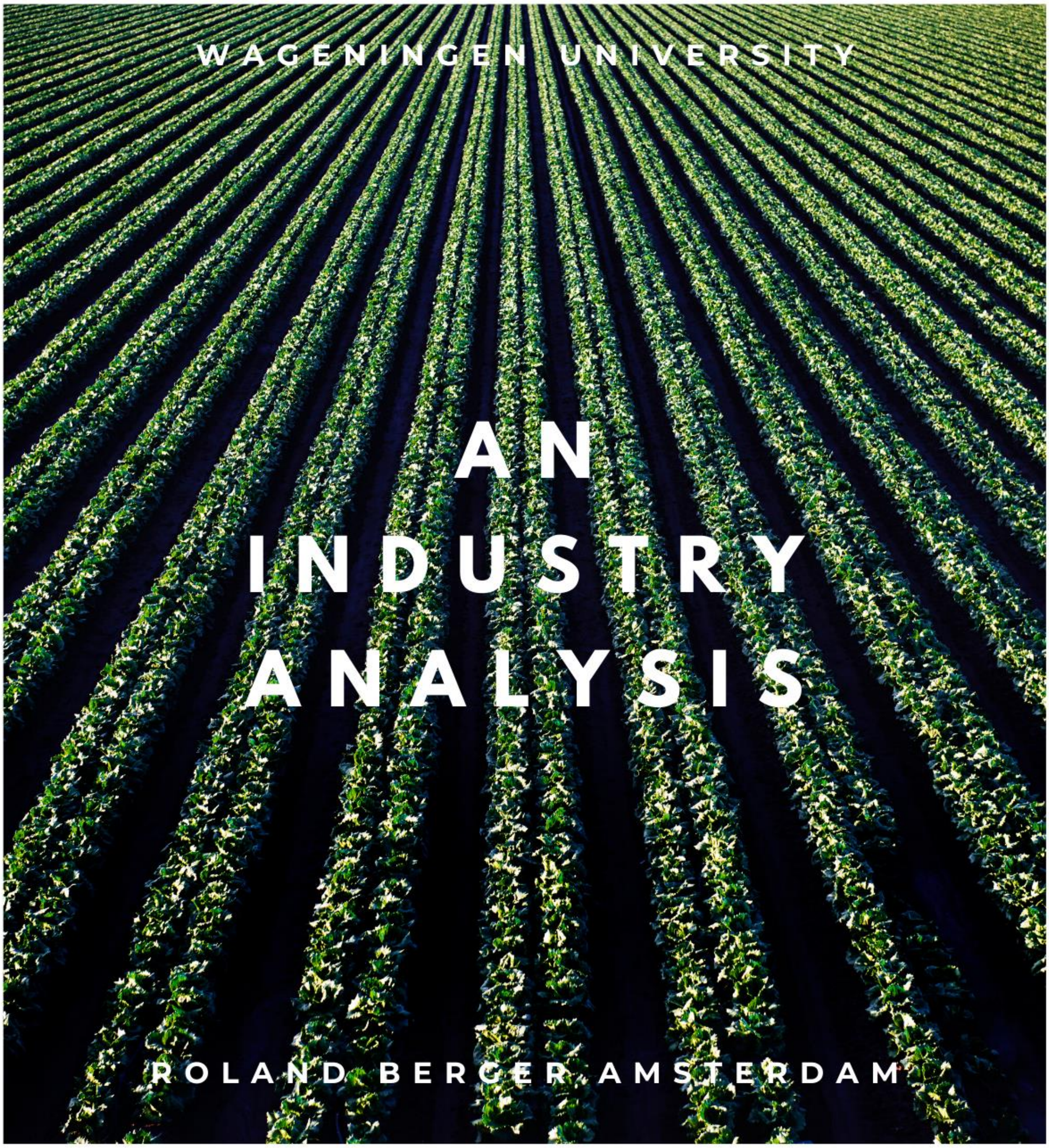

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Abstract

As the world's population is rising, the demand for food is evermore increasing. Chemical pesticides and synthetic fertilizers have been, and still are, contributing heavily to meet this demand. However, certain governments, such as the European Union, have not extended the approvals of the most broadly applied pesticides or have increased restrictions on the usage. This is a worrying development for farmers who are dependent on these chemical products. As gene editing is inconsiderable in the EU, the only viable long term option is to adopt biological alternatives. Of these biological alternatives, microbials (biological pesticides, fertilizers and stimulants based on micro-organisms) show the most growth potential. This study aims to give a rudimentary description of the European microbials industry, and analyses what external factors and competitive forces are influencing developments. Firstly, a description of the current composition of the microbials industry is given, based on reviews of scientific literature and internet research. Secondly, an analysis of the external factors is provided, using a PEST analysis. Third, the competitive forces were analysed using the Porter's five forces analysis. These analyses were based on semi-structured interviews with n=14 experts. Results showed that within Europe, n=106 companies are active in the microbials industry and that approximately 46% of the companies are small to medium sized companies. The PEST analysis showed that political and social pressure will create openings for the microbials industry to gain market share and that with current technologies, the efficacy of the microbials will improve over time. Social and political pressure will be essential for both reducing the amount of agrochemical products on the market and amending the regulations that currently limit the introduction of microbial products. Another limiting factor is that microbials are considered more expensive compared to agrochemicals as farmers are highly price sensitive due to the small margins on crops. Therefore, limited availability of agrochemicals will be essential for microbials to gain market share. Currently, the highest growth potential lies in organic farming, as the use of agrochemicals is prohibited and most microbials are allowed in organic food production. The combination of technology and biology will be vital for the future of the microbials industry. With the current level of technology the efficacy of microbials can be improved. The threat of new entrants is medium; bargaining power of suppliers is low, the bargaining power of buyers is high; and the threat of substitutes low to medium. The rivalry among competitors is considered high due to a fragmented market, creating a highly competitive industry. Ideally, microbials will compete with agrochemicals, which might happen over time. The expectation is that in the long run, chemicals will be set aside and biologicals will prevail, as our understanding of the many variables in nature increases, making it evident that chemicals have no place in the future of agriculture. This study therefore recommends that European companies, who are interested in future developments of the crop protection industry, enter this industry as soon as possible and start developing these novel products.

Key words: microbials, MBCA, biologicals, Europe, industry analysis.

Acknowledgements

This Master thesis was written as part of the Master Management, Economics and Consumer studies for the Business Economics department of Wageningen University and Research in The Netherlands. Roland Berger Amsterdam commissioned the subject as the biologicals and microbials industry is getting increased attention from media and companies. At first, this subject was something that I never considered before, and it took me some time to understand the subject of microbials. During the period that I have been working on my thesis, I learned a lot about both the agrochemical industry and the biologicals industry, interviewed key players of universities and companies in Europe and the United States, and learned new methods of research. Furthermore, I would like to thank the people that have made this research reality. First, Alexander Belderok and Arnoud van der Slot. I would like to thank you for providing me with this subject, giving me the opportunity to broaden my research interests and opening up a complete new industry to discover. Discussing with you on the subject or on research methods made me push myself to critically reflect on my decisions. Second, Emmy van Schijndel, thank you for always finding time to help me, introduce me to people with further knowledge on specific factors, for reviewing the papers I wrote and providing an unwavering constructive opinion during brainstorm sessions and discussions. This research could not have been conducted without intensive supervision and therefore, I would like to thank Dr. Mariska van der Voort for her continuous support and time for reviews. I have appreciated the discussions about every part of the research and the focus to note all the steps I was making during this research. Also, I appreciate the flexibility that you have shown, always making sure meetings were still conducted, even when we were not able to meet in person. This research was focused more on the macro-environment of the microbials industry. As not only the macro environment was to be considered, Luc Meerkerk conducted a micro-environmental analysis, specifically on the price developments of the microbials industry. I would like to thank Luc for his contribution to this research as we were able to critically reflect on each other's' findings, resulting in new interesting finds. Moreover, I would like to thank the experts for allowing me to conduct interviews and gain knowledge through their expertise. The experts were all highly motivated about the biologicals and microbials industry. Subsequently, I would like to thank Roland Berger Amsterdam for providing a productive working environment, conference call and transport support when interviews had to be conducted within The Netherlands and abroad. It was great to experience how other employees were eager to support me and how I was adopted as one of their own. Finally, I would like to thank my friends and family for supporting me and also providing me with new insights and inspiration.

Boudewijn A.C.M. Beerkens
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List of Contents

List of Abbreviations

Abbreviation	Meaning
AI	Active Ingredient
Ag	Agricultural
Ag chems	Agricultural chemicals
AS	Active Substance
Avg	Average
BCPP	Biological Crop Protection Product
bn	Billion
BPPP	Biological Plant Protection Product
Bt	Bacillus thuringiensis
CAGR	Compound Annual Growth Rate
CPC	Cooperative Patent Code
EBIC	European Biostimulants Industry Council
EC	European Commission
ECHA	European Chemicals Agency
ECI	European Citizens Initiative
ECOFI	European Consortium of the Organic-based Fertilizer Industry
EFSA	European Food and Safety Authority
EIL	Economic Injury Level
EPA	Environment Protection Agency
EPO	European Patent Office
EU	European Union
EUBIA	European Biomass Industry Association
EUR	Euro; Currency
FAO	Food and Agriculture Organisation
GMO	Genetically Modified Organism
IARC	International Agency for Research on Cancer
IBMA	International Biocontrol Manufacturers Association
IPM	Integrated Pest Management
NPK	Nitrogen, Phosphorus, Potassium
m	Million
n	Amount
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne
M&A	Mergers and Acquisitions
MBCA	Microbial Biological Control Agent
PIP	Plant Incorporated Protectants
PPP	Plant Protection Product
ROI	Return On Investment
R&D	Research and Development
SME	Small to Medium sized Enterprises
SUD	Sustainable Use Directive
UN	United Nations
US	United States
USD	United Stated Dollar; Currency
VC	Venture Capital

List of Tables

List of Figures

1. Introduction

1.1 General introduction

As long as humans have been cultivating crops, they have found that pests destroy the yields, forcing them to think about ways to protect their crops from insects, weeds and diseases (Dent, 2000; Oerke, 2006). This began as early as 8000 years ago, when Europe's first farmers were spreading manure on fields to increase the yield from their crops, archaeologists discovered (Balter, 2013). The first recorded use of pesticides was in 3000 BC, where the ancient Sumerians used sulphur to control insect pests. Around 600 BC the Greeks and Romans started using oil and ash and, in the 17th century, farmers used tobacco infusions for crop protection. Later, in the 19th century, sulphur and copper compounds were developed to protect yields from pests. These became known as the first human made pesticides (CropLife, 2017; Brodeur et al., 2018). Generally speaking, pesticides can be defined as insecticides, herbicides and fungicides (Usta, 2013). It took up until around 1930 to develop the first fungicides and the first synthetic (man-made) chemical crop protection products, which increased agricultural yields drastically (Croplife, 2017; Brodeur et al., 2018). In 1905, Fritz Haber and Carl Bosch developed the first synthetic fertilizer that would revolutionize agriculture by providing a near infinite source of nitrogen (Mingle, 2013; Splitter, 2018). This was particularly necessary as the amount of fertilizer that animals could produce was not sufficient to sustain the food demands of an ever-growing world population. The invention of synthetic fertilizers resulted in crop yields and food supply surging (Mingle, 2013; Splitter, 2018).

For years, it was considered that chemical pesticides and synthetic fertilizers were indispensable ingredients to battle pests and to increase yields (Brodeur et al., 2018). In the period 1940 to 1960, the crop protection industry mostly focussed on creating cheap and chemical pesticides. This period was dubbed 'the dark ages of pest control' due to the amount of chemical pesticides that were being developed and used in agriculture, which in turn ended up having harmful side effects for humans and the environment (Newsom, 1980; Kogan, 1998). This triggered the industry to consider alternatives for chemical pesticides, with the main focus to create products that are less harmful to people and the environment**.** This encompassed not only chemical pesticides, synthetic fertilizers also came with a trade-off that is now causing a number of environmental and human health issues. Due to the increased use of synthetic fertilizers, the amount of excess nitrogen has become a global problem (Splitter, 2018). The negative effects of the chemical pesticides and synthetic fertilizers resulted in three developments. First, governmental institutions started to regulate the use of pesticides. For example, the use of Dichlorodiphenyltrichloroethane (DDT) was banned in 1972 in the US and 1986 in the EU (Lear, 1998). Second, Integrated Pest Management (IPM) was introduced and widely supported by entomologists and ecologists (Knipling, 1972; Croplife, 2017). Third, the research on alternatives for chemical pesticides and synthetic fertilizers gained momentum, which resulted in biological crop protection products (BCPP's) or biological plant protection products (BPPP's), grouped in the term agricultural (ag) biologicals (hereafter: biologicals) (Nicot et al., 2011; Barratt et al., 2018).

The results from the research within the crop protection industry is visualised in how the market developed over the past 60 years. In 1960, the crop protection industry was worth less than USD 10 billion, with only 100 chemical active ingredients that were available to crop protection manufacturers (Philips McDougal, 2018). Today, the industry is valued at over USD 50 billion (Philips McDougal, 2018; EPA, 2019). Over the past 50 years, the world's major research-based companies focused on crop protection products. These companies invested an estimated 7-10% of their turnover into research and development (R&D), resulting in an annual 3 billion dollar investment in the crop protection industry (Philips McDougal, 2018). By investing this capital into the crop protection industry, companies have been able to improve the efficacy and safety profiles of their chemical products and do research for alternatives. From this R&D budget, 9.2% is invested into the development of biologicals (Philip McDougal, 2016). Estimates by Agrow Agribusiness Intelligence (2018) show that the biologicals sector is the fastest growing sector in the crop protection market. The global biologicals sales in 2003 were estimated around USD 0,6 billion compared to an estimated USD 3 billion in 2018. The sales are projected to reach USD 11 billion by 2025 (showing a 16-17% Compound Annual Growth Rate (CAGR)) with the current market share for biologicals in the global crop protection market being 6.1% (Philips McDougal, 2018).

Biologicals are divided into three major product categories; biofertilizer (plant nutrition), biostimulants (plant growth), and biological control (plant protection) (Agricen, 2019). Biological control is the use of living organisms to reduce the population density or impact of pests in agriculture and is one of the oldest non-chemical ways to manage pests (Smith, H. S., 1919; Eilenberg, Hajek and Lomer, 2001; Stenberg, 2017, Barratt et al., 2018). The products within these categories are derived from natural products, semio-chemicals, macrobials and microbials (Croplife, 2018).

Within the biologicals market, microbials were responsible for 47% of biologicals sales in 2018 (Agrow Agribusiness Intelligence, 2018). Microbials are currently the biologicals segment with the most growth potential according to Ravensberg (2011). Even though the microbials industry size and value has been growing, the social acceptance of the use of microbials in agriculture is relatively low (Brodeur et al., 2018). Furthermore, factors such as; low adoption rate by farmers, inconsistency in the product results, low in-field performance and relatively high registration costs, keep the market growth of the microbials industry limited (Business Insider, 2017; Agrow Agribusiness Intelligence, 2018; Frederiks and Wesseler, 2018). According to Brodeur et al. (2018) and Frederiks and Wesseler (2018), the registration procedures for microbials are complex and expensive. The reasons for this are firstly, a lack of expertise of regulators and secondly, the fact that the EU microbials are assessed in all member states individually (Brodeur et al., 2018; Frederiks and Wesseler 2018).

Biologicals and in particular microbials will be important in the future when considering the agricultural growth potential of the world's developing regions, the increase of awareness among consumers about food consumption and the popularity of IPM. Due to this, there is a vast increase in start-ups which could provide the developing microbial sector with a positive future perspective (Laurita and Kerovuo, 2018). These developments are leading to interests from companies active in the crop protection industry, investors and consultants. Additionally, companies with similar technological capabilities are interested in the development of microbials. To determine what the developments of the microbials industry might entail, an industry analysis will be conducted. An industry analysis is a type of case method research that is used to create new knowledge related to the industry (Aithal, 2017). Up to date, there has not been a scientific industry research on the European microbial industry, thus this thesis will be filling a knowledge gap. This gap is present due to microbials being a newly developing industry, but also due to a vast inconsistency in terminology and in scientific, regulatory and commercial literature. The consequence of which is the limited availability of information on the topic. The results of the industry analysis will be of informative value for both seed- and crop protection product manufacturing companies, and companies interested to invest or enter the microbials industry. Furthermore, the results will be of importance for consultants and investors who need this information before advising about or investing in the microbials sector.

1.2 Objective and sub-objectives

The main objective of this thesis is to conduct an industry analysis of the European microbials industry and investigate whether it would be a strategic decision for investors and companies active in the crop protection industry, to consider the future prospects and opportunities of microbials in the EU. In order to study this objective, the following sub-objectives will help.

To answer the main objective, four research questions were developed:

- What companies and start-ups are operating in the European microbials industry?
- What are the external factors influencing the European microbials industry?
- What are the factors influencing the competitive climate of the European microbials industry?
- What factors will determine the success of companies in the European microbials industry?

The focus of this analysis is on the microbials industry, a segment within the biologicals industry. Many companies, especially established companies, active within the microbials industry, do not only operate within these sectors but are also active in other segments within the agricultural biologicals-, agrochemical crop protection-, chemical- and biotech industry. Therefore, it is not possible to estimate the financial performance of this industry.

1.3 Research outline

Chapter 1 includes an introduction and provides an overview of this research. Chapter 2 includes background information about crop losses and agrochemicals, IPM, biologicals and microbials and the regulation for microbials in the EU. Chapter 3 contains the research approach of this research and Chapter 4 will discuss the results found during the literature/data collection and the interviews. Chapter 5 discusses the research approach, the data collection methods, the interview methods and gives recommendations for future research. Chapter 6 gives the conclusion of the findings. Chapter 7 notes the external interests of this research.

2. Literature review on background of microbials industry

There have been three large developments in the crop protection industry over the past 50 years. First, regulation on chemical pesticides and synthetic fertilizers have increased. Second, there was a call for innovation in the chemical pesticide and fertilizer industry, aiming for less impact on human- and environmental health. Third, IPM became increasingly popular among governing bodies and professional plant growers. As microbials are one of the four segments that entail biologicals (see chapter 2.2), it is important to portray how IPM enables the use of microbials and which regulations are used for microbials.

2.1 Crop losses and agrochemicals

In short, there are two groups of factors that cause crop losses in agriculture; abiotic and biotic factors (Oerke, 2006). Abiotic factors are the factors that are physical rather than biological. Abiotic factors consist of irradiation, water, temperature and nutrients. Biotic factors are relating to or resulting from living organisms. Biotic factors consist of weeds, animal pests and pathogens (Figure 1) and are estimated to cause between 20% to 40% of losses to global production of cultivated crops. If there would be no crop protection, this percentage could go up between 48% and 83% (Oerke, 2006). Animal pests by themselves create an estimated USD 470 billion (bn) in global crop yield losses every year, according to Culliney (2014).

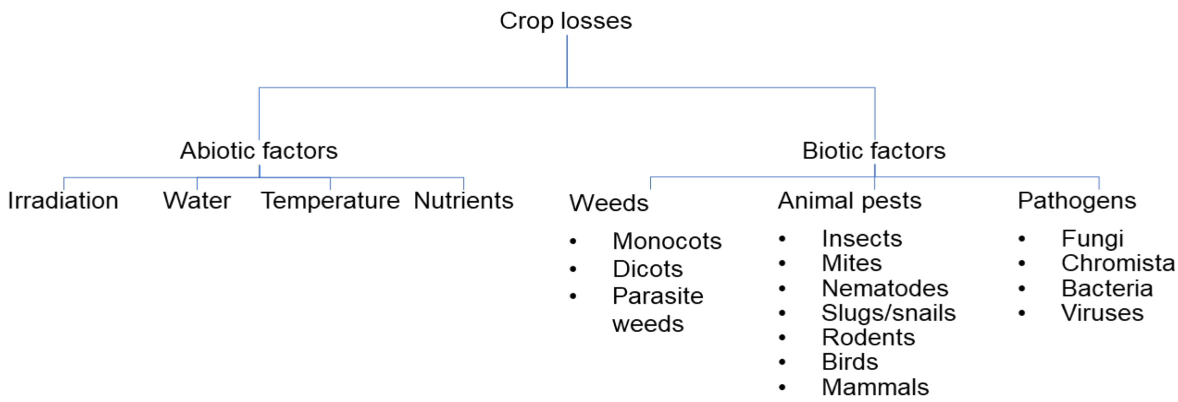


Figure 1 - Factors causing crop losses (based on Oerke, 2006)

With the use of chemical Plant Protection Products (PPP's), the percentage of losses to biotic factors is lowered significantly to between 10 and 20% (Savery et al., 2019). Studies conducted in Denmark and France showed that yield losses increased significantly when PPP's were not utilized or the used amount was lowered. In this Danish study however, it was found that in general, the use of PPP's could be reduced without dramatic economic losses using IPM methods, crop rotation- and adapted cultivation systems (Orum, Jorgensen and Jensen, 2002; Lechenet et al., 2014). But even with the use of PPP's, economic losses have been increasing, mostly due to irresponsible use of chemical pesticides. Over the past 80 years, there has been an increase in new cases of agrochemical resistance by anthropods and weeds (Figure 2), which resulted in an increase of crop losses (Croplife, 2019; Heap, 2020).

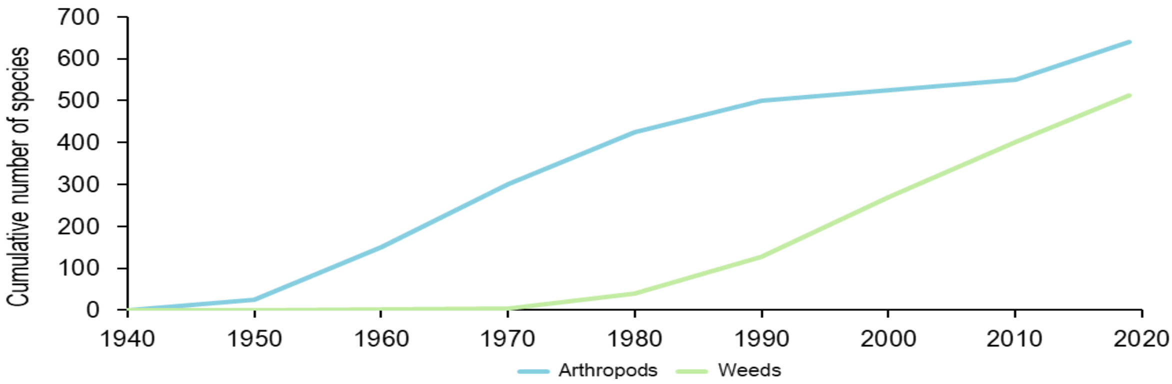


Figure 2 - Number of globally reported cases of resistance (Croplife 2019; Heap, 2020)

Whilst resistance is one problem, farmers in Europe are increasingly worried about political developments concerning broadly applied PPP's. Three of the most used agrochemicals have been either banned or their approvals have not been extended, and one is under heavy critique, due to negative effects on both human and environmental health. First, the residual effects of Neonicotinoids were identified as a threat to the environment, and in particular to honeybees, which led to social upheavals. Neonicotinoids are widely used as insecticides, chemically similar to nicotine and were first approved in the EU in 2005. In 2013 five neonicotinoids (clothianidin, imidacloprid, thiamethoxam, acetamiprid and thiacloprid) were approved as active substance. Almost directly after this approval, three out of the five substances were severely restricted due to danger to honeybees and soil and water contamination (clothianidin, imidacloprid, thiamethoxam). These three were banned on the 30th of May 2018. A fourth neonicotinoid, acetamiprid, was established as low risk to bees and therefore it is still allowed to be used. The fifth neonicotinoid, thiacloprid, approval will expire on the 30th of April 2020, after the European Food Safety Authority (EFSA) established that the active substance has a negative impact on groundwater and human health (European Commission, 2020).

Second, a less well known agrochemical active substance was reputed by the European Commission (EC) (Carrington, 2019). It concerned chlorothalonil, which is used in fungicides. Chlorothalonil is the most used fungicide in the UK. The residual effects of the active substance posed a wildlife and human risk, and therefore authorizations were withdrawn by the 20th of November 2019. Third, the approval for the active substances chlorpyrifos and chlorpyrifos-methyl, which are used in many insecticides, were not renewed. EFSA reported on the 2nd of August 2019, that the active substances could have possible effects on genotoxicity and developmental neurotoxicity. On the 10th of January 2020, the EC formally adopted the regulation that proposed not to renew the approvals and member states had till the 10th of February 2020 to withdraw all authorizations (European Commission, 2020).

