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Biological Control in Swiss Agriculture: Potentials, Limitations, and Its Role in Shaping Agri-Food Futures

GEO 511 Master's Thesis

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Abstract

Plant protection is essential for global agricultural productivity. It often relies on synthetic chemical pesticides, which pose environmental and human health risks. Biological control (biocontrol), involving the use of plants or living organisms to manage pests, weeds, and diseases, offers a promising strategy for reducing reliance on synthetic chemicals. This research investigates the potentials and limitations of biocontrol in Swiss agriculture, focusing on how representatives of the Swiss pesticide complex legitimize their positions on biocontrol and how they discursively situate it in relation to chemically intensive agriculture and alternative agri-food arrangements. Drawing on 13 expert interviews and an analysis of scientific literature, policy reports, and official documents, the discourse-analytic examination reveals that the primary potentials of biocontrol lie in its environmental and human health benefits and in resistance prevention, whereas its limitations relate to product availability, regulatory barriers, operational complexity, knowledge requirements, and economic constraints. The research identifies distinct legitimation patterns, including ecological and moral rationales, functional and food security considerations, and business and market logics. Overall, biocontrol is framed not as a standalone replacement for synthetic chemical pesticides but as a complementary approach that both reinforces dominant agricultural structures and provides entry points for alternative practices.

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Abbreviations

AP PPP	National Action Plan for Risk Reduction and Sustainable Use of Plant Protection Products
BASF	Baden Aniline and Soda Factory
Bt	Bacillus Thuringiensis
CABI	Centre for Agriculture and Bioscience International
CDA	Critical Discourse Analysis
CSA	Community Supported Agriculture
FAO	Food and Agriculture Organization of the United Nations
FiBL	Research Institute of Organic Agriculture
FOAG	Swiss Federal Office for Agriculture
FSO	Swiss Federal Statistical Office
GPC	Global Pesticide Complex
IBMA	International Biocontrol Manufacturers Association
IP	Interviewed Person
IPM	Integrated Pest Management
IP-Suisse	Swiss Association of Integrated Producing Farmers
NGO	Non-Governmental Organization
UPL	United Phosphorus Limited
USD	United States Dollar
WHO	World Health Organization

Contents

1 Introduction

Protecting crops in global agricultural production is essential for food security (Savary et al., 2019) and the economic stability of the agricultural sector (Tudi et al., 2021). Currently, plant protection relies heavily on agricultural pesticides, which play a crucial role in reducing crop losses and enhancing both yield and quality (Savary et al., 2019; Tudi et al., 2021). These pesticides, predominantly based on synthetic chemicals, are considered an affordable and effective means of managing pests (Beck et al., 2018; Möhring et al., 2025). However, their widespread use is associated with adverse effects on non-target organisms (Beaumelle et al., 2023; Nicholson et al., 2024), environmental health (Gunstone et al., 2021; Tang et al., 2021), and human well-being (Kim et al., 2017; Larsen et al., 2017).

Rising awareness of these consequences has driven interest in alternative pest management strategies. Climate change and its effects on insect pests, crop yields, and the risk of pesticide resistance further highlight the need to adapt current plant protection practices (Deutsch et al., 2018). Alternative approaches include improving pesticide efficiency, developing alternative agricultural inputs, promoting farming practices less susceptible to pest pressure, and replacing synthetic chemical pesticides with less toxic options like biological control (hereinafter "biocontrol") (Finger, 2021; Möhring et al., 2020). For these strategies to effectively reduce the use of synthetic chemicals, they must be technically viable, economically feasible, and accepted by society (Finger, 2024b). This underscores the importance of research that integrates technical, socio-economic, and policy perspectives on pesticides.

This Master's thesis focuses on biocontrol as a specific approach to reduce the use of synthetic chemicals in agriculture. Recognizing that different strategies are required across geographic regions and production systems (Möhring et al., 2025), the thesis focuses on Switzerland, where pesticide use and regulation are prominent in public and political debate. The research provides an in-depth analysis of how representatives of the Swiss pesticide complex perceive the role of biocontrol in Swiss agriculture. The guiding research question is:

What potentials and limitations do representatives of the Swiss pesticide complex attribute to biocontrol in Swiss agriculture?

a. *How do the representatives legitimize their positions on biocontrol?*
b. *How is biocontrol discursively positioned in relation to chemically intensive agriculture and alternative agri-food arrangements?*

To address these questions, I conducted expert interviews with 13 representatives of the Swiss pesticide complex and analyzed the material using critical discourse analysis (CDA). This approach allows for an exploration of how experts frame the potentials and limitations of biocontrol and how they situate it within broader agri-food arrangements. The thesis has two main aims: first, to provide insight into how the representatives of the Swiss pesticide complex legitimate their positions on biocontrol; and second, to evaluate the potential of biocontrol to contribute to alternatives to chemically intensive agriculture.

The thesis is structured as follows: Chapter 2 reviews the literature, points out the research gaps, and formulates the research questions. Chapter 3 introduces key concepts, including the global pesticide complex, the economics and sociology of conventions, and alterity. Chapter 4 details the research design. Chapter 5 explores the potentials and limitations of biocontrol in Swiss agriculture, while Chapter 6 examines how the representatives of the Swiss pesticide complex legitimize their positions on biocontrol. Chapter 7 then analyzes how biocontrol is discursively positioned relative to chemically intensive agriculture and alternative agri-food arrangements. Chapter 8 discusses the findings and answers the research questions, and Chapter 9 concludes the thesis by summarizing the main results.

2 State of Literature and Research Questions

This chapter starts by defining agricultural pesticides and introducing biocontrol in Section 2.1. Section 2.2, I examine pesticide use and regulation in Switzerland. Section 2.3 then explores strategies to reduce reliance on synthetic chemicals, including substitution, efficiency improvements, and redesigning production systems. Finally, in Section 2.4, I identify the research gap and present the main research question.

2.1 Agricultural Pesticides and Biocontrol

Agricultural pesticides are commonly defined as substances used to reduce or eliminate pests, diseases, and weeds that threaten crop production (Glare & Nollet, 2023; Liu et al., 2021). They consist of biologically active compounds, organic or inorganic, applied to protect plants by targeting undesirable organisms (Hezakiel et al., 2024). Agricultural pesticides are biocidal agents, including fungicides, insecticides, herbicides, and rodenticides, that target organisms that cause crop damage or spread disease (Werner, 2025). The pesticidal chemicals that directly affect pests are known as active ingredients; when combined with additives such as surfactants and adjuvants to enhance effectiveness, usability, and distribution, they form the final products referred to as "formulated products" (Berndt et al., 2025; FAO & WHO, 2014). While the terms "pesticides" and "agrochemicals" (or "agrichemicals") are often used interchangeably, the latter refers more broadly to chemicals used in agriculture, including fertilizers and additional chemical agents (Werner, 2025). This thesis focuses specifically on agricultural pesticides.

Although natural substances have historically been used as agricultural pesticides for pest control, modern agriculture relies predominantly on synthetic chemicals for their effectiveness, affordability, and ease of application (Beck et al., 2018; Glare & Nollet, 2023). The widespread adoption of synthetic chemicals began during the "Green Revolution" in the 1940s, marking a shift toward a techno-scientific agricultural model that prioritized capital interests and productivity over social and ecological concerns (Bertomeu-Sánchez, 2019; Werner, 2025). Since the 1970s, the release of synthetic chemicals into ecosystems, dominated in volume by pesticides, has increased more rapidly than any other driver of global change, including greenhouse gas emissions (Bernhardt et al., 2017). This trend has accelerated in the 21st century: global imports of formulated pesticides, which serve as a reliable proxy for overall use, doubled from 2.5 million metric tons in 2005 to 5 million metric tons in 2023 (Werner, 2025).

In contrast to agricultural pesticides based on synthetic chemicals, biocontrol refers to an alternative approach grounded in biologically based methods. Following the definitions of the Centre for Agriculture and Bioscience International (CABI) and the International Biocontrol Manufacturers Association (IBMA), I define biocontrol as the management of pests, weeds, and plant diseases using living organisms, such as insects, microorganisms, or pathogens, or naturally derived compounds. Biocontrol agents act by killing, suppressing, deterring, or otherwise disrupting target organisms (CABI, n.d.).[1]

Biocontrol is a segment of the wider agricultural biologicals sector. For completeness, this sector also includes biofertilizers and biostimulants, the latter of which enhance plant growth, nutrient uptake, and stress tolerance (IHS Markit, 2020). In 2023, biocontrol was the largest segment of the agricultural biologicals sector, accounting for about half (47%), followed by biostimulants (37%) and biofertilizers (16%) (Bullion, 2024). This thesis focuses on biocontrol, which can be divided into two main categories: beneficial organisms and biopesticides (see Figure 1). Beneficial organisms comprise macrobials, such as insects, mites, and nematodes, that act as natural enemies by preying on or parasitizing pests (CABI, n.d.). Biopesticides, in contrast, generally refer to products whose active ingredients are derived from natural materials (Ayilara et al., 2023; Glare & Nollet, 2023; Koul, 2023). Although these active agents originate from natural sources, they may, in some cases, be produced synthetically (IHS Markit, 2020).

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[1] There is no universally accepted definition of biocontrol. Terminology in the literature is often used inconsistently, with terms like biocontrol, bio-based crop protection solutions, and bioprotection used interchangeably.

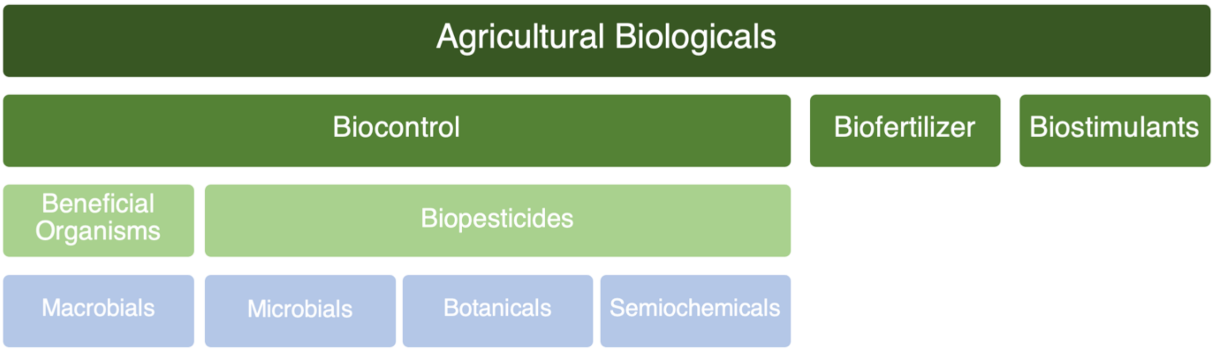

Figure 1: Classification of agricultural biologicals.
Overview of agricultural biologicals, highlighting biocontrol and its division into beneficial organisms and biopesticides (own illustration).

Biopesticides can be further categorized into three subgroups. According to the WHO and FAO (2017), these include products containing active substances derived from microbials, botanicals, or semiochemicals. Microbials consist of bacteria, fungi, protozoa, viruses, and other microorganisms, whether viable or non-viable. Botanicals are natural substances such as plant extracts, oils, or minerals with insecticidal, antifungal, or repellent properties. Semiochemicals are naturally occurring compounds emitted by plants, animals, or other organisms, such as pheromones, which influence pest behavior.

The literature highlights several benefits and limitations of biocontrol compared to synthetic chemicals. Generally, biocontrol products are characterized by high target specificity, low toxicity to non-target organisms, and limited environmental persistence (Ayilara et al., 2023; Beck et al., 2018; Hezakiel et al., 2024). At the same time, challenges include product stability, efficacy, performance variability, and shelf life concerns (Glare & Nollet, 2023; Bullion & Shoham, as cited in Rana et al., 2022).

Agricultural biologicals are not a recent innovation. Natural substances have been employed in plant protection for centuries (Beck et al., 2018). Since the 1960s, products based on the bacterium Bacillus thuringiensis (Bt) have been commercially available as biocontrol agents, and pheromone-based products were introduced in the 1970s (Bullion & Shoham, 2021). Nevertheless, widespread adoption and popularity have accelerated only in recent years. Today, biocontrol accounts for roughly 10% of the total global pesticide market (Marrone, 2024). This market segment is projected to outpace synthetic chemical products in growth, with industry sources anticipating double-digit annual increases. The projections indicate growth from approximately USD 5 billion in 2023 to USD 15 billion by 2029 (Bullion & Shoham, 2021; Marrone, 2024).

Europe and North America currently represent the largest biocontrol markets, each accounting for roughly 30% of global sales, followed by Asia (20%) and Latin America (16%) (Bullion &

Shoham, as cited in Rana et al., 2022). Latin America is experiencing the fastest growth among all regions (Baylis, 2021). Reflecting this geographical distribution, IHS Markit (2020) reports that the majority of companies producing biological products are concentrated in North America and Europe.

The growing global demand for agricultural biologicals has attracted significant interest from the agrochemical industry. By 2022, more than 500 companies – including start-ups, diversified agribusinesses, input producers, and specialist biologicals companies – were active in this sector (Bullion & Shoham, as cited in Rana et al., 2022; IHS Markit, 2020). These companies usually not only market biocontrol substances but also other biological products such as biostimulants (IHS Markit, 2020). Major agrochemical corporations have expanded into the biocontrol market through acquisitions, technology licensing, and joint ventures, coupled with substantial investments (Marrone, 2024). This involvement of large agrochemical companies is expected to accelerate innovation and market expansion (Bullion & Shoham, 2021).

According to Bullion and Shoham (2021), the agrochemical market has seen a higher rate of biological product introductions than synthetic chemical plant protection products over the past five decades. By 2023, around 175 biopesticides were officially registered worldwide, with approximately 700 active ingredients available for use (Hezakiel et al., 2024). Bullion and Shoham (2021) identify several factors contributing to the growth of the biocontrol market. These factors vary by region and include the expansion of the organic market, increasing demand for more “natural” products, and the sector’s overall attractiveness. Additionally, the authors note that concerns about pesticide resistance have further enhanced the relevance of biological products as components of integrated resistance management strategies. Regulatory dynamics also play an important role: in Europe, more than half of the crop protection products available in the 1990s have since been withdrawn, creating commercial gaps for biocontrol products.

2.2 Pesticide Use and Regulation in Switzerland

Chemically intensive agriculture continues to dominate global food production (Shattuck, 2021), and Switzerland is no exception. According to the Swiss Federal Statistical Office (FSO, 2025), less than 20% of agricultural land in Switzerland is managed organically. Beyond this organically managed area, the Swiss Federal Office for Agriculture (FOAG, 2025a) reports that a growing share of non-organic farmland is cultivated without the use of herbicides, fungicides, insecticides, growth regulators, or synthetic chemical stimulants, representing a distinct category of pesticide-free but non-organic farming.

According to Guntern et al. (2021), as of 2020, more than 300 pesticide substances were authorized for use in Switzerland. Up to 90% of the products are applied in agriculture, with the remainder used in urban areas and forestry. The external costs associated with pesticide use are estimated to range between 100 and 500 million Swiss Francs annually (Dümmler & Anthamatten, 2020; Schläpfer, 2020). The FSO (n.d.) reports that sales in Switzerland declined from nearly 2,250 tons of active ingredients in 2008 to 1,557 tons in 2023, with fungicides accounting for about half (47%) of the pesticides sold, followed by herbicides (28%), and insecticides (15%).

In the Swiss context, pesticides may be approved as plant protection products, biocides (for protecting humans and animals), or pharmaceuticals, depending on their intended use (Guntern et al., 2021).[2] The authorization of plant protection products is legally grounded in the Swiss Plant Protection Product Ordinance (SR 916.161). A completely revised version of the ordinance took effect on December 1, 2025. The main changes include a simplified authorization process for plant protection products already approved in neighboring countries (Germany, Austria, Italy, and France), and the immediate approval (or ban) of active ingredients upon their authorization (or ban) in the EU, eliminating the previous time lag.

Swiss agricultural practices follow the principles of integrated pest management (IPM). These principles stipulate that pesticides should only be applied when indirect measures (e.g., biodiversity promotion, resistant crop varieties, and optimized planting locations), combined with decision-support tools (e.g., forecasting or warning systems) and direct non-chemical plant protection measures (e.g., biological, biotechnical, or physical control), are insufficient to manage pest pressure (FOAG, 2025c). Biocontrol is considered a non-chemical plant protection measure that should be applied before any chemical intervention (see Figure 2).

[2] In Swiss legal terminology, pesticides are referred to as “Pflanzenschutzmittel” (plant protection products).