And then the active substance that has been dominating the agrochemical news for the past two years, glyphosate. This active substance, used as a broad-spectrum herbicide and better known under the name Roundup, has been accused of causing cancer to thousands of farmers globally (Bender, 2019). In Europe, there has been an increased pressure to assess the negative effects of glyphosate. After approval in 2002, there have been multiple comprehensive scientific assessments between 2012 and 2015 where no proof of carcinogenic hazards to humans were found by the EFSA (European Commission, 2020). The International Agency for Research on Cancer (IARC) did however conclude that glyphosate had a probable carcinogenic effect on humans (International Agency For Research on Cancer, 2017). These contradictory statements resulted in an independent assessment by the European Chemicals Agency (ECHA), who concluded on the 15th of March 2017, that there was no evidence that there was a link between glyphosate and cancer in humans. Even though the same conclusion was given by the EFSA, national authorities of Canada, Japan, Australia and New Zealand and the Food and Agriculture Organization (FAO) of the United Nations (UN), an European Citizens Initiative (ECI) was successfully submitted supporting the 'Stop glyphosate' initiative which was supported by over 1 million citizens from at least 7 EU member states. On the 27th of November 2017 however, the renewal of the approval for glyphosate was extended for 5 years in the EU. Nevertheless, in 2019, Austria decided to ban the use of glyphosate directly, although it is to be seen what the EC will do. France has determined that it will phase-out the use of glyphosate by the end of 2020 and Germany by the end of 2023 (Agrow Daily Newsletter, 2020). The application for renewal of approval has been submitted on the 12th of December 2019, as the approval for the active substance is to expire on the 15th of December 2022 (European Commission, 2020). The controversy, relatively quick phase-out of agrochemicals and hardly any alternatives with the same efficacy, leaves conventional farmers worried about effective ways to manage pests in their field.

2.2 Biologicals

One of the alternatives to agrochemicals are biologicals. Due to the increasing resistance against insecticides, herbicides and fungicides by pests, consumer demand for chemical free produce, the interest in the possibilities of sustainable crop production and protection was re-invigorated (Clark and Hillocks, 2014; Laurita and Kerovuo, 2018). Biological control and biopesticides (biopesticides are defined as preparations containing micro-organisms, botanical compounds and semio-chemicals (Kiewnick, 2007)) almost disappeared between 1940 and 1960 due to the increase of chemical pesticides. But, already in 1962, Rachael Carson wrote the book 'Silent Spring', where she noted the impact of chemical pesticides on the environment and wildlife, as non-target wildlife was also negatively impacted (Carson, 1962). This book is seen as an important trigger that made scientists and consumers become more aware of the impact of chemical pesticides and introduced the opportunity for biological control to make a comeback (Pimentel and Peshin, 2014).

There are many differences between product categories and functions of biologicals. Biologicals contain active ingredients that are divided into four segments. These segments each represent a broad category of products that are being used for crop protection, soil treatment and seed treatment (Marrone, 2019). The products are being derived from semio-chemicals, natural products, macrobials and microbials, as presented in Table 1 (Agrow Agribusiness Intelligence, 2018; Croplife, 2018).

Table 1 - Segments of biologicals and their characteristics (Croplife, 2018)

Biological segments	**Characteristics**
Semio-chemicals	• Communication tools found in nature (pheromones and plant volatiles) • Used to disrupt mating success of pests • No killing effect
Natural products	• Botanicals and other natural substances present in nature • Used as base elements to repel pests from crops
Macrobials	• Nature's predators (insects and mites), parasites and nematodes • Used to minimize the population of pests
Microbials	• Micro-organisms with pesticide-like qualities such as viruses, bacteria and fungal pathogens • Used as preventive protection, direct protection, seed and soil treatment • Bacteria, fungi, virus, protozoan and yeasts are the functional microbials

These four segments are being used for biological control and to produce biologicals, which are divided in three product categories: biostimulants, biofertilizers and biological control (Figure 3). Biological control is divided into two sub segments; biopesticides and macrobials. In 2018, biopesticides represented 51.8% of the biologicals market share (Fortune Business Insights[1], 2019).

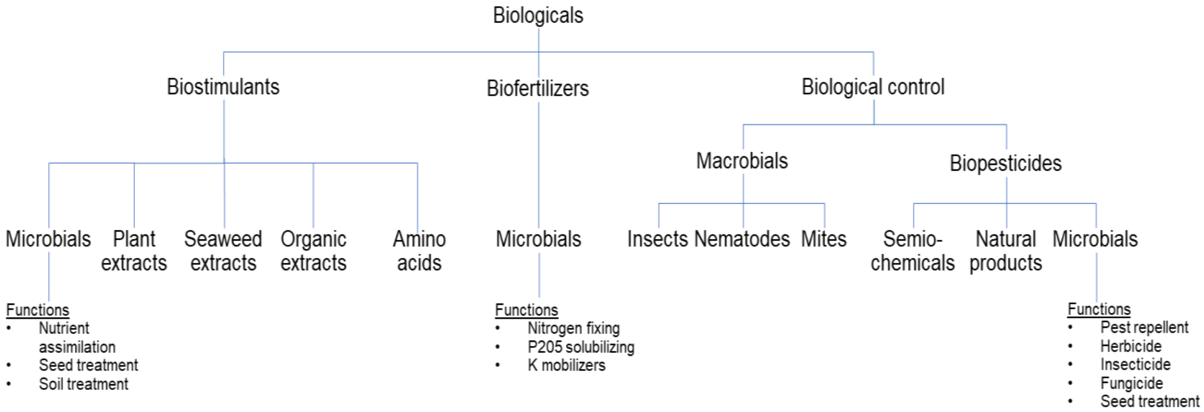


Figure 3 - The three product categories of Biologicals and its subsequent components (based on Dunhamm Trimmer, 2019)

As can be seen in Figure 3, biostimulants aim at promoting plant and yield growth without acting as a pesticide (Seedworld, 2019). Biostimulants are manufactured using humic substances, seaweed extracts, microbial inoculants, amino acids and others (Figure 3) (Calvo et al., 2014). Europe dominates the global market for biostimulants (40.2%) with North America following as second. The potential for growth lies within the Asia / Pacific region as productivity increases are needed to sustain the growing population. In 2018, the market was valued at USD 2.19 bn and it is expected to become USD 4 bn in 2024, retaining a CAGR between 12.4 and 12.7% (Mordor Intelligence[2], 2019; Fortune Business Insights[3], 2019). Closely related are biofertilizers, which have micro-organisms as active ingredients (Figure 3). At this moment, North America is the leading market for biofertilizers and accounting for 28% of the global market share. It is expected that in Europe, Asia / Pacific, and Northern Africa the market size is estimated to grow the upcoming years. In 2018, the global market was valued at USD 1.5 bn and it is expected to increase to around USD 2.5 bn in 2025. The CAGR is estimated to be between 10 and 11.5% (Mordor Intelligence[1], 2019; Fortune Business Insights[3], 2019).

According to the European Biomass Industry Association (EUBIA), the use of biofertilizers and biostimulants will result in higher yields as it enriches the soil with useful micro-organisms and nutrients and increases the uptake of nutrients whilst protecting the crops by destroying harmful components from the soil. Functions of Synthetic fertilizers do have a higher Nitrogen Phosphorous Potassium (NPK) ratio compared to biofertilizers, which, when applied, is directly available to plants. But, due to the slow release of nutrients by biofertilizers and stimulants, overfertilization and nutrition is hard to achieve (Mazen et al., 2018). Currently, when biofertilizers and synthetic fertilizers are combined, the best results are achieved (Mahanty et al., 2017, Mazen et al., 2018). Next to this, if biofertilizers are used as complete substitutes for chemical fertilizers, this will result in less soil degradation and impact on the surrounding biotope (Mazen et al., 2018). One big downside of biofertilizers on the other hand is that it is potentially more expensive due to the lower nutrient density compared to chemical fertilizers. Furthermore, there is a need for different machinery to apply biofertilizers, which limits the adoption rate of biofertilizers (Mazen et al., 2018).

As previously mentioned, the biggest share of biologicals consists of biopesticides. Estimates by Agrow Agribusiness Intelligence (2018) show that the biopesticides sector is the fastest growing segment in the global crop protection market sector. As visible in Figure 4, the CAGR of the biopesticides sector is estimated to be around 14 to 16% by 2025 (Agrow Agribusiness Intelligence, 2018). Currently biopesticides are responsible for 6.1% of the global crop protection industry sales but this is projected to rise to 15,9% by 2025 (Philips McDougal, 2018). Biopesticides are costlier compared to agrochemicals, but have a reduced amount of application, the persistence and residual effect is lower as it is mostly biodegradable, there is a delayed knockdown effect, the handling is in bulk, pest resurgence and resistance is less prone to happen, there is less effect on beneficial flora and the product is mostly host specific, thus only targeting pests (Laurita & Kerovuo, 2018; Shukla et al., 2019). On the other side, there is also criticism about biopesticides. The future of biologicals poses multiple challenges. Anna Rath, CEO of Vestaron was interviewed by agfundernews and stated: "*Interestingly, in contrast to pharma, 'biologicals' in agriculture has come to be synonymous with 'microbials.' While there is certainly a rich portfolio of microbial crop-enhancement technologies, there are very few microbial crop protection technologies. This is in part because effective crop protection technologies require known and proven modes of action, which microbials often lack*." (agfundernews.com, 2019). Secondly, the efficacy of microbes is always researched in sterile environments, potentially not showing what the negative effects could be when taken out of such an environment (Nicot et al., 2011; Parnell et al., 2016). Besides this, the shelf life of microbials is shorter compared to those of chemical pesticides, there is a high versatility of ecological trade-offs (the compound is only active at certain periods of plant growth), some micro-organisms are not practical or too expensive to grow and the microbials should be able to adapt and survive to multiple outdoor conditions and ranges of application techniques without losing efficacy and dying (Begemann, 2019). For microbials in general, shelf life is an important limiting factor, as micro-organisms die or become less efficient after a certain period.

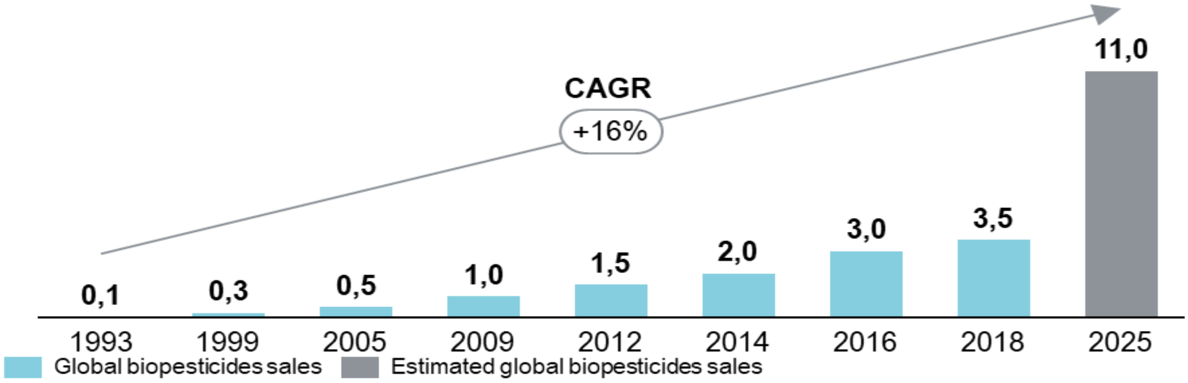


Figure 4 - Global biopesticides sales 1993 – 2025 in USD bn (Agrow Agribusiness Intelligence, 2018)

2.2.1 Microbials

Multiple studies over the past decade focussed on the highly complex microbial mixtures, associated with plants and soil, such as in the roots but also in the stems, leaves, flowers and fruits of plants (Vorholt, 2012; Reinhold-Hurek et al., 2015; Hardoim et al., 2015). These microbiota (i.e. all the micro-organisms) have important functions concerning plant growth and health (Vorholt, 2012; Hardoim et al., 2015; Compant et al., 2019) and are being used to develop biologicals (Rahman et al., 2018). This specific segment is called microbials. Microbials are micro-organisms with pesticide-like qualities (Table 1) and could be used for preventive protection, soil treatment, seed treatment and direct protection (biopesticides). Since micro-organisms are found in soil and on plants, application has potentially limited consequences for the direct environment if applied correctly. Therefore, microbials will be used more frequently as preventive measures against pests and disease in the future (Abuamsha, 2011; van Lenteren et al., 2017).

Currently, North America is the leading region in the global agricultural microbial market, followed by Europe. The Asia Pacific region and Latin America are emerging and gradually growing towards the industry. Up till now, the most successful aspect of microbials has been the use of biopesticides and most research has been conducted in this field (Bale et al., 2008). It is forecasted that the share of bio insecticides is going to grow to 47% of the global biopesticide market by 2020 (Ravensberg, 2017). Bio fungicides (44%), bioherbicides (1%), bionematicides (3%) and others (5%) will encompass the rest of the industry (Ravensberg, 2017; Agrow biopesticides, 2019).

As can be seen in Figure 3, biologicals are divided in biostimulants, biofertilizers and biological control. Biofertilizers are made using microbials that enhance plant nutrient uptake from the soil and mobilizers of specific nutrients and mycorrhizal fungi (Marrone, 2019). The largest group of microbial biofertilizers are used for nitrogen fixing, which is an environmental friendly option to reduce and balance nitrogen levels in soil and counterweigh the negative effects that synthetic fertilizers created (Dunham Trimmer, 2019). Biostimulants use microbials for the improvement of plant traits by inoculating seeds, although this has not been proven to be fully applicable in the field (Compant et al., 2019). Therefore, seaweed extracts are still responsible for the largest market share of biostimulants (37%). There is a lot of investment from venture capital (VC) and private equity entities within this market due to the lower regulatory standards needed for stimulants (Marrone, 2019). Even though initiatives to inoculate seeds, that trigger crop resistance against pests, have not yet been an in-field success, the use of microbials in biopesticides have been a bigger success (Compant et al., 2019).

As visible in Figure 3, macrobials or biopesticides are used for biological control. Biopesticides are branched in three categories: biochemical pesticides, microbial pesticides, and plant-incorporated protectants (PIPs) (Marrone, 2019). Biochemical pesticides use natural products, semio-chemicals and naturally occurring acids to control pests. Microbial pesticides are created using bacteria, fungi, virus, protozoan and yeasts. Products with bacteria and fungi combined have a share of approximately 90% (Dunham Trimmer, 2019). PIPs are substances with pesticidal characteristics that contain genetic material added to the plant, often through genetic engineering (Marrone, 2019). Microbials are generally applied in three different ways. Modes of application of microbials are soil treatment, foliar spray and seed treatment. As the microbials industry is growing, it is estimated to become one of the major pillars of preventive crop protection in the future (Agrow Agribusiness Intelligence, 2018).

One example of a well-known microbial is the Bacillus thuringiensis (Bt) bacterium which is used as biopesticide. According to Brookes and Barfoot (2010), insect resistant crops are modified to produce insecticidal toxins from the bacterium Bacillus thuringiensis, better known as Bt crops. Bt crops are known to decrease the use of insecticides and to reduce input costs.

2.3 Regulation

There are strict regulations in the EU for biologicals as these products come into direct contact with food products for animal and human consumption. Huber (2019) states that these regulations are strict due to the lack of regulation on synthetic pesticides and synthetic fertilizers, which lead to health and environmental problems. First of all, these regulations are in place to protect environmental, animal and human health and safety. Secondly, regulations are in place to characterize products, which will ensure products of consistent quality (Chandler et al., 2011). Until recently, government regulators—with the exception of the US—were relatively unfamiliar with biologically based pest management and were therefore slow to make the regulatory process appropriate for biologicals rather than treat them in the same way as chemical pesticides (Frederiks and Wesseler, 2018).

Globally, microbials are regulated differently. In the EU, safety profiles are required by the EFSA, which does the risk assessments for the EU's pesticides markets (Philips McDougal, 2018; Frederiks and Wesseler, 2018). Currently, approximately 600 agrochemical active ingredients have been registered and 366 biological active substances and organisms have been registered in the U.S., whilst only 151 biological active substances and ingredients are registered in the EU. Since 2000 there have been 47 registrations of microbial active substances in the EU and 73 in the US (EPA, 2019; Grosbeau, 2019). Only 14 have been registered in the EU after reforms in 2009, which might be an indication that regulations in the EU seem to have become stricter (Frederiks and Wesseler, 2018).

Within the European Union (EU), there are extra requirements concerning the efficacy of the products. The EU legislation for biopesticides is extensive and complicated and built on the same framework for chemical pesticides (for timeline of regulatory changes view Appendix A). Not only does the regulation have to be passed through all European member states, it also has to comply with multiple EU regulations and directives that have been developed since 1991. In 2011, the EC passed Regulation 1107/2009/EC in a legislative package (Sustainable Use Directive (SUD), Reg. 1185/2009 and Directive 2009/127). In this package, active substances were differentiated into high and low risk substances. Even though this differentiation was made to make the registration process of biologicals easier, only 14 low risk substances have been approved since 2000 (Frederiks and Wesseler, 2018; Agropages, 2019). Köhl et al. (2011) proposed a stepwise screening system aiming to improve the screening of micro-organisms for commercial use in biological control as a response to the introduction of Regulation (EC) no 107/2009 and its strict requirements.

The most recent regulations have been focused on a more environmental approach, but there has not yet been a movement towards making the registration process for biologicals easier (Table 2). Regulation 283/2013 states that each microbial active substance should be identified and characterized. The registration process poses difficulty as there is no guidance in the EU on the characterization of micro-organisms. The EU recognise that something needs to change. Hubert (2019) states: '*The EU has recently expressed the view that the application and success of biological control (with macrobial* *and microbial agents, and semio-chemicals) has been lower in Europe than in other parts of the world, and questioned whether this relative lack of success is attributable to a fragmented or over-cautious regulatory process in different European countries*.' Moreover, there are regulatory grey areas in the EU as biostimulants and fertilizers, in some cases, have crop protection traits, nutritional and plant health benefits.

Table 2 - Overview of current regulations for the microbials industry

Regulation	Topic	Source
EC No 1107/2009	Sustainable Use Directive; regulation for both synthetic and bio-based active substances and products.	Link to regulation
EC No 1185/2009	Collection of data and statistics on pesticides.	Link to regulation
EC No 283/2013	Microbial active substances, ID and characterisation.	Link to regulation
EC No 834/2007 Article 16	Organic food production; what PPP's are allowed to be used.	Link to regulation
EU 2019/1009	Amendment for fertilizers; special attention to use of micro-organisms; both for biofertilizer and biostimulants.	Link to regulation

Furthermore, the answer to whether microbials can be used for organic food production in Europe is found in article 16 of Regulation (EC) No 834/2007. This article stipulates that the use of plant protection products (PPP's) is only accepted when this is necessary for the sustainable production and essential for the production process. The article states that the only PPP's that can be used in organic farming are products and substances that are of plant, animal, microbial or mineral origin. The exceptions are if products or substances from such sources are not available in sufficient quantities or qualities or if alternatives are not available.

2.4 Integrated Pest Management

IPM is seen as enabler for biologicals. This is due to the special focus of IPM to discourage the use of chemical pesticides with a holistic bottom-up system. The EU has endorsed IPM as the future paradigm for crop protection for the sustainable use of pesticides in professional crop growth (Stenberg, 2017). The current definition of IPM, according to the Food and Agriculture Organisation (FAO) of the United Nations, is;

'*IPM means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment. IPM emphasizes the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms'* (FAO, 2019).

In other words, IPM is based on the idea that it should be possible to manage insect pests by only using crop protection products when it is absolutely necessary. Every decision should be both economically and ecologically driven and motivated. Even though IPM is adopted and promoted by governmental institutions, IPM should not be seen as 'the' one solution regulated by strict rules and regulations that fit whole countries or continents (Stenberg, 2017). IPM strategies rather focus on actions that consider an environmental approach. This approach includes principles, strategies and tactics that contribute to the reduced use of chemicals as well as to higher food security and sustainable production (Vetek et al., 2017). In order for IPM to succeed, it should be regionally adopted to ensure the best effect (Stenberg, 2017). Additionally, Stenberg (2017) argues that current scientific research into IPM is not holistic enough, making existing IPM systems less efficient than the sum of the separately applied crop protection products and actions. This is because scientists so far have only focused on individual parts of IPM and have not, or barely, conducted an integrated and interdisciplinary research on the topic.

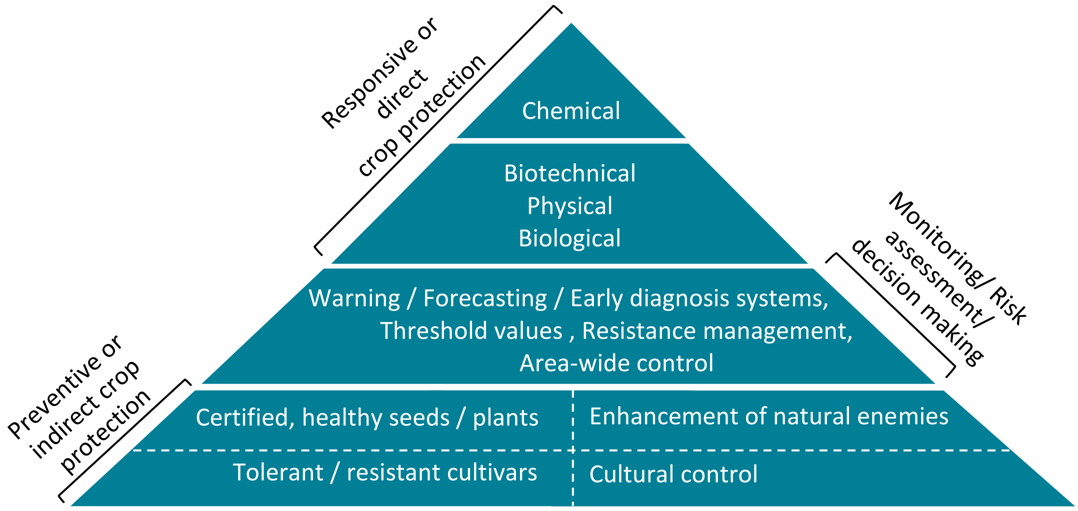


Figure 5 - Principles of Integrated Pest Management (Based on Meissle et al., 2011 and Vetek et al., 2017)

First, the main focus of IPM was to reduce or suppress disease and pest populations to, or below the Economic Injury Level (EIL). Later this evolved into considering the environmental impacts, as this also affects the economic value in the long term (Pimentel, 2009). IPM is a holistic bottom-up system, divided into three phases to determine what type of crop protection should be used and when (Figure 5). First, preventive (or indirect) crop protection measures are considered. The aim of this is to act in a preventive manner against pests and diseases. Options to consider are: buying certified and healthy plants and seeds and the enhancement of natural enemies. Other examples of preventive crop protection are using tolerant and/or resistant cultivars or cultural control (Vetek et al., 2017). Second, succeeding the preventive crop protection phase, is the monitoring phase. This phase examines if there are indications of the presence of pests. If so, a risk assessment is done and consequently a decision is made whether or not responsive crop protection is needed. This phase focusses on assessing the risk of the (possible) pests and what the developments might entail for yield and environment (Meissle et al., 2011). In the third phase, the responsive (or direct) crop protection products are presented as final solutions to keep the levels of the present pests below the EIL (Boller et al, 2004; Meissle et al., 2011; Vetek et al., 2017). As can be seen in Figure 5, the final phase is divided into two segments. Initially, the use of biotechnical, biological and physical responsive crop protection measures are preferred over the use of the final solution; the chemical crop protection products (Meissle et al., 2011; Vetek et al., 2017). Currently, the best way to practice IPM is by combining biologicals and chemical crop protection products. According to Barrat et al. (2018), the future developments of IPM will most likely lead to an increase in the use of biologicals, which will be used more frequently than chemical products.

2.5 Concluding

Biologicals can be divided in three product categories; biostimulants, biofertilizers and biological control. Biological active ingredients are divided in four segments; semio-chemicals, natural products, macrobials and microbials. The biologicals industry is becoming increasingly popular within the crop protection industry due to an increase in pest resistance against chemical pesticides and the EU not renewing approvals of broadly applied agrochemicals. Without PPP's, yield losses can get up to 83% of annual yields. An enabler for biologicals is the popularity of IPM and the strategies that focus on preferring biologicals over chemical pesticides. Microbials are responsible for 47% of the biologicals sales in 2019 and are being used for every product category. Microbials are estimated to have a CAGR between 12 to 16% and it is estimated that this growth will remain or even increase in the upcoming years.

3. Research approach

3.1 Industry description

To answer the first sub-research question; 'What companies and start-ups are operating in the European microbials industry?' indications were given how the microbials industry is compiled. First, web-based research was conducted to find active companies in the microbials industry. The European market was chosen for this research as information and experts of the microbials industry were easily available. Using the database of the European Patent Office and Google Patents, insights were given in the market share. After this, the companies were identified in the company information database Orbis, for access to secondary data.

3.1.1 Literature collection

This research dealt with the current- and future status of the microbials industry. Microbials have been researched for decades, but only for the past ten years it has increasingly become its own industry. Due to this new developed industry, the research literature on the characteristics and effects of microbials was abundantly available, but papers on the microbials industry were limited. First a query was compiled using the keywords '"microbials" OR "MBCA" OR "Microbial control agent" AND "crop protection" OR "biopesticide" OR "biostimulant" OR "biofertilizer" AND "Industry analysis" OR "Market analysis" AND "agriculture". It was found that there were no articles that were published in any agricultural business economics, economics or business journals concerning the microbials industry. Figure 6 shows an overview of the amount of publications per research field between 2000 and 2020.

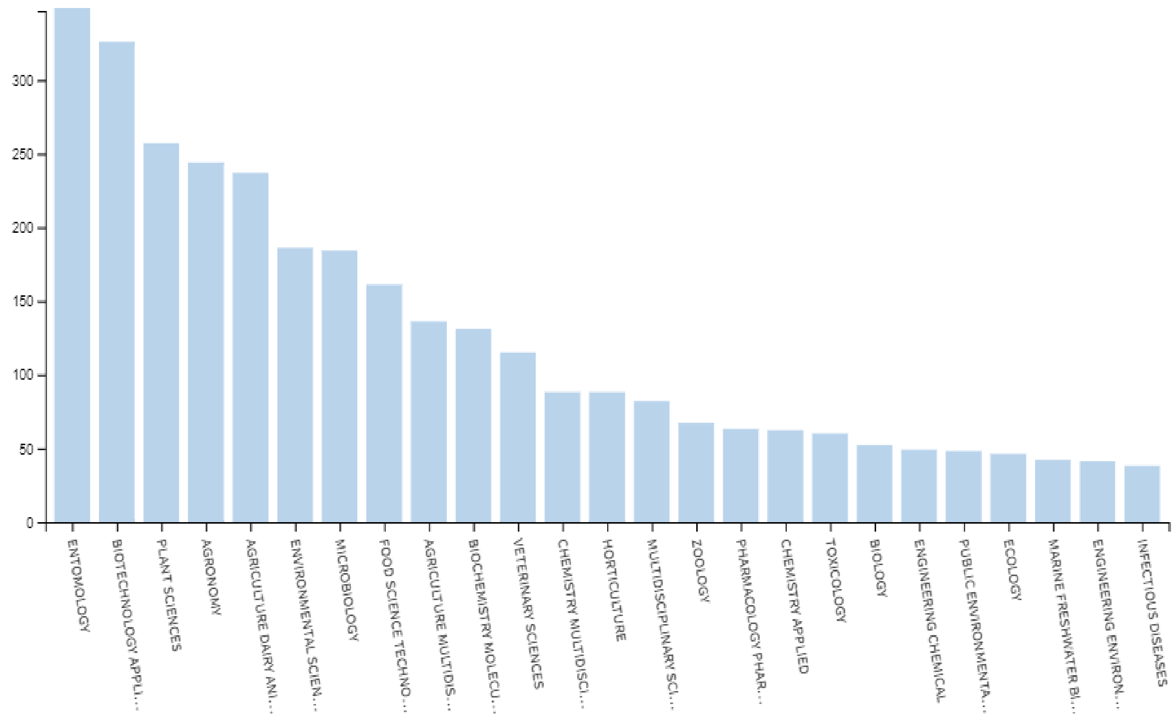


Figure 6 - Publications per research field between 2000 - 2020 on Web of Science

Using this query on Web of Science, there were around 2586 articles published between 2000 and January 2020 researching microbials. As this amount was high, only the most cited articles (50 cites and above) were used, resulting in papers published in a combination of mainly entomology, biotechnology and plant sciences research papers. Within this query, the most cited papers were chosen for closer review concerning the microbials industry and the future potential. The amount of publications per year did show a increase over the past 20 years, visible in Figure 7.

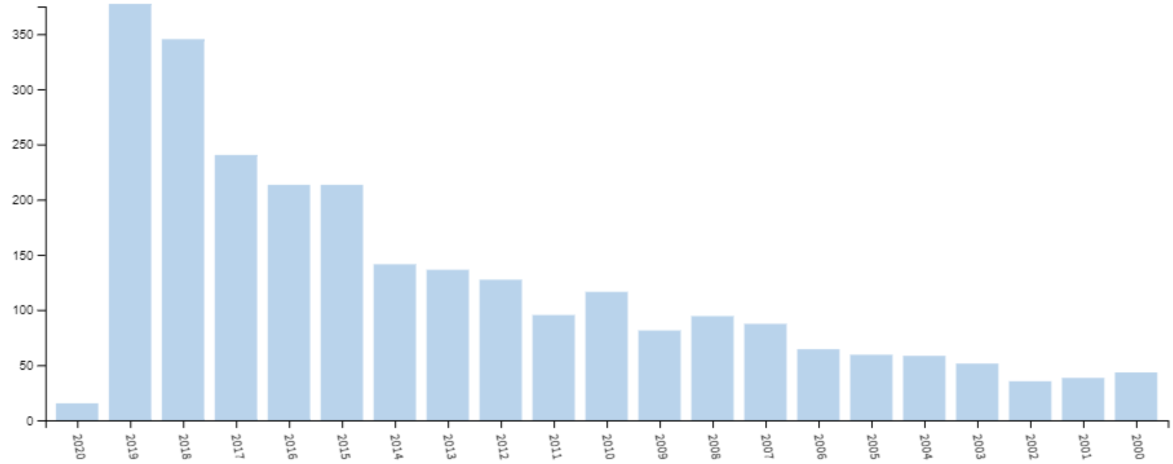


Figure 7 - Amount of publications between 2000 and 2020 on Web of Science

To enlarge the amount of literary sources for the literature review, the snowball sampling method was used. The snowball sampling method, as stated by Atkinson (2004), is a method of finding literary sources through the reference list of scientific articles. Using this method, references that were being used in these papers were analysed for relevant information concerning industry composition and market share.

3.1.2 Data collection

Using the member database of International Biocontrol Manufactures Association (IBMA), European Biostimulants Industry Council (EBIC), European Consortium of the Organic-Based Fertilizer Industry (ECOFI) and Bureau van Dijk's financial database Orbis, companies active in the microbials industry were identified. The market share of companies active in the microbials industry were found by searching for patent filings for microbial products using the Cooperative Patent Codes (CPC) stated in Table 3. The query used on the European Patent Office (EPO) website was: " ia = "Company name" AND (cpc = "A01N63/00" OR cpc = "C05F11/08" OR cpc = "A01N65/00" OR cpc = "A01N25/00") ". The query used on google patents was: " ((A01N65/00) OR (A01N25/00) OR (A01N63/00) OR (C05F11/08) OR (Y10S435/8215)) country:EP ".

Table 3 - Codes used for patent identification (Cooperativepatentclassification.org, 2019)

Cooperative Patent Code	Description
A01N63/00	Biocides, pest repellents or attractants, or plant growth regulators containing micro-organisms, viruses, microbial fungi, enzymes, fermenters or substances produced by, or extracted from, micro-organisms or animal material.
A01N65/00	Biocides, pest repellents or attractants, or plant growth regulators containing material from algae, lichens, bryophyte, multi-cellular fungi or plants, or extracts thereof.
A01N25/00	Biocides, pest repellents or attractants, or plant growth regulators, characterised by their forms, or by their non-active ingredients or by their methods of application, {e.g. seed treatment or sequential application}; Substances for reducing the noxious effect of the active ingredients to organisms other than pests.
C05F11/08	Other organic firtilizers; Organic firtilizers containing added bacterial cultures, mycelia or the like.
Y10S435/8215	Chemistry: molecular biology and microbiology – Micro-organisms.

After this, the companies that were found were identified in the database Orbis. Nomenclature des Activités Économiques dans la Communauté Européenne (NACE) codes were used to identify what the main economic focusses were of the found companies. This information will give an indication of related industries to the microbials industry. There were three variables that were identified to indicate the differences between company sizes and to assess their speed of growth over the past 10 years, calculating the CAGR. The variables were the operating revenue, employee count and the year of incorporation. The operating revenue and employee count indicated what size the companies were and how much they have been growing over the past 10 years. Of the incorporation date, the average was taken per company segment, to show when the companies in size segments were created. The CAGR of the operating revenue was compared to the economic growth of the Eurozone over the past 10 years.

To give an overview of industry activity, an overview was given with the latest mergers and acquisitions (M&A) within the microbials industry, using the Mergermarket.com database. M&A helps firms to improve their competitive position within an industry in domestic markets, but also if they want to expand their position internationally (Mudde and Brush, 2004). According to Mudde and Brush (2004), there are multiple types of M&A. A merger is a scenario where two companies unite and one of the companies ceases to exist after complete integration in the other company. An acquisition happens when one company purchases a majority stake of shares in a target company. The target company does keep its name and legal structure in this case. A consolidation results when a completely new company is created. Tender offers are acquisitions of publicly traded companies and the acquirer directly contacts the stockholders and offers to buy a specific number of their shares. Acquisition of assets is when assets are bought of other companies. The reasons for M&A are creating synergies, obtaining growth, increase supply chain pricing power and eliminating competition (Palmer, 2019). Assessing the M&A history of an industry gives an indication on the level of competitiveness (Schoenberg and Reeves, 1999).

3.2 Industry analysis

For this research, the microbials industry is analysed using an industry analysis. Industry analysis is defined as *'a type of case method research used to study an industry with an objective to create new knowledge related to it'* by Aithal (2017). An industry analysis can be conducted using any of 23 different types of analysis, each assessing a different part of the industry (Aithal, 2017). As this is too many types of analysis to conduct, the focus was aimed at only two types of analysis. Michael Porter (2008) paper 'The Five Competitive Forces That Shape Strategy', proposes that industry analysis should set the focus on the structural underpinnings of profitability. Also, as Cadle et al (2014), state, it is important for industries to assess their operating business environment and thus far, this has not been set for the microbials industry. Therefore, an external industry analysis was conducted. To answer the sub-research questions; 'What are the external factors influencing the European microbials industry?', 'What are the factors influencing the competitive climate of the European microbials industry?' and 'What factors will determine the success of companies in the European microbials industry?', interviews with experts were conducted. These interviews were interpreted using two types of industry analysis; an external environment analysis and a competitor analysis. The external environment analysis is conducted using the PEST analysis and the competitor analysis is done using the Porter's five forces analysis (Aithal, 2017). According to Perera (2017), to complete a situational analysis for a company, the PEST analysis should be complemented with a Porter's five forces analysis. As the PEST analysis covers the macro-environmental factors influencing the industry and Porter's five forces covers the micro-environmental factors that influence the industry, combining the results of these analyses will result in comprehensive understanding of the current industry and how this industry will develop in the future.

3.2.1 Interview design

The interview questions that have been developed are established based on the information found in scientific literature, white papers, news articles and company websites during the literature review. The interviews are used to provide primary data for the PEST and Porter's analyses. The expertise of the experts supports the future prospects and outlook on the potential for the microbials industry.

The interviews that were conducted were semi-structured. Semi-structured interviews are well suited to assess the new developing industry and what perspectives the experts have on the topic (Longhurst, 2003; Galletta, 2013). For the interviews, an interview format (Appendix B) was created which was used for direction during the interviews and served to question the experts comprehensively and systematically (Sargeant, 2012). The interview format was divided into five main topics, after the general introduction, and divided in different sub-questions. It is important to note that not all questions were relevant for this research as the interviews were conducted together for another research, concerning the economic feasibility of microbials. The interviews contained both closed-ended as open-ended questions, in which the open-ended questions led to in-depth information about specific topics. The main topics were focussing on the current situation (product prices, adoption rate by farmers, industry competition, industry drivers and challenges), the market forecast (expectation of regulatory development, industry forecast, probability of different scenarios), the price development and margins and the value of revenue increase. Even though the interview was guided through an interview format, it depended on the expertise of the expert what questions were asked and answered. The interview format was written in English, as the experts were from The Netherlands (n=7), Belgium (n=1), Germany (n=3) and the United States (n=3).

Whilst conducting the interviews, notes were taken of the conversation and later transcribed by two researchers. After the first four interviews, questions were removed, added or edited to fit the expertise of the experts. The interviews took on average 1.25 hours to complete and were conducted at multiple locations or by telephone, depending on the expert's preference. Prior to the interview, it was explained that the interviews were conducted for an exploratory research for Wageningen University & Research and for Roland Berger Amsterdam. After this, the researchers explained what their respective research topics were and how the interview would be structured.

3.2.2 Selection of experts for interviews

For this research, six scientific and eight business experts were interviewed. Further information on the experts is presented in Tables 4 and 5. The reference to the experts was given in tables 17 and 18 in Appendix D. The interviews were conducted in two shifts. The first shift was in the week of the 16th of December 2019. Four scientific and two business experts were interviewed. The second shift was in the week of the 6th of January 2020, two scientific and six business experts were interviewed. The interviews were conducted with a total of n=14 experts.

First, the scientific experts were selected by analysing what they had written on the topics of microbials and biologicals, either in academic papers, white papers and news articles, but also if they would be keynote speakers at conferences. The first expert from Wageningen Bio Interactions & Plant Health Research, was selected because he wrote an article subsequently named: 'Microbials: the need for a pragmatic approach to the market and to its constraints. The second expert was the business unit manager of the microbiology department, managing all the research that was being conducted on microbials at Wageningen Bio Interactions & Plant Health Research. The expert from Wageningen UR was selected because he co-wrote an article about the regulatory system of microbials in the EU and the US. The expert from Utrecht University was selected because he was a keynote speaker at a microbials convention that took place during this research. The experts from Rutgers School of Environmental and Biological sciences and the Georg-August-University of Göttingen were both references from earlier mentioned experts. Second, the business experts were selected by contacting businesses directly and through academic papers, white papers, news articles, blogposts and company websites. Two of the experts were selected through multiple remarks, that were found both in academic papers, and news articles. Six of the business experts were selected through the snowballing method. The first expert from Koppert Biological Systems was selected because the expert had written significant literature on the topic of microbials. Moreover, this expert was active at the IBMA and focussed mainly on translating the industries problems with the current EU regulation. The expert from Novozymes wrote an article concerning the efficacy of microbials and how this could be improved. The second expert from Koppert Biological Systems and the experts from Aphea.Bio, Marrone Bio innovations, Plantum, Rijk Zwaan and EuropaBio were referred by earlier mentioned experts.

Table 4 - Background on institutions of scientific experts

Experts (n=6)	Description of expert institutions
Scientific	Wageningen Plant Research, NL (n=2): The experts of Bio Interactions & Plant Health Research study the harmful and beneficial effects of insects, viruses, bacteria and fungi on plants. They focus on biological control and crop losses due to pests. Research on IPM is also of interest in the department. Wageningen University and Research, NL (n=1): The Agricultural Economics and Rural Policy Group studies the economic and institutional issues within the bio-economy with a focus on sustainable development. Utrecht University, NL (n=1): Plant-Microbe Interactions department is a research group that focusses mainly on how plant immune systems orchestrate the interactions with beneficial microbes, pathogens and insects, on a molecular level. Rutgers School of Environmental and Biological Sciences, US (n=1): The goal of the department of Agricultural, Food and Resource Economics is to support the need of economic analysis and business management in the agricultural sector with a focus on the environment for the society. Georg-August-University Göttingen, DE (n=1): The Department of Crop Sciences studies biotic and abiotic interaction between plants, pests and their natural enemies.

Table 5 - Background on organisations of business experts

Experts (n=8)	Description of expert organisations
Business	Koppert Biological Systems, NL (n=2): Koppert Biological Systems a global industry player with their core focus on biological control products. They deliver mainly macrobials to the consumer (e.g. bumblebees for pollination) and are also active in the microbials industry. Currently their biggest sales of microbial products are in Latin-America. Their microbials research department focuses on application in arable agriculture. Novozymes North Carolina, US (n=1): Novozymes' main focus is on research, development and production of industrial enzymes, micro-organisms and biopharmaceutical ingredients and is the world leader in biological solutions. In 2015 Novozymes increased their activities on the microbials market by starting the BioAg alliance with Monsanto which mainly focused on developing microbials. Aphea.Bio, BE (n=1): Aphea.Bio is a spin-off from UGhent and KU Leuven, two Belgian universities. The current focus lies mainly on commercialization of research output from the both universities in the fields of biostimulants and biological control agents for maize and wheat. They are preparing for their first product to go through regulation. Plantum, NL (n=1): Plantum is the Dutch industry association of growers of seeds and small plants. Currently, they represent 350 companies in The Netherlands. Their main goal is to serve the interests of the seed/plant producers in the governmental decision making process on national and EU level. Marrone Bio Innovations, US (n=1): Marrone Bio Innovations is an American biologicals company which creates products from micro-organisms and plant extracts. They have screened over 18,000 micro-organisms and 350 plant extracts and have created 9 products since their start in 2006. Rijk Zwaan Breeding B.V., NL (n=1): Rijk Zwaan develops both regular and organic vegetable seeds which are sold globally. EuropaBio, BE (n=1): EuropaBio is the biggest European association/lobby group representing the biotech industry.

3.2.3 Data analysis interviews

In this section, the method of interview data analysis is elaborated upon. First, the way the interviews were transcribed is specified. After this, the coding process is specified which resulted in the categorization of the results. According to Clausen (2012), under certain conditions, the replacement of audio transcriptions could be done, using a combination of simultaneously taken and jointly produced notes without affecting reliability, validity and transparency. The conditions that had to be met were professional experts with diverse backgrounds, thorough planning of the interview with well-focused themes and a thorough and repeated introduction to the interview. All of these conditions were met during this research. The interviews were conducted by two researchers and were transcribed within 24 hours after conduction of the interview. The transcribing was done by the researchers together, which gave different views of statements of the experts, as the researchers each have their own way of interpreting and combining these two interpretations would give a complete overview. According to Bailey (2008), this is useful as transcribing interviews by the researchers themselves, gives the researchers familiarity with the data which results in early realizations and ideas. This influenced what questions were further asked in the interview process.

The transcripts were added in a shared document which was updated after every interview. The interviews were divided using the name of the expert, function, time and date of interview. To utilize as much information from the experts as possible, the interviews were transcribed using the edited transcription method. The reason for this was to limit the amount of irrelevant information for this research. As part of the interviews were conducted in English, the interviews in Dutch were translated to English to make creating results easier. It should be noted though, that translations might change the context of the transcripts (Moerman, 1996).

The results of the interviews were uploaded to the qualitative research coding software Atlas.ti (ATLAS.ti, Scientific Software Development GmbH, version 8.44.22.0). Atlas.ti is a software program that is used for large bodies of text. The tool was used to give the researcher a systematic way to arrange, reassemble and manage the large amount of qualitative data.

Coding is a commonly used method for the analysis of large amounts of quantitative data. The coding process aimed at reducing the volume of the qualitative data and to identify and group categories together. The coding process consisted of three different phases, according to the method of Boeije (2009). The first phase was open coding, the second axial coding and the third selective coding. Within this process, typical key words and sentences were categorized and grouped. These categorizations were used to make connections, which resulted in conclusions drawn from the collected data (Dingemanse, 2017).

In the first phase, every interview was read through and for every answer that was given, a relating code was given. For example, if the answer was related to regulation, which at the same time was a barrier of entry, this would be coded as both barrier of entry and regulation. The second phase, axial coding was used to label the existing codes more specifically. The labels between and within all the interviews were compared and those that were similar to one another and belonged to the same theme, were connected in overarching code names. As statements often related to other overarching categories, these were adopted by both categories, resulting in an overlap of data. For more information of the codes that were used and their sub-codes, Appendix E can be consulted.

3.2.4 PEST analysis

The PEST analysis is a macro-environmental framework used to analyse external factors that may have impact on an organisation's or industry's performance. The external factors cannot be, or hardly be influenced by organisations and industry (Perera, 2017). The PEST analysis is a method developed by Francis Aguilar which is described in the book, "Scanning the Business Environment" (Aguilar, 1967). The method is one of the most used methods for the evaluation of external business environment, especially in industries that are highly dynamic (Gupta, 2013). By assessing four external factors; which can be found in Table 6, the external environment can be assessed. Political factors to be considered are the extent to which a government might influence the economy or specific industries. The economic factors to be considered are the macro-economic factors that could affect the demand or supply models within the economy. Social factors are considered societal impacts on the industry. The technological factors are important as these focus more on innovation and development of the products and their effect on the industry (Perera, 2017). When considering a PEST analysis, several subjects have to be considered (McGee et al., 2010). The subjects that were deemed relevant for this study are visible in Table 6. Within each European member state, legislation and tax policies are state specific, thus these were not considered in this research.

Table 6 - Subjects to consider per external factor (based on McGee et al., 2010)

External factor	Subjects to consider	
Political	• EU Regulation • Regulatory bodies and processes	• Lobbying and pressure groups • Political conflicts and stability • Tax policy
Economic	• Economic growth • Interest rates • Inflation rates • Technology costs	• Competition • Producer cost and prices levels • Farmer adoption
Social	• Health consciousness • Population growth rate • Age distribution • Career attitudes	• Emphasis on safety • Lifestyles • Attitudes towards ecological products
Technology	• R&D activity, innovation • Technological developments	• Related/dependent technologies • Technological maturity • Manufacturing capacity

3.2.5 Porter's five forces analysis

The Porter's five forces analysis is a comparative analysis strategy which provides both offensive as defensive strategic context to identify opportunities and threats within a sector or industry (Porter, 2008). Porter's five forces analysis consists of five competitive forces that influence an industry. The suggested framework of Porter's five forces consist of the threat of new entrants (Force 1), the bargaining power of suppliers (Force 2), the bargaining power of buyers (Force 3), the treat of substitutes (4) and the rivalry of existing competitors (Force 5), visible in Figure 8. To understand how this model works, every force has been defined. The threat of new entrants focusses on the ease for companies to enter an industry. New entrants put a cap on the profit potential of an industry because these new entrants want to bring new capacity and desire to gain market share. The threat of new entry is dependent on the barriers of entry, such as the supply-side economies of scale, demand-side benefits of scale, customer switching costs, capital requirements, incumbency advantages independent of size, unequal access to distribution channels and restrictive government policies. So, when the threat of new entrants is high, the barriers to entry are low and the industry becomes more competitive. When the threat is low, competitive forces are less present (Porter, 2008).