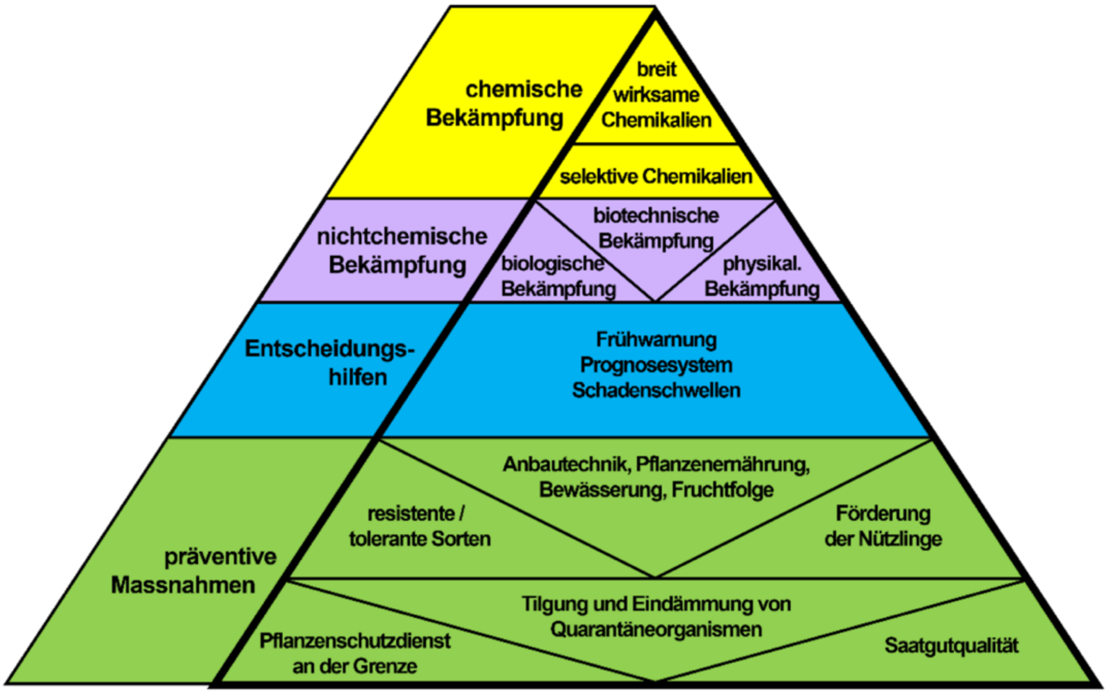

Figure 2: The concept of Integrated Pest Management.
The IPM concept is typically depicted as a pyramid: preventive measures form the base, followed by decision-support tools and direct non-chemical plant protection methods, with synthetic chemical interventions reserved as a last-resort measure at the top (FOAG, 2025c).

Pesticide use and regulation are central to recent and contemporary Swiss public and policy debates. In Switzerland's direct-democracy system, multiple actors actively shape the agricultural policy agenda. In her analysis of advocacy coalitions in Swiss pesticide policy, Wiget (2024) identifies two dominant coalitions: a "pro-environment coalition" prioritizing health and environmental protection through strict regulatory measures, and a "pro-agriculture coalition" emphasizing economic viability and resisting additional regulatory or fiscal measures. Positioned between these poles, an intermediate coalition adopts more moderate stances and plays a pivotal role in shaping Swiss pesticide policy.

Driven by concerns about health and environmental risks, Switzerland's recent pesticide policies focus on minimizing the hazards of plant protection products. In 2017, the Swiss Federal Council adopted the National Action Plan for Risk Reduction and Sustainable Use of Plant Protection Products (AP PPP). The AP PPP seeks to halve the risks associated with plant protection products by 2027 (relative to 2012/2015) and to promote alternatives to synthetic pesticides (Der Bundesrat, 2017). In 2023, additional policy measures were introduced to advance the AP PPP's objectives. These included increased direct payments for reduced- or pesticide-free cropping (outside organic systems) and stricter restrictions on harmful substances under cross-compliance standards (Dueri & Mack, 2024).

Public demand for stricter pesticide regulations has been expressed through two federal initiatives, on which voters in Switzerland voted on June 13, 2021. Their launch reflected the perceived mismatch between the negative consequences associated with pesticide use in Swiss agriculture and adequate policy responses (Finger, 2021). Although both initiatives on pesticide-free agriculture in Switzerland were rejected, with about 40% voting “yes,” Finger (2021) argues that they nonetheless had a substantial impact on Swiss agriculture and prompted governmental and industry responses.

The latest 2024 update of the AP PPP reports progress in reducing pesticide-related environmental risks in Switzerland, but also highlights persistent gaps in viable alternatives for plant protection. In response, the FOAG published the “Strategie für einen nachhaltigen Schutz der Kulturen 2035” in January 2026.[3] This strategy aims to establish concrete measures to strengthen plant protection in Switzerland over the coming decade and to support sustainable plant production in the long term (FOAG, 2026). Investigating the potentials and limitations of biocontrol is therefore particularly relevant, as it can help address these gaps and inform strategies for more sustainable plant protection practices in Swiss agriculture.

2.3 Approaches to Reducing Synthetic Pesticides

The widespread use of synthetic chemicals has created a paradox: while intended to protect plants, these substances can simultaneously harm organisms essential to food production (Bertomeu-Sánchez, 2019). Currently, about two-thirds of the world’s farmland is at risk of pesticide pollution (Tang et al., 2021). Against this background, Finger (2026) identifies three main directions for reducing the reliance on synthetic chemicals in agriculture. To transition from pesticide-intensive agricultural systems to agricultural arrangements less dependent on synthetic chemicals, three interrelated strategies are needed: increasing the efficiency of pesticide use; substituting chemical inputs with mechanical or biological methods; and fundamentally redesigning agricultural production systems to reduce pest pressure (see Figure 3).

[3] Translation: Strategy for Sustainable Crop Protection 2035.

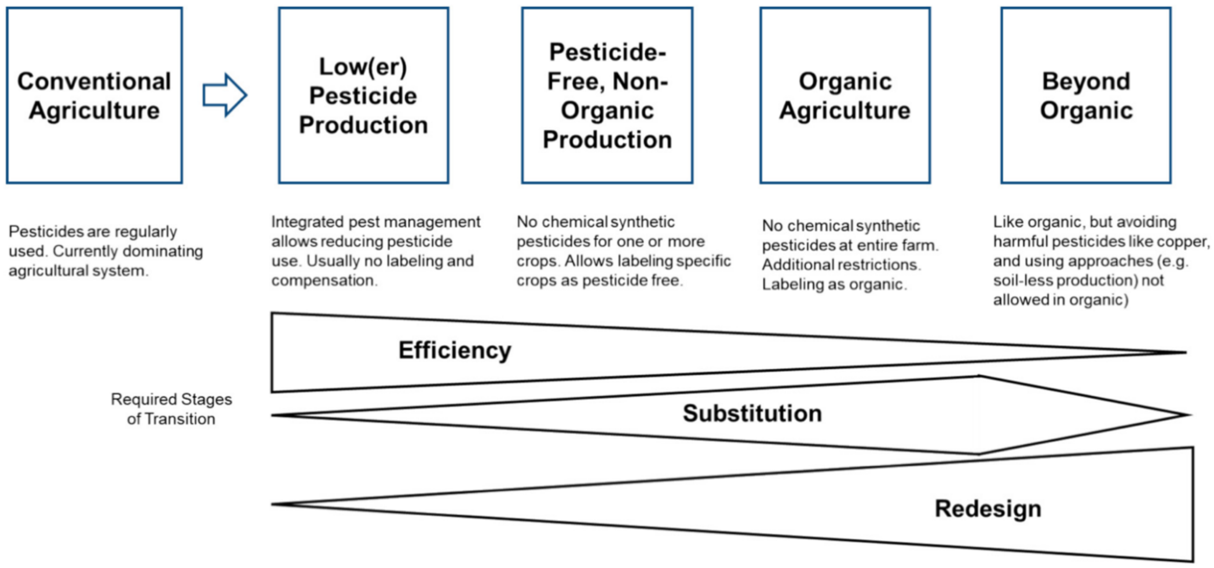

Figure 3: Efficiency, substitution, and redesign of agricultural production systems.
The three nonlinear stages of transition towards more sustainable plant protection in production systems as illustrated by Finger (2026).

In dominant agricultural structures, synthetic chemical pesticides remain widely used. Agricultural arrangements less dependent on synthetic chemicals include low-pesticide systems and pesticide-free, non-organic approaches, in which farmers voluntarily omit synthetic pesticides in parts of the crop rotation without pursuing full organic certification. This intermediate model, bridging chemically intensive and organic farming, is an emerging practice in Switzerland (Finger & Möhring, 2024).

Organic farming represents a further stage of this transition, fully banning synthetic chemical pesticides. However, organic systems may still rely on potentially harmful inputs such as copper, restrict the use of technologies like new breeding methods and soilless cultivation, and often produce lower yields (Finger, 2026). To address these limitations, so-called "beyond organic" systems have been proposed, aiming to further reduce environmental impacts per unit of production by eliminating harmful chemicals while allowing restricted technologies that can close yield gaps and reduce pest-management risks.

Next, I outline approaches to enhance pesticide efficiency, substitute chemical inputs, and redesign agricultural production systems, illustrating selected examples from Swiss agriculture. Practices grounded in agroecology, regenerative agriculture, permaculture, Community Supported Agriculture (CSA), and subsistence or small-scale diversified farming exemplify strategies that support the transition toward more sustainable plant protection. These production approaches prioritize ecological prevention strategies, often minimizing or eliminating the need for synthetic chemical inputs. A notable Swiss example is the “HofLabor” project in Mönchaltorf, which combines strip cropping, mulching, soil-friendly tillage, and controlled traffic farming to cultivate vegetables, grains, and potatoes without synthetic chemical pesticides or fertilizers (HofLabor, n.d.). This project illustrates how integrating technologies can support the redesign of production systems.

Advanced digital technologies – including precision farming, remote sensing, drones, artificial intelligence, digital twins, robotics, and a wide range of other innovations – offer additional, non-chemical approaches to reduce reliance on synthetic chemicals by enhancing efficiency, enabling substitution, and supporting system redesign (Finger, 2023, 2026). For example, precision agriculture technologies, such as drones for targeted spraying or artificial intelligence-based pest warning systems, allow precise interventions that minimize environmental and health risks (Bullion & Shoham, 2021; Finger, 2023).

In Switzerland, drone-based plant protection treatments have been authorized since 2019 and are applied in vineyards and orchards (Anken et al., 2025). However, acceptance and adoption of precision agriculture technologies among Swiss farms remain heterogeneous. Their use is often motivated by reducing manual labor rather than by directly supporting pest management decisions (Groher et al., 2020). Projects like “Optimizing Plant Protection with Precision Farming” (FOAG, 2025b) aim to reduce adoption barriers and demonstrate the benefits of precision farming for plant protection in Switzerland.

Policy frameworks and civil society initiatives play a central role in facilitating the redesign of agricultural production systems. Legislative instruments designed to reduce reliance on pesticides include performance-oriented incentive schemes (Finger, 2024a) and risk-based pesticide taxation (Finger & Pedersen, 2025; Nielsen et al., 2023). These regulatory regimes are not developed in isolation but are shaped by the influence of social movements and organizations (Mansfield et al., 2024). Complementing formal regulation, civil society initiatives, such as community-based advisory services and peer coaching, facilitate knowledge exchange and resource sharing, supporting the adoption of alternative practices. A notable example is the Swiss Network for Agroecology (Agroecology Works!, n.d.), which fosters participatory learning networks that encourage reflection on pesticide use and support the transition toward agroecological farming practices.

2.4 Research Gap and Research Questions

The existing literature identifies multiple strategies for reducing reliance on synthetic chemicals in agriculture. These strategies focus on improving input efficiency, redesigning production systems, and substituting synthetic inputs with less harmful alternatives. While agrarian scholarship has long examined the role of chemical inputs in agriculture, critical research from the early 2000s onward has increasingly focused on alternatives to chemically intensive farming arrangements (Shattuck, 2021; Werner, 2025). Although pesticides have re-emerged as a key topic in agrarian studies over the past decade (Werner, 2025), comparatively less attention has been paid to substitution strategies aimed at replacing synthetic chemicals with alternative plant protection products.

Against this backdrop, this thesis examines the potentials and limitations of biocontrol as an alternative to chemically intensive plant protection. Transitions toward more sustainable plant protection require multiple, context-specific approaches that vary across production systems and geographical regions (Möhring et al., 2025). Within Switzerland's evolving policy landscape (see Section 2.2), biocontrol has gained prominence as an approach that offers the potential to reduce dependence on synthetic chemicals while enhancing the resilience of plant protection strategies. Despite this growing interest, there remains a limited understanding of how actors within the Swiss pesticide complex assess the context-specific feasibility, potentials, and constraints of biocontrol in Swiss agriculture. To address this gap, I conduct an in-depth, place-based analysis guided by the following research questions:

What potentials and limitations do representatives of the Swiss pesticide complex attribute to biocontrol in Swiss agriculture?

a. *How do the representatives legitimize their positions on biocontrol?*
b. *How is biocontrol discursively positioned in relation to chemically intensive agriculture and alternative agri-food arrangements?*

By addressing these questions, I aim to bridge policy ambitions, scientific debates, and expert perspectives, thereby illuminating the opportunities and constraints associated with integrating biocontrol into Swiss agricultural practice. Addressing this topic requires an interdisciplinary perspective, as pesticides constitute what Mansfield et al. (2024) describe as a "multifaceted research object" (p. 406), embedded within ecological, social, economic, and political dynamics and encompassing material, socio-natural, cultural, and political dimensions (Werner, 2025). Accordingly, the thesis adopts an approach grounded in political and economic geography. Rather than focusing on the biophysical properties of biocontrol, I examine the practical, socio-economic, policy, and discursive dimensions that shape its role in Swiss agriculture. Through this lens, the research contributes to broader debates on pathways toward agricultural futures that are less dependent on synthetic chemical pesticides.

3 Theoretical Approach

To examine biocontrol and its positioning within contemporary agriculture, I draw on three theoretical concepts. The first is the Global Pesticide Complex (GPC), presented in Section 3.1, which situates biocontrol within the evolving patterns and dynamics surrounding agrochemical production and use. The second is the economics and sociology of conventions, introduced in Section 3.2, which provides a basis for analyzing how the representatives of the Swiss pesticide complex legitimize their positions on biocontrol. The third is the concept of alterity, outlined in Section 3.3, which provides an analytical lens for assessing the extent to which biocontrol challenges, reproduces, or reshapes chemically intensive agricultural arrangements.

3.1 The Global Pesticide Complex

The GPC is one approach to analyzing the patterns and dynamics surrounding agricultural pesticides from a social science perspective. Werner (2025) defines the GPC as "a framework to analyze the multifaceted dimensions of pesticides and their compounding interactions across production, trade, regulation, and use" (p. 2). The GPC facilitates the identification of multi-scalar interactions throughout the entire pesticide lifecycle – from development and production to regulation, use, and the resulting social and environmental impacts – shaped by global industry structures, regulatory feedbacks, and evolving understandings of chemical toxicity (Galt, 2008; Mansfield et al., 2024; Werner, 2025).

Tracing the nearly century-old history of the widespread use of synthetic pesticides, Werner (2025) highlights the central role of pesticides in shaping agrarian transformations and politics. Synthetic chemicals, the author argues, not only drive capital accumulation in agriculture but also modify agroecosystems, reinforcing dependency on chemical inputs. They reorganize land, labor, and capital, influencing resource and land control, and the transmission of local knowledge across generations. Acting in recursive ways, their impacts are often subtle and cumulative, and span pesticide application, production, trade, and regulation. Building on the concept of the GPC, I recognize that pesticides must be understood not in isolation but as embedded within complex networks of actors, relationships, and institutions.

I now outline the main characteristics that shape Switzerland's position within the GPC. At the national level, pesticides are not only a matter of agricultural practice but also a prominent topic in public and political debates in Switzerland (see Section 2.2). Regarding its connection to the global industry structures surrounding pesticides, Switzerland is home to relevant actors globally embedded in production networks. One of these is Syngenta, headquartered in Basel. Following its acquisition by ChemChina in 2017, it became one of the world's five largest agrochemical companies, alongside Bayer, BASF, Corteva, and UPL (Berndt et al., 2025).[4] These multinational companies dominate the market share in both the plant protection and seed sectors (Deconinck, 2020). Operating worldwide, Syngenta produces and distributes synthetic chemical pesticides, while participating in the agricultural biologicals sector: with roughly 100 million USD in sales in the biologicals sector and a strategy focused on research and development collaborations and acquisitions, the company is expected to become a leading player in the agricultural biologicals market (IHS Markit, 2020).