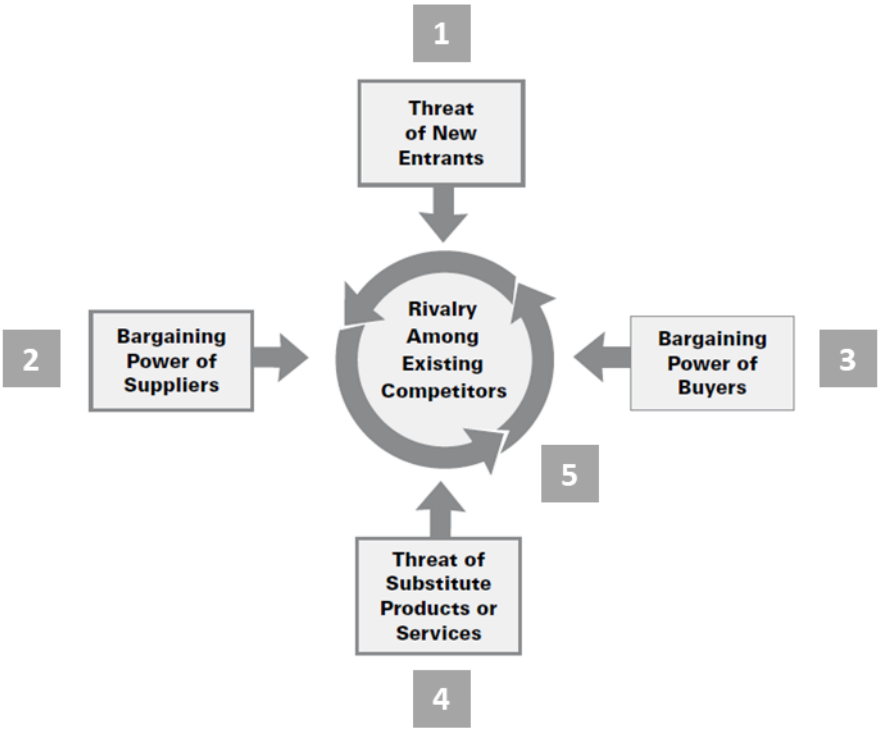


Figure 8 - The five forces that shape industry competition (Porter, 2008)

The bargaining power of suppliers is how much value suppliers are able to capture for themselves. This happens when a supplier group is more concentrated than the industry it is serving or if they do not depend heavily on the revenues from the industry. Furthermore, the bargaining power of suppliers becomes bigger when industry participants have switching costs if they want to change suppliers, if suppliers have a diversified product portfolio but also if there are no substitute products for what the supplier supplies. If participants are more profitable than their suppliers, there is a risk of suppliers entering the industry as this is a more attractive market (Porter, 2008). The bargaining power of buyers increases when buyers are able to capture more value for themselves. When there is a limited number of buyers able to buy the product, if the offered industry products are undifferentiated, if there are barely any switching costs and when it is more viable to integrate backwards, the bargaining power of buyers will be high. So, for both suppliers and buyers, when the bargaining power is high, profitability is limited and when bargaining power is low, profitability is high. The threat of substitutes indicates the industry's vulnerability to substitution by other industries or products. Substitutes can perform the same or a similar function as the product that is produced or marketed in the industry. For industries to distance themselves from substitutes is important for industry performance, as this will result in product dependency. When threat of substitutes is high, profitability is low and when the threat is low, profitability is high (Porter, 2008). Rivalry among competitors results often in price discounts, increased product innovation, extra marketing budgets and increase in (customer) services. When rivalry is high, the overall industry will improve and innovate, but profitability will be limited. This is because a lot of capital has to be invested in generating returning customers. When rivalry is low, profitability rises but innovation will be limited. These five forces create awareness that can help a company understand the structure of its industry and could therefore determine what position within this industry is the most profitable and the least vulnerable to attack (Porter, 2008). Table 7 shows the subjects that were considered per competitive force.

Table 7 - Subject to consider per force (based on Porter, 2008)

Force	Subjects to consider	
Force 1 - Threat of new entrants	• Barriers to entry • Government policy (regulation) • Capital requirements • Economies of scale	• Brand equity • Switching costs • Expectation on retaliation • Access to distribution channel
Force 2 - Bargaining power of suppliers	• Supplier switching costs relative to firm switching costs • Degree of differentiation of inputs • Impact of inputs on cost and differentiation	• Presence of substitute inputs • Strength of distribution channel • Supplier to firm ratio • Employee solidarity • Supplier competition (for example forward integration)
Force 3 - Bargaining power of buyers	• Buyer to firm ratio • Degree of dependency • Buyer switching costs	• Availability of existing substitute costs • Buyer price sensitivity
Force 4 -Threat of substitutes	• Buyer propensity to substitute • Relative price performance of substitute • Buyers switching costs	• Perceived level of product differentiation • Number of substitute products • Ease of substitution • Availability of close substitute
Force 5 - Rivalry among existing competitors	• Sustainable competitive advantage through innovation • Access to distribution channel	• Firm concentration ratio • M&A activity

4. Results

4.1 Description of microbials industry

In this chapter, a description about the European microbials industry is constructed. First, an approximation was made for the amount of companies that are active in the microbials industry within the European region. First, the market share of the five biggest companies was estimated according to filed patents. Second, these were divided in four company segments, according to size, and the average operating revenue, the CAGR of operating revenue, average amount of employees and the average date of incorporation was given. Third, to describe which related industries were active in the microbials industry, an overview was given of the primary economic activities of the companies in the sample group. Last, as literature indicated that the microbials industry was deemed an industry with increasing transactional activity, an overview of the M&A transactions of the microbials industry between 2011 and the beginning of 2020 was given.

For the assessment of market share, patents were used as an indicator of market share. Overall, as of 15 January 2020, there were 46,793 patents filed at the EPO, and globally 169,759 patents, classified with one of the CPC codes (Table 3). Only considering the patents filed at the EPO, Table 8 shows the companies with the most patents in the microbials industry. Using the identification codes, visible in Table 3, the top 5 of these companies cover 12,7% of all the patented microbials.

Table 8 - Top 5 contributors to the total patents filed for microbial products at the European Patent Office, 2019

Company	Market share according to % of patents
Bayer Ag	4,1%
Corteva Ag	3,3%
BASF SE	2,7%
Syngenta Ag	1,7%
Sumitomo Chemical	0,9%
Smaller contributors	87,3%

According to consulted literature over 500 companies are active in the microbials industry of which 80% are small to medium sized companies (SME's) (IBMA, 2019). Table 9 gives an overview of the top 5 companies per company size. The full list of companies can be found in Appendix C. The amount of companies that were identified to be active in the European microbials industry were n=106. It is interesting to note that n=49 companies are SME's.

Table 9 - Overview of the top 5 companies per segment active in EU microbials industry, 2019

Very Large (n=29)	Large (n=28)	Medium (n=36)	Small (n=13)
BASF SE	Biobest group	Agrichem SA	Bionovatik
Corteva Ag	Biogard (CBC group)	Humintech GMBH	Akinao
Bayer Ag	SCAM Spa	Agrometodos SA	Agrinewtech
Syngeta Ag	Agronutrition	E-Nema	Artemisa Svetova
Sumitomo Chemical	Angibaud DS	L. Gobbi	IAB SL

The company size in Tables 9 and 10 is estimated according to the amount of people working at the company and operating revenue. Company size categories depend on if specific criteria are met which were found in the Orbis user guide (Orbis user guide, 2019). Table 10 shows what the difference is in average operating revenue, average number of employees and average date of incorporation between the different company sizes. The CAGR of the operating revenue indicates that both small and medium sized companies have increased their operating revenue faster compared to very large companies. The CAGR of the Eurozone was 1.5% over the past 10 years, indicating that the very large companies did not perform up to par, compared to the economic growth in the eurozone.

Table 10 - Industry information per company size segment, 2019

Company size	Avg Operating revenue (2010-2018) (x1.000)	CAGR (%)	Avg # of employees (2010-2018)	Avg date of incorporation
Very large	€ 164.953.622	0,4	313.789	1979
Large	€ 620.643	7,6	1.360	1987
Medium	€ 94.133	12,5	421	1999
Small	€ 2.033	9,3	11	2010

Companies that are currently active within the microbials industry are for example university spin-offs and start-ups, chemical manufacturing companies and seed breeders. There are some companies with the technical capabilities to start operating within the microbials industry. The relevant European companies that are active in the microbials industry do not have the production of microbials as their core business. Existing companies are differentiating their product portfolio towards microbials. The companies that were considered in the analysis were only companies which were available in the Orbis database. As microbials is not a completely defined industry, it does not have identification codes yet. Therefore, the primary economic activities of companies active in the microbials industry was given in Table 11.

Table 11 - Primary economic activities of companies active in the microbials industry (Orbis, 2019)

NACE-code	n =	Description
2015	26	Manufacture of firtilizers and nitrogen compounds
2020	19	Manufacture of pesticides and other agrochemical products
4675	9	Wholesale of chemical products
7211	8	Research and experimental development on biotechnology
7490	3	Other professional, scientific and technical activities
2059	3	Manufacture of other chemicals products
Other	38	E.g. R&D in natural sciences, mining of chemical and firtilizer materials, manufacture other food products, support activities for crop production and chemical products.
Total	106	

Over the past ten years, large agrochemical companies have been becoming increasingly active in the biologicals industry. These companies have become involved in the biologicals industry through in-licensing of technology and products, joint ventures, mergers and acquisitions. In addition to, collaboration is a key strategy adopted by companies, for example in consortia. This gives companies the ability to pool their R&D investments and activities to produce one product together. There have been three mega-mergers in the agrochemical field over the past five years, which has rattled the crop protection industry. The acquisition of Monsanto by Bayer (€57 bn), the merger between Dow Chemicals and Dupont de Nemours (€130 bn) and the acquisition of Syngenta by ChemChina (€42 bn), were seen as a move to consolidate power in the agrochemical industry. It was expected they might be doing so in the biologicals industry as well (Varinsky, 2018). To show the amount of M&A transactions that have been taking place over the past 10 years, Table 12 was created. The overview shows how the mergers and acquisitions in Europe have remained fairly stable, but the acquirers/partners show that companies such as Syngenta, Bayer, Novozymes and FMC were relatively early in acquiring companies with technologies for microbial products. An indication that Marrone Bio Innovations (a U.S. based company) acquired Pro Farm shows that acquisitions can be used to enter foreign markets.

Table 12 - Overview of mergers and acquisitions and joint ventures within microbials industry (Marrone, 2019; agfundernews, 2019; Mergermarket, 2019)

Target	**Year**	**Price (EUR m)**	**Acquirer/partner**	**Motivation**
Pathway BioLogic	2020	Not disclosed	Plant Response Biotech	Strengthening biologicals capabilities
Koch Biological Solutions	2019	697	Plant Response Biotech	Develops live microbial and biologically-derived chemistries that aim to improve plant performance at every stage of the growth and market growth towards US
Pro Farm	2019	22	Marrone Bio Innovation	Biostimulant company
Sicit 2000 SpA	2019	100	Sprintitaly SpA	Biostimulant manufacturer
Arysta Lifescience	2018	3.595	UPL Corporation Ltd	Biostimulants and innovative nutrition
Ginkgo Bioworks	2018	85	Bayer Crop Sciences	Joint venture for synthetic biology to create microbes that can enhance nutrient uptake
Amendis SARL	2018	Not disclosed	Olmix Group	Biofertilizer
The real IPM Co. ltd	2016	Not disclosed	Biobest Group	Entering market in East-Africa and complementing portfolio with microbial products
Ritzobacter	2016	Not disclosed	BioCeres	Microbial inoculants for soybean and others
Arysta Lifescience	2014	2748	Element Solutions inc.	Biostimulants and biopesticides
Laboratorios Biagro SA	2014	Not disclosed	Bayer AG	Biological seed treatment
Chr. Hansen	2013	Not disclosed	FMC	Joint venture for microbial screening
TJ Technologies	2013	30	Novozymes	Bacillus-based plant health products
BioSolutions	2013	Not disclosed	FMC	Microbial endophyte discovery
Prophyta	2013	35	Bayer AG	Fungi based biopesticides
AgraQuest	2012	270	Bayer AG	Biofungicides & bioinsecticides
Pasteuria	2012	86	Syngenta	Bionematicide
EMD	2011	210	Novozymes	Microbial inoculants

4.2 External industry analysis

For the external industry analysis, interviews with n=14 experts were conducted. First, a PEST analysis was used to present the external factors that have been influencing the European microbials industry. Second, a Porter's five forces analysis was used to present the forces that influence the competitive climate within the European microbials industry. For elaboration and exact paraphrases of the experts on positive, neutral and negative influences on both external factors as competitive forces, Appendix F and Appendix G can be consulted. Furthermore, during the interviews, key success factors for companies and growth factors for the microbials industry were identified.

4.2.1 PEST Analysis

Political factors influencing the microbials industry are political pressure, current EU regulations, lobbying groups, political conflicts and the tax policy. Between 2018 and 2020, the EC decided that the four broadly (see 2.1) used agrochemicals either would be phased-out, their approvals not extended or the approval would need reviewal. The experts considered that the most and widely used pesticides are being and will be banned in the future, resulting in a need for (biological) alternatives. According to Expert 2, the introduction of a new chemical active ingredient roughly costs between EUR 400 – 500 million, and with the prospect that they will be restricted for use, agrochemical companies are aiming for new possibilities. For companies creating a new microbial product, there are strict regulations on national and EU level. The current legislation is a topic that was mentioned by n=14 experts as topic of big importance for the microbials industry. The microbial product categories; biopesticides, biostimulants and biofertilizers, each have their own regulation. The most discussed regulatory framework concerns biopesticides, but there have also been discussions about the recently revised fertilizers regulation (Table 2). According to n=14 experts, the regulatory framework that is currently used by the EU to regulate biopesticides was based on the regulatory framework that was developed for chemical pesticides. The framework does not fit with the regulatory needs that are required for microbials and is unnecessarily extensive and expensive. Furthermore, it was stated that the data requirements for micro-organisms have not been changed since 2001, making these outdated. The regulatory frameworks used by the US and Brazil are better developed for microbials and can be used as an example (Expert 12). Moreover, the recently revised fertilizer regulation contains a list of (currently 4)[1] micro-organisms that are allowed in production of biofertilizers and stimulants. Whilst this is a positive development, this list is not frequently updated and thus limiting innovation according to Expert 1. Due to the unfittingly strict regulation, to dodge excessive costs, companies have found a way to circumvent the regulatory process by introducing microbial pesticides on the market as biostimulants, as they have both qualities. According to n=4 experts, microbials should be strictly regulated as they are not per definition safe, but currently the regulation is not suited for the intrinsic characteristics of micro-organisms. However, according to Expert 1 and Expert 6, it is clear that there is a political willingness to change the current regulation, as there are working groups that are actively trying to change the regulation. Subsequently, the Green Deal of the EC was considered a positive step forward. The EC will be presenting its future workplan around April, 2020 according to Expert 4. Three experts were more sceptical and noted that it should be seen if this would actually become reality. As the EU's decisiveness is not fast, due to compromises and limited knowledge of the regulators about microbials, the regulation will most likely not change in the short term (Expert 6; Expert 8). Between n=14 experts, it was estimated that it would be taking between 2 to 10 years before the regulations would be amended. As n=13 experts conclude, regulatory change is the biggest barrier for the microbials industry. One of the experts stated that the regulatory system might be limiting the market, but it is not restricting it. It was interesting to note that they deemed Europe as the market with the most potential for the introduction of microbials compared to anywhere else in the world, due to the political willingness to ban chemicals and adopt biological alternatives.

[1] [Link to regulation]

Economic factors influencing the microbials industry are technology costs, competition, producer costs and price levels, possible substitutes, price sensitivity of farmers and consumers. The direct competing products of microbials are chemical pesticides and synthetic fertilizers. There are no competing products for biostimulants and according to n=4 experts, biostimulants will have the most future potential, as this sector is new and underdeveloped. Biopesticides however, currently have the highest growth potential as these products have a better efficacy. A US based microbials company, Marrone Bio Innovations recently acquired Pro Farm Technologies, a Finnish biostimulants company for USD 31.8 m. The product performance of Pro Farm Technologies was estimated to achieve an average yield increase between 5 to 20%. According to n=14 experts, the price of microbials is higher compared to off-patented chemicals but one of the experts noted that farmers have been proven to get a return on investment (ROI) of 4x for rice, 3x for corn, 5x for potatoes and 5 to 9x for almonds. Currently, chemicals can be produced on a large scale and microbials cannot. Although, to compare the prices between agrochemicals and microbials, true costs should be considered for the production of the chemical pesticides according to n=2 experts. True costs would be the costs including the residual effects of the chemical products. The price difference is due to scaling properties and specificness of biological products. According to n=12 experts, scaling could decrease the price of microbials due to economies of scale. But, it would be a problem to scale up production of microbials as there have not been microbials that are broadly applicable. According to Expert 9, the technology that is being used to produce microbials require significant investment, so full commitment is needed. The capital requirements can be a limiting factor, especially for smaller companies. The adoption rate of microbials by farmers at this moment is low according to n=14 experts. This is due to microbials being a novel product, the efficacy of microbial products is lower than that of agrochemicals, the reputation of being 'snake oils', but also according to n=4 experts, due to learning and switching costs. Over the past 100 years farmers and the agricultural sector have been adapting to agrochemicals, from systems thinking to reductionist thinking. Another factor influencing the adoption rate of microbials by farmers are the pesticide distributors and consultants offering chemical package deals for a reduced price. For consultants and distributors, agrochemicals are easy to sell as their clients almost guaranteed of a successful yield, through package deals it is possible to get higher margins and in some cases bonusses according to quantity sold. Also, through To change this, a paradigm shift will be needed and will require a lot of effort and capital. It was stated by n=8 experts that microbials would be first adopted by organic farmers as these are not allowed to use agrochemicals in their crop production. According to Expert 14 though, for microbials to become a successful industry, the market share of the organic food production is not large enough as the market cap is as high as 20% of the total food production market. For microbials to become truly successful, microbials should be used in 80% of the agricultural food industry. Furthermore, according to Expert 6, biologicals are estimated to surpass the market share of agrochemicals by 2050. According to Expert 8, organic farmers already determined that soil health is very important and that is why they started farming organically. Additionally, Expert 8 stated that conventional farmers are also becoming aware about soil health and the negative impacts of agrochemicals, but as long as chemical products are still on the market, conventional farmers will not switch to microbials. It was mentioned by n=9 that the real motivation for conventional farmers will be necessity. This is due to the banishment of agrochemicals, the effects of soil degradation or resistance of pests.

Social factors influencing the microbials industry are the health consciousness, population growth rate, career attitudes, emphasis on safety, lifestyles and attitudes towards ecological products. Although the population in Europe is stagnating, and is even expected to decrease, the world population will be growing. Globally, the need for food is still increasing. Within Europe, societies are demanding healthier food and becoming more environmentally aware of the consequences of chemical pesticides and fertilizers. The increased awareness on the effects of conventional food production is increasing the demand for organic food production. Microbials are estimated to have the highest potential of adoption in the organic food production industry, which is expected to increase to 20% of the total food production in Europe. Retailers are pushing for a more environmental approach of crop production. According to Expert 12, this has a positive effect on the adoption of microbials but could potentially have negative effects for the farmers. Currently, the margins for farmers are slim, and retailers are not inclined to reward farmers for using biological alternatives, even though the use of these is currently more expensive. Another issue on the topic of retail according to Expert 3, is that food is currently too cheap and organic alternatives are less in demand due to price differences. This will have to change in the future as food prices will have to go up. Retailers do not reward farmers as they want to keep the lowest price possible, as consumers are cost sensitive. Next to this, according to Expert 2 and Expert 10, if organic food production and the use of microbials will increase, consumers should become less demanding about the aesthetics of products and '*Get used to one or two spots on our apples'*. Within the EU, food safety is held in high regard. Therefore, communication will be key for success for the microbials industry according to n=5 experts. If there will be one bad case, that ends up in publicity, there is a high possibility that public opinion might turn negative about microbials, as microbials are not understood by the general public. However, attitudes towards ecological products are becoming increasingly positive. This is due to the increased awareness of negative effects of chemicals on environmental- and social health.

Technological factors influencing the microbials industry are the R&D activity and innovation, the technical developments, the related and dependent technologies, the technical maturity and the manufacturing capacity. As stated by n=4 experts, technology is a major driver for the microbials industry. The combination of technology and biology will be important on every aspect for microbials (Expert 1; Expert 12). The gap between science and reality is still large due to complexity of the characteristics of micro-organisms. According to Expert 9 and Expert 10, micro-organisms have been evolving for millions of years and have created their own natural balance. Therefore, it will take time for scientists to understand the multiple variables that affect micro-organisms and how they impact the environment. On another note, Expert 10 stated that currently complete microbiomes can be processed as the technology has matured. The industry used to be based on the 'spray and pray' method, but currently there is more targeted research which improves the reliability of microbials, step by step. According to Expert 5, current agrochemicals were not developed in 5 years, so what we need is time. Furthermore, rapid technological advancements and the popularity of IPM will increase the growth of microbial innovation (Expert 5). Due to increased awareness of the decreasing amount of legal agrochemicals, investments in research and development of biologicals have been increasing. It was noted that most innovation come from universities, university spin-offs and small companies. Equally important, the science of microbials is becoming more and more commercialised. Scientists prefer to develop a microbial product and get them through the regulation process instead of writing articles (Expert 6). Technologies that are being used in other industries are also being used for creation of new microbial products. For example, the Danish company Chr. Hansen is a company that is mainly focused on food and pharma and has differentiated their products using their existing technology to develop agricultural microbials. Technically limiting factors of microbials are, according to n=4 experts, that microbial products' regional and environmental sensitivity and shelf life is short in comparison to agrochemicals. Moreover, microbials do not have the same efficacy as agrochemicals, which creates a barrier for farmers who are used to the high efficacy of chemical products. The applicability of microbials was recalled as a barrier for adoption by farmers but according to Expert 10, microbials can be applied as seed coatings, which does not require any new material and making application easy.

4.2.2 Porter's five forces analysis

The threat of new entrants (Force 1) is the threat of new companies entering the microbials industry. Microbials are considered a serious alternative to agrochemicals, as big corporations have been moving into the biologicals industry, according to n=14 experts. When asked about the motivation of the bigger companies that moved into the microbials industry answers varied. Motives that were mentioned were a greener image or brand value (n=2), social and political pressure regarding the effect on the environment (n=10) and due to the commercial potential of the industry (n=2). According to Expert 11, the bigger agrochemical companies missed out on the revolution that the biotech industry brought and therefore, the motivation is mainly to not miss out on potential future opportunities. The barriers to entry vary per company and size. Most barriers to entry are especially high for SME's, as the capital requirements (for R&D, registration- and marketing costs) are high. The regulatory process is overly complex and takes at least 4 to 6 years before a new product can be introduced, meaning that SME's need to have a lot of capital to get their products on the market, whilst continuously filling their product pipeline (Expert 8; Expert 12). Expert 14 argued that VC investments would be needed for SME's, or multinationals need to increase their investments. Expert 14 stated concerning VC, that within the EU there are regulations restricting proper funding and that therefore, the US would be a better place to enter the microbials market. A downside would be that it would be harder to introduce the product in the EU if it is a US based company. Current barriers of entry are the low margins on microbials, research and information capacity and the existing marketing infrastructure of competitors in the agrochemical industry (Expert 6; Expert 11). The barriers of entry will be lower for companies with an existing distribution channel or value chain, as commercialisation of microbials will be easier, according to n=12 experts. Companies with similar (micro) biological technologies will be able to enter the market easily due to relatively low switching costs. Overall, the threat of new entrants was assessed as **medium** as barriers are high but large companies do not want to miss out on this particular opportunity.

The bargaining power of suppliers (Force 2) **and buyers** (Force 3) are the amount of pressure these stakeholders have for their own gain on the companies active in the microbials industry. There were no considerable suppliers identified in the microbials industry as it is a manufacturing industry. However, according to Expert 8, supplying the licenses of technologies from one company to the other could be seen as a supplier, thus creating bargaining power. Overall, the bargaining power of suppliers was determined as **low** but could increase with licenced technology.
When considering the bargaining power of buyers, there are still a lot of cheap agrochemicals and synthetic fertilizers on the market, making adoption by farmers low according to n=6 experts. Farmers are considered price sensitive, which is the reason that agrochemicals have been subsidized for so long (Expert 12). Furthermore, distributors are less likely to recommend microbial products as they could earn more with the sale of chemical products. Within the organic food production, there are high adoption possibilities as margins are higher and no agrochemicals are allowed to be used. Once adopted, the degree of dependency of buyers is very high, as the microbials are specific to the soil and crop type where it has to be applied. The buyer switching costs can be rather high as switching to microbials would mean switching to a complete new cultivation system, requiring significant investment and dedication and in the meanwhile lowering their bargaining power. The buyer to firm ratio is high as demand is increasing and firms mostly produce niche products. Overall, the bargaining power of buyers were determined as **high** but with the potential of decreasing after the adoption of microbial products.

The threat of substitutes (Force 4) is the possibility and ease that products are substituted with alternative or similar products. Microbials are considered substitutes of agrochemicals and fertilizers but will most likely only be substituting due to necessity. It was noted by n=5 experts that there was no threat of substitutes. Genetically modified organisms (GMO) are not considered a substitute in the EU, as gene editing techniques are not allowed in the EU in food production (Expert 6; Expert 12). Using these techniques will damage the reputation of microbials industry according to Expert 6. In Europe, the use of Crispr-Cas is considered a gene editing technique, and regulated through GMO regulation. However the regulation, Crispr-Cas could be lucrative and improve the efficacy of microbials faster (Expert 5). According to Expert 10 and Expert 12, innovations in peptides and synthetic biology might become substitutes. Expert 2 notes however, that there is a lot of social and political resistance against synthetic biology and that this will not become a substitute in the near future. Expert 5 states that functional agrobiodiversity, pest resistant cultivars, macrobials and other biologicals could be seen as substitutes. Microbials can only be effective once it is used in an IPM strategy with all these proposed 'substitutes'. These substitutes are rather complements to the microbials. Product differentiation is hard as within the EU as micro-organisms cannot be gene edited in any way. On the other hand, most microbials are developed for specific regions and other farmer needs, and therefore every product is different. But as gene editing techniques are not legal in the EU, the quality of the same micro-organisms will be hard to differentiate. The creation of specific consortia however could improve efficacy, increase the shelf or field life. The durability and performance of the micro-organisms will differentiate microbial products (Expert 10). Furthermore, once used by the farmers, the ease of substitution with microbial products is rather low as microbials are specific to the soil and crop. This is both the greatest strength as the greatest weakness of microbials, according to Expert 9. Therefore, the threat of substitutes was assessed as **low to medium**.

The rivalry among competitors (Force 5) forces companies to innovate rapidly and the industry to develop fast. The microbials industry is a highly fragmented industry with +/- 500 different companies of which 80% are SME's. For the past ten years the microbials industry has had a rich history of M&A activity. The first round of acquisitions started around 2011 and the second round around 2016. During this period there was a lot of M&A activity on the agrochemical market. Monsanto tried to acquire Syngenta, which would create the biggest chemical corporation within the whole agrochemical industry, but failed. According to Expert 7, this might have triggered the other big agrochemical businesses to start merger negotiations, which eventually resulted in the acquisition of Monsanto by Bayer, the merger of Dow Chemicals and Dupont and the acquisition of Syngenta by ChemChina. Multinationals aim at broadly applicable products, for usage on cash crops such as soy and maize. SME's will be able to innovate in the niche markets that require more specific microbial needs. The cycle of the industry is as follows: universities come up with new ideas, which are commercialised by SME's. If the big companies see that the technology or product is applicable in broader markets, the smaller companies with this technology or product might be acquired (Expert 11). According to Expert 8, acquisitions could also be considered as defensive actions by the big agrochemical companies, as they see the microbial innovations as a potential threat. For example, AgroQuest was acquired by Bayer in 2012, between 2012 and 2020, Bayer have not introduced one new active ingredient. For the big agrochemical companies it is cheaper to acquire a company and get the returns on their chemical products as the R&D costs for these have already been made, rather than creating substitutes for their own products, cannibalizing their own products. The rivalry among competitors was assessed as **high** due to the fragmented market and the increasing interest of multinationals. Table 13 gives an overview of the Porter's five forces analysis for the microbials industry.

Table 13 - Porter's five forces analysis on the microbials industry according to interviews

Competitive force	Force effect	Factors found in Interviews
Threat of new entrants Force 1	Medium	• Multinationals and companies with similar technology moving into industry • Lower barrier of entry compared to chemical pesticide industry (lower reg costs) but barrier is still high • Registration costs are high (SME's need a long breath or VC backing) • Difficult to find the specific knowledge to develop promising microbials • Companies need to be able to commercialize microbials
Bargaining power of suppliers Force 2	Low but can increase	• Microbials are harvested from nature, supplying the product • Companies can licence technology, creating supplier power
Bargaining power of buyers Force 3	High but will go down after adoption	• Still a lot chemical pesticides and fertilizers available; especially off-patent agricultural chemicals are cheap • Distributors are less likely to recommend microbial products due to commission • Image and performance of microbials are not at the same level of chemicals • Due to resistance against chemical pesticides, microbials are the only way to protect crops • Only when it is necessary, farmers are willing to switch to microbials • Once farmers are committed to the product, it needs to use it (custom built) • When regulation changes, buyer bargaining power will go down
Threat of substitutes Force 4	Low to medium	• Other biologicals (semio-chemicals, macrobials, natural extracts) • Synthetic biology will not be as easily adopted as this is socially still not acceptable • CRISPR-Cas shows a lot of potential but is restricted by EU GMO legislation • GMO, but restricted by EU GMO legislation • Breeding seeds and resistant crops (but this takes very long)
Rivalry among existing competitors Force 5	High	• Highly fragmented market (+/- 500 businesses), mainly SME's • A couple of (chemical) multinationals with capital to fund R&D and develop technologies • Innovation mainly from universities and SME's • Waves of M&A activity; easy way to acquire technology and products but mainly fear of missing out • Differentiation of products is difficult but technological advancements help

4.2.3 Key success factors and barriers of growth for the microbials industry

During the interviews, experts noted specific characteristics that companies within this industry should have to become successful in the microbials industry. These factors that are key to success in the microbials industry according to the experts, are stated in Table 14. For businesses to become successful, 15 key success factors were identified as partly or completely necessary. It was stated by n=12 experts, that value chain is very important if a company wants to successfully commercialize its products. According to n=8 experts, if a small company does not have the ability to market their product, the company should either try to create or improve their own marketing network, license their technology or be acquired. If the company fails to do so, the company will not gain income and will be forced to bankruptcy. Subsequently, other factors such as full commitment to the R&D of new microbial products and technologies, a thorough business plan and a good estimate of own capabilities and knowledge are crucial. An example by Expert 6 and Expert 10, Koppert Biological Systems was mentioned as a company containing most of the mentioned key success factors.

Table 14 - Key success factors for companies active in the microbials industry according to interviews

Key success factor	Description
Thorough business plan	Businesses should not underestimate the expense and complexity of producing microbials and need a thorough business plan.
Full commitment and microbial mindset	Companies and the boards should be fully committed to the projects that they are developing and change their mindset from chemical to biological.
Estimate own capabilities and knowledge	Companies have to know the potential of their own capabilities and knowledge, but should not overestimate it.
Flexibility and agility	The company has to be flexible and agile enough to assess what the needs are for the market, what the latest developments have been, what regulations have changed and anticipating on what will change in the future.
Knowledge sharing	Partnerships with other companies active in the microbials industry will create pooling of resources and therefore a competitive advantage.
Advisory role, guidance and communication	Good guidance, support and communication from the company to the farmer/consumer will make a difference in how the products are perceived to address that microbials work and pose no threat.
Capital requirements	For big companies it will be hard to survive in the microbials market if they do not commit capital. They have to go all in or all out. SME's need a long breath as the market is highly competitive and regulatory process takes long.
Value chain and commercialisation of microbials	Big chemical companies have the advantage that they already have a worldwide marketing network and are able to sell new products through these channels. They can do this and at the same time protect their own chemical products. This will be harder to achieve for SME's.
Value chain partnerships	Partnerships between companies could become worthwhile to reduce value chain costs, it could be beneficial for both actors.
Product differentiation and market potential	Differentiating the product is important but it is also important for companies to assess the market potential as gaining a large market share gives competitive advantage.
Creativity	Knowledge of subjects and being creative with this knowledge will create innovative products. Innovative scientists have to lead the R&D process.
Entrepreneurship	There has to be an innovative and entrepreneurial mindset within the company, closely related to flexibility, agility and creativity.
Research and information capacity and access to knowledge	The access to knowledge about this market segment is challenging to get, as it is very specific, Therefore, the research and information processing capacity will give the company a competitive advantage as more micro-organisms can be analysed and products developed.
Data analytics	Companies should have the data analytic capabilities to analyse the thousands of variables that concern microbials, especially in consortia.
Transportation capacity	Companies should be able to transport their product to remote areas whilst keeping the microbials alive.

Furthermore, during the interviews, interviewees noted that there were certain factors that had to change before the microbials industry would start to grow faster. For the microbials industry to eventually become a success and a fully-developed industry, a couple of changes still have to happen in society, politics and science. The factors that have to change in order to give the microbials industry a big boost are presented in Table 15. The most important factor that will have to change is the availability of agrochemicals (n=14). As long as these are available, conventional farmers will not use microbials and growth of the industry will be slow.

Table 15 - Needed conditions for microbials to become successful according to interviews

Condition	**Description**
Size of target market and growth	As long as agrochemicals are still on the market, microbials will not be fully adopted. Subsequently, the target market for microbials has to increase for the industry to become successful.
Change in regulation	By changing the EU regulation for microbials, regulatory and registration costs will decrease, making the R&D of microbials more accessible to companies with less capital.
Paradigm shift reductionist to holistic thinking	Once farmers shift towards systems thinking instead of reductionist thinking, microbials will become a crucial part of their IPM system, therefore stimulating growth.
Change of cultivation systems	In current monoculture, microbials are not performing optimally. To increase the effectivity of biological PPP's, it has to start with pest prevention with resistant cultivars.
More research	Increased research on the characteristics of micro-organisms will increase knowledge about functions. Increase of research gives a higher possibility to create broadly applied consortia of microbials.
Consumer acceptance	Communication with consumers will be necessary to avoid a negative association of food scare (humans playing with nature).

5. Discussion and recommendations

This research aimed to map the European microbials industry, what external factors and competitive forces impacted the industry and to assess company key success factors for the microbials industry. During this research, more details of the 'Green Deal' were announced, with one of the main topics being the 'farm to fork' topic, which aims at more sustainable farming within the EU. This farm to fork principle also noted the aim to reduce the amount of agrochemicals being used and to explore biological alternatives. It was acknowledged by the interviewed experts that within the EU, microbials are a heavily discussed topic, mainly aiming at the way the microbial biopesticides are regulated. With the rapid banishment and disapproval of extensions of agrochemical active ingredients, farmers need viable alternatives as soon as possible and this regulatory framework is limiting microbials to fill this gap.

The results indicated that the current companies active in the European microbials industry consist of n=106 companies. The estimated amount of companies that are active in the global microbials industry were estimated around n=500 of which 80% are SME's (IBMA, 2019). As 49 out of 106 European companies is only 46,2%, the estimation of the IBMA does not come close. However, as through the patent search, the five biggest companies had a combined owned patent share of 12,7%, leaving the rest of the industry with 87,3%, making IBMA's estimation more considerable. A reason for might be that the small companies do not publish any public information, which was available in the Orbis database. Subsequently, the CAGR of the average operating revenue showed that the growth of SME's is way larger compared to very large companies. The average operating revenue, average employee count and average incorporation date were taken as these variables were the only variables that were available for the n=106 companies. Companies that are active in the microbials industry mostly consist of companies that are also active in manufacturing of fertilizers, nitrogen compounds, pesticides and other agrochemical products. During the interviews, this was confirmed by the experts. It was noted however that companies that have similar microbiological knowledge and technical capabilities can be or are also active in the microbials sector. During the interviews, the experts noted that multinationals and large companies are less innovative, but rather acquire smaller companies that have innovative products and technologies (in their product pipeline). This coincides with the findings on the M&A activity within the European microbials industry which showed that there has been a lot of transactions over the past 10 years.

The experts confirmed that the main positive factor influencing the European microbials industry is the political pressure to ban agrochemicals and to increase research for biological alternatives. This political pressure is due to the societal acknowledgement of the negative residual effects of agrochemicals and due to an increase in health awareness of society (Marrone, 2019). Furthermore, the technological advancements that have been made over the last years have resulted in extensive research on microbials (van Lenteren et al., 2017). This resulted in the creation of microbial biostimulants, which is a newly created product category with a lot of growth potential. In addition, due to pest resistance to, and increasing restrictions on, broadly used chemical pesticides, biologicals are the only considerable alternatives for effective pest management (Laurita and Kerovuo, 2018). The main negative factors influencing the European microbials market are the current European regulatory framework, registration procedure and the limited education of regulators (Frederiks and Wesseler, 2018). The efficacy of microbials is currently lower compared to agrochemicals and the prices are higher. Therefore, it is not interesting for conventional farmers to use microbials as a substitute of agrochemicals (Parnell et al., 2016). Moreover, the adoption of microbials requires a systems approach, which requires farmers to change from reductionist thinking towards a more holistic approach. This is associated to switching and learning costs and has a negative effect on the farmers adoption rate. Next to this, the microbials industry is highly competitive with both very large and small companies. Companies will have to be seriously committed to succeed in the microbials industry and to become key players within this industry and offering a 'whole IPM package' would be the best way for companies to attract customers and show best results (Ravensberg, 2011; Marrone, 2019).

During the mapping of the microbials industry, acquiring information appeared to be a challenge. This was due to the fact that it was unclear how the microbials industry would be defined. There were no clear boundaries which companies did- or did not participate in the microbials industry. Furthermore, many companies active in the microbials industry are SME's and most of these companies are private companies. Information about private companies is limited and subject to what is published by themselves. Therefore, the given tables and overviews will give a relative indication and not an absolute indication of the current market share, number of companies, average revenues, average amount of employees and dates of incorporation. However, the CAGR shows the difference in growth between the different company sizes and is also a relative measure. If more data would have been available, financial analysis could indicate how the industry would have performed historically. Historical financial performance can give an idea on future performance, underpinning or undermining a statement of commercial viability of microbials (Brealey, 2001).

To find the companies, the member databases of the IBMA, EBIC and ECOFI were used. These alliances represent most of the companies within the European microbials market, but due to the amount of small companies, that mostly consist of laboratories with 1 to 3 employees, not all the companies could be mapped. This was because there was no further financial and descriptive company information in the Orbis database. As these companies do not or barely report publicly available company information, it was not possible to completely map the microbials industry. Through patent search, a first insight into the microbials market was attempted to be shown, but it should be noted that companies with a lot of capital are able to pay for patent registration costs and many SME's cannot, which probably resulted in an overestimation of the market share that was held by the 5 largest companies.

Considering the interviews and the method of analysis, first, the semi-structured interviews ended up being relatively open interviews which were guided by the interview format, as it was found that the experts had more specific knowledge within their own respective field. Knowing this, more in-depth and follow up questions could be asked about these topics to gain more information. Therefore, this method was viewed as a valid method to develop insights for the researchers' assessment of the microbials industry (Longhurst, 2003; Galletta, 2013). However, as was previously found in scientific literature, the experts use a lot of different terminology, which resulted in experts understanding and answering questions in an unexpected way. The microbials industry is a recent upcoming and trending topic, which does not have its terminology specifically defined. Therefore, the perception on topics were often intertwined. For example, interpretational errors of the experts could have influenced the external validity of this research. On another note, misunderstandings often did give new usable insights for this exploratory research. Second, according to Berg (2004), the quality of data is highly dependent on the researcher that reviews the interviews. For this research, the interviewed format was tested beforehand, compiling all questions that were relevant in the researchers opinion. After the first interviews, there were several answers that were answered and were not asked to other experts, as their answer would only confirm the already answered the questions. Even though not all experts got asked these questions, the answers were considered in the results. These questions also were not used in the results, as these could also be answered with the literature review. As the researchers were not professional interviewers, and questions could differ between experts, consistency of the interviews might have been limited, resulting in a decrease of internal validity. Finally, the number of interviewed experts could be considered a limitation as fourteen experts on diverse topics of the microbials industry does not cover the whole extent of the industry. The interviews rest upon the experts experiences, knowledge and opinions. Therefore, the results could be different when conducted with other experts, but not significantly. Furthermore, no expert from the agrochemical industry was interviewed to offer an opposite or other view. It could be expected that agrochemical experts do see the social and political pressure, but that they would have a different opinion on the time horizon of changes.

The PEST analysis has an extension of legal and environmental aspects, called the PESTLE analysis. As legislation within the EU is member state specific and the environmental factors are (up until now) considered positive and therefore, these aspects were not studied specifically. This could however, be useful to research once a company wants to enter the market. The PEST analysis does have its limitations. External factors change over time and will need constant attention and reviewing and is therefore time consuming to work with (Wolfe and Buchwald, 2000; Pereira, 2017). Equally important, Burt et al. (2006) stressed that the lack of interrelationship between the variables will cause difficulties in understanding how the factors influenced the environment. The outcome of the PEST analysis can be distorted due to the use of false inputs (Vronti and Pavlou, 2008). Finally, Vrontis and Pavlou (2008) stated that the limitations of the PEST analysis should be considered by the individual business that is using it. This research therefore chose to complement the PEST with the Porter's five forces analysis. It is recommended that if another PEST analysis is conducted, that this would be done in consideration of a literature review. Not all factors that are important as external drivers or brakes can be answered by experts and could be easily answered with literature (for example: the economic growth, interest rates, inflation rates can be easily found on EU sites). However, these results would not influence the conclusion as the factors cannot be influenced by the industry. These factors simply give a better indication whether microbials would be adopted sooner or later.

The Porter's five forces framework has been challenged by other academics and strategists (Grundy, 2006; Merchant, 2012). According to Coyne and Subramaniam (1997), there are three dubious assumptions that underlie the five forces of Michael Porter. The first one is that buyers, competitors and suppliers are not related to one another and do not interact and collude. The second assumption is that the source of value is a structural advantage, which creates barriers to entry. The third assumption is that the level of uncertainty is low. This allows participants in a market to plan for and respond to competitive behaviour. Also, Brandenburger and Nalebuff (1997) proposed an extension to the framework, which was the concept of complementors, which would help to explain the reasoning behind strategic alliances. As microbials work in consortia and complement other biologicals, it would not be strange to think this would also happen in the industry. The microbials industry contains a lot of companies that work together, combining technical capabilities and creating new products and therefore, adding the extension of complementors would be a good addition to the framework in the case of the microbials industry.

The PEST and Porter's five forces analysis have a certain amount of overlap and interdependencies as these are both seen as external analyses. For example, subjects to consider to assess the economic external effect on the microbials industry are the industry competition and barriers of entry. The industry competition is the outcome of the Porter's analysis and the barriers of entry is a part of subjects that was analysed to assess the 'Threat of new entrants'. It is proposed by Grundy (2006), that the Porter's five forces model could be complemented by combining and interrelating it with other tools such as PEST factors. Another thing to note is that both analyses are prone to the subjectivity of the researcher. This means that the external factors are identified and perceived as important by the researcher and that the lists of factors influencing the European microbials industry might be perceived as wrong or only partly true by others. The conclusion of this research is therefore prone to subjectivity and readers should be aware of such. Furthermore, the key success factors that were stated are not a recipe for success, but an indication that the experts gave.

The qualitative data gathered in the interviews could not be quantified in this research. The data would not be representative due to terminology constraints. In the case of this exploratory research, the lack of a detailed explanation can make the analysis process seem obscure (Viljoen, 2018). Qualitative research results can be subjected to subjectivity, whilst quantitative research can conclude more objective and finite results. If a quantitative analysis is to be considered, it is recommended that the terminology for not only the microbials industry would be defined, but for the whole biologicals industry (Viljoen, 2018). Currently there are too many different uses for the same subjects, which makes the literature difficult to compare. Once terminology is defined, it is also recommended to quantify the qualitative data, giving the researcher the possibility to organize, understand and interpret data better, and give the possibility to create new insights into this industry.

Companies are becoming more aware of the possibilities of the microbials industry and are therefore interested in the market itself. It is recommended for companies to use more industry analysis tools, focussed on the companies individual ability to enter the market. To complement this research, it is recommended to conduct a SWOT analysis for the specific company before starting with strategic planning and the decision making process. The SWOT analysis will give an indication how the company could perform and what specific factors it has to point out. These factors can be highly differentiated between different companies and could result in a negative or positive recommendation to enter the microbials industry.

As an addition to the industry analysis, a financial analysis would have been a large part of this study. The aim of the financial analysis would be to assess if companies in the microbials industry are profitable and if so, what financial variables influences this (Lessambo, 2018). Financial analysis can be used for the selection, evaluation and interpretation of financial data with information in the investment and financing decision-making process, whilst it can also be used to assess issues such as operation and employee productivity (Brealey, 2001; Eti and Inel, 2016). This should give a good overview of performance and how this industry should compare against other industries (e.g. agrochemical industry or biotech industry). The financial analysis would have been conducted by analysing financial ratios that are either compiled through literature, annual reports or Bureau van Dijk's financial statement database Orbis. When examining the relationship between two or more variables, regression is frequently used (Eti and Inel, 2016). Eli and Inel (2016) argued that multiple linear regression is the best way to assess an industries profitability. Therefore, a multiple regression should be used to assess what variables influence the profitability of the microbials industry. Unfortunately, this could not take place in this research as preliminary results showed that the financial data of companies active in the microbials industry could not be specified to just the microbials industry. Furthermore, as 80% of the industry consists of SME's, financial data that would be available would not be representable due to variable valuations (Waldron and Hubbard, 1991). Conducting the financial analysis would give a first insight in the financial performance of the industry, but due to uncertainties, this would only result in a misrepresentation. To assess the financial performance of start-ups in the microbials industry, a suggestion would be to use the proposed methods by Miloud et al. (2014). By assessing and comparing the balance sheets, cashflow statements and the profit and loss statements, industry multiples will be generated, which can be used to assess the financial performance of the industry and new entrants of the microbials industry. Therefore, it would be interesting to do this assessment for multiple regions, after which regions can be compared to one another. This could result in an indication which region would be the most interesting to invest in (or not).

An important factor that has barely been considered, but could be interesting to be researched is how the development of the microbials industry could be increased. For example, chemical pesticides have been subsidised for years by many countries, which was great for the development of new and better agrochemicals. What would be the effects of subsidising research and/or development of microbials? Furthermore, more research is needed concerning the development of broad applicable microbials, as the unfathomable amount of variables have undiscovered potential.

As the social and political pressure is increasing, regulations on agrochemicals will be sharpened, perhaps even completely banned and regulations on biopesticides will be adjusted to fit the needs that are required for proper assessment. The limited availability of agrochemicals is a crucial necessity for microbials to be adopted by conventional farmers. Once product efficacy and reliability will increase, the adoption will be significantly increasing, as the environmental effects of most biologicals are undisputedly more positive compared to most agrochemicals. Microbials increase yields, stimulate soil recovery, protect plants from pests and the environmental impacts are deemed negligible, if not positive. As societies are becoming increasingly aware about societal and environmental wellbeing and farmers and companies will follow this trend, the use of microbials will be the future of crop protection and yield improvements. Chemical companies know that agrochemicals have an (political) expiration date, and that their main focus will have to be on (micro)biology for the upcoming decades. The more companies enter the microbials market and start innovating, the faster better products will be developed. Therefore, it is recommended that companies start as soon as possible with field trials, as microbials tend to change their behaviour in uncontrolled circumstances. What is needed are broadly applied microbial products which are easy to use and highly efficient.

6. Conclusions

The microbials industry is still in a juvenile growth stage, meaning rapid innovation and increasing interest of related industries. The number of companies active in the European microbials industry that were found in this research is n=106. The study indicates that SME's (between 10% and 12,5%) have a higher growth rate compared to very large companies (~0,4%) and that most companies active in the microbials industry operate in the pesticide (n=26) and fertilizer (n=19) manufacturing industry. Furthermore, it was concluded that 49,2% of the microbials industry consists of SME's, which is not in line with the estimations of the IBMA.

Within the industry, there is a high level of rivalry as the industry is highly fragmented, there are rapid innovations and there is a lot of M&A activity. Based on interviews, this study concludes that there is increasing political and social awareness and pressure towards sustainable agriculture in Europe, providing the opportunity for the initial phase-outs of agrochemicals, giving microbials the chance to gain market share. As gene editing techniques are not legal in food production in the EU, the adoption of IPM strategies, containing the uses of microbials, will be the best option for farmers in the upcoming years.

This study showed that conventional farmers are starting to realise what negative residual effects agrochemicals have on their land and that this can be avoided with the use of microbials. Subsequently, it was found that the large agrochemical companies are entering the microbials industry, as they see commercial potential and do not want to miss out on potential opportunities. They enter the microbials industry mostly through acquisitions, joint ventures, technology licencing and knowledge sharing. Moreover, it is expected that biologicals will surpass the market share of agrochemicals by 2050, indicating that the large agrochemical companies see commercial growth potential.

However, there are still several challenges. First, consumers mostly choose crops based on aesthetics. It is expected that with the use of biological alternatives, the products will be less aesthetically pleasing. This habit will have to change if society wants enough sustainably produced food and decreased food waste. Second, consumers and farmers alike, are very price sensitive, so, as long as cheaper agrochemicals are on the market, microbials will only be used in the organic food production industry. Third, it was found that the combination of technology and microbials is going to be crucial for the success of microbials. It is expected that this combination will increase in the future as most new technologies are being developed by universities, university spin-offs and start-ups, even though currently, the barriers to entry for SME's are high due to capital requirements. The barriers of entry for large companies are less high.

Concluding, considering the global changes concerning the increase in demand for food and the awareness of the environmental vulnerability, it will become lucrative for companies to start investing in the microbials industry. The lack of microbial products that work on a broader scale indicates that there is still a lot of untapped potential and large gains are to be made, both economically and environmentally.