Besides multinational agrochemical companies, specialized biocontrol companies shape the Swiss pesticide complex. A prominent example is Andermatt Biocontrol Suisse, a pioneering company in the development and production of biological plant protection products. According to company sources, its portfolio encompasses nearly the full spectrum of effective biological plant protection products available worldwide (Andermatt Biocontrol Suisse, n.d.). The Andermatt Group is independently owned by its founders and employees and operates through twenty subsidiaries worldwide, exemplifying how Swiss-based firms are embedded in transnational production networks.

Switzerland's embeddedness in the GPC thus unfolds across several interrelated dimensions: On the one hand, companies such as Syngenta and Andermatt Biocontrol Suisse connect domestic agriculture to global markets through research and development, production, and international corporate structures. On the other hand, Swiss regulatory frameworks and public debates shape how pesticides are governed, applied, and contested at the national level. This dual position illustrates Switzerland's role in sustaining processes of agricultural intensification and chemical dependency, while also serving as a site for the development and promotion of biological plant protection approaches such as biocontrol.

3.2 The Economics and Sociology of Conventions

While the GPC framework conceptualizes the embedding of pesticidal and biocontrol substances within broader socioeconomic, cultural, and ecological relations, the economics and sociology of conventions provide a complementary lens for examining how the representatives of the Swiss pesticide complex legitimize their positions on biocontrol. This approach shifts

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[4] Measured by sales in 2023.

the focus from structural embedding to the interpretive and justificatory practices through which biocontrol is rendered legitimate.

The economics and sociology of conventions emerged in the 1980s as a critical response to French neostructuralism and has since developed into an “interdisciplinary and international institutionalist movement” (Diaz-Bone, 2024). At its core lies the concept of the convention, understood as shared rules and assumptions that are taken for granted, regardless of whether they originate from explicit agreements, contractual arrangements, or founding moments (Storper & Salais, 1997). Building on this understanding, Diaz-Bone and De Larquier (2024) define conventions as the “institutional logics for the valuation or valorization of goods, actions, and persons” (p. 1). Conventions thus provide a normative basis for actors to evaluate social situations and practices, such as biocontrol.

Conventions are not conceptualized as fixed or external constraints imposed on actors, but rather as interpretive frameworks actively applied, negotiated, and potentially contested. Conventions are not permanent; they are neither temporally nor spatially fixed (Ponte, 2016). Actors may question and critique prevailing conventions, switch between different conventions, and mobilize alternative conventions as resources for critique and justification (Diaz-Bone & De Larquier, 2024). Accordingly, the economics and sociology of conventions explain decision-making and evaluations by analyzing how actors invoke conventions to make sense of economic and social situations.

A central assumption of convention theory is that social situations are shaped by a plurality of conventions and justification logics. As Diaz-Bone and De Larquier (2024) emphasize, multiple evaluative principles and logics can coexist and simultaneously guide coordination and judgement within a given context. To account for this plurality and to explain institutional differences, coordination mechanisms, and collective evaluation processes (Diaz-Bone & De Larquier, 2024), several analytical models have been developed within the economics and sociology of conventions.

Among the most influential contributions to the field are Stroper and Salais’s “Worlds of Production” (1997) and Boltanski and Thévenot’s “On Justification” (2006). In “On Justification”, Boltanski and Thévenot (2006) develop the “orders of worth” approach to analyze how individuals justify their actions to others by appealing to different principles of evaluation. In this perspective, conventions both enable coordination and interpretation, but they must be enacted, evaluated, and applied by actors within specific situations.

Boltanski and Thévenot (2006) identify six primary orders, or "worlds," of justification: the domestic convention, the market convention, the industrial convention, the inspired convention, the civic convention, and the convention of opinion. These "worlds" are not hierarchically ordered; each is associated with distinct criteria of evaluation (Ponte, 2016). Subsequent work has extended this model to include additional conventions, most notably the green convention (Lamont & Thévenot, 2000) and the network convention (Boltanski & Chiapello, 2005). The model assumes that most social situations are organized through a plurality of quality conventions that actors implicitly understand as part of their culturally embedded knowledge (Diaz-Bone & De Larquier, 2024). In this way, the set of conventions provides a culturally established logic that actors draw upon when justifying or criticizing the worth of persons, actions, and objects (Diaz-Bone & De Larquier, 2024).

An analytical approach informed by convention theory is widely applied in geography and agri-food studies. According to Ponte (2016) and Allaire (2025), the economics and sociology of conventions have shaped agri-food research since the 1990s at theoretical, analytical, and empirical levels. In this thesis, convention theory informs the analysis of how the representatives of the Swiss pesticide complex legitimize their positions on biocontrol. In combination with critical discourse analysis (see Section 4.2.2), the approach is used to identify the distinct logics of justification that structure expert framings of biocontrol within Swiss agriculture.

3.3 The Concept of Alterity

While the economics and sociology of conventions relate to the evaluative logics and criteria through which actors justify and coordinate their actions, the concept of alterity provides a lens for examining how biocontrol is discursively framed and distinguished from synthetic chemicals. The concept of alterity thus serves as a foundation for investigating how biocontrol is positioned as "other" relative to dominant agricultural practices.

In broad terms, alterity refers to an ongoing, performative process of making and enacting difference. Through "doing things differently," alternative possibilities, often obscured or marginalized within dominant structures, become visible and thinkable (Carolan, 2013). This performative dimension is inherently subversive, challenging the assumption that there is a singular, predetermined way of organizing social arrangements. As Fois (2019) emphasizes, experimenting with alternative spaces and practices does more than provide material alternatives; they also reshape subjectivities, relationships, and social worlds. The value of alterity thus lies in cultivating spaces that question and disrupt habitual practices and established norms, reconfiguring thought and emotion (Carolan, 2013). This opens new ways of thinking, being, relating to others, and engaging in society.

In the agricultural context, alternative food arrangements consist of groups or individuals actively challenging mainstream practices of food provision (Sharp et al., 2015). Around the world, diverse initiatives – such as CSA, food cooperatives, community gardens, subscription farming, and farmers' markets – have emerged as counterpoints to dominant modes of food production and distribution (Cameron & Wright, 2014; Sharp et al., 2015). Rosol (2020) argues that the geographies of alternative food arrangements have gained increasing significance in response to ecological degradation, social inequalities, health risks, ethical concerns, and economic instabilities linked to the industrial food complex.

While pluralistic in nature, these initiatives share an ethical and political commitment to reimagining food provisioning. Practices of "doing agri-food differently" serve as tangible expressions of alterity, creating space for more democratic, self-reliant, and resilient food futures (Sharp et al., 2015). Fostering such alternative futures does not depend on fully developed or universally applicable solutions. On the contrary, Carolan (2013) cautions that fixed solutions may be counterproductive, as they risk narrowing the very diversity and plurality on which transformative change depends. Instead, projects of alterity contribute to disruption by resisting or seeking to reconfigure the political economy of globalized agri-food relations.

In practice, projects of alterity are often identified through their association with alternative products and the networks through which these circulate, such as non-traditional distribution channels and unconventional production-consumption relationships. Reflecting this, alterity is frequently examined through a "capitalocentric" lens (Gibson-Graham, 2006), meaning it is primarily interpreted in relation to capitalism and positioned in contrast to dominant industrial agri-food arrangements (Sharp et al., 2015). This oppositional framing, which contrasts "alternative" with "traditional" or "conventional," can reinforce the idea of a dominant food arrangement against which alternatives are defined. As Cameron and Wright (2014) note, labeling a set of practices as "alternative" assumes the existence of a mainstream and gives that mainstream more weight than it may deserve.

The limitations of such a binary framing are also evident in the process of conventionalization, whereby alternative practices are absorbed into mainstream markets (Rosol, 2020). A key example is the incorporation of organic or fair-trade labels into supermarket chains, which, according to Goodman et al. (2010), allows corporate actors to market these alternatives for profit purposes while largely reinforcing dominant food industry logics. This process of conventionalization is interpreted as eroding the distinct identity of the organic sector, particularly in contrast to its originally intended alternative model (Allaire, 2025).

Noting that many projects of alterity replicate market-based practices that closely mirror dominant economic models, Rosol (2020) calls for a more critical examination of the economic logics that underpin them and proposes a conceptual framework that distinguishes between three dimensions of alterity (see Table 1): the nature of the products themselves; the distribution and relational networks through which they circulate; and the underlying economies. This framework allows for a nuanced analysis of whether, and to what extent, a given initiative enacts difference across these intersecting dimensions. In the context of this thesis, these dimensions provide a framework for assessing how biocontrol is understood differently compared to synthetic chemicals and how it is associated with alternative practices or embedded within dominant agri-food structures.

Table 1: Dimensions of alternative food arrangements.
Examples adopted from Rosol (2020), building on Watts et al. (2005).

Alternative Products	**Alternative Networks**	**Alternative Economies**
• Organic food • Quality and specialty food • Regional/local food labels • …	• Direct marketing • Community Supported Agriculture • Urban gardening • Fair Trade • …	• Social enterprises • Cooperatives • Solidarity economy • Food sharing • Volunteer and in-kind labor • …

The concept of alterity is applied to examine biocontrol not simply as a technical substitute for synthetic inputs but as a potential catalyst for reconfiguring the logics, relationships, and values underpinning food production. This perspective allows for an exploration of whether biocontrol can open up alternative agricultural practices and futures beyond chemically intensive approaches. Following Gibson-Graham (2008), the aim is to expand the possibilities (of biocontrol as an alternative to synthetic chemical pesticides) via scholarly inquiry. By connecting empirical insights to broader theoretical debates on difference-making, I examine how biocontrol can contribute to reconfiguring the logics, relationships, and values that underpin food production. In this sense, the research itself becomes part of a process of difference-making. Or, as Carolan (2013) puts it, “to explore difference is to *do* difference” (p. 148).

4 Research Design

In this research, I adopted a qualitative approach to explore how the representatives of the Swiss pesticide complex perceive the potentials and limitations of biocontrol in Swiss agriculture. I combined a literature and document review with semi-structured expert interviews to investigate how biocontrol is framed and positioned within agricultural arrangements. The literature and document review provided a macro-level understanding of the biocontrol sector, relevant policy and regulatory frameworks, and broader market dynamics. The interviews with the representatives of the Swiss pesticide complex complemented this by offering micro-level insights into expert perspectives and interpretive frames. Together, these methods allowed me to develop a holistic understanding of biocontrol's potentials and limitations in Swiss agriculture. In Section 4.1, I first outline the methods of data collection, before explaining the approach to data analysis in Section 4.2. The chapter concludes with methodological reflections in Section 4.3.

4.1 Methods of Data Collection

A comprehensive review of scientific literature, policy documents, and reports provided the contextual foundation for this research. The review included both international and Swiss-specific publications on pesticides and biocontrol. Including international literature is essential for learning from comparative experiences and situating Swiss practices within broader global trends. The review also drew on theoretical literature on the GPC, the economics and sociology of conventions, and the concept of alterity. In addition, industry reports and market analyses, particularly those published by the rating agency "Standard and Poor's" (S&P Global), were used to contextualize the agricultural pesticide and biologicals sector and to capture prevailing industry dynamics. The literature and document review served two primary purposes. First, it informed the development of the semi-structured interview guide by identifying key debates, knowledge gaps, and contested issues surrounding biocontrol. Second, it established a foundation for interpreting the empirical data, enabling the interview material to be situated within broader policy, economic, and theoretical contexts.

The empirical core of this research consists of semi-structured expert interviews with the representatives of the Swiss pesticide complex. The interviews aimed to capture expert knowledge, individual experiences, interpretive framings of biocontrol, and the social meanings attached to its use in Swiss agriculture. Rather than eliciting factual information alone, the interviews focused on how the representatives of the Swiss pesticide complex position biocontrol in relation to chemically intensive agriculture and alternative agri-food arrangements.

For this thesis, a representative of the Swiss pesticide complex is broadly defined as any individual with professional, practical, or scientific expertise in agricultural pesticides, including actors from agricultural practice, academia, civil society, policymaking, and industry. This inclusive definition and diversity reflect the understanding that agricultural expertise is multifaceted and distributed (Legun et al., 2023).

The interview participants were identified through a snowball sampling strategy. Initial participants were selected based on their involvement, influence, or stake in biocontrol and in pesticide governance and use in the Swiss agricultural context. Subsequently, the interview participants were asked to recommend additional relevant actors, which facilitated access to interconnected expert networks within the Swiss pesticide complex. In total, 12 interviews were conducted with 13 interview participants, including one double interview conducted at the participants' request.

The final sample includes representatives of the Swiss pesticide complex from the economic, political, and civil spheres (see Table 2), all of whom engage with plant protection practices in theoretical or practical ways. Economic actors comprise industry representatives and crop protection advisors from the agricultural technology and agrochemical industry, as well as from biotechnology and biocontrol companies; an organic farmer applying biocontrol; and a representative of the Swiss Farmers' Union. In addition, the sample includes a political actor, namely a federal policymaker involved in pesticide legislation, regulation, and oversight. Civil society actors are also represented, including an expert from an environmental NGO as well as researchers in phytopathology, agrochemicals, and agricultural economics and policy from various academic institutions who monitor, critique, and produce knowledge on pesticide use.

Table 2: Overview of interview participants.

Interview Participant (IP)	Primary Affiliation
IP1	Biotechnology industry representative
IP2	Phytopathology researcher
IP3	Federal policymaker
IP4	Biocontrol industry representative, crop protection advisor
IP5	Environmental NGO representative
IP6	Organic farmer and biocontrol user
IP7	Phytopathology and entomology researcher
IP8	Agrochemicals researcher
IP9	Swiss Farmers' Union representative
IP10	Agrochemical industry representative, crop protection advisor
IP11	Agrochemical industry representative, crop protection advisor
IP12	Agrochemical industry representative, sustainability expert
IP13	Agricultural economics and policy researcher

The preparation, conduct, and analysis of the interviews were guided by qualitative research methodologies from Gläser and Laudel (2009), Helfferich (2009), and Lareau (2021). The interviews followed a semi-structured format using an interview guide developed from the literature review (see Appendix A). The guide ensured systematic coverage of key themes relevant to the research question while allowing flexibility to pursue emergent topics and participant-led narratives (Hay & Cope, 2021). The questions were adapted to participants' professional backgrounds and areas of expertise.

The interviews lasted between 30 and 70 minutes and were conducted primarily in German, with English used when the participant preferred. The research objectives and procedures were communicated both in the initial contact emails and at the beginning of each interview. The participants were informed of the intended use of their data, and explicit consent for audio recording was obtained before each interview.

4.2 Methods of Data Analysis

Following each interview, brief reflective field notes were compiled to document immediate impressions, contextual observations, and preliminary analytical reflections. The data analysis then proceeded with the systematic transcription and coding of all interview material, providing a structured foundation for the subsequent discourse analysis.

4.2.1 Transcription and Coding Procedures

All interviews were transcribed using noScribe, a free, open-source AI-based transcription tool that converts audio to text locally, without cloud dependency. The auto-generated transcripts were then imported into the research software MAXQDA, where they were manually reviewed and prepared for systematic analysis. Each transcript was checked manually for accuracy by reading the transcript and correcting transcription errors. While the interview conducted in English needed only minimal revision, the interviews conducted in Swiss German and transcribed into standard German required more substantial editing to ensure clarity and accuracy. During the transcription process, all personal and identifying information was anonymized; personal identifiers were removed, and only general affiliations or expert categories were retained for analytical purposes. A dedicated code ("anonymized data") was created in MAXQDA, and the software's anonymization function was used to generate a project version in which all sensitive passages were consistently masked.

The transcription followed a transparent and consistent notation system adapted from qualitative research guidelines. According to Gläser and Laudel (2009), no universally standardized transcription system exists. Accordingly, the scheme was adapted from Hay and Cope (2021, p. 170), whose approach is specifically tailored to qualitative research in human geography, and was applied consistently across all transcripts. In line with Gläser and Laudel (2009), paraverbal fillers (e.g., "ähm") and repetitive word sequences that did not alter meaning were removed to improve readability, while non-verbal expressions were transcribed only when relevant for understanding the interaction. Interruptions and unintelligible passages were marked accordingly. Where necessary for clarity and coherence, Swiss German grammatical structures were translated into standard German while preserving semantic content.

The subsequent coding combined inductive and deductive approaches within an iterative framework. The coding process and construction of a coding frame were informed by Chapters 6 and 8 of Kuckartz and Rädiker (2019) and Chapter 18 of Hay and Cope (2021). I conducted two main rounds of coding, complemented by ongoing refinement of the code system throughout the analysis.