7. External interests

This research has been conducted as a Master thesis for the Wageningen University and Research and for Roland Berger Amsterdam, both situated in The Netherlands. Roland Berger Amsterdam commissioned this exploratory research to give more insight in the biologicals and microbials industry, its current developments and its future potential. As this research aims at exploring this up and coming industry, no external interests have influenced this research. As this research is publicly available, the results of this research may be used by Roland Berger Amsterdam and others. This (or parts of) thesis may be used for publications, but it must be noted that these publications will be based on their individual view on the developments of the crop protection industry.

List of References

Abuamsha, R., Salman, M., & Ehlers, R. U. (2011). Effect of seed priming with Serratia plymuthica and Pseudomonas chlororaphis to control Leptosphaeria maculans in different oilseed rape cultivars. European journal of plant pathology, 130(3), 287-295.

Agfundernews.com. (2019). Vestaron closes 40m series b for peptide based biopesticide with proven modes of action unlike microbials. Retrieved from: https://agfundernews.com/vestaron-closes-40m-series-b-for-peptide-based-biopesticide-with-proven-modes-of-action-unlike-microbials-says-ceo.html on 15 October 2019.

Aguilar, F. J. (1967). *Scanning the business environment*. Macmillan.

Aithal, P. S. (2017). Industry Analysis–The First Step in Business Management Scholarly Research. *International Journal of Case Studies in Business, IT and Education (IJCSBE)*, *1*(1), 1-13.

Begemann, S. (2019). Biologicals are here to stay. Retrieved from https://www.agprofessional.com/article/biologicals-are-here-stay on 22 October 2019.

Agrow Agribusiness Intelligence. (2018). Biologicals 2018 (an analysis of corporate, products and regulatory news in 2017/2018).

Agrow biopesticides. (2019). Biopesticides 2019: Biofungicides; bioinsecticides; bionematicides & bioherbicides.

Agrow Daily Newsletter. (2020). Europe review 2019: Posturing on glyphosate and ai bans dominate news.

Bale, J. S., van Lentern, J. C., & Bigler, F. (2008). Biological control and sustainable food production. Philosophical Transactions of the Royal Society, 363(1492), 761–776.

Bailey, J. (2008). First steps in qualitative data analysis: transcribing. Family Practice, 25(2), 127-131. doi:10.1093/fampra/cmn003.

Balter, M. (2013). Researchers discover first use of fertilizer. Retrieved from: https://www.sciencemag.org/news/2013/07/researchers-discover-first-use-fertilizer on 18 October 2019.

Barratt, B. I. P., Moran, V. C., Bigler, F., & Van Lenteren, J. C. (2018). The status of biological control and recommendations for improving uptake for the future. *BioControl*, *63*(1), 155-167.

Berg, B. L. (2004). Qualitative research methods. *New York: Parson Education*.

Boeije, H. (2009). Analysis in Qualitative Research. London: Sage publications.

Brealey, R. A. (2001). *Fundamentals of corporate finance*. McGraw Hill.

Brodeur, J., Abram, P. K., Heimpel, G. E., & Messing, R. H. (2018). Trends in biological control: Public interest, international networking and research direction. *BioControl*, *63*(1), 11-26.

Burt, G., Wright, G., Bradfield, R., Cairns, G., & Van Der Heijden, K. (2006). The role of scenario planning in exploring the environment in view of the limitations of PEST and its derivatives. *International Studies of Management & Organization*, *36*(3), 50-76.

Business Insider. (2017). Global Biological Control Market Report 2017 - Growth Attributed to High Cost of Agrochemicals. Retrieved from: https://markets.businessinsider.com/news/stocks/global-biological-control-market-report-2017-growth-attributed-to-high-cost-of-agrochemicals-1002378111 on 12 September 2019.

Cadle, J., Paul, D., & Turner, P. (2014). *Business analysis techniques*. Chartered Institute for IT.

Calvo, P., Nelson, L. & Kloepper, J.W. Plant Soil (2014) 383: 3. https://doi.org/10.1007/s11104-014-2131-8.

Carrington, D. (2019). EU bans UK's most-used pesticide over health and environment fears. The Guardian. Retrieved from: https://www.theguardian.com/environment/2019/mar/29/eu-bans-widely-used-pesticide-over-safety-concerns on 20 November 2019.

Carson, R. (1962). Silent Spring. New York: Fawcett Crest.

Chandler, D., Bailey, A. S., Tatchell, G. M., Davidson, G., Greaves, J., & Grant, W. P. (2011). The development, regulation and use of biopesticides for integrated pest management. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *366*(1573), 1987-1998.

Clausen, A. S. (2012). The individually focused interview: Methodological quality without transcription of audio recordings. *The Qualitative Report*, *17*(19), 1-17.
Compant, S., Samad, A., Faist, H., & Sessitsch, A. (2019). A review on the plant microbiome: Ecology, functions and emerging trends in microbial application. *Journal of advanced research*.
Coyne, K. P., & Subramaniam, S. (1996). Bringing discipline to strategy. *The McKinsey Quarterly*, (4), 15-16.
Croplife. (2017). 4500 years of crop protection. Retrieved from: https://croplife.org/news/4500-years-of-crop-protection/ on 10 September 2019.
Croplife. (2018). What are biologicals and why are they important? Retrieved from: https://croplife.org/wp-content/uploads/2018/08/Why-are-Biologicals-Important_2.pdf on 9 September 2019.
Culliney, T. W. (2014). Crop losses to arthropods. In Integrated pest management (pp. 201-225). Springer, Dordrecht.
Dent, D. (2000). *Insect pest management*. Cabi.
Dingemanse, K. (2017). Ultiem stappenplan voor het coderen van interviews. Retrieved from https://www.scribbr.nl/onderzoeksmethoden/coderen-interview/ on 15 January 2020.
Eilenberg, J., Hajek, A., & Lomer, C. (2001). Suggestions for unifying the terminology in biological control. *BioControl*, *46*(4), 387-400.
EPA. (2019). Ingredients used in pesticide products; active ingredients in biopesticide.Retrieved from: https://www.epa.gov/ingredients-used-pesticide-products/biopesticide-active-ingredients on 12 September 2019.
Eti, Serkan and İnel, Mehmet. (2016). A Research on Comparison of Regression Models Explaining the Profitability Base on Financial Data. THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT. 4. 470-475.
European Commission. (2020). European Commission on pesticides. Glyphosate, Neonicotinoids and other active substances. Retrieved from: https://ec.europa.eu/food/plant/pesticides_en on 3 February 2020.
European Parliament (2017). Demographic outlook for the European Union. Retrieved from: http://www.europarl.europa.eu/RegData/etudes/IDAN/2017/614646/EPRS_IDA(2017)614646_EN.pdf on 21 November 2019.
FAO. (2019). Integrated Pest Management. Retrieved from: http://www.fao.org/agriculture/crops/thematic-sitemap/theme/pests/ipm/en/ on 11 September 2019.
Frederiks, C. and Wesseler, J. H. (2018). A comparison of the EU and US regulatory frameworks for the active substance registration of microbial biological control agents. *Pest management science*, *75*(1), 87-103.
Grosbeau, K. (2019). IBMA: Bioprotection: the FUTURE. Retrieved from https://www.ibma-global.org/upload/documents/2019novkarinegrosbeaubioprotectionthefuture.pdf on 6 December 2019 on 20 January 2020.
Fortune Business Insights[1]. (2019). Market report: Biologicals market. Retrieved from: https://www.fortunebusinessinsights.com/industry-reports/agricultural-biologicals-market-100411 on 10 October 2019.
Fortune Business Insights[2], (2019). Industry report; Biofertilizers. Retrieved from: https://www.fortunebusinessinsights.com/industry-reports/biofertilizers-market-100413 on 10 October, 2019.
Fortune Business Insights[3], (2019). Industry report; Biostimulants. Retrieved from: https://www.fortunebusinessinsights.com/industry-reports/biostimulants-market-100414 on 10 October, 2019.
Galletta, A. (2013). *Mastering the semi-structured interview and beyond: From research design to analysis and publication* (Vol. 18). NYU press.
Grundy, T. (2006). Rethinking and reinventing michael Porter's five forces model. *Strategic Change, 15*(5), 213-213.
Gupta, A. (2013). Environment & PEST analysis: an approach to the external business environment. *International Journal of Modern Social Sciences*, *2*(1), 34-43.

Hardoim, P. R., Van Overbeek, L. S., Berg, G., Pirttilä, A. M., Compant, S., Campisano, A., ... & Sessitsch, A. (2015). The hidden world within plants: ecological and evolutionary considerations for defining functioning of microbial endophytes. *Microbiol. Mol. Biol. Rev.*, *79*(3), 293-320.

Heap, I. (2020). The International Survey of Herbicide Resistant Weeds. Retrieved from: www.weedscience.com on 3 February 2020.

IBMA (2019) Two B Monthly; The global Biocontrol & Biostimulants Newsletter. Retrieved from https://www.ibma-global.org/upload/documents/ibmafeb20192.pdf on 21 November 2019.

International Agency for Research on Cancer. (2017). Some organophosphate insecticides and herbicides. *IARC monographs on the evaluation of carcinogenic risks to humans*, *112*, 1-452.

Knipling, E. F. (1972). Entomology and the management of man's environment. Australian Journal of Entomology, 11(3), 153-167.

Kogan, M. (1998). Integrated pest management: historical perspectives and contemporary developments. *Annual review of entomology*, *43*(1), 243-270.

Köhl, J., Postma, J., Nicot, P., Ruocco, M., & Blum, B. (2011). Stepwise screening of microorganisms for commercial use in biological control of plant-pathogenic fungi and bacteria. *Biological Control, 57*(1), 1-12. doi:10.1016/j.biocontrol.2010.12.004.

van Lenteren, J. C., Bolckmans, K., Köhl, J., Ravensberg, W. J., & Urbaneja, A. (2018). Biological control using invertebrates and microorganisms: plenty of new opportunities. BioControl, 63(1), 39-59.

Laurita, T. and Kerovuo, J. (2018). Plant Microbiome Innovation: M-Trophs. Industrial Biotechnology, Vol. 14, No. 3.

Lear, L. (1998). *Rachel Carson: witness for nature*. Macmillan.

Lechenet M, Bretagnolle V, Bockstaller C, Boissinot F, Petit M-S, Petit S, Munier-Jolain NM. (2014). Reconciling Pesticide Reduction with Economic and Environmental Sustainability in Arable Farming (RNC Guedes, Ed.). PLoS ONE 9, e97922.

Lessambo, F. I. (2018). Financial Ratios Analysis. In Financial Statements (pp. 207-247). Palgrave Macmillan, Cham.

Longhurst, R. (2003). Semi-structured interviews and focus groups. *Key methods in geography*, *3*(2), 143-156.

Mahanty, T., Bhattacharjee, S., Goswami, M., Bhattacharyya, P., Das, B., Ghosh, A., & Tribedi, P. (2017). Biofertilizers: A potential approach for sustainable agriculture development. Environmental Science and Pollution Research International, 24(4), 3315-3335.

Marrone, P. G. (2019). Pesticidal natural products–status and future potential. *Pest management science*.

Mazen, M. B., Ramadan, T., Nafady, N. A., Zaghlol, A., & Hasan, S. H. (2018). Comparative Study on the effect of Chemical Fertilizers, Bio-fertilizers and Arbuscular Mycorrhizal fungi on Maize Growth. In *Biological Forum–An International Journal* (Vol. 10, No. 1, pp. 182-194).

McGee, J., Thomas, H. and Wilson, D. (2010) Strategy: AnalysisandPractice, McGraw-Hill, Maidenhead.

Meissle, M., Romeis, J., & Bigler, F. (2011). Bt maize and integrated pest management-a European perspective. Pest Management Science, 67(9), 1049-1058.

Michelbacher, A., and Bacon, O. (1952). Walnut insect and spider-mite control in northern california. Journal of Economic Entomology, 45(6), 1020-1027. doi:10.1093/jee/45.6.1020.

Miloud, T., Aspelund, A., & Cabrol, M. (2012). Startup valuation by venture capitalists: An empirical study. *Venture Capital, 14*(2-3), 151-174. doi:10.1080/13691066.2012.667907.

Mingle, J. (2013). Synthetic nitrogen was born 100 years ago; it's why half of us are alive. Retrieved from https://slate.com/technology/2013/03/nitrogen-fixation-anniversary-modern-agriculture-needs-to-use-fertilizer-more-efficiently.html on 22 October 2019.

Moerman. (1996). The field of analyzing foreign language conversations. Journal of Pragmatics, 26(2), 147-158. doi:https://doi.org/10.1016/0378-2166(96)00009-4.

Mordor Intelligence[1], (2019). Industry report; Biofertilizers. Retrieved from: https://www.mordorintelligence.com/industry-reports/global-biofertilizers-market-industry on 10 October 2019.

Mordor Intelligence[2], (2019). Industry report; Biostimulants. Retrieved from: https://www.mordorintelligence.com/industry-reports/global-plant-biostimulant-market-industry on 10 October, 2019.

Mudde, P. A., and Brush, T. (2004). Firm Competitiveness and Acqisition: The Role of Competitive Strategy and Operational Effectiveness in M&A. *Mergers and Acquisitions. Creating Integrative Knowledge*, 60-81.

Nalebuff, B. J., and Brandenburger, A. M. (1997). Co-opetition: Competitive and cooperative business strategies for the digital economy. *Strategy & leadership*, *25*(6), 28-33.

Newsom, L. D. (1980). The next rung up the integrated pest management ladder. *Bulletin of the ESA*, *26*(3), 369-374.

Nicot, P. C., Bardin, M., Alabouvette, C., & Köhl, J. (2011). Potential of biological control based on published research. 1. Protection against plant pathogens of selected crops. In *Classical and augmentative biological control against diseases and pests: critical status analysis and review of factors influencing their success* (pp. 1-11). IOBC/WPRS.

Oerke, E. (2006). Crop losses to pests. The Journal of Agricultural Science, 144(1), 31-43.

Orlob, G.B. (1973) Ancient and medieval plant pathology, Pflanzenschutz-Nachrichten 26: 65-294.

Orum, J. E., Jorgensen, L. N., & Jensen, P. K. (2002). *Farm economic consequences of a reduced use of pesticides in Danish agriculture* (No. 1026-2016-82006).

Palmer, B. (2019). Why do companies merge with or acquire other companies? *Corporate Finance & Accounting > mergers & acquisitions.* Retrieved from: https://www.investopedia.com/ask/answers/why-do-companies-merge-or-acquire-other-companies/ on 14 January 2020.

Parnell, J. J., Berka, R., Young, H. A., Sturino, J. M., Kang, Y., Barnhart, D. M., & DiLeo, M. V. (2016). From the lab to the farm: an industrial perspective of plant beneficial microorganisms. *Frontiers in plant science*, *7*, 1110.

Pimentel D. (2009) Environmental and Economic Costs of the Application of Pesticides Primarily in the United States. In: Peshin R., Dhawan A.K. (eds) Integrated Pest Management: Innovation-Development Process. Springer, Dordrecht.

Pimentel, D., and Peshin, R. (Eds.). (2014). *Integrated pest management: pesticide problems* (Vol. 3). Springer Science & Business Media.

Philips McDougal. (2016). The cost of new agrochemical product discovery, development and registration in 1995, 2000, 2005-8 and 2010-2014. R&D expenditure in 2014 and expectatioins for 2019. Retrieved from: https://croplife.org/wp-content/uploads/2016/04/Cost-of-CP-report-FINAL.pdf on 19 December 2019.

Philips McDougal. (2018). Evolution of the crop protection industry since 1960. Retrieved from: http://www.feccia.org/files/feccia/News/Phillips%20McDougall%20Evolution%20of%20the%20Crop%20Protection%20Industry%20since%201960.pdf on 9 September 2019.

Porter, M. E. (2008). Competitive strategy: Techniques for analyzing industries and competitors. Simon and Schuster.

Porter[1)], M. E. (2008). The five competitive forces that shape strategy. Harvard business review, 86(1), 25-40.

Pratissoli, D., Lima, V. L., Pirovani, V. D., & Lima, W. L. (2015). Occurrence of Helicoverpa armigera (Lepidoptera: Noctuidae) on tomato in the Espírito Santo state. *Horticultura brasileira*, *33*(1), 101-105.

Sargeant, J. (2012). *Qualitative Research Part II: Participants, Analysis, and Quality Assurance.* Journal of Graduate Medical Education*, 4(1), 1-3. doi:10.4300/JGME-D-11-00307.1.*

Savary S, Willocquet L, Pethybridge SJ, Esker P, McRoberts N, Nelson A. (2019). The global burden of pathogens and pests on major food crops. Nature Ecology & Evolution, 1.

Schoenberg, R., and Reeves, R. (1999). What determines acquisition activity within an industry?. *European Management Journal*, *17*(1), 93-98.

Seedworld, J. Funk, (2019). Are biostimulants finally finding their place? Retrieved from: https://seedworld.com/are-biostimulants-finally-finding-their-place/ on 5 November 2019.

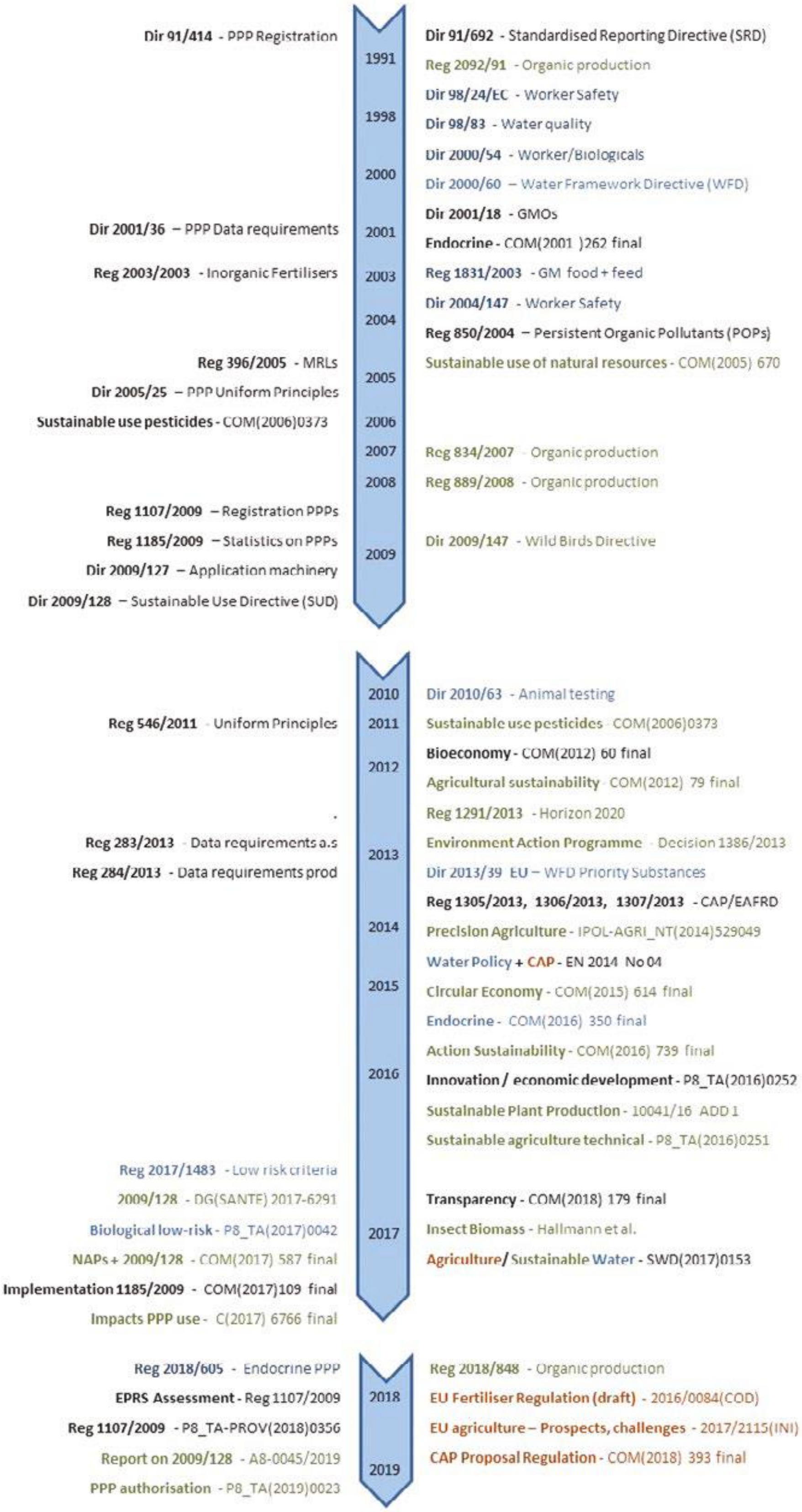
Shukla, N., Singh, E. A. N. A., Kabadwa, B. C., Sharma, R. and Kumar, J. (2019). Present status of future prospects of bio-agents in agriculture. *International Journal of Current Microbiology and Applied Sciences.*
Smith, H. S. (1919). On some phases of insect control by the biological method. *Journal of Economic Entomology*, *12*(4), 288-292.
Splitter, J. (2018). These super-microbes could fix agriculture's nitrogen problem. *Forbes.com.* Retrieved from https://www.forbes.com/sites/jennysplitter/2018/09/20/these-super-microbes-could-fix-agricultures-nitrogen-problem/#40b6e4e43db6 on 22 October, 2019.
Stenberg, J. A. (2017). A conceptual framework for integrated pest management. *Trends in plant science*, *22*(9), 759-769.
Ravensberg (2017). The future of microbial products and regulatory issues. IBMA. Retrieved from: https://www.ibma-global.org/upload/documents/ravensbergthefutureofmicrobialproductsandregulatoryissues.pdf on 20 November 2019.
Reinhold-Hurek, B., Bünger, W., Burbano, C. S., Sabale, M., & Hurek, T. (2015). Roots shaping their microbiome: global hotspots for microbial activity. *Annual review of phytopathology*, *53*, 403-424.
Usta, C. (2013). Microorganisms in biological pest control—a review (bacterial toxin application and effect of environmental factors). *Current progress in biological research*, 287-317.
Varinsky, D. (2018). The $66 billion Bayer-Monsanto merger just got a major green light—but farmers are terrified. *Business Insider*.
Vétek, G., Timus, A., Chubinishvili, M., Avagyan, G., Torchan, V., Hajdú, Z., Veres, A. & Nersisyan, A. (2017). Integrated pest management of major pests and diseases in eastern Europe and the Caucasus.
Viljoen, L. Beyond the Numbers: Why Qualitative Data Should Not Be Used to Make Quantifying Claims--Understanding the Real Value of Qualitative Research.
Vorholt, J. A. (2012). Microbial life in the phyllosphere. *Nature Reviews Microbiology*, *10*(12), 828.
Vrontis, D., and Pavlou, P. (2008). The external environment and its effect on strategic marketing planning: a case study for McDonald's. *Journal for International Business and Entrepreneurship Development*, *3*(3-4), 289-307.
Wolfe, J. P., and Buchwald, S. L. (2000). Scope and limitations of the Pd/BINAP-catalyzed amination of aryl bromides. *The Journal of organic chemistry*, *65*(4), 1144-1157.

List of used databases

Database	Website
Bureau van Dijk's Orbis	https://orbis.bvdinfo.com
Mergermarket.com	https://www.mergermarket.com/deals/search
European Patent Office	https://www.epo.org/searching-for-patents.html
Google Patents	https://www.google.com/?tbm=pts
ECOFI	http://www.ecofi.info/about-ecofi/members/
EBIC	http://www.biostimulants.eu/about/members/
IBMA	https://www.ibma-global.org/en/all-ibma-members

Appendix

Appendix A: EU regulation timeline



Appendix B: Interview format

Name of interviewee: ………………………………………………………………………………
Date: ……………………………………………………………………………………………………

Topic overview

General introduction

In our Master theses, we are looking into the market potential of microbial products in agriculture. Boudewijn is looking into the competitive climate and the financial performance of the industry, whilst Luc is researching the market potential of microbial products based on price development. The focus is on the European market.
The purpose of this interview is to gain an insight on the expectation of several experts in the microbial industry on the development of the market in the upcoming years and to verify data found in literature.
The results of this interview will be used to provide a prospect on development of the microbial market in the European Union in the upcoming years for the Wageningen University and Research and Roland Berger Amsterdam. This interview will approximately take one hour.

2. Introduction and background

How big do you estimate the market shares of the following market segments in the use of microbials in the EU?

…% Arable agriculture …% Floriculture …% Horticulture …% Amateur use
…% Herb growing …% Other: …

Which market segment do you expect to have the most potential for a growth of use of microbials?