In the first coding round, I followed an inductive approach to reconstruct the discursive context of biocontrol in Switzerland. To this end, I coded all interview material inductively to identify how the interview participants define and understand biocontrol, the potentials and limitations they associate with it, and the additional themes that emerge from their accounts. This process helped me contextualize individual statements and ground the analysis in participants' own framings, thereby directly addressing the core research question about the perceived potentials and limitations of biocontrol attributed by the representatives of the Swiss pesticide complex.

In the second coding round, I conducted a structural and interpretive analysis of the discursive positioning and legitimation of biocontrol in the Swiss agricultural context. Here, the analysis concentrated on identifying argumentative patterns and legitimation strategies used by the interview participants to legitimize their positions on biocontrol. In addition, a deductive coding framework was applied to examine how biocontrol was positioned in relation to chemically intensive agriculture and alternative agri-food arrangements. This framework explicitly draws on the dimensions of alterity – alternative products, networks, and economies – as introduced in Table 1.

Although broadly structured into two main coding phases, the analytical process was iterative and nonlinear. I continuously added, merged, refined, or discarded codes as familiarity with the material grew and analytical insights evolved. The final coding system is structured hierarchically, with top-level codes aligned with the main focus of the research questions and subcategories organizing the topics raised by interview participants (see Appendix B).

4.2.2 Critical Discourse Analysis

CDA was employed to identify key discursive terms, positions, and narratives that shape how biocontrol is framed within Swiss agriculture. As such, CDA is well-suited to uncover the underlying conventions through which the representatives of the Swiss pesticide complex legitimize their positions on biocontrol.

The use of interview material for discourse-analytic purposes is well established in qualitative research (O'Rourke & Pitt, 2007). The CDA conducted in this thesis followed the approach developed by Jäger et al. (2019, 2024), which is explicitly grounded in Michel Foucault's understanding of discourse. From this perspective, discourses are conceptualized as "flow[s] of knowledge through time and space" (Jäger et al., 2024, p. 35). Methodologically, the analysis reconstructs statements by organizing related discourse fragments into topics and subtopics, and empirically examining their content and formal structures, thereby mapping the conditions under which specific statements become legitimate. Rather than aiming to establish objective truths, CDA seeks to reconstruct discursive horizons by identifying what can be said, by whom, and under which conditions, and to critically reflect on the boundaries of these horizons.

A central concern of the CDA is the relationship between knowledge and power. Discourses are understood as sites where power operates by defining what counts as legitimate knowledge and socially accepted "truth" (Jäger et al., 2024). Accordingly, CDA does not treat prevailing truths or "normalities" as given but examines how they emerge and how socio-cultural and economic power structures shape their production. This focus aligns with convention theory's emphasis on justification, as both approaches attend to how legitimacy is constructed and defended in social situations.

Particular attention is paid to so-called collective symbols, which are foundational to the structuring of discourses. According to Link (2013), collective symbols comprise the set of images most widely shared within a culture, including allegories and emblems, extended metaphors, comparisons, illustrative examples, and analogical models that shape how reality is represented and interpreted. Jäger et al. (2019) further describe these symbols as "cultural stereotypes" (p. 70) that are familiar to everyone within a society and routinely used in communication, yet typically remain unreflected in everyday discourse. In relation to convention theory, collective symbols function as shared resources for meaning-making and can be understood as discursive vehicles through which evaluative principles are rendered self-evident.

In addition, CDA examines how different discourse strands intersect and reinforce one another, and how they are articulated across various discourse levels, including science, politics, industry, advisory services, and agricultural practice. These levels are treated as interconnected and mutually influential. I also considered discourse positions, the subject positions from which statements are articulated, as well as discursive events that may reconfigure the discourse. In the Swiss context, federal popular initiatives on pesticides constitute such events, as they have influenced both the intensity and direction of debates on biocontrol.

Through this discourse-analytic approach, I aimed to reconstruct the discourses surrounding biocontrol in Swiss agriculture and identify the thematically coherent discourse strands that constitute them. The CDA revealed how biocontrol is discursively constructed and positioned within the Swiss pesticide complex. Rather than directly mapping the predefined "orders of worth" developed by Boltanski and Thévenot (2006) onto the empirical material, the analysis drew on the economics and sociology of conventions as a sensitizing theoretical approach to inductively identify the evaluative criteria and the logics of justification mobilized by the interview participants (see Section 3.2). In doing so, the approach elucidated both how biocontrol is socially constructed and how its legitimacy is defended within the Swiss pesticide complex, with the resulting legitimation patterns presented and discussed in Chapter 6.

4.3 Methodological Reflections

4.3.1 Quality Criteria

In planning, conducting, and reporting this research, I was guided by qualitative research criteria to ensure and critically assess the quality of the material and findings throughout the research process. Because there is no single, universally accepted set of criteria for qualitative research and the field of application is heterogeneous, a variety of approaches exist to ensure and enhance research quality. Against this background, I focused on four criteria particularly relevant to my research context: reflexivity, reliability, validation, and credibility. In the following, I outline these criteria and explain how they are addressed within my methodological approach.

Reflexivity is regarded as a core principle in the preparation and reporting of qualitative research (Müller et al., 2025). It involves continuous reflection on my role, position, and influence as a researcher, and on making this positionality explicit (see Section 4.3.2). Reflexivity thus requires both engagement with the empirical field and the creation of analytical distance. Strübing et al. (2018) describe this as "adequacy," which refers to defining the research topic through close interaction with the field while simultaneously retaining analytical distance through theory. The aim is not to achieve objectivity in a positivist sense, but rather to ensure that data collection and interpretation are, to a sufficient extent, independent of the specific person conducting the research (Flick, 2010). Furthermore, by writing short memos after each interview and reflecting on the data collection and analysis process (see Section 4.3.3), I created explicit space for reflection on the research process.

Reliability is addressed in a procedural manner by making the process of data collection and interpretation transparent. Following Flick (2010), I aimed to explicate the emergence of the data in a way that makes it clear which statements originate from the research participants and where my own interpretation begins. This is ensured through transparent and consistent transcription rules, clear attribution of interview statements to the respective participants, and explicit marking of my analytical interpretations. In doing so, I adhered to the principle of "textual performance," which emphasizes the clear, coherent, and traceable presentation of empirical findings (Strübing et al., 2018).

In line with Flick (2010), I approached the criterion of validity by shifting the focus from validity as an outcome to processes of **validation** throughout the research process. This entails moving away from evaluating isolated research steps toward ensuring transparency across the entire research design and execution. In my research, validation was supported by a detailed, transparent account of the research procedure, made accessible to both the interview participants and the readers. Furthermore, validation was strengthened by including different actor groups, namely representatives of the Swiss pesticide complex with diverse personal and professional backgrounds and differing perspectives on agricultural pesticides and biocontrol.

I analyzed, integrated, and discussed multiple sources and forms of knowledge and data. I recognize that the statements from the 13 representatives of the Swiss pesticide complex reflect subjective viewpoints and are not statistically representative. To enhance the validity and **credibility** of the findings, data sources were combined using a triangulation strategy (Gläser & Laudel, 2009). Specifically, the interview data were related to the scientific literature and to the insights gained from document and report analysis. The interpretation of the data was guided by the principle of empirical saturation, ensuring that analytical conclusions are firmly grounded in the empirical material (Strübing et al., 2018). In addition to data triangulation, regular discussions with my supervisor, Prof. Dr. Christian Berndt, with the researcher Dr. Milena Wiget, and in the colloquium of the Economic Geography Group at the University of Zurich served as forms of "peer debriefing" (Flick, 2010). These exchanges supported reflexive engagement with the research process, helped identify potential blind spots, and further strengthened the thesis's credibility.

4.3.2 Positionality

In this section, I reflect on my role and positionality as a researcher and on how my background, experiences, and perspectives may have shaped the research process and the interpretation of findings. I approached this thesis as a female Master's student at the University of Zurich. As a mindful consumer concerned with environmental sustainability and personal health, and with the privilege of voting in Switzerland, I am regularly confronted with the ecological, social, and political debates surrounding pesticide use. In particular, the two Swiss popular initiatives addressing pesticide regulation (see Section 2.2) prompted me to engage critically with the topic and to form an informed opinion.

My interest in the global pesticide complex was further deepened through my work as a Research Assistant in the Economic Geography Group at the University of Zurich. In this role, I analyzed data on international pesticide trade flows. In addition, academic courses, including

GEO 433 Global Economic Geographies of Agriculture and Food Systems (University of Zurich, Prof. Christian Berndt), *751-1560-00 Produktion, Investition und Risikomanagement in der Landwirtschaft* (ETH Zurich, Prof. Robert Finger), *751-2312-00L Agrarpolitik* (ETH Zurich, Dr. Robert Huber), and *GEOG 738 Future Food and Biological Economies* (University of Auckland, Prof. Nicolas Lewis), enhanced my understanding of global agri-food assemblages. These courses enabled me to examine contemporary agri-food issues from environmental, social, political, and economic perspectives. As I became increasingly aware of the challenges inherent in current agri-food structures, my interest in alternative agricultural practices grew.

While this engagement was a key motivation for choosing the research topic, I recognize that I entered the research process with prior knowledge and normative assumptions. To address this, I endeavored to conduct the thesis with methodological reflexivity. I aimed to gather and analyze perspectives from a broad range of representatives of the Swiss pesticide complex. During the interviews, I consciously adopted a stance of curiosity and openness, striving to engage with divergent viewpoints without presupposing their legitimacy or validity.

Although my academic training has provided me with a theoretical understanding of global agricultural arrangements, I have no practical experience in agricultural pest management. I do, however, maintain a personal connection to farming through my aunt and uncle, who operate a dairy farm in the Bernese Oberland. Recognizing that my perspective is shaped primarily by scholarly knowledge rather than hands-on agricultural experience, I prioritized transparency and self-reflexivity throughout this research.

4.3.3 Research Process

In the Swiss context, the topic of pesticides can be politically sensitive and emotionally charged. Agricultural actors, in particular, may feel unfairly blamed or subjected to public scrutiny in debates about sustainability and environmental responsibility. For this reason, I familiarized myself in advance with potential power relations and conflicts of interest among the diverse actors within the Swiss pesticide complex. During data collection and analysis, I kept in mind that social hierarchies, as well as historical and geographical factors shaping the relationships, must be carefully considered (Mansfield et al., 2024). Against this backdrop, I deliberately adopted a research stance grounded in curiosity, empathy, and openness, with the intention of fostering mutual understanding rather than judgment.

At first, I was unsure how the representatives of the Swiss pesticide complex would respond to my interview requests. However, once the research process began, I quickly observed that most potential interview participants were highly willing to share their perspectives on biocontrol. Thus, sampling interview partners proved less challenging than initially anticipated. I compiled a list of potential interview participants by identifying relevant actor groups within the Swiss pesticide complex through media coverage, document analysis, and informal exchanges with individuals knowledgeable about the field. This list evolved continuously and was expanded throughout the exploratory phase.

I sent out interview requests on a rolling basis, allowing me to schedule interviews over approximately three weeks. As a result, I never conducted more than two interviews per day and, when possible, traveled to interview participants' workplaces or offices to conduct the interviews in person. Some participants preferred conducting the interview online, which I accommodated. Farmers applying biocontrol proved the most difficult group to reach; an attempt to establish contact via a regional farmers' union did not yield additional participants.

During the interviews, it became evident that many participants held strong views on plant protection and were keen to share their experiences and opinions. Given the potential for power asymmetries and emotionally charged discussions, I consciously sought to create a respectful and non-judgmental interview atmosphere in which participants felt comfortable expressing their perspectives openly. At times, it proved challenging to keep the focus narrowly on biocontrol, as participants frequently situated it within broader issues within agricultural policy and IPM strategies. This tendency may reflect the conceptual embeddedness of biocontrol within integrated approaches, as well as ambiguities in terminology and understanding, as discussed in Section 2.1.

Conducting the research also strengthened my methodological skills. As only my second experience using interviews as a method of data collection, I initially felt some uncertainty. Several preparatory steps supported my confidence-building process. First, I engaged with methodological literature, notably Listening to People (Lareau, 2021), and discussed interview practices with peers who had practical experience. Second, I familiarized myself with the research topic through scientific literature and policy reports. Third, I developed an interview guide and circulated it for feedback. The guide helped maintain a clear focus on my research questions while remaining flexible enough to accommodate topics raised by interview participants. Finally, I conducted mock interviews with friends to practice interview dynamics. While each interview situation remained unique, I noticed an increase in confidence and fluency over time.

As the interviews spanned an extended period, I was able to listen to the recordings multiple times and begin coding in parallel with data collection. Transcribing alongside ongoing data collection enabled continuous reflection on interview dynamics, question phrasing, and interactional patterns. The iterative engagement with the audio material not only enabled further corrections and refinements to the transcripts but also allowed me to reflect on what was said in the interview and to capture nuances I was not aware of during the interview. I also tried to reflect on my approach to asking questions and communicating with the interview participants to capture the associated “learning effects” (Gläser & Laudel, 2009, p. 194) and improve or adjust for the subsequent interviews.

5 Potentials and Limitations of Biocontrol in Swiss Agriculture

In this chapter, I examine how the representatives of the Swiss pesticide complex perceive the potentials and limitations of biocontrol. To situate these perspectives within their broader discursive context, I begin by examining how the interview participants define and understand biocontrol. Subsequently, Section 5.1 analyzes the potentials that the representatives of the Swiss pesticide complex associate with biocontrol, while Section 5.2 addresses the challenges and limitations they perceive in its implementation and adoption.

The interviews reveal a high degree of conceptual ambiguity surrounding biocontrol. There is no single, shared definition, and – consistent with the scientific literature (see Section 2.1) – the representatives of the Swiss pesticide complex articulate heterogeneous and sometimes conflicting understandings of the concept.[5] A key factor contributing to this conceptual vagueness is the absence of a legally anchored definition of biocontrol in Switzerland. As the representative of the environmental NGO IP5 (pos. 32) notes, while Swiss regulation includes a "low risk" category for plant protection products, it also encompasses substances with minimal impacts that are not necessarily considered biocontrol. This lack of legal clarity creates interpretative leeway and leads to divergent understandings of what qualifies as biocontrol in Swiss agriculture. Accordingly, several interview participants explicitly highlight the difficulty of defining biocontrol clearly and consistently, describing it as complex, blurry, or hard to delineate (IP3, pos. 8; IP4, pos. 6; IP5, pos. 12; IP13, pos. 6).

Despite this ambiguity, the interview participants recurrently associate biocontrol with notions of "naturalness." The farmer IP6 (pos. 14) emphasizes its "natural base," describing biocontrol as a strategy that reinforces ecological processes already present in nature. Similarly, the biocontrol industry representative IP1 (pos. 8), the federal policymaker IP3 (pos. 8), and the agrochemical industry representative IP10 (pos. 9) characterize biocontrol as being derived from, or closely resembling, naturally occurring substances. In line with scientific definitions, researcher IP2 (pos. 40), along with IP5 (pos. 12), and IP10 (pos. 9), further points out that while biocontrol products are based on natural substances, they may nonetheless be chemically synthesized.

The association with naturalness is closely tied to a recurring link between biocontrol and organic agriculture. From this perspective, biocontrol can be understood as a category of plant

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[5] In the interviews conducted in German and Swiss German, I used the term "biologischer Pflanzenschutz." According to IP7 (pos. 14), this term is the appropriate translation of biocontrol.

protection products permitted under organic-farming standards in Switzerland, as defined by the Research Institute of Organic Agriculture (FiBL). However, equating biocontrol with organic production can be misleading. The representatives of the biocontrol industry IP1 (pos. 40) and IP4 (pos. 16), along with the representative of the Swiss Farmers' Union IP9 (pos. 10), emphasize that biocontrol is not inherently tied to a specific production system. Rather, biocontrol strategies can be applied across different forms of agricultural production and are not restricted to organic farming alone.

5.1 Potentials of Biocontrol

The representatives of the Swiss pesticide complex primarily associate the potentials of biocontrol with environmental and human health benefits, resistance management, and social dimensions. At the same time, the interview participants emphasize that these potentials are not universally applicable but context-dependent. The effectiveness and applicability of biocontrol products are described as varying considerably across crop types (IP3, pos. 12–16, 67; IP9, pos. 16). In this regard, IP4 (pos. 16) notes that biocontrol is currently used predominantly in specialty crops such as vineyards, berries, fruit, and vegetables, whereas its application in arable farming remains comparatively limited. Against this background, the following sections synthesize the perceived potentials of biocontrol in Swiss agriculture in a cross-cutting manner.

5.1.1 Environmental and Human Health Benefits

A central potential of biocontrol, as all interview participants note, is its capacity to reduce environmental and human health risks compared to synthetic chemical plant protection products. The interview participants generally perceive biocontrol products as less hazardous to ecosystems, although they emphasize that this depends on the specific substance used (IP10, pos. 19). A frequently cited reason for this assessment is the comparatively rapid degradation of many biocontrol agents in the environment. As the biocontrol industry representative IP1 (pos. 12), the phytopathology and entomology researcher IP7 (pos. 38), and the agrochemicals researcher IP8 (pos. 20) explain, biocontrol substances tend to break down rather than persist or accumulate, thereby reducing environmental exposure and the likelihood of long-term ecological damage. This reduced persistence is therefore considered a key mechanism through which biocontrol mitigates environmental risks.

Beyond degradation dynamics, the high specificity of biocontrol agents is widely regarded as a further environmental advantage. IP5 (pos. 22) and IP7 (pos. 38) highlight that many biocontrol products target specific pests, which limits unintended effects on non-target organisms.

As a result, biocontrol is associated with a smaller environmental footprint, fewer residues, and reduced long-lasting “scars” in ecosystems (IP9, pos. 46; IP7, pos. 23; IP13, pos. 16). These advantages are particularly emphasized concerning soil health, which IP1 (pos. 14) describes as “a big advantage” of biocontrol, a view echoed by IP2 (pos. 34), IP4 (pos. 24), IP6 (pos. 14), and IP10 (pos. 23, 45). Taken together, reduced residues and targeted modes of action underpin the perception of biocontrol as environmentally benign.

At the same time, the interview participants acknowledge that the specificity of biocontrol agents also constitutes a practical limitation. Because biological agents often target only individual pests, farmers may need to apply multiple products to manage complex pest spectra (see Section 5.2.3). However, IP4 (pos. 24) stresses that this drawback must be weighed against a crucial countervailing benefit: biocontrol preserves beneficial organisms that contribute to natural pest regulation. In contrast, synthetic chemical substances often eliminate these beneficial species, inadvertently triggering additional pest problems that then require further interventions. From this perspective, the selectivity of biocontrol is not merely an ecological advantage but can also support more stable and resilient plant protection practices.

In addition to reduced impacts on organisms and residues, the interview participants highlight the lower likelihood of persistent or harmful metabolites forming after application of biocontrol products. According to IP8 (pos. 20), biocontrol agents are less prone to generating transformation products that accumulate in the environment, as they are typically integrated into natural biochemical processes. This characteristic further differentiates biocontrol from many synthetic chemicals whose metabolites may pose long-term environmental risks.

Finally, biocontrol is associated not only with environmental benefits but also with improved human health outcomes. IP1 (pos. 18) frames biocontrol as a means of protecting soils and ecosystems while simultaneously safeguarding consumers. The agrochemical industry representatives IP10 (pos. 19) and IP12 (pos. 18) note that growing market demand for food products with no or minimal residues strongly drives interest in biocontrol. Beyond consumer health, IP2 (pos. 18) emphasizes the relevance of user health, particularly for farmers and farm workers who are directly exposed during application of plant protection substances. In this context, the biocontrol industry representative IP4 describes user safety and health in chemically intensive agricultural arrangements as a taboo topic:

> Über das [Anwendersicherheit und Gesundheit] wird unter Produzenten auch recht wenig gesprochen. Also, man getraut sich nicht darüber zu reden. Weil man, also es ist halt immer die Angst, dass man die guten Mittel verliert. Und irgendwie, ja, dort ist es manchmal auch beängstigend, was einem gesagt wird. Ich sage jetzt

> mal, vielleicht wird uns fast noch mehr erzählt, weil wir von der anderen Seite kommen. Aber da werden einem unter vier Augen natürlich zum Teil schon auch Sachen erzählt, ja. Also, sei es jetzt irgendwie, dass man nicht schlafen kann oder extremen Durst hat in der Nacht, nachdem man gespritzt hat, bis hin zu Depressionen, die man nach dem Spritzen hat, oder einfach auch gewisse, ja, Probleme, wo man merkt, dass es wegen dem Spritzen ist.[6] (IP4, pos. 26)

While such experiences cannot be generalized, IP4 observes generational and gender differences: younger farmers are more willing to address health-related issues, and women often display greater sensitivity to the risks associated with plant protection practices. In this sense, biocontrol is perceived as having the potential to contribute not only to environmental protection but also to safer working conditions for users and, more broadly, to improved public health outcomes.

5.1.2 Resistance Prevention

Another key potential of biocontrol identified by the interview participants is its contribution to preventing or slowing the development of pest resistance. IP12 (pos. 56) explains that effective resistance management ideally requires at least three different modes of action per pest, whereas in Switzerland and much of Europe, often only two remain available due to the ban of certain synthetic chemicals for their environmental and human health risks. The representative of the Swiss Farmers' Union IP9 (pos. 34) and the agricultural economics and policy researcher IP13 (pos. 26) argue that the reduction of synthetic chemical options, combined with insufficient alternatives, intensifies selection pressure on the remaining products and exacerbates resistance problems, also in Swiss agriculture. IP1 states: "We use things that are being overused, and they become unsafe because they are overused. It's not because of the chemical itself, but because you don't have an alternative, you create resistance" (pos. 26). Similarly, the agrochemical industry representative IP11 emphasizes the practical consequences of relying on a limited set of synthetic chemical substances:

> Wenn man immer mit dem gleichen Hammer draufhaut, und diese Situation haben wir bei gewissen Schädlingen wirklich, weil wir nur noch einen Wirkmechanismus haben, dann geht es nicht lange und dann wirken diese Produkte auch nicht mehr.[7] (IP11, pos. 55)

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[6] Translation: About this [user safety and health], very little is also talked about among producers. In other words, people don't dare to talk about it. Because, well, there's always the fear of loosing the good substances. And somehow, yes, what you're told there can sometimes be frightening. I'll say, maybe we're told even more because we come from the other side. But there are, of course, some things that are shared with us one-on-one, yes.
For example, that they can't sleep or have extreme thirst at night after spraying, all the way to depression that they experience after spraying, or simply certain issues that you notice are related to the spraying.

[7] Translation: If you always use the same hammer, and that's exactly the case with certain pests because we only have one mode of action left, then it won't be long before these products lose their effectiveness.

Against this background, biocontrol is perceived as a means to fill this gap by providing additional or alternative modes of action, thereby diversifying plant protection strategies and mitigating resistance risks.

Beyond adding additional control options, biocontrol is also considered inherently less prone to resistance development. According to IP4 (pos. 24), resistance tends to emerge more slowly because biocontrol products typically do not rely on a single, linear mode of action. Unlike chemically intensive plant protection strategies, which often rely on repeated applications of the same groups of synthetic chemicals, biocontrol introduces a more diverse array of modes of action. Consequently, their effects often involve more complex biological interactions, making adaptation by pests more difficult. This intrinsic property underscores biocontrol's potential for preventing resistance.

Finally, biocontrol can indirectly extend the effectiveness of existing chemical products. By reducing selection pressure on synthetic chemicals, biocontrol helps preserve their efficacy over the long term. As IP1 explains: "This [biocontrol] is going to help the chemicals, because by introducing biocontrol, you reduce the resistance pressure on chemistry, and you actually help the chemicals to stay longer in the market" (pos. 18). In this sense, biocontrol is valued not only for its direct plant protection effects but also as a complementary approach that supports the use of synthetic chemicals.

5.1.3 Social Acceptance and Farmer Engagement

Another potential of biocontrol identified by the interview participants is its high level of social acceptance in the Swiss agricultural context. Public perception differs markedly between synthetic chemicals and biocontrol products: while synthetic chemicals carry a significant reputational burden in Swiss agriculture, biocontrol is generally associated with a more positive image (IP3, pos. 26, 52; IP7, pos. 20, 50). IP11 (pos. 15) reflects on this dichotomy, noting that public discourse often portrays synthetic chemicals as inherently harmful and biological products as inherently beneficial, without sufficient differentiation. IP7 (pos. 50) considers this perception gap as an opportunity, suggesting that biocontrol can help improve the public image of plant protection practices in Swiss agriculture.

At the same time, farmers themselves are described as receptive to strategies for protecting plants that extend beyond synthetic chemicals. IP7 (pos. 46) observes that farmers are generally open to using substances that are less hazardous than synthetic chemicals. This view is echoed by the environmental NGO representative IP5 (pos. 20), who points to an existing community actively supporting and promoting biocontrol approaches. Similarly, researcher IP13 notes:

> Ich hab jetzt noch nie einen Landwirt getroffen, der jetzt sagt, er findet jetzt die biologischen Bekämpfungsstrategien an sich schlecht. Also es macht gar keinen Sinn, weil sie sind ja genauso daran interessiert, möglichst wenig Pflanzenschutzmittel einzusetzen. Also ja von daher sehe ich da eigentlich keine Akzeptanzprobleme.[8] (IP13, pos. 30)

These perspectives suggest that social openness provides a favorable foundation for broader adoption of biocontrol in Swiss agriculture. Researcher IP2 challenges prevailing public stereotypes of farmers as resistant to change, noting that many are highly receptive to innovation and deeply concerned about long-term soil quality as the basis of their livelihood:

> Unsere Bauern sind eigentlich, im grossen Teil, auch sehr offen für Neuerungen. Also das ist ein bisschen falsch in den Köpfen der Allgemeinheit, dass […] die einfach auf den Traktor sitzen wollen und spritzen. Das ist wirklich nicht so. Es gibt schon solche, schwarze Schafe, aber sehr viele sind sehr offen und sind auch daran interessiert, dass quasi ihr Boden gut bleibt, oder, weil das ist ja ihre Lebensgrundlage.[9] (IP2, pos. 34)

The agrochemical industry representative IP12 (pos. 70) reinforces this point, emphasizing that the primary objective of agriculture is not to harm the environment or to apply pesticides for their own sake, but to produce goods essential to human needs.

Several interview participants also suggest that acceptance and adoption among farmers is less a matter of willingness than of practical availability. The representative of the Swiss Farmers' Union IP9 (pos. 34) emphasizes that Swiss farmers are generally ready to consider any solution that helps address practical challenges. In line with this, IP1 states: "If the product is available, then people will start the transition" (pos. 26). This indicates that access to effective biocontrol products is a critical prerequisite for adoption.

In addition to acceptance and accessibility, the interview participants highlight farmers' adaptive and innovative capacity, characterizing Swiss agriculture as a creative sector. For example, the biocontrol industry representative IP4 (pos. 18) points to farmers' frequent

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[8] Translation: I've never met a farmer who would say that they think biological control strategies are bad in principle. That wouldn't make any sense, because they are just as interested in using as little plant protection product as possible. So, yes, from that perspective I don't really see any acceptance problems.

[9] Translation: Our farmers are actually, for the most part, very open to innovations. So it's a bit of a misconception among the general public that […] they just want to sit on the tractor and spray. That's really not the case. Of course, there are some 'black sheep,' but many are very open and are also interested in keeping their soil in good condition, because, after all, it's the basis of their livelihood.

modification or self-construction of machinery as evidence of practical ingenuity and cites the rapid pace of innovation observed during the COVID-19 pandemic as an example of how quickly change can occur when external pressures demand it.

Nevertheless, other interview participants caution that social acceptance of biocontrol is not uniform across all agricultural and social contexts in Swiss agriculture. Farmer IP6 (pos. 54) observes that perceptions are strongly influenced by the social context in which farmers operate: some communities promote openness and experimentation, while others prioritize yield maximization without questioning environmental or input-related consequences. This divergence illustrates that although biocontrol enjoys general acceptance, adoption is shaped not only by public perception and availability but also by prevailing norms within specific farming communities.

Finally, several interview participants stress that acceptance of biocontrol requires a broader societal shift that extends beyond positive public perception and openness by individual farmers. IP2 (pos. 54) and IP5 (pos. 16) emphasize that all actors in the Swiss agricultural context – including advisors, retailers, and consumers – must participate in rethinking production practices. Without such systemic acceptance, individual farmers may face conflicting incentives that hinder the adoption of biocontrol in Swiss agriculture.

5.2 Limitations of Biocontrol

Despite the identified potentials of biocontrol, its adoption in Swiss agriculture is constrained by a range of interrelated limitations. The representatives of the Swiss pesticide complex highlight that these challenges include product availability, regulatory issues, operational constraints, and social and economic considerations. The following sections analyze the key limitations of biocontrol within the Swiss agricultural context.

5.2.1 Product Availability and Market Access

A fundamental limitation of biocontrol is the restricted availability of effective biocontrol products. For example, policymaker IP3 (pos. 32) notes that suitable beneficial organisms or biological agents do not exist for every pest, which limits the scope of application. This constraint is particularly pronounced for herbicides, as only a very small number of biocontrol-based herbicidal products are currently available (IP10, pos. 15; IP11, pos. 34). Consequently, biocontrol remains of marginal relevance in arable farming, where effective weed control is a central challenge.

The limited availability of biocontrol products in arable farming is driven by economic and market factors. The biocontrol industry representative IP4 (pos. 16) explains that arable farmers typically operate with substantially smaller budgets for inputs such as plant protection products and fertilizers than producers of high-value specialty crops. While specialty crop producers can often offset higher input costs through premium prices for quality, arable farmers face tighter margins and economic pressures. Combined with the fact that organic arable farming in Switzerland allows almost no plant protection substances except in potato cultivation, the potential market for biocontrol products in this segment is extremely limited. From a business perspective, these conditions discourage investment in developing biocontrol solutions for arable crops and help explain the restricted availability of biocontrol in this area.

In addition to market constraints, several interview participants identify a structural gap in research and funding as a major limitation on product availability. According to the researcher IP2 (pos. 6, 36) and the biocontrol industry representative IP4 (pos. 30), funding is insufficient, particularly at the interface between basic research and applied development. As a result, many promising concepts fail to advance to commercially viable biocontrol products. IP4 (pos. 30) and IP7 (pos. 42) argue that overcoming this bottleneck requires longer-term public funding and enhanced collaboration across institutions, sectors, and national borders. This highlights that limitations in product availability are closely linked to broader research and innovation structures.

Finally, even when biocontrol products exist, bringing them to the Swiss market poses challenges, particularly for international companies. As the representative of a global biotechnology company IP1 explains, products targeting smaller markets or less prominent pest problems often struggle to justify the regulatory and commercial effort required for market entry: "if you don't have a big product with a big problem, then it's very difficult to get into Switzerland" (pos. 24). The representative of an internationally operating agrochemical company IP12 (pos. 37) adds that Switzerland's small market size reduces its strategic importance. Consequently, product availability in Switzerland is shaped not only by biological feasibility and research capacity but also by economic scale and market prioritization.

5.2.2 Regulatory Barriers and Approval Complexity

Regulatory barriers constitute a major limitation that further constrains the availability of biocontrol products in Switzerland. Once a biocontrol product has been developed, companies face lengthy, costly, and administratively demanding registration processes (IP1, pos. 24; IP2, pos. 6; IP5, pos. 28). According to the representative of an internationally operating agrochemical company IP10 (pos. 15), the development of a biocontrol product typically takes eight to ten years from initial research to market launch. Registration represents one of the most significant bottlenecks, particularly in the Swiss context (IP10, pos. 3). The representative of a global biotechnology company IP1 (pos. 24) notes that Swiss registration dossiers are not fully integrated with EU dossiers, resulting in duplication and higher costs for internationally operating companies. Recognizing approvals from neighboring countries could significantly ease market entry, as emphasized by IP1 (pos. 26). While political efforts toward harmonization with EU regulations are ongoing (IP5, pos. 8), the interview participants describe the current regulatory landscape in Switzerland as challenging (IP9, pos. 28).

A structural issue underlying these challenges is that the regulatory framework was originally designed for synthetic chemicals and is poorly suited to biological agents. IP1 explains: "you have a system that has been developed for chemical substances. And it's really not working for biological substance[s]" (pos. 6). A case in point is that biocontrol products are subject to the same approval requirements as synthetic chemicals, including toxicological, ecotoxicological, and environmental tests, which do not adequately reflect the characteristics of biological modes of action (IP2, pos. 28; IP10, pos. 15; IP12, pos. 44).