□ Arable agriculture □ Floriculture □ Horticulture □ Amateur use
□ Herb growing □ Other: …

In literature, it is found that microbials are divided in three product categories; biopesticides, bio stimulants and biofertilizers. In which product category lies the most potential for growth within the microbials industry and how big do you estimate this growth?
□ Biopesticides □ Biostimulants □ Biofertilizers …%

Will the microbials market according to you grow, decline or remain steady?

In the next three years:
□ Grow □ Decline □ Remain steady

And with how many percent? …%

In the next ten years:
□ Grow □ Decline □ Remain steady

And with how many percent? …%

Additional comments:

…

3. Current situation
3.1 Balance current prices

3.1.1 Which crop protection products have currently higher purchasing costs?

□ Chemical □ Microbial □ Prices are similar

3.1.2 And how much higher?

□ The costs are similar □ Between 1 and 2 times as high □ More than 2 times as high

3.1.3 It has often been stated in literature that a normal cost-benefit analysis (only direct costs and benefits are taken into account) is not sufficient to compare microbials with their chemical alternatives to decide which one to use. Do you agree on this, and why (not)?
…

3.1.4 Which crop protection products have currently higher indirect costs (for example environmental and human health externalities)?

□ Chemical □ Microbial □ Prices are similar

3.1.5 And how much higher?

□ The costs are similar □ Between 1 and 2 times as high □ More than 2 times as high

3.1.6 The RIVM has stated that microbial products in The Netherlands are currently already price competitive for the end user, but the production costs are higher, so the profit margin for the producer is lower than for when they produce chemical products. Do you agree on this, and why (not)?
…

3.1.7 Do you think the profit margin for the producer can get bigger for the same products when the adoption rate gets higher, and why (not)?
…

3.1.8 Results from a big study on economic feasibility of microbials in the INBIOSOIL project show that a switch to using microbials can be beneficial for revenue per hectare in maize production, but in potato production, it would decrease the revenue per hectare. What are in your opinion crops for which the biggest increase in value can be reached?
…

3.1.9 It also resulted from the study that a switch to the use of microbials in conventional potato production is not beneficial, but it could be very beneficial in organic potato production, if the crops can still be sold as organic after the application of microbials. Do you think crops produced with the application of microbials can be sold as organic crops on the short term, and why (not)?
…

And on the long term?
…

3.2 Current adoption

3.2.1 How many of the crop farmers in Europe are according to you currently using microbials?

□ 0-5% □ 5-10% □ 10-20% □ 20-50% □ more than 50%

3.2.2 How many of the crop farmers in Europe are according to you currently using <u>only</u> microbials?

□ 0-5% □ 5-10% □ 10-20% □ 20-50% □ more than 50%

3.2.3 Do you think the adoption of microbials by farmers in Europe is currently high?

□ Yes □ No

b) If yes/no why?
…

3.2.4 Are the switching costs (for example learning costs or costs of no harvest in switching period) considered as a barrier for adoption?

□ Yes □ No

3.2.4 Do you think the adoption by farmers in Europe has the potential to grow?

□ Yes □ No

b) Why?
…

A how big percentage of all of the farmers in the EU do you estimate as adoption ceiling of microbials?

…%

3.2.5 A study by Benjamin et al. from 2018 suggests that increasing the adoption ceiling would have a lot more positive influence on the market potential than increasing the adoption speed. So increasing the volume of the target group would be on the longer term more beneficial than increasing the speed of adoption by the current target group. Do you agree on this, why (not)?

…

3.3 Industry competition

3.3.1 According to Marrone (2019) and van Lenteren (2017), there are many big companies moving into the microbials industry, but the biggest share of companies are SME's. What is the current company composition of the industry and who are the major players in microbials production?
….

3.3.2 Who are more important for the microbials industry and what is their market share?

□ Multinationals □ SME's

3.3.3 What would be the reason that companies operate in this industry?

…

3.3.4 Why do multinationals make the move towards the microbials industry?

…

3.3.5 What are the most promising SME's at this moment and why?

…

3.3.6 What are the three most important barriers of entry to the microbials industry?

…

3.3.7 Is there a threat of new entrants in the microbials market and why?

…

3.3.8 How is the buyer and supplier power divided in the industry? Do you estimate the bargaining power of suppliers higher/lower compared to the buyers of the microbials industry and why?

Buyer power -------------------------------------0--Supplier power

3.3.9 Microbials are can be seen as (part) substitutes for chemical ppps. What three factors could be a threat of substitute products or services for the microbials industry and why?

1) ...
2) …
3) …

3.3.10 As the industry is developing and the market is highly fragmented, companies have to have different strategies. What strategic initiatives are being implemented by key players (i.e. Bayer, Novozymes, Koppert and BASF) for business growth?

1) …
2) …
3) …

3.3.11 What are the top three key success factors for these companies?

1) …
2) …
3) …

3.4 Market drivers

3.4.1 What are the top three external drivers of the microbials market?

Drivers

- Existing technology (T)
- Changing regulation (L)
- Social pressure (S)
- Environmental issues (En)
- Prices of microbials (Ec)
- Policymakers support (P)
- Other …

3.4.2 What are the top three external challenges of the microbials market?

- Adoption rate by farmers (S)
- Consumer opinion (S)
- Microbials in field performance (T + Ec)
- Development of new technologies (T)
- Changing regulations (L)
- Resistance against weather anomalies (En)
- Other …

3.4.3 What are the top three risks for the microbials industry?

- Strength of chemical industry and lobby groups
- Current regulation system that is based on chemical pesticide regulation
- Snake oils and safety claims
- The willingness to adopt by farmers
- Methods of comparison between chemical and biological products
- Commodity prices of crops
- Other?

Additional comments: …

4. Market forecast
4.1 Expectation on development of EU regulation

4.1.1 Which factor do you think is currently mostly holding the industry in Europe back?

□ High costs □ Regulations □ Too little investment □ Other…

4.1.2 Do you think the regulation of implementation of new microbial products in the EU is currently holding the development of the microbials industry back?

□ Yes □ No

4.1.3 Do you think EU regulations on implementation of new microbial products will change in the upcoming five years?

□ Yes □ No

b) If yes, how will it change according to you?

…

c) Do you think these changes will influence the production costs of the microbial products?

…

d) If yes, in what way?

…

4.2 Industry forecast

4.2.1 What are the new product developments in the agricultural microbials market? Which companies are leading these developments?

…

4.2.2 What are the competitive products and processes in this agricultural microbials area and how big of a threat do they pose for loss of market share via material or product substitution?

…

4.2.3 Which global regions will grow at a faster pace and why? And at what percentage or value?

…

4.2.4 What will be the effect on the microbials industry?

4.2.5 What are some of the most promising potential, high-growth opportunities for the global microbials market?

…

4.3 Probability of different scenarios

4.3.1 How big do you estimate the chance that microbials will gain, lose or not gain nor lose market share in the pesticide industry in the EU in the upcoming five years?

Gain: …%

Not gain nor lose: …%

Lose: …%

4.3.2 How big will according to you the market share of microbials in the EU be in five years?

…%

4.4 Concluding

4.4.1 In the article by Pratissoli et al. (2015), it is stated that microbials will be the only option due in some cases due to the insect resistance against chemical pesticides. Do you think the microbials industry has the potential to on the long run outperform the chemical pesticide industry?

□ Yes □ No
…

By what percentage? …%

4.4.2 What type of microbials manufacturing companies will be expected to become successful in the future and why?

…

Additional comments:

…

5. Price development and margins

5.1 Expected price decrease

5.1.1 Do you think upscaling of the production and sales would be the solution for the products to become cost-competitive, or do you think most of the upscaling of the industry has already happened and not much cost-advantage is left to be gained this way?

…

5.1.2 Do you think the cost price of current microbial products will decrease if the production will upscale?

□ Yes □ No

5.1.3 How much cheaper do you think the products can get with upscaling of the production?

□ Not cheaper □ 3/4 of the current price □ 1/2 of the current price
□ 1/4 of the current price □ Less than 1/4 of the current price

5.1.4 Do you think the cost price of future microbial products will be lower if the production will upscale?

□ Yes □ No

5.1.5 Do you think microbials can eventually match the price of their chemical alternatives?

□ Yes □ No

5.2 Expectation on benefits such as price premiums and their margins

5.2.1 Can farmers currently ask a higher price if they only use microbials or other biological products?

□ Yes □ No □ I don't know

5.2.2 Do you think price premiums linked to quality marks for crops produced with the use of microbials can boost the sales in the industry in Europe?

□ Yes □ No □ I don't know

Why?
…

Additional comments:

…

6. Value of revenue increase
6.1 Expected yield increase with microbials use

6.1.1 In literature it is often stated that microbials can be economically feasible because they can increase yield. From the INBIOSOIL study it indeed turned out that for grain maize the yield level can be increased by 2.6 tons per hectare, ceteris paribus. Do you think a yield increase of 26% is an assumption that can be made when assessing the benefits of microbials? Why (not)?

…

6.1.2 For which crops do you expect the yield to increase the most when switching to the use of microbials?

1) …
2) …
3) …

6.1.3 For which crops do you expect production risks in case of extreme weather conditions can be decreased the most when switching to the use of microbials?

1) …
2) …
3) …

Additional comments and recommendations for further research:

…

Would you like to receive a summary of our report when we are finished writing our theses?

□ Yes □ No

Thank you for taking time to participate in our thesis research.

Appendix C: List of companies active in the EU microbials industry

Table 16 - List of companies active in the European microbials industry

Company size	Company name	Company name	Company name
Very large	Amoeba Evogene Ltd Plant Health Care Plc Olmix Charles River Microbial Solutions International Limited Biolchim S.P.A. Isagro Spa Sumitomo Chemical Agro Europe Sas Corteva Ag	Valagro - S.P.A. Ait Austrian Institute Of Technology Gmbh Dva International Gmbh Arysta Lifescience Benelux Fertinagro Biotech Sl. Koppert Beheer B.V. Certis Europe B.V. Prinova Europe Limited Borregaard Asa Taminco Lallemand plant sciences	Sipcam Oxon S.P.A. Chr. Hansen A/S Eurochem Agro Gmbh Vilmorin & Cie Novozymes A/S K+S Aktiengesellschaft Syngenta Ag Evonik Industries Ag Bayer Ag Basf Se Evergreen Garden Care Incotec
Large	Agrinos As Biovert Sl Elephant Vert France Agro Industrie Recherches Developpement Azufrera Y Fertilizantes Pallares Grabi Chemical S.P.A. Seipasa Sa. Sbm Developpement Green Has Italia S.P.A. Siglabile Organazoto Fertilizzanti – Societa' Per Azioni	Chemia Sp. Z O.O. Intermag Sp. Z O.O. Staphyt Fargro Limited Ilsa S.P.A. Desarrollo Agricola Y Minero Sa Probelte Sau Atlantica Agricola Sa Frayssinet Symbiota	Agronutrition Scam Spa Finap S.R.L. Cbc (Europe) S.R.L. Sipcam Iberia Sl. Biobest Group Helmut Aurenz Gmbh & Co. Kg Italpollina S.P.A. Angibaud – Derome Et Specialites Verdesian Lifesciences
Medium	Fluegel Gmbh Green Micro Tech S.P.A. Iden Biotechnology SL Symborg SL Algaenergy SA Xeda Italia S.R.L. RITTMO Agroenvironnement Green Universe Agriculture SL Agricola 2000 SCPA Tbio Crop Science SlL Bio-Ferm Gmbh Bioestimulantes Agricolas	Soiltech AS Tradecorp Italia S.R.L. Quimicas Meristem SL Biotecnologie B.T. Lida Plant Research L. Gobbi S.R.L. E-Nema Mbh Agrometodos SA Serbios S.R.L. Humintech Gmbh Agrichem, SA Gab Consulting Gmbh	Uab Bioenergy Lt Eibol Iberica Sociedad L Agrifutur S.R.L. Biopreparaty, S.R.O. Eurofins Agroscience Chemsafe SRL Agrauxine Sicit S.R.L Biovitis Biocolor Sl Agritecno Fertilizantes Probodelt Sl
Small	Bionovatik Artemisa ASPE agrobiologico	Akinao IYA biotecnologicas	Agrinewtech S.R.L. Cobiotex

Appendix D: List of Experts

Table 17 - List of scientific experts

Scientific experts	Institute	Position
Expert 5	Wageningen Bio Interactions & Plant Health Research, NL	Business Unit Manager
Expert 6	Wageningen Bio Interactions & Plant, Health Research, NL	Senior Researcher
Expert 10	Utrecht University, NL	Professor
Expert 11	Rutgers University, US	Distinguished professor
Expert 13	Göttingen University, DE	Professor
Expert 14	Wageningen University, NL	Professor

Table 18 - List of business experts

Business experts	Organisation	Position
Expert 1	Aphea.Bio, BE	Executive
Expert 2	Rijk Zwaan, NL	Team leader
Expert 3	Koppert Biological Systems, NL	Business Unit Manager
Expert 4	EuropaBio, BE	Regulatory Affairs Officer
Expert 7	Plantum, NL	Managing Director
Expert 9	Novozymes, US	Senior Scientist
Expert 8	Marrone Bio Innovations, US	Executive
Expert 12	Koppert Biological Systems, NL	Senior Manager

Appendix E: Coding

For the PEST and Porter's five forces analysis, the interviews were analysed and coded as stated in the research approach (3.2.3). The codes that were used consisted of: Barrier of entry, capital, chemical substitute, cost of chemicals, cost of chemicals, farmer adoption, future potential, IPM, Key success factors for microbials, key success factors for companies, multinationals, political pressure, regulations, SME's, social pressure, substitute, tax advantage, tech factors and expert examples. These codes have been used at least once in one of the analysis factors and forces (Table 19). The codes for future potential and expert example were used to give an indication for the key success factors and barriers of growth of the European microbials industry.

Table 19 - List of codes used for interpretation of interview results

Analysis factor and force	Subsequent codes used
Political	Political pressure, Regulations
Economic	Tax advantage, Farmer adoption, Costs of microbials, Capital
Social	Social pressure
Technical	Tech factors, IPM
Threat of new entrants	Barrier of entry, Multinationals, SME's, Tech factors
Bargaining power of buyers	Farmer adoption, Costs of microbials, Costs of chemicals
Bargaining power of suppliers	Key success factors for companies
Threat of substitutes	Chemical substitutes, substitutes
Rivalry among competitors	Cost of microbials, cost of chemicals, SME's, Multinationals, Key success factors for companies

Appendix F: Results PEST analysis

Table 20 - Complete interview results of PEST analysis

Subject	Positive	Neutral	Negative
Political	There is willingness to change within the EU. There are many groups active for the EC that research how to change regulation. (Expert 6)	True costs are not considered at this moment for agrochemicals. True costs is a political stimulated subject and could be changed, which will show that economically it would be more attractive to choose microbials. There are different regulations for biopesticides, biostimulants and biofertilizers. Support of policymakers is crucial for the industry. (Expert 6)	A barrier for the microbials industry is the current regulation. There are too many unnecessary questions that are being asked. Products that are being developed in US are earlier on the market and go through heavy regulation in EU. (Expert 6)
	Innovation box helps the development of microbials as companies get tax cuts (NL). Due to regulations, chemical active substances will not be approved or extended in the near future. In Denmark there is already taxation on ag chems that depends on environmental impact. (Expert 12)	There will be no room for GM edited microbials in the EU. The Green Deal is a good start and it will be interesting what they will actually accomplish. (Expert 12)	Current regulation by EU was developed using framework of agrochemicals. Distributors have been making ag chem deals, leaving them with high profit margins. In France there has been lobbied to make it mandatory to divide between the prices of the product and the advice. Put a product on the market in EU, Brazil and US. Product in the US and Brazil were three times as early on the market compared to EU. Product almost became irrelevant after it went through the system. There will not be changes of the regulation any time soon. (Expert 12)
			Regulation is the biggest challenge for the microbials industry. Many unnecessary questions that need answering in current regulatory framework. Changes are taking a lot of time and it is a frustrating process. The EU is bad at decision making as there are too many compromises that need to be made. This will not change in the near future.

			The regulation process is disastrous for SME's as they do not have as much capital. (Expert 10)
	True costs should be determined to make microbials more economically attractive, but this is politically driven. (Expert 14)	To dodge the regulation on pesticides, products are introduced as biostimulants or they use the emergency clause when there are no alternatives for the specific disease. Member states have their own approval regulations and EU regulation should not be needed. Businesses do not want to sell products that do not work or are dangerous as they would negatively impact their own company and industry. Organic products are political matters, and not scientific. The use of microbials in organic production will be a political matter. The regulation will change in the upcoming 5 to 10 years. (Expert 14)	There is a call for the need to change the regulation coming from the industry. Approval process and data requirements have not, or not significantly, been changed since 2001, and therefore outdated. Safety protocols differentiate between every member state and what the EU requires, therefore there is a lot of double work to be done. Regulation is the biggest problem for the industry. It is likely that most innovation will come from the United States, but introducing these in the EU will be a tough process. (Expert 14)
		Changes of the regulatory will change between 5 to 10 years. The changes of the regulatory process will result in conflicted feeling for the chemical industry. It could be seen that regulation changes or easing for microbials is competition distortion. (Expert 5)	The registration process is expensive, the duration is long and the outcome is unpredictable. Reports that are delivered often result in more questions that are not relevant for microbials. The regulatory framework is built on the idea of spray, kill and dissolve as quick as possible, which does not apply to microbials. (Expert 5)
	In the US there is willingness to change the regulation on chemicals, but not as radical as in the EU due to the domino effect. If companies want to export to the EU, they will have to comply with EU requirements. (Expert 9)		The regulation has to change for the microbials industry to fully reach its potential. Currently the US is more open for innovation compared to the EU. (Expert 9)
	In the future regulation on introduction of microbial products will change because there is a lot of ongoing discussion on this: they should be declared as minor risk substances.	There is a way around the registration process for biopesticides and that is by registering them as plant strengtheners. (Expert 13)	

	The expectations of politicians already created the legal differentiation between high and low risk substances and the regulation will change in 2-3 years. If politicians demand that chemicals will be banned, then biologicals will have to substitute these products. Europe is a promising market because the politicians want the market to change and the political situation is fairly stable. In other parts of the world chemical lobby groups are way stronger compared to the lobby in the EU. (Expert 13)		
	There is a willingness of politicians to reduce the complexness of the regulatory system. This is visible in the revised fertilizer regulation for example. Changes are slow on the other hand. (Expert 1)		
	Agrochemicals are being pushed out due to political pressure. Green deal is a positive initiative but it should be seen what is actually accomplished. (Expert 7)		The regulatory framework is underdeveloped and not functioning at this moment. (Expert 7)
	The regulation will change in the upcoming 5 years and will drive the global growth of the microbials industry. (Expert 8)	Biopesticides are now being introduced on the market as biostimulants to bypass the regulations. This loophole will be closed soon by regulators though. (Expert 8)	The EU has a very strict regulatory framework for biopesticides. Products that take 1 or 2 years in the US or Latin America to be approved take almost double the time in the EU. The EFSA is a nightmare. (Expert 8)
	For the past ten years, 50% of the chemical ai's have disappeared and the upcoming years at least a quarter will disappear. (1400 registered and ~880 have been not approved so far). The regulatory process will change soon. NL & FR are already working hard towards this goal (2030), new cultivation systems and less chemicals. (Expert 2)		Regulatory process should be adapted to microbials. Lesser developed EU member states are less prepared for the adoption of microbials, which will become a problem when agrochemicals are abolished. If regulation is not changed accordingly, innovative companies will leave the EU and it will lose its current lead. (Expert 2)

	Regulation will change as the lobby of biological alternatives will become stronger. There are chemical users with the necessity to change to MBCA's. There is some demand from the market, as farmers realise that they need to take care of their soil. (Expert 3)	Regulatory bypass is often used at this moment. Regulation is not essential for this industry to become a success but it will help. If the EU gets left behind it will give incentive to change more radically. (Expert 3)	
	Scaling would lower the costs as most products are produced on a small scale. Big businesses do not see microbials as their core focus, so smaller companies can fill the gap. In Brazil microbials are being used on millions of hectares instead of agrochemicals, that shows that is a profitable option. Pests develop resistance against chemical pesticides. This will create the need for alternatives, where microbials come in. (Expert 6)	The market share for microbials is estimated around 5% of the total pesticide market and it shows a potential of +/- 16% CAGR. It is estimated that this will increase even more as it is difficult and more expensive to develop new chemical active ingredients compared to the microbial active ingredients. Multinationals entering the market are motivated by possible profits and environmental image. Multinationals focus on cash crops and big markets and SME's should look at niche markets. (Expert 6)	The price of microbials is higher compared to chemical products. This is due to the scaling and current biological products are region specific. Even though this is a big challenge for the industry, it could also drive the industry (if true costs would be applied). Chemical products are simply more reliable at this moment, and therefore preferred. There have been two cases of resistance against microbials and these was either from one specific active substance (forced in lab). The second case was a very rare case of resistance of a pathogenic virus in the field, but this also due to just one active substance. (Expert 6)
Economic	Scaling will be very important to lower costs. Almost all microbials can be used for organic food production. The microbials market is very young (early growth stage) and therefore innovation comes from start-ups. Through partnerships, innovation could increase and the industry will take better shape. Knowledge creation is key. (Expert 12)	Currently, the individual systems are expensive, but if you consider the whole system it is more economically considerable. (Expert 12)	Prices of microbial active substances will never be as low as the chemical active substances that have lost their patents. (Expert 12)
	How microbes can feed the world- 20% more food and 20% less ag chemicals. Prices will go down due to scaling. (Expert 10)	If microbials are used and taken care of correctly, they can save a lot of costs. Synthetic pesticides will not disappear in the short run, but the market share of biologicals will increase. (Expert 10)	Chemicals are more efficient compared to microbials, therefore they are still used on a large scale. (Expert 10)

	Upscaling will be viable for microbials, especially in seed treatment. There are big multinational companies investing in scaling up microbials production but for SME's to increase production more VC capital is needed. There is a lot of potential for the upscaling of nematodes. (Expert 14)	There will be much to gain in the organic market, but there is a market cap of approximately 20%. (Expert 14).	Macro-economically speaking, the organic market is not interesting for microbials as their market cap limits adoption. Investment of a couple million by governmental institutions are great and all, but there is a need of at least one billion euro's to fully develop this industry. The chemical industry will not necessarily benefit from accelerating microbials production as innovation costs more money compared to already existing (chemical) products. (Expert 14)
	The reason companies are moving into the microbials industry is because they see the economic potential. This is also because they anticipate on changing regulations and social pressure regarding environment. (Expert 9)	Scaling should become possible. Seed coaters have proven that they are able to coat many seeds on large scale, this can also be done with microbials. However, it is not very likely as this is difficult. Farmers sell their produce depending on weight, not on nutritional value, therefore, nutritional value will not have the priority. This should be changed. (Expert 9)	
	Big companies have been moving into the microbials industry for the past 5 years. Over the past years the industry has increased due to the interest in organic production and the social pressure for environmental responsible products. (Expert 11)	The big companies missed out earlier on the biotech industry, so motivation might be not to miss out on the growing microbials industry. (Expert 11)	Scaling will not significantly lower the costs as the products are specific per crop, soil type and area. Microbials need a broad market, similar to Roundup, where they can get a big market share. This would kickstart the industry but is not likely. (Expert 11)
	Farmers are likely to adopt microbials if they are forced by the supermarkets, who are pushing the green and organic market. If the organic market is pushed by these supermarkets, than the organic production ceiling will increasingly opening up a bigger market for microbials to operate. Farmers will be incentivized to grow organic not due to the extra margin but due to the quantity that could be sold. (Expert 13)		The scaling of microbials will not result in lower costs. The only costs that will be lowered are the constant costs, but the variable costs will still be very high. Price of microbials will be higher than ag chemicals. Costs for introducing new products and going to the registration period are on average for microbial products 1 million euros. This is very high for SME's.