Moreover, the requirement to demonstrate a high and consistent level of efficacy poses a particular hurdle for biocontrol products, which typically do not achieve the near-complete control rates associated with synthetic chemicals. Therefore, as the agrochemical industry representative IP11 explains, products with lower efficacy levels are often difficult to register:

> Eine grosse Hürde ist wirklich auch die Wirksamkeit. Also, auch für die Biologischen. Also man muss, wenn man ein Produkt zulassen will, […] zeigen, dass das Produkt wirkt. Und bei den Produkten, die man bis jetzt gehabt hat, hat man halt einen sehr hohen Wirkungsgrad gehabt, praktisch 100 Prozent. Und das ist mit biologischen Produkten fast nicht möglich. Und das ist aber zugleich die Hürde. Also viele Produkte mit 60 oder 50 Prozent Wirksamkeit sind dann viel schwieriger zuzulassen, weil man einfach diese Hürde nicht schafft. Und da muss auch etwas in der Erwartungshaltung ändern, einerseits von den Behörden, aber auch von den Produzenten.[10] (IP11, pos. 45)

These efficacy requirements are further complicated by methodological challenges in proving performance under regulatory conditions. The agrochemical industry representative IP10

[10] Translation: A major hurdle is really the effectiveness. This also applies to biological products. If you want to approve a product, you have to […] show that the product works. With the products we've had so far, the effectiveness rate has been very high, practically 100 percent. And this is almost impossible to achieve with biological products. And that is precisely the hurdle. So, many products with 50 or 60 percent effectiveness are therefore much harder to approve because they simply do not meet that threshold. At the same time, expectations need to change; not only from the authorities but also from the producers.

(pos. 25) emphasizes that it is difficult to reproduce stable environmental conditions over extended periods to demonstrate consistent efficacy in field trials. As a result, IP5 (pos. 34) argues that, under current procedures, registering biocontrol products explicitly based on reduced risk remains very limited in Switzerland.

However, regulatory hurdles vary by the type of biocontrol agent. According to IP2 (pos. 30), certain agents, such as nematodes, can be registered relatively easily, whereas fungi and bacteria face substantially stricter requirements under the current regulatory framework. IP7 (pos. 20) highlights the paradox that natural substances, including organisms that have been used for centuries, are subject to particularly stringent regulatory scrutiny. IP4 (pos. 16) similarly finds it problematic that substances derived from nature, and in some cases even edible, must undergo complex and costly approval procedures.

From an industry perspective, strict and repetitive regulatory requirements constitute a major barrier to market participation. The interview participants point out that re-registration obligations, combined with Switzerland's small market size, can discourage companies from maintaining or reintroducing products: Using the example of a biocontrol product against Colorado potato beetle larvae on potatoes and eggplants, IP7 (pos. 28) notes that the company producing this bacterial preparation is considering market re-entry despite the product's established usefulness. This dynamic illustrates how regulatory burden can directly translate into reduced product availability for farmers.

To address these obstacles, several representatives of the Swiss pesticide complex advocate for regulatory reform. The biocontrol industry representative IP1 (pos. 30), researcher IP2 (pos. 6), and agrochemical industry representative IP10 (pos. 45) argue that meaningful progress in biocontrol adoption will require reform of the current registration system. IP1 (pos. 24) and IP2 (pos. 28) advocate for more pragmatic and differentiated approval procedures tailored to biocontrol products. The environmental NGO representative IP5 (pos. 36), in line with biocontrol industry representative IP4 (pos. 30), emphasizes that simplified procedures adapted to the specific properties of biological agents could improve incentives for product development and registration. In this context, IP5 (pos. 10) notes that a parliamentary motion currently under discussion in Switzerland aims to establish a simplified approval procedure for low-risk and biocontrol substances.

While the representatives of the agrochemical industry similarly support the creation of a dedicated regulatory pathway for biocontrol products, IP12 (pos. 44, 67) cautions against a full "fast track" approach that might overlook potential risks associated with biocontrol products.

Such concerns regarding biological safety remain prominent in discussions about regulatory reforms (IP9, pos. 26; IP10, pos. 45; IP13, pos. 20). The phytopathology and entomology researcher IP7 (pos. 20) explains that these concerns are often shaped by historical cases in which biocontrol introductions led to unintended consequences, such as the spread of the Asian lady beetle. IP7 further argues that many biocontrol agents, particularly fungi, have been used safely for centuries, and that the absence of documented harm should be more strongly reflected in risk assessment practices. As a concrete proposal to facilitate market access, IP7 (pos. 30) suggests introducing a positive list system similar to that used for food supplements in the European Union, under which substances without identified adverse effects would be approved automatically.

The interview participants also reflect on the relationship between regulatory delays in biocontrol development and approval, and the banning of synthetic chemicals. Some representatives of the Swiss pesticide complex oppose rapid bans on synthetic chemicals, noting that regulatory complexity can lead to unintended and counterproductive responses. Researcher IP2 (pos. 36) warns that the advancement of alternatives is too slow relative to the pace at which synthetic pesticides are being withdrawn. This leads to a situation in which, as long as biocontrol registration remains slow and complex, industry associations often respond to bans of synthetic chemicals by seeking emergency authorizations over multiple years (IP4, pos. 18). This practice risks exacerbating resistance development through repeated use of the same active ingredients (see Section 5.1.2). Agrochemicals researcher IP8 similarly cautions that, without adequate preparation, authorities and farmers may eventually revert to older chemical solutions, reinforcing potential resistances:

> Was natürlich ein bisschen zu befürchten ist, ist dass, wenn man sich dem nicht genügend gut vorbereitet, man am Schluss sagt, ja, es gibt nichts anderes und jetzt holt man die alten Chemikalien wieder hervor. Und sagt, ja, wir müssen einfach das spritzen, weil sonst sind unsere Kulturen weg.[11] (IP8, pos. 36)

While some representatives of the Swiss pesticide complex oppose bans on synthetic chemicals, others view regulatory pressure as an opportunity for biocontrol. They argue that consistent bans on problematic substances can foster the development of alternatives. For example, farmer IP6 (pos. 58) and agricultural economics and policy researcher IP13 (pos. 26) contend that regulatory pressure can incentivize research, industry, and farmers to invest

[11] Translation: Of course, one thing that's a bit to be feared is that if you're not sufficiently well prepared, in the end you'll say, 'Yes, there's nothing else,' and then the old chemicals are brought back out. And one says, 'Yes, we just have to spray because otherwise our cultures are lost.'

more seriously in biocontrol approaches. The biocontrol industry representative IP4 adds that lowering approval hurdles for biocontrol could reduce reliance on stopgap measures: “Also, wenn wir erstens kleinere Hürden hätten, von der Zulassung her, man zum Teil gewisse Sachen nicht so lange immer schützen würde […], würde [ich] jetzt sagen, es würde für alles eine Lösung geben” (pos. 18).[12] As phytopathology and entomology researcher IP7 (pos. 22) emphasizes, the full potential of biocontrol has not yet been realized: there is a variety of modes of action to be explored, which is currently hindered mainly by regulatory hurdles.

In addition to procedural complexity, limited administrative capacity further slows the registration process in Switzerland. Several interview participants highlight a shortage of specialized expertise and administrative overload within the federal authorities responsible for product evaluation and approval (IP2, pos. 44, 46; IP4, pos. 22; IP9, pos. 28; IP10, pos. 35). According to IP5 (pos. 8), approximately 700 approval requests are currently pending. This backlog illustrates that regulatory challenges are not only a matter of regulatory frameworks but also of institutional resources.

5.2.3 Operational and Agronomic Challenges

Even when biocontrol products are available and approved, their preventive mode of action introduces substantial operational complexity for farmers. Although curative biocontrol products exist (IP12, pos. 12), most biocontrol products must be applied before pests or diseases become visible (IP1, pos. 30; IP6, pos. 8; IP10, pos. 15). As IP1 (pos. 30) summarizes, biocontrol focuses on preventing pests and diseases from establishing rather than eliminating them after they occur. This preventive requirement demands careful timing and monitoring, making operational planning more challenging for farmers.

Another source of operational complexity stems from the limited persistence of many biocontrol agents. The industry representatives IP4 (pos. 14) and IP10 (pos. 13) explain that most biocontrol products act through contact rather than systemic uptake by the plant. Since these substances are not absorbed, they are vulnerable to degradation by ultraviolet radiation or to being washed off by rainfall (IP9, pos. 24; IP11, pos. 15; IP12, pos. 14). IP7 (pos. 36) further notes that these characteristics also complicate storage and reduce shelf life. Consequently, the biological properties that make biocontrol environmentally advantageous (see Section 5.1.1) simultaneously reduce its operational and agronomic robustness.

[12] Translation: So, if we had fewer hurdles in terms of registration, if certain things weren’t protected for so long, [...], [I] would say that there would be a solution for everything.

Due to the rapid degradation of biocontrol agents, more frequent applications are needed in practice. The researcher IP2 (pos. 10) and the representative of the Swiss Farmers' Union IP9 (pos. 32) highlight that repeated applications of biocontrol products are required to maintain effectiveness. The representative of the biocontrol industry IP1 illustrates this contrast by noting that microorganisms die quickly and do not provide season-long protection in the way systemic chemical products can:

> I say, my microorganism, it dies quickly. So, yeah, I mean, it's not gonna stay on the soil, as the chemical, that is gonna go on the plant, enter the plant, enter the crop, and protect the crop through the season. It's not gonna do that, right. So, it's not systemic. So, you need to apply and apply, and that's a blockage first. (IP1, pos. 20)

This need for repeated applications increases labor requirements and operational complexity, creating both practical and economic constraints for farmers.

Operational complexity is further compounded by the pest specificity of many biocontrol agents. Farmers often need to use multiple products to manage complex pest spectra (IP4, pos. 24), increasing labor demands and the logistical burden of crop protection. Frequent applications can also lead to indirect negative effects, such as elevated risks of runoff into waterways and increased soil compaction from repeated field traffic (IP8, pos. 14). Thus, the combination of preventive use, repeated applications, and narrow pest specificity intensifies the operational burdens of biocontrol compared to synthetic chemicals.

Finally, the reliability and consistency of biocontrol products remain key concerns. As the agrochemical industry representative IP12 (pos. 14) notes, the closer products are to natural substances, the more variable their behavior tends to be. IP10 (pos. 13) explains that while synthetic chemicals may achieve protective effects of up to 99%, biocontrol products typically achieve efficacy levels between 30 and 70% even under optimal conditions. Researcher IP2 (pos. 26) emphasizes that in biocontrol, even a 20% protective effect can be considered successful, underscoring fundamentally different performance expectations. Alongside preventive use and rapid degradation, the variability of biocontrol agents makes achieving consistent, predictable outcomes a core operational challenge in practice (IP2, pos. 4; IP7, pos. 24, 28).

5.2.4 Knowledge and Collaboration Requirements

The operational complexity associated with biocontrol products requires higher levels of knowledge and competence for effective use. IP10 (pos. 31) and IP11 (pos. 61) emphasize that successful biocontrol application depends on increased commitment, technical expertise, and accumulated experience. As IP13 (pos. 30) notes, even if acceptance is generally high, the operational challenges associated with biocontrol must be considered alongside availability and economic factors. Without sufficient expertise, the preventive and targeted nature of biocontrol can reduce its practical effectiveness.

The effective use of biocontrol also requires a thorough understanding of the farm system. The representatives of the biocontrol industry IP4 (pos. 22) and the environmental NGO IP5 (pos. 26) note that this can be particularly challenging in contemporary agricultural practice, especially in Swiss arable farming, where farms are often managed as side businesses and plant protection tasks are outsourced to contractors. In such contexts, farmers may lack detailed knowledge of which substances are applied and under what conditions.

The knowledge requirements for biocontrol and the technical skills needed necessitate collective efforts. The interview participants IP3 (pos. 58), IP7 (pos. 24), and IP12 (pos. 18, 22) observe that the high demand for specific knowledge and the complexity of application, including timing, efficacy, and integration with other substances, make biocontrol challenging for farmers. As IP13 (pos. 30) explains:

> Die Wirksamkeit, die Kosten, halt auch dieser Arbeitszeitbedarf, dieser Wissensbedarf. Und das ist natürlich halt eben um einiges komplizierter, den richtigen Zeitpunkt mit den richtigen Mittel zu treffen. Von daher glaube ich, ist das halt auch noch ein wichtiger Punkt, der da auch mitreinspielt. Da ist jetzt nicht nur Kostenwirksamkeit, sondern halt eben auch, wie viel muss ich mich eigentlich damit vertraut machen.[13] (IP13, pos. 30)

The interviewed farmer IP6 (pos. 52) stresses that the knowledge requirements often exceed the capacity of individual farm managers, making participation in training events, field visits, and peer exchange critical. In particular, field inspections focused on biological plant protection and regular interaction among farmers are described as essential learning environments. This indicates that biocontrol adoption depends not only on individual expertise but also on access to structured and collective learning networks.

Beyond technical know-how and collective learning within the farming community, trust and collaboration among all actors involved in plant protection are a critical component for biocontrol adoption. From research and development to distribution and application, cooperation

[13] Translation: The effectiveness, the costs, and also the labor requirements, as well as this need for knowledge. And of course, it's much more complicated to apply the right measures at the right time. Therefore, I believe this is therefore also an important point that plays a role here. It's not just about cost-effectiveness, but also about how much I actually need to familiarize myself with it.

among scientists, advisory services, policymakers, industry actors, and farmers ensures accurate knowledge transfer and effective implementation.

During the development stage, the interview participants especially emphasize the importance of cooperation among academic research institutions, industry, and advisory services. According to IP1 (pos. 20), IP2 (pos. 6), and IP7 (pos. 10), such cooperation is necessary to bridge the gap between research and practice. During distribution, coordination among industry actors is necessary due to the short shelf life of many biocontrol products (IP1, pos. 22, 24). In the application phase, continuous communication supports learning processes and adaptation under real-world conditions (IP1, pos. 18; IP7, pos. 36).

Advisory services play a pivotal role in facilitating the effective use of biocontrol products. The biocontrol industry representatives IP1 (pos. 18, 26) and IP4 (pos. 14) stress that companies marketing biocontrol must provide detailed guidance on product selection, timing, and potential combinations with other substances. While private advisors at agricultural companies integrate biocontrol into their proposed plant protection strategies, IP4 (pos. 30) argues that other advisory services often lack biocontrol expertise or prioritization. Similarly, agricultural economics and policy researcher IP13 (pos. 40) notes the limited capacity of cantonal advisory services, emphasizing that staff often lack the time and resources to engage with innovations and advise farmers on strategies such as biocontrol:

> Bei den kantonalen Fachstellen ist es so, dass halt eben oft, in kleinen Kantonen, Pflanzenschutz halt 50 Stellenprozente ist. Und die Personen haben 0,0 die Kapazität jetzt irgendwie Innovationen irgendwo mitzunehmen und halt dann dementsprechend auch weiterzugeben. Also, ich glaube, das ist ja mal die ganz grosse Knacknuss.[14] (IP13, pos. 40)

Both IP4 (pos. 12) and IP13 (pos. 40) stress the importance of farm visits by advisors, which allow recommendations to be tailored to local conditions, especially given the narrow application windows and the higher sensitivity of biocontrol products. At the same time, growers contribute experiential knowledge, providing feedback that helps companies refine usage instructions. IP1 (pos. 26) explains: "[The growers] teach us, I can tell you, they teach us how best to use the product" (pos. 26). This reciprocal exchange builds trust and improves product performance over time.

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[14] Translation: At the cantonal specialist offices, it's often the case that, in small cantons, plant protection is only staffed at 50 percent of a full-time position. And the people have essentially zero capacity to take in innovations and, accordingly, to pass them on. So, I believe that's really the big bottleneck.

Collaboration requirements extend beyond farmers and industry to include educational institutions and the broader agricultural complex. Given the operational challenges and the prevalence of misinformation surrounding biocontrol (IP1, pos. 18), several interview participants highlight that advisory services, agricultural schools, and training centers share responsibility for generating and disseminating knowledge about biocontrol. IP4 explains:

> Auf der Ebene der Beratung, Offizialberatung, aber auch der Ausbildung, muss der biologische Pflanzenschutz noch einen viel grösseren Stellenwert haben. Da fehlt zum Teil auch das Know-how von diesen Leuten. Oder sie getrauen sich auch gar nicht. Also jetzt auch in der Beratung, weil es auch zu unsicher ist.[15] (IP4, pos. 30)

In a similar vein, farmer IP6 (pos. 40) advocates for educational institutions to actively present, advise on, and encourage alternatives to synthetic chemicals. While some advisory services already integrate these recommendations into regular communication channels, such as weekly newsletters (IP6, pos. 42), broader and more systematic integration is considered necessary. Additionally, peer-to-peer learning within farming communities remains a key mechanism for sharing experiences and building confidence in biocontrol approaches (IP6, pos. 52).

The importance of knowledge extends beyond primary production to retailers and consumers throughout the entire agri-food value chain. Researcher IP2 (pos. 16, 22, 24, 38) notes that reduced use of synthetic chemicals can increase cosmetic defects in agricultural products, which are poorly tolerated by Swiss retailers and consumers, and in turn creates the risk that farmers may be unable to sell compromised produce. The environmental NGO representative IP5 therefore argues that acceptance of biocontrol requires transformation across the entire value chain, as isolated efforts at the farm level are insufficient if consumer preferences and retail standards remain unchanged: "es muss entlang der gesamten Wertschöpfungskette Wandel passieren, da es niemandem hilft, wenn nur der Bauer die resistente Kartoffensorte anbaut, wenn dann der Konsument am Ende sie zu rund und zu hässlich findet und deswegen nicht kauft" (pos. 16).[16] In this sense, the successful adoption of biocontrol depends not only on farmer knowledge and collaboration but also on broader societal learning and acceptance beyond agriculture itself.

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[15] Translation: At the level of advisory services, official advisory services, and also education, biological plant protection must have a much higher priority. In part, these people also lack the necessary know-how. Or they simply don't dare to act, also in advisory work, because it is considered too uncertain.
[16] Translation: Change must occur along the entire value chain, because it doesn't help anyone if only the farmer grows the resistant potato variety, and in the end the consumer ends up finding it too round or too ugly and therefore doesn't buy it.

5.2.5 Economic Constraints

The regulatory and operational challenges associated with biocontrol are closely intertwined with economic considerations, as higher costs and variable effectiveness affect crop yield, marketability, and business risk. From the farmer's perspective, adopting biocontrol entails accepting increased production risk. Farmer IP6 explicitly notes that agricultural practitioners using biocontrol operate under increased uncertainty and are required to tolerate reduced short- to medium-term output:

> Wir gehen mehr Risiken ein, wir setzen unsere Kulturen mehr Risiken aus. Wir müssen damit leben, dass wir weniger abliefern, dass unsere Äcker weniger Kalorien liefern. Auf kurze-, mittelfristige Sicht. Auf langfristige Sicht kommt wieder meine Überzeugung: Nein, es ist mehr.[17] (IP6, Pos. 28)

While several interview participants report that yields tend to be lower under biocontrol-based management, particularly in the short term (IP3, pos. 58, 68; IP11, pos. 34), farmer IP6 argues that biocontrol may contribute to increased productivity over the long run by strengthening system resilience. The willingness to accept short-term risk associated with biocontrol reflects a trade-off between immediate performance and anticipated long-term benefits. As a result, risk tolerance emerges as a key determinant of biocontrol adoption.

Higher production costs constitute another major economic barrier to the use of biocontrol. IP10 (pos. 13) and IP11 (pos. 34) note that frequent applications and increased labor input requirements raise overall production costs. Similarly, IP1 explains that repeated field entry increases labor and machinery costs, which are particularly high in Switzerland:

> The disadvantage is, of course, you have more costs to spray that microorganism. So, you need to enter the fields more time, which means you need more labor, which means you need more machines, which means in Switzerland you increase the price by ten times. (IP1, pos. 12)

These additional costs can erode farm profitability, especially in production systems without price premiums. In organic farming, higher production costs associated with biocontrol are often partially offset by label-based price compensation payments (IP11, pos. 19). In contrast, farmers operating outside certified organic schemes do not benefit from such compensatory structures (IP9, pos. 12, 48; IP11, pos. 59). As the representative of the Swiss Farmers' Union IP9 (pos. 48) underscores, adopting organic production practices without access to

[17] Translation: We take more risks; we expose our cultures to greater risks. We have to accept that we deliver less, that our fields produce fewer calories. In the short to medium term. In the long term, however, my conviction returns: no, it actually yields more.

corresponding market premiums creates an economically untenable situation, because farmers bear the higher costs, risks, and management efforts of organic production while being forced to sell their products at standard market prices. Therefore, without adequate price differentiation or compensation, biocontrol adoption remains economically unattractive for many non-organic producers.

The purchase price of biocontrol products is often higher than that of synthetic chemicals, representing another economic barrier. IP7 (pos. 24) and IP9 (pos. 6) identify this as a major obstacle to biocontrol adoption. Nevertheless, while certain biocontrol agents, such as nematodes, are particularly expensive, others – especially some fungal and bacterial products – are comparatively affordable (IP2, pos. 32; IP4, pos. 22). Agricultural economics and policy researcher IP13 (pos. 26) argues that the price differences between synthetic chemicals and biological products partly reflect the failure to internalize the externalities of synthetic chemicals. Similarly, IP1 (pos. 18) emphasizes that the external environmental and human health costs associated with synthetic chemicals remain unaccounted for. From this perspective, the perceived cost disadvantage of biocontrol is, at least in part, a consequence of current pricing structures.

Given these cost pressures, the interview participants discuss policy instruments as potential mechanisms to improve the economic feasibility for farmers. Suggested measures include direct payments for biocontrol use (IP5, pos. 28) and incentive-based taxes on pesticides to internalize external costs (IP13, pos. 18). However, these approaches are contested; the representatives of the Swiss Farmers' Union IP9 (pos. 48) and the agrochemical industry IP12 (pos. 37) express skepticism about additional financial burdens or regulatory interventions.

The economic risks associated with biocontrol impact not only farmers but also producers of agricultural biologicals. A key challenge for industry actors is the limited shelf life of many biocontrol agents, which contrasts sharply with the storage stability of synthetic chemicals (IP1, pos. 18; IP2, pos. 26; IP10, pos. 23). IP4 (pos. 14) explains that short shelf life restricts inventory management and forces companies to operate on a "made-to-order" basis, significantly increasing commercial risk:

> Wir können nicht gleiche Risiken einnehmen, wirtschaftliche, wie wir es bei einem Produkt können, wo man zwei oder drei Jahre lagern kann. Weil dort können wir

> dann das Risiko eingehen, dass das, was wir nicht verkauft haben in einer Saison, dass wir es in der nächsten brauchen können.[18] (IP4, Pos. 14)

Similarly, IP1 notes that unsold biocontrol products often must be written off within weeks, directly affecting profitability: “If you don’t sell it [the product] in the next weeks, you score it. If you don’t sell the virus, you write off a loss” (pos. 20). Taken together, the major limitations associated with biocontrol, as reported by the representatives of the Swiss pesticide complex, include product availability, regulatory barriers, operational complexity, knowledge-intensive processes, and economic constraints.

[18] Translation: We cannot take the same risks economically as we can with a product that can be stored for two or three years. Because then, we can take the risk that what we haven’t sold in one season, we might use in the next.

6 Legitimizing Biocontrol in Swiss Agriculture

Building on the discussion of biocontrol's potentials and limitations in Swiss agriculture in Chapter 5, this chapter examines how the representatives of the Swiss pesticide complex legitimize their positions on biocontrol. The focus is on patterns of legitimation and the reasoning logics that these actors employ, whether to support or caution against the adoption and promotion of biocontrol. These logics include ecological responsibility, functional pragmatism, food security imperatives, and market-oriented business rationales.

6.1 Ecological Responsibility: Restoring Environmental Balance

A central way in which the representatives of the Swiss pesticide complex legitimize their position on biocontrol is through ecological reasoning. In line with biocontrol's potential to reduce environmental and human health risks (see Section 5.1.1), several interview participants frame biocontrol as a means to restore balance in agroecosystems disrupted by intensive human intervention. The representatives of the biocontrol industry, IP1 (pos. 28) and IP4 (pos. 8), describe chemically intensive agricultural production as a system in which human activity disturbs natural equilibria, creating a need for interventions that re-align these imbalances. IP1 articulates that biocontrol aims to maintain systemic balance and emphasizes the relational dimension between humans and nature: "It's an open system to nature. And therefore, everything that exists in nature goes through your system […]. So I think biocontrol is there to keep the balance" (pos. 28). In this context, biocontrol is understood as an approach to align agricultural systems more closely with natural processes.

The naturalness of biocontrol is frequently invoked as a central justification for its use. The farmer IP6 (pos. 14) reinforces this perspective, describing biocontrol as mimicking naturally occurring mechanisms in ecosystems. In line with IP6, biocontrol industry representative IP1 explains:

> I usually say, this [biocontrol] is the old technology […]. And this is like going back to look at nature and see how nature operates. And then you can try to mimic it somehow and to try to bring it back to balance. (IP1, pos. 30)

The naturalness associated with biocontrol is thus used to legitimize interventions that respond effectively to ecological dynamics. By emphasizing alignment with natural processes, actors frame biocontrol as both ecologically coherent and minimally disruptive, thereby reinforcing its legitimacy as a plant protection strategy that works in concert with the environment.

This ecological logic is also reinforced through explicit references to environmental outcomes. For instance, the representative of the environmental NGO IP5 legitimizes biocontrol by highlighting its potential to reduce ecosystem impacts: “Also, warum biologischen Pflanzenschutz? Ganz klar, wegen der reduzierten Umweltauswirkung” (pos. 22).[19] This approach includes the goal of phasing out highly toxic pesticides, reducing overall pesticide use, and supporting alternatives along the IPM pyramid (IP5, pos. 6).

Moral considerations are closely intertwined with ecological reasoning. Several interview participants frame biocontrol adoption as an ethical responsibility to protect natural systems, arguing that agricultural practices should leave the environment at least as healthy as it was found. Biocontrol industry representative IP1, for example, frames this responsibility as a commitment to preserve or improve the state of the planet: “If you have a way to minimize the impact on the soil, they minimize the impact on the environment, primarily, and then on the consumers, why shouldn’t you do it, right” (IP1, pos. 18).

Emotional dimensions further support ecological legitimation. The farmer IP6 refers to the moral conviction that biocontrol allows working with naturally occurring mechanisms rather than relying solely on synthetic inputs:

> Die emotionale [Seite] und die aus Überzeugung ist, dass man eigentlich alle Mechanismen nutzt, die schon vorhanden sind und diese noch verstärkt. Wie auch die Biodiversität zum Beispiel. Oder wie wir jetzt auch im Rebberg gesagt haben, wir wollen lieber auf ein paar Reihen verzichten. Dafür wollen wir mehr Nützlingsstreifen machen. Und wir sind fest der Überzeugung, dass uns die Natur selber auch hilft. Oder, dass die Mechanismen, welche die Natur uns gibt, eigentlich uns unterstützen, ja, Schädlinge auch in Grenzen zu halten.[20] (IP6, pos. 14)

This reasoning extends to the adoption of biocontrol as a deliberate choice to reduce broader environmental harm. By minimizing negative impacts on soil, ecosystems, and ultimately consumers, biocontrol is positioned not merely as a production input but as a morally preferable option. This moral dimension strengthens biocontrol’s legitimacy as a conscientious choice that aligns agricultural practice with broader personal values and moral convictions.

While ecological reasoning is central to the interviewed biocontrol industry representatives IP1 and IP4, the farmer IP6, and the environmental NGO representative IP5, it is framed as one

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[19] Translation: Why biological plant protection? Obviously, because of the reduced environmental impact.
[20] Translation: The emotional side and the conviction is that we actually use all the mechanisms that are already there and strengthen them. Like biodiversity, for example. Or, as we have also mentioned in the vineyard, we prefer to give up a few rows in order to create more strips for beneficial organisms. And we firmly believe that nature itself helps us. Or that the mechanisms provided by nature actually support us in keeping pests within limits.

factor among others by the representatives of the agrochemical industry. They recognize biocontrol's environmental benefits but also cite other factors to legitimize their position on biocontrol, such as residue management and market-driven trends (IP10, pos. 23; IP12, pos. 37). IP12 (pos. 20, 37) situates biocontrol's ecological benefits within broader challenges, including food security, planetary boundaries, pest pressures, and mitigating climate and biodiversity impacts. At the same time, IP12 (pos. 20) cautions that nature adapts rapidly, creating new pest pressures that farmers must be able to counteract. In this way, the ecological logic is leveraged to acknowledge biocontrol's potentials and to contextualize its limitations within agricultural arrangements.

Similarly, the representative of the Swiss Farmers' Union IP9 (pos. 4) recognizes environmental concerns, such as water protection and non-target effects, but frames them as secondary to the primary goal of economically viable production. IP9 argues: "Wir brauchen immer noch irgendwo eine Menge […] um wirtschaftlich zu produzieren, das ist das Hauptziel" (pos. 6).[21] While ecological considerations are acknowledged, market-driven priorities remain dominant, indicating that ecological logic is often integrated into broader, pragmatic, and functional justification logics.

6.2 Functional Pragmatism: Expanding the Plant Protection Toolbox

In general, plant protection is recognized as functionally indispensable for contemporary agriculture. Across all interview participants – including the agricultural researcher IP2 (pos. 12), the representatives from the environmental NGO IP5 (pos. 22), the Swiss Farmers' Union IP9 (pos. 54), and both the agrochemical industry actor IP12 (pos. 20) and the biocontrol industry representative IP4 (pos. 8) – there is consensus that protecting crops from pests is essential to maintain economically viable yields. IP2 emphasizes that maintaining economically viable production levels in Swiss agriculture requires plant protection:

> Wenn wir produzieren, und zwar in einer Anzahl, die für einen Bauer relevant ist, und […] möglichst viele Nahrungsmittel selber produzieren, muss man die Pflanzen schützen. Das liegt daran, weil in einer Kultur, das sind halt, in Gottes Namen, meistens Monokulturen, dann ist das ein gedeckter Tisch für Schädlinge, und man muss sie irgendwie schützen. Also, ohne geht es nicht. Also, fullstop. Also, wirklich nicht. Ganz sicher nicht.[22] (IP2, pos. 16)

[21] Translation: We still need a certain amount […] in order to produce economically; that is the main goal.
[22] Translation: When we produce, and in a quantity that is relevant for a farmer, and […] produce as much food as possible ourselves, we have to protect the plants. This is because, in a crop – well, for God's sake, mostly monocultures – that's like a laid table for pests, and you have to protect them somehow. So, it just doesn't work without it. Full stop. Really, not at all. Definitely not.

Beyond the general need for plant protection, biocontrol is pragmatically legitimized as soon as it proves effective in the field. Policymaker IP3 notes that the adoption of biocontrol depends primarily on its practical results and cost-effectiveness: “Wenn eine gute biologische Methode funktioniert und im Prinzip zahlbar ist, […] dann wird es in der konventionellen Landwirtschaft angewendet” (pos. 22).[23] Similarly, the agrochemical industry representative IP12 argues that biocontrol can only be considered a viable approach if it is functional and scalable: “Es müssen funktionierende, at scale Alternativen sein. Und nicht einfach etwas, das so in einem kleinen Feldversuch mal getestet worden ist” (pos. 20).[24] This statement reveals a pragmatic and market-oriented understanding of biocontrol, in which alternatives are evaluated against the performance criteria of chemically intensive agriculture. Consequently, biocontrol is accepted only to the extent that it can be integrated into existing production regimes. From this perspective, biocontrol is valued for its ability to deliver measurable outcomes rather than for ideological or moral reasons, reinforcing a results-driven approach to legitimation.

The representative of the Swiss Farmers’ Union IP9 (pos. 8) likewise adopts a pragmatic orientation toward biocontrol, focusing on effectiveness and problem-solving without distinguishing between synthetic chemicals and biocontrol: As IP9 puts it: “Die Landwirtschaft [ist] offen für alles, was kommt. Wir wollen einfach eine Lösung […]. Wir wollen die Probleme gelöst haben” (pos. 34).[25] Moreover, IP9 (pos. 12, 24) emphasizes that in everyday practice, farmers rely on a mix of approaches, and that ideological preferences or public perceptions play little role in day-to-day decision-making unless farmers operate under specific label schemes, such as IP-Suisse, where stricter rules may apply. Functional legitimacy, in this sense, is explicitly outcome-driven: any method that effectively controls pests and stabilizes yields is considered acceptable.

The “toolbox” symbol is frequently used to underscore the functional logic of biocontrol. The representatives of the Swiss Farmers’ Union IP9 (pos. 54) and the agrochemical industry IP11 (pos. 55) and IP12 (pos. 22, 54), as well as the agricultural economics and policy researcher IP13 (pos. 22), frame biocontrol as an extension of existing plant protection options. Against the backdrop of increasing political and technical pressure on synthetic chemicals, IP11

[23] Translation: If a good biological method works and is basically affordable, […] then it will be used in conventional agriculture.
[24] Translation: There must be functional, scalable alternatives. And not just something that has only been tested in a small-scale field trial.
[25] Translation: Agriculture [is] open to whatever comes. We just want a solution […]. We want the problems to be solved.

emphasizes that any additional option that helps producers maintain yield levels is welcomed by the market, regardless of whether it is a synthetic chemical or a non-chemical substance:

> Jede Möglichkeit, die der Pflanzenschutz bekommt, um auf eine gute Art und Weise die Probleme im Feld bekämpfen, wo den Produzenten helfen, ihr Ertragsniveau zu halten, wird begrüsst im Markt. Also egal, ob chemisch oder nicht chemisch, das finde ich ganz wichtig zu sagen. Die Ergänzung der Toolbox, das finde ich einen der zentralsten Punkte der Biologicals.[26] (IP11, pos. 55)

This framing emphasizes biocontrol's practical contribution to the broader set of tools available to farmers, thereby reinforcing its functional legitimacy.

Resistance management further strengthens the functional justification for biocontrol. As the portfolio of approved synthetic chemicals declines, alternating or combining chemical and biological strategies is increasingly necessary (see Section 5.1.2). In this sense, researcher IP13 (pos. 22) notes that the diversification of pest management strategies is becoming a structural necessity, also for chemically intensive agriculture. This diversification is framed as both a functional necessity and a potential business opportunity, allowing companies to fill gaps left by unavailable chemicals (IP4, pos. 18). Biocontrol is thus legitimized as a pragmatic, strategic addition to IPM approaches.

Closely linked to this functional logic is a narrative that emphasizes farmer autonomy, flexibility, and freedom of choice. Biocontrol is considered beneficial because it expands the range of available tools in the "toolbox" of plant protection. Both the representatives of the agrochemical industry (IP12) and the Swiss Farmers' Union (IP9) stress that its adoption should expand plant protection options without restricting access to chemical products. Specifically, IP12 (pos. 65) highlights the importance of preserving farmers' decision-making autonomy, independent of labels or subsidy schemes. Similarly, IP9 voices concern that regulatory or political promotion of biocontrol could result in the withdrawal of synthetic chemical tools:

> Also wenn es jetzt so ein bisschen eine schnelle Variante gibt für ein biologisches Produkt, wenn es dann auch wirklich sicher ist, dann ist das sicher gut. Voraussetzung ist einfach, dass man dann nicht ein chemisch-synthetisches zurückstellt. Das ist ja ein bisschen die Befürchtung, die mitschwingt, oder. Dass

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[26] Translation: Any opportunity that plant protection receives to effectively address the problems in the field and help producers maintain their yield levels is welcomed in the market. So, regardless of whether it's chemical or non-chemical, I think it's very important to mention. The expansion of the toolbox is, in my opinion, one of the most central aspects of biologicals.

man dann wie sagt, ah, jetzt lassen wir zwar wieder ein bisschen zu, aber nur die Biologischen.[27] (IP9, pos. 48)

Both the biocontrol industry representative IP1 (pos. 18) and the environmental NGO representative IP5 (pos. 20) confirm that this concern is widespread and often driven by a fear of loss, namely that effective and familiar substances could be taken away too quickly. From the standpoint of the agrochemical industry and the Swiss Farmers' Union representatives, biocontrol is thus legitimized as a practical means to expand farmers' options while maintaining operational flexibility and autonomy.

This functional and pragmatic framing of biocontrol is not uncontroversial. While researchers IP2 (pos. 50) and IP13 (pos. 38) argue that expanding the "toolbox" should ultimately contribute to an overall reduction in synthetic chemical use, IP7 (pos. 44) observes that empirical evidence so far suggests an increase in biocontrol without a corresponding decline in synthetic chemicals. Rather than the substitution of synthetic chemicals, coexistence appears to dominate. This dynamic raises concerns about path dependency and system stabilization. IP13 (pos. 34) warns that biocontrol, if promoted uncritically, may contribute to preserving unsustainable agricultural structures: "Also, in dem Sinne kann natürlich auch eine dramatische Subventionierung von biologischen Pflanzenschutzmitteln, […] dazu führen, dass man einfach falsche Strukturen konserviert" (IP13, pos. 34).[28] This critique highlights that functional legitimacy depends on balancing short-term efficacy with long-term considerations regarding the redesign of farming arrangements toward more sustainable agricultural practices.

6.3 Food Security Imperatives: Balancing Short- and Long-Term Yield Stability

Food security considerations are invoked to underscore the perceived limitations of biocontrol regarding short- and medium-term yield stability. In the interviews, the representatives of the Swiss pesticide complex express skepticism that biocontrol alone can sustain current production levels and meet global nutritional demands. For example, IP12 (pos. 70) notes that organic production systems often experience crop losses that are economically manageable only due to state support in Switzerland, and would be insufficient to achieve global food security targets. This feeds into a broader narrative suggesting that biocontrol could lead to production shortfalls and, consequently, that it is inadequate to feed the world's population.

[27] Translation: So, if there's a somewhat quick option for a biological product, and it's truly safe, then that's certainly good. The only condition is that we don't put a synthetic chemical product on hold. That's kind of the concern that's lingering, right. That it would be like, 'Okay, now we allow some of them, but only the biologicals.'

[28] Translation: So, in this sense, a dramatic subsidization of biological plant protection products could of course also lead to simply preserving the wrong structures.

Switzerland is portrayed as a privileged case, where losses in crop yield can be "afforded" (IP9, pos. 44). These statements underline that, while biocontrol reduces ecological impact, it is perceived as potentially compromising reliable production in the short term.

Several interview participants therefore stress that fully abstaining from synthetic chemicals would compromise Switzerland's ability to maintain production and quality. Researcher IP2 (pos. 50) argues that without some form of synthetic chemical plant protection, existing food production levels could not be maintained. Relying exclusively on biocontrol, IP2 (pos. 52) notes, would likely reduce output, leading to increased imports, often from contexts with less transparent or less controllable production standards. This underscores the inherent tension between aspirations for more "natural" farming systems and the expectation of maintaining yields, quality, and affordability (IP2, pos. 38). Therefore, eliminating synthetic chemicals entirely is viewed as incompatible with current production and consumption patterns, as it would significantly reduce outputs and increase prices.

The food security concerns are further complicated by the need to respect environmental limits. The agrochemical industry representative IP12 highlights the dual challenge of ensuring sufficient food for a growing global population while operating within planetary boundaries: "Wir müssen eine Landwirtschaft fördern, die zukünftige Nahrungsmittel sicherstellt und eben auch den Anstieg der Weltbevölkerung damit abdeckt und gleichzeitig die planetaren Grenzen […] mitberücksichtigt […]. Das ist so das Spannungsfeld, wo man drin ist" (IP12, pos. 37).[29] From IP12's perspective, sustainable agricultural performance should be evaluated not only in terms of land use but also in terms of output per unit of production, such as calories or quantity.

While these considerations point to biocontrol's limitations regarding yield constraints and food security in the short- to medium term, biocontrol is also recognized for its potential to enhance food security in the long run. The farmer IP6 acknowledges that in the short term, biocontrol-based agriculture cannot match yields produced in chemically intensive agricultural systems, raising both ethical and practical challenges: „Die ethische Frage, wie stellen wir die Welternährung sicher, das löst der Biolandbau nicht. Aktuell und wahrscheinlich auch mit dem Bevölkerungswachstum, wahrscheinlich auch mittel- und langfristig nicht, da müssen wir

[29] Translation: We need to promote an agriculture that ensures future food security, and also covers the increase in the world population, while simultaneously taking planetary boundaries […] into account […]. That is the kind of tension we are dealing with.

einen Weg finden, zwangsläufig“ (IP6, pos. 34).[30] Nevertheless, IP6 remains optimistic about the long-term potential of biocontrol and related approaches that contribute to resilient food production practices that maintain yields while minimizing environmental harm.

Rather than being framed as a solution to fundamental food security challenges, biocontrol is often presented as a means to improve food safety and reduce residues. The agrochemical industry representative IP10 explains that while biocontrol cannot stabilize the global food supply or address fundamental food security challenges, it is valuable as a tool for producing lower-residue foods:

> Ich [habe] nicht die Hoffnung, dass die biologischen Mittel […] die Ernährungssituation tatsächlich stabilisieren können, ja. Ja, wenn dann eben dafür, dass man die einsetzen kann, um eben schadstoffärmere Lebensmittel zu produzieren. Also hinten raus, also rückstandsfreie oder so. Ja, da sehe ich sie, aber um wirklich die Probleme zu lösen, eher nicht.[31] (IP10, pos. 45)

According to this view, biocontrol contributes to reducing residues, but it does not yet guarantee the yield stability required for global food security.

6.4 Business Rationales: Leveraging Market Opportunities

Another central line through which the representatives of the Swiss pesticide complex legitimize their positions on biocontrol in Swiss agriculture is a business-oriented logic that frames biocontrol primarily as a strategic market opportunity. The representatives of the agrochemical industry highlight that biocontrol is a rapidly growing market segment. IP10 (pos. 19) explains that the biocontrol segment is growing faster than the synthetic chemicals segment, albeit from a smaller base, and that this market growth is a relevant reason the company invests in biocontrol. IP12 (pos. 18) quantifies this trend, noting that the growth potential for biologicals is estimated to be 4.5 times that of synthetic chemicals. Like IP10, IP12 highlights the strategic importance of the expanding biocontrol sector, which offers new opportunities for investment and profit: “Es ist ein Wachstumsmarkt, und wo gewachsen wird, wollen wir dabei sein als Leader in der Branche” (IP12, pos. 18).[32] This market expansion creates niche investment

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[30] Translation: The ethical question of how we ensure global food security cannot be solved by organic farming. Currently, and probably also with population growth, likely not in the medium or long-term either. We must find a way, inevitably.
[31] Translation: I don’t really have the hope that biological products […] can actually stabilize the nutritional situation, no. Yes, rather, they can be used to produce foods with fewer residues. So, ultimately, residue-free or similar. Yes, that’s where I see them, but to really solve the problems? Not really.
[32] Translation: It’s a growth market, and where there is growth, we want to be present as a leader in the industry.

opportunities and offers significant economic potential, which the representatives of the agrochemical industry cite as a reason for integrating it into existing business strategies.

Evolving consumer preferences, supply chain pressures, and anticipated efficiency gains further reinforce the business rationale for biocontrol. Beyond internal business considerations, the representatives of the agrochemical industry, IP10 (pos. 19) and IP12 (pos. 18), and the phytopathology researcher IP2 (pos. 40), note that external societal demand for low-residue products incentivizes investments in biocontrol. Thus, beyond internal corporate strategies, biocontrol is legitimized as a response to external market dynamics and consumer expectations.

At the same time, the representative of the Swiss Farmers' Union IP9 (pos. 48) notes that the commercial viability of biocontrol depends on aligning product pricing, regulatory incentives, and market willingness to pay. This assessment reflects a market-driven logic and aligns with IP9's (pos. 4) explanation that in the field of plant protection, the decisions of the Swiss Farmers' Union are guided by market requirements. Production that fails to meet market demand is considered futile: "es nützt nichts, wenn wir am Markt vorbei etwas produzieren" (IP9, pos. 6).[33] Similarly, the agrochemical industry representative IP12 stresses that market conditions ultimately determine feasibility:

> Wir können in der Schweiz schon denken, wir möchten eine möglichst umweltfreundliche Produktion haben, aber am Schluss haben wir einen Markt, der dann auch sehr opportunistisch agiert und wo dann einfach importiert wird, wenn da die Erträge nicht da sind.[34] (IP12, pos. 74)

In this context, Switzerland's comparatively small domestic market, combined with high consumer expectations for standardized quantity and quality, is regarded as a constraining factor for the economic feasibility of production systems based on biocontrol.

Biocontrol's market potential is further limited by operational and economic constraints, reflecting reasoning logics that caution against its adoption. Several factors suggest that biocontrol alone may not align with commercial industry interests. For instance, IP7 (pos. 28) notes that although biocontrol is intended to control specific organisms in a targeted way, this specificity conflicts with industrial priorities. From the industry perspective, narrowly targeted products are less attractive than broadly applicable solutions that promise higher commercial

[33] Translation: It's no use if we produce something that does not meet market expectations.
[34] Translation: We may want production in Switzerland to be as environmentally friendly as possible, but ultimately, we have a market that acts very opportunistically and simply imports goods when the yields are not there.

returns. Additionally, the release of beneficial organisms may replace other inputs entirely, reducing opportunities for repeated sales (IP3, pos. 24).[35] Complex registration procedures (see Section 5.2.2), combined with lower profit margins compared to synthetic chemicals, further discourage investment in potentially viable biocontrol products (IP4, pos. 16, 30). To enhance biocontrol's commercial attractiveness within the agro-industrial sector, IP1 (pos. 12, 20) emphasizes the need for alternative business models and incentive structures.

[35] This specific type of biocontrol is called classical biocontrol.

7 Discursive Positioning of Biocontrol

Building on the discussion of the perceived potentials and limitations of biocontrol in Swiss agriculture in Chapter 5, and the legitimation logics employed by the representatives of the Swiss pesticide complex in Chapter 6, this chapter examines how biocontrol is discursively positioned relative to chemically intensive agriculture and alternative agri-food arrangements. In Section 7.1, I focus on discursive framings that position biocontrol within alternative agri-food arrangements. In Section 7.2, I contrast these framings with narratives that embed biocontrol within chemically intensive agricultural structures.

7.1 Biocontrol within Alternative Agri-Food Arrangements

Alignment with Organic Principles

In the Swiss agricultural context, biocontrol is discursively framed as an alternative product due to its biological, and thus "natural," basis. The representatives of the Swiss pesticide complex repeatedly emphasize that biocontrol substances are derived from biological processes or living organisms rather than from synthetic chemistry (see Chapter 5). This emphasis on naturalness positions biocontrol as aligned with ecological principles and distinguishes it from standardized chemical interventions.

This positioning is reinforced through biocontrol's close association with organic agriculture. The representatives of the biocontrol industry, IP1 (pos. 40) and IP4 (pos. 16), identify organic farming as the primary market for biocontrol products, framing biocontrol as a means of producing food outside chemically intensive agriculture. Through this association with organic agriculture, biocontrol becomes embedded in broader projects of alterity that respond to ecological degradation and the health risks associated with industrial agriculture. Consequently, biocontrol is discursively positioned as an alternative input within farming arrangements that seek to diverge from chemically intensive agricultural practices.

Context-Specific and Holistic Approaches

Beyond its material composition, biocontrol is discursively positioned close to alternative agri-food arrangements because it resists standardized, universal solutions and instead requires context-specific adaptation. As IP5 (pos. 26) notes, biocontrol does not follow a "one-size-fits-all" logic but must be adjusted to specific ecological and agronomic conditions. This requirement differentiates biocontrol from chemically intensive plant protection practices, which are often based on standardized application regimes. The preventive nature of biocontrol is a case in point that exemplifies this distinction. The interviewed farmer IP6 (pos. 8) describes biocontrol-based systems as more complex than chemically intensive ones because they lack fast-acting interventions and require foresight and proactive decision-making. Rather than reacting to outbreaks, farmers must anticipate ecological dynamics and integrate plant protection measures into broader farming strategies.

Accordingly, biocontrol is repeatedly framed as one element within a holistic approach to plant protection. The interview participants emphasize that biocontrol alone does not constitute a sufficient solution; instead, greater emphasis must be placed on preventing the emergence of pests and diseases and on combining multiple measures (IP4, pos. 16; IP13, pos. 22). Such measures include the adaptation of cultivation practices (IP2, pos. 16; IP8, pos. 32); the adoption of robust and disease-resistant varieties (IP3, pos. 20; IP8, pos. 24; IP10, pos. 43); the strengthening of plants (IP4, pos. 8); and the integration of (digital) technologies (IP6, pos. 56; IP12, pos. 8). Likewise, IP8 (pos. 22, 24, 32) stresses that biocontrol alone is insufficient but can incentivize innovation in plant protection by introducing new practices. In this sense, biocontrol contributes to alternative agricultural logics that prioritize plurality and systemic thinking over singular, standardized fixes.

Transformation of Farming Practices

Biocontrol is further differentiated from chemically intensive agriculture through its effects on everyday farming practices and modes of engagement with agroecosystems. Biocontrol's effective use requires careful observation, precise timing, and ecological knowledge, thereby fostering attentiveness and sustained engagement with the field (see Section 5.2.4). Although the interview participants acknowledge the complexity of biocontrol, they also frame it as intellectually stimulating. As farmer IP6 explains, the absence of fast-acting chemical interventions requires farmers to think ahead and engage more deeply with ecological processes, making farming both more demanding and more engaging:

> Ja gut, eigentlich ist es einfach im Biolandbau. Man kann nicht viel machen, oder