			Biologicals are developed mainly at universities, which are paid for by the government, and these costs are not considered. The real question is; is the market large enough, currently it is not. (Expert 13)
	There is an increase in demand for organic or environmentally friendly crop production. Biostimulants especially will have a lot of potential as this product category did not exist yet. Scaling up will decrease the price of microbials. If the microbials are growing faster, the costs will be lower but they are living organisms with specific requirements so very broad upscaling will be difficult. We need patience for the broadly used product as chemical PPP's were also not developed in 5 years. Eventually, big companies are likely going to use microbials for branding purposes. Investors know that there is no other way than biological alternatives. (Expert 1)		Microbials are currently more expensive than chemical products. (Expert 1)
	Biostimulants and fertilizers have high potential, as long as the soil contains enough nutrients by itself. (Expert 7).	Currently, the big chemical companies are still focussing on chemical products but as soon as the market will take shape, it could be possible that they will change their core business. (Expert 7)	By scaling up the production of microbials, there will be a higher chance of creating resistance against the microbials. The current regulation is the biggest hurdle to overcome for the microbials industry. (Expert 7)
	Developing a new chemical active ingredient could cost up to 500 million euros and with the potential fast abolishment of chemicals, this will not be interesting to invest in. Therefore, companies are forced to make the move towards biological alternatives. Growth in the organics sector could kickstart the microbials industry, there is a shift in paradigms incoming in agriculture,	Consumer products might have to become more expensive and the profit distribution of the food chain has to be revised to compensate farmers that are using IPM. (Expert 2)	Suppliers and distributors want to sell chemical pesticides because, they will get a certain commission on the sales they make. (Expert 2)

	stimulated by the government and systems thinking. Organics sector can only get extra margins as long as it is differentiated from conventional farming. Microbial products will become cheaper when regulation changes. (Expert 2)		
		Currently food is way too cheap and more expensive alternatives are less chosen. This will change in the future. Food prices will go up. (Expert 3)	
	Learning costs are not higher for microbials application compared to agrochemicals and are not a barrier for adoption. Adoption rate of farmers, social pressure and consumer opinion are important drivers. (Expert 6)		The use of GM on biologicals is not possible in EU as it would damage the reputation of the industry. Within the US this is legal and being used. Farmers have to adapt and learn about usage of microbials in their fields. For PPP consultants and advisors it is easier to recommend chemical PPP's. For microbials, they will have to reschool and possible economic interests could implicate their motivation. (Expert 6)
Social	Retailers are pushing towards a more environmental friendly approach, but they do not reward this by paying more, this is a complex situation for farmers. (Expert 12)	Drivers for the microbials industry are social and political pressure. For farmers, necessity will be an important driver. Adoption rate of farmers and the communication to the consumer are important challenges. Especially the consumer opinion is important as this is a big risk and could go very wrong. (Expert 12)	Learning and switching costs will be a barrier for farmers to adopt microbials. The food chain is making adoption hard as they increase the demands to farmers, but do not increase the amount that is paid to the farmer. (Expert 12)
	Learning and switching costs will not be a barrier for farmers to adopt microbials, as long as there are no radical changes. Farmers are intrinsically interested in biological alternatives (especially NL farmers). (Expert 10)	There should be good communication to the consumer. (Expert 10)	
		Adoption will be relevant on the knowledge level of the farmer, the price they will receive for their product and if the	

		consumer will be willing to pay extra for their products. The most important factors for companies that are commercialising microbials will be to communicate and offer consulting services to farmers. (Expert 5)	
	There is social (due to health requirements) and political pressure needed to make microbials a success, but this is coming. (Expert 9)	There is willingness towards adopting microbials by farmers, but the products should be at least of similar performance. (Expert 9)	A barrier for adoption by farmers is the application system of microbials. The supply chain is not yet adapted to the usage of microbials and therefore the performance of microbials is low. (Expert 9)
			Learning costs are definitely a barrier of adoption as farmers are sceptical about the use of biologicals. This is because they have been burned by previous not working products. Also, the impact of synthetic pesticides is direct and the impact of microbials is more focussed on preventing. (Expert 11)
	The organic industry has no other option than biological protectants, so the first products will be for this segment. (Expert 13)	Farmers have been using chemicals for the past 100 years, they have to be taught new methods before they change 'back' Only with a market push, the industry will grow. There is a political pull though. (Expert 13)	Costs are a barrier for farmers. As long as chemical alternatives are available, conventional farmers will not switch to microbials. (Expert 13)
	Eventually the farmer will need to change to biological alternatives due to sustainability issues. (Expert 1)	Reputation will be very important for the industry to convince suppliers and farmers to use microbials. (Expert 1)	
			There is too much hype surrounding the biopesticides and this will result in very high expectations. (Expert 7)
		An issue at hand is that there should be awareness of consumers, politicians, retailers, farmers and more stakeholder for the microbials industry to become a success. Another issue is education, which is needed to teach the farmers how to use microbials.	

		If these two issues are resolved, the infrastructure will follow. (Expert 8)	
		Consumers have to accept small imperfections in their food. (Expert 2)	
	Technology is an important driver. The science of microbials is increasingly commercialised. Scientists active in the microbials industry prefer to develop microbial products and get them through the regulation process compared to writing articles. (Expert 6)	There is a big difference between science and reality, but there is progress. (Expert 6)	A big challenge is that microbials are often compared to snake oils or they do not have comparable efficiency to agrochemicals. Product resilience against weather anomalies could become a problem. (Expert 6)
Technology	Combination of tech and biology will be important on every aspect for microbials. (Expert 12)		Microbials are currently only well applicable in areas where there is more protection and where there are less weather anomalies. (Expert 12)
	Microbiomes can be processed (multiple micro-organisms at the same time), especially if there is enough capital. There used to be spray and pray, now there is specific target research. Bioprotectants are going to substitute the ag chems partly and the market is going to grow. The ability to put multiple coatings on one seed is now possible, giving the possibility to apply a whole consortia to the seed. (Expert 10)	Microbials can be applied using coating, which would not require new material. We think we know a lot, but actually we are just at the start of comprehending biology. Microbials (and biologicals) will not be able to protect against every disease but new innovations and technological advances will increase reliability. (Expert 10)	Microbials have been branded vague or as snake oils, as products only work in 8/10 cases. Crops have been bred to fit with chemical pesticides, these should be reverse engineered to complement the use of biological protectants. (Expert 10)
	The microbials sector will be growing due to the rapid advancements of the technology and the popularity of IPM. (Expert 5)	Not all microbials are always safe, therefore extensive research should be done to assess what their impact is. If it goes wrong once, there will be a very high impact on the industry. (Expert 5)	
		The greatness of the specificity of microbials is also its greatest weakness. Microbials are very variable in performance and they work depending on temperature, soil type, the original microbiome and uncountable other variables. It will take time and a lot of research to overcome all	Microbials are not comparable to chemical pesticides performance wise, but the willingness to change is there, just as long as the microbials will have the same performance as chemical pesticides. Using one microbial on a wide array of locations is not possible, microbials will

		the variables but eventually we will be able to create functioning consortia. There is a possibility that microbials will create extra oils and proteins in the crops, which could change the taste or texture of the product. (Expert 9)	have to be specifically designed per location. Shelf life is big barrier for adoption, but there are developments coming. (Expert 9)
	The science is improving and the farmers are seeing better results. Also the effectivity of microbials is increasing and therefore the confidence of the farmers to use them. (Expert 11)		
		Link between research and product is becoming stronger, the problem is the registration process which costs money. The industry still needs a lot of research, because current knowledge is limited. Better application systems would increase the efficacy of microbials. (Expert 13)	Biologicals will never be able to completely replace chemicals, there will always be gaps that cannot be controlled by biology. Chemical products always work. Big companies have the tendency to acquire innovative companies and then put the technology in the 'drawer'. Partly to protect their own interests in chemical products. (Expert 13)
	The combination between technology and microbials will help the industry develop. (Expert 1)		Microbials are often less efficient compared to chemical products. (Expert 1)
	In The Netherlands, farmers are smart enough to use microbials and switching will most likely be feasible. (Expert 7)	Seed coated microbials can be very effective against soil fungi, but against soil insects it will be harder. (Expert 7).	Farmers in poorer countries in the EU will most likely not be able to adapt to the fast changing regulations and still rely heavily on agrochemicals, adoption will be very hard. (Expert 7)
	Once farmers use microbials in an IPM system, they see the results and are very satisfied. They have to integrate all the tools they can get to achieve success, this is the new way of farming. Companies should start field trials as soon as possible. Technology is ready to do great things. (Expert 8)	The industry needs time to grow and produce by trial and error, much like the chemical PPP's were developed, but this time is not given. The microbials industry has full potential if you integrate it with other biological and technical innovations. (Expert 8)	Currently the biggest hurdles for microbial products are the shelf life, ease of use and field life, but there are promising signs of improvement. (Expert 8)

	IPM will be very important for adoption of microbials; this will result in systems thinking by the farmers. It will enable microbials to grow, but the main focus of IPM will be to prevent before react. (Expert 2)	Biologicals are centre of discussion as they are not always necessarily safe and should be still regulated. If we want that microbials will be broadly applicable, combinations should be found and used. (Expert 2)	As long as there are chemical pesticides, microbials will not be used as they are second best compared to chemicals. (Expert 2)
	Dutch technology can be used to implement new products. There is also demand in other countries, but it is often hard to apply. (Expert 3)	Our current knowledge about micro-organisms is only the tip of the iceberg, there should be a lot of research on this topic before the industry could mature. Research on biopesticides is the most developed, stimulants still in child shoes and therefore not yet viable. (Expert 3)	There are corners being cut in R&D which could have negative impact on the industry. (Expert 3)
			Venture capital is easier in the US as there are more restricting regulations in the EU. (Expert 14)

Appendix G: Results Porter's five forces analysis

Table 21 - Complete interview results of Porter's five forces analysis

Forces	Increase	Neutral	Decrease
Threat of new entrants		Greener image and commercial viability is also the reason that multinationals enter the market and explore where profits can be made. SME's are more important than multinationals. The large companies do not have it yet as their core business, so there is certainly a profit to be gained there. (Expert 6)	
		For multinationals, hopefully it is not just about image, but also commercial interest. (Expert 12)	
			Chemistry is more reliable, which means that it is still being used on a large scale. (Expert 10)
	Microbials are often coated, so application does not need any other extra material. Also, if the large companies see that a small company has a better product than they do, they acquire this company to make their own product better, as long as they keep the market share. It also remains interesting for these large companies because they see major obstacles for the chemical industry in the future and they see that they have to make the switch to biologicals. These companies are also mainly interested in the so-called cash crops, large vegetables, such as corn, soy and wheat. (Expert 10)		

		Research from small companies is the most important for market development. Multinationals will focus primarily on the so-called cash crops.(Expert 5)	The adaptation of the regulation will create mixed feelings for chemical companies. It is possible that they would consider adapted regulations as competition forgery. (Expert 5)
	Large chemical companies also recognize that chemical products are less accepted by consumers, that the regulations have changed drastically, that pests resistances and that farmers want to take better care of their land. A strategic advantage of large companies, chemical companies, seed breeding companies or seed production companies is that they have the complete value / supply chain. There are many great ideas in start-ups, but to make a real impact, larger companies are needed. (Expert 9)	That is why these companies are often bought by larger companies. Eventually it will be possible to create consortia of micro-organisms, but with seed treatment, for example, there is only so much surface on where the micro-organisms can settle. The coaters currently produce hundreds of kilos of coated seeds per minute: this should also be possible for microbials. (Expert 9)	
	Uni's come up with good ideas that are being commercialized by small companies, which are bought by multinationals. Multinationals have more of a market, big companies missed out earlier on biotech so it might be that they just don't want to miss out anymore. (Expert 11)	SME's and multinationals are both important for market share, but SME's are most important for innovations. (Expert 11)	
	Innovation will come from SME's and universities, but to really open up the market, multinationals are also needed. Multinationals notice that more and more products are being banned, existing and new products , so microbials are going to eat market share. (Expert 1)	The combination between technology and microbials will help. (Expert 1)	Also biopesticides, in the majority of cases are less efficient than chemical pesticides, the chemicals are extremely efficient (90% efficacy). (Expert 1)
		Due to high costs, products can currently only be supplied by large companies. (Expert 7)	

		Technology will not be the issue at least, we are there already. Effective biostimulates can be counted on one hand so far. There are more results with the pesticides, a higher profit can also be achieved here . Stimulants give an average 5-10% yield increase. (Expert 8)	Big companies are moving into seed treatment, but keep the chemical mindset. This will not help them. (Expert 8)
	IPM is very important. In IPM, biopesticides are the predecessor of chemical agents, which is the last resort. This means that the main aim is risk reduction. IPM is an enabler for microbials. In view of the chemicals that are being banned, large companies cannot take the risk that their new investments will be phased out before earning back their costs. (Expert 2)		As long as the chemical alternative exists, there is no room on the market for microbials: they are always second best. They will never achieve the 90% effectiveness that chemicals have and microbials have had mixed result so far. A parallel could be made to the medicine industry. An example is that a microbial works well in 7 cases, has no effect in 1 and even has a negative effect in 2 cases. (Expert 2)
	Technology in The Netherlands makes it possible to try new products. In poorer countries, this is more difficult for farmers for example in Southern Europe. (Expert 3)		We cannot easily find microbes that have a very broad effect. (Expert 3)
Bargaining power of suppliers	They either license from, or acquire SME's that are innovative in this field. (Expert 8)		

Bargaining power of buyers	However, prices of chemical products are cheaper than those of microbials. This is because biological products are much more specific, while chemical products can be used on a large scale. (Expert 6)	Farmers have to learn a lot before applying microbials. But learning costs are not much greater than what is needed to use chemical agents. According to Jurgen, a good grower always thinks organic, so learning costs are not a major barrier for farmers to switch to microbials. (Expert 6)	That is because it is much more expensive to find a working chemical compared to existing biological working substances, which gives biology a head start compared to chemistry. In addition, TRUE COST are not yet included for chemical products, this is politically stimulated and could be changed. The final costs of chemical products are not yet included but are ultimately much higher compared to organic products. (Expert 6)
	The system is currently more expensive, also due to learning costs. Systems must be compared with each other and not the individual products. In addition, the adoption is a challenge. The adoption at the moment differs per sector, this ranges from 1 to 20%. The reasons for adoption include necessity, political pressure (but slow) and the differences in sectors. Also switching costs can be seen as a barrier to adoption, but it is expected to grow. The price of micro-organisms will never get the low price of seasoned chemicals that are patent-free. (Expert 12)	The large economies of scale are yet to come. (Expert 12)	Scale is very important: a lot can be gained here. By scaling up the costs of organic products could be lowered and therefore the margins higher. There is a lot to be gained here because small companies are currently still producing; the large companies do not yet have it as their core business, so there is certainly a profit to be gained there. You have a production level, a batch, you increase that batch with an investment in, for example, a new fermenter, then you increase the scale and lower the costs per product (effective profit per product will therefore go up). (Expert 12)

	A barrier and challenge for the microbial industry is primarily the image. It still has the image that product security is very low. (Expert 10)		Switching costs will not be a very large barrier, provided there are no extreme changes. The prices of microbials will certainly go down due to scaling. The application of, for example, seed coating with multiple micro-organisms is one of the innovations that comes from research, these microbes will then grow with the plant as it grows into a plant and thus protect the plant. Especially if it is used on cash crops, a large profit can be achieved due to the large volume. However, margins will be higher with high value crops. (Expert 10)
		So, either the big players need to scale up or VC is needed to increase innovation and scale at the SME's. Good questions would be: How are we going to market it, can it be scaled up and is the product stable enough to use? (Expert 14)	The prices of the products will go down if there is going to be an upscaling, but that does require capital and/or for SME's VC activity. Scaling up for microbials is likely, especially for seed treatment. Upscaling for the time being especially likely in America. (Expert 14)
	The prices for the microbials are higher and therefore protecting yields will be more expensive. Upscaling the production is difficult. (Expert 9)		

	Upscaling of microbials is not really comparable to upscaling for, for example biofuel, because for biofuel much bigger initial investments were needed. This means that economies of scale were much larger for biofuel because of relatively higher constant costs. Scalability? Problem. Microbials will have to keep focusing on smaller markets because there probably won't be one product for all the crops to use. Products will keep being specific per crop, soil and area. This will be a problem for scalability > products will probably stay more expensive. (Expert 11)		
	Upscaling from lab to factory won't really reduce the price of the product. For biologicals you will always have to check and refresh production, which is costly. (Expert 13)		
	Until now, they only seem to be effective for nitrogen uptake since phosphorus and calcium are relatively cheap to add extra. For improving potassium intake very expensive microbials are needed and for phosphorus is actually enough in the soil (in GB!). (Expert 1)		Scaling up can certainly make the products cheaper. Some micro-organisms grow faster than others. If they grow faster, the costs are naturally lower. The living organisms prefer specific environmental factors, which incidentally depend on the micro-organism that you work with. Scaling might make it more difficult for broad applicance. (Expert 1)
		With industrial production of microbials and upscaling, there is a greater chance that there will be resistance to the substances. Which company can handle the diversity of all micro-organisms, pests and products? Due to high costs, products can currently only be supplied by large companies. (Expert 7)	

	Currently there are a lot of barriers but there is also a lot of potential. The current infrastructure though is still focused on chemicals. The number one barrier is awareness of consumers, politicians, retailers, farmers, everyone. The second barrier is education, when those are out of the way, the third, the infrastructure will change too. (Expert 8)		
			This means that farmers must quickly find alternatives (which are often not available at the moment). Producing new active substance just takes 400-500 m. In view of the chemicals that are being banned, large companies cannot take the risk that this investment will be cancelled out. (Politically, socially and therefore economically). Chemical agents disappear very quickly, about half have already disappeared in the last 10 years. At least a quarter will disappear in the coming years, is expected. This is going to be a problem because although some products are perfectly safe to use, active ingredients are banned and therefore also the products automatically will be banned. (Expert 2)
	Microbials are products with a higher cost price. (Expert 3)		
Threat of substitutes			GMO on biologicals is a no go in the EU, because that will damage the image of the industry. A no-go for organic products, but in the US we are working hard to get GMO microbials on the market. (Expert 6)

			GMO has no future for microbials in Europe. Crispr-cas maybe. RNAI or GMO can be seen as a substitute. Furthermore, much is being innovated with peptides and synthetic biology. (Expert 12)
			What can be seen as substitutes for microbials are agro products made by microbials and synthetic biology. The products of microbials remain functional longer, if they live in a good habitat and therefore the need to replace will be less often. Synthetic biology is a long and expensive process, but if it produces synthetic micro-organisms, it could mean a longer shelf life or increased efficacy. There are also non-GMO ways to improve microbes, including experimental evolution, breeding and microbial breeding. This can be achieved by, for example, allowing different types of micro-organisms to grow on roots and then picking out the best variant. Until 5 years ago this was bogus research but now great progress has been made. (Expert 10)
			Substitute microbials can be gene adaptation techniques, which are still subject to GMO laws and are therefore not permitted. We will see what this will entail in the future, but this would be a big step. In the US it will in any case be better and easier to apply this than in the EU. In addition, synthetic biology could also be a substitute. (Expert 14)

			Alternatives/substitutes for microbials: Crispr-cas (breeding), functional agrobiodiversity (ie flowering field edges, growing straw), (sex) pheromones, physical (technological) methods (ie UV radiation or drones that fly against moths), RNAI, natural products. (Expert 5)
			If we look at substitutes for microbials, that may be synthetic biology, but this will be built on the foundation that microbials will lay. (Expert 9)
			Not too optimistic on other innovations as substitutes. Crispr cas: nice idea but not allowed, resistant crops; these cannot be resistant to all pests. (Expert 13)
			Plant breeding can be a substitute for microbials, as well as other cultivation methods, such as vertical farming or strip farming. (Expert 7)
			In principle, there are not really substitutes that pose a threat to microbials. There will be too much resistance to ideas such as synthetic biology. (Expert 2)

Rivalry among competitors	This is also the reason that multinationals enter the market and explore where profits can be made. It makes no sense to only do it for microbials, but it does make sense for overarching biologicals or IPM production methods. There is a lot to be gained here because small companies are currently still producing; the large companies do not yet have it as their core business, so there is certainly a profit to be gained there. SME's are more important than multinationals. the large companies do not yet have it as their core business, so there is certainly a profit to be gained there. (Expert 6)		
	For multinationals, hopefully it is not just about image but also commercial interest. Real innovation on the market comes from the smaller companies: these are currently playing a more important role, and certainly over the next 20 years. (Expert 12)		

	It also remains interesting for these companies because they still see major obstacles for the chemical industry in the future and they see that they have to make the switch to biologicals automatically. These companies are also mainly interested in the so-called cash crops , large vegetables, such as corn, soy and wheat. Research from small companies is the most important for market development and multinationals that will focus primarily on the so-called cash crops. This can be disastrous especially for small businesses, since you cannot continue working on other projects until the first product is through the registration process (capital problem). Also, if the large companies see that a small company has a better product than they do, they acquire this company to make their own product better, as long as they keep the market share. Koppert, for example, has biologicals in its DNA, is already doing a lot in greenhouses and can ultimately deliver a total package of a complete biological IPM strategy. Also, if the large companies see that a small company has a better product than they do, they acquire this company to make their own product better, as long as they keep the market share. The smaller vegetable markets are interesting for SME's. (Expert 10)		

	The prices of the products will go down if there is going to be a scaling up, but that does require multinational capital and/or for SME's VC activity. So, whether the big players need to scale up or VC is needed to increase innovation and scale at the SME's. (Expert 14)		
	Research from small companies is the most important for market development and multinationals that will focus primarily on the so-called cash crops. Microbials sector continues to grow due to technological progress and the popularity of IPM. The adaptation of the regulation might create mixed feelings as agrochemical companies would possibly consider it as competition forgery. (Expert 5)		
	A strategic advantage of large companies, chemical companies, seed breeding companies or seed production companies is that they have the complete value/supply chain. Small companies will in all likelihood sell directly to farmers and produce more a customized product for specific crops in certain circumstances. There are many great ideas in start-ups, but to make a real impact, this should also be the case with larger companies. That is why these companies are often bought by larger companies. Large chemical companies also recognize that chemical products are less accepted by consumers, that the regulations have changed drastically, that pests resistances and that farmers want to take better care of their land. (Expert 9)		

	SME's and multinationals are both important for market share, but SME's mainly for innovations. Universities come up with good ideas that are being commercialized by small companies, which are bought by multinationals. SME's mainly for innovations. Microbials will have to keep focusing on smaller markets because there probably won't be one product for all the crops to use. Multinationals have more of a market, big companies missed out earlier on biotech so it might be that they just don't want to miss out anymore. Marketing infrastructure/value chain. Big chemical companies have the advantage that they already have a worldwide marketing network and can sell new products through this way and at the same time protect their own chemical products. This is very challenging for SME's operating in this industry. (Expert 11)		

	Costs for introducing a new product and going through the regulation period are on the average for a microbial product 1 million euros. SME's can hardly afford this. Industry is not interested in small markets. Those are for SME's, which bring high costs, but here is a growing chance for them. Big companies are trying to outcompete the SME's, therefore they buy them. Many SME's are active in the sector, but several are already owned by the big five (Bayer, BASF, ChemChina, Syngenta and Corteva). SME's need a long breath as the market is highly competitive and regulation is taking long. (Expert 13)		
	Innovation will come from SME's and universities, but to really open up the market, multinationals are also needed. Multinationals notice that more and more products are being banned, existing and new products, so microbials are going to eat market share. (Expert 1)		
	Due to high costs, products can currently only be supplied by large companies. In general, there is a consensus that small businesses are the most important for industrial innovation. In the medical world, for example, small companies do the research and large companies buy what they find interesting. In the microbials world, smaller companies still find their way to the niche markets fairly well. The involvement of SME's can be very much driven by regulations. (Expert 7)		

	Big companies are moving into seed treatment but keep the chemical mindset. This will not help them. SME's will focus on innovation and niche markets while the lesser agile big companies will focus on broadly used products for cash crops for example. Once farmers use IPM , they see the result and are very satisfied. The regulation will definitively change the upcoming 5 years and will drive growth of the microbials industry globally. For SME's, this will be tough. SME's will keep their niche markets and big companies moving into seed treatment more and more. They either license from, or acquire SME's that are innovative in this field. (Expert 8)		
	The Dutch government has presented a plan for the future until 2030 for new cultivation systems with the elimination of chemicals and the effective implementation of IPM by all farmers. In view of the chemicals that are being banned , large companies cannot take the risk that this investment will be cancelled out. Products may have to become more expensive in supermarkets to compensate for shift to IPM for farmers. It is smarter for these companies to take over small businesses once they have achieved their own commercialization potential. (Expert 2)		

	In the period from 2012 onwards, the large agrochemical companies all incorporated smaller companies, which was a kind of hype. Interaction with the end customer must be close and that is somewhat larger for the smaller companies. You really look for solutions together with your client. This allows smaller companies. Companies that are bought up are all so large that it really stands out. (Expert 3)		

MICROBIALS

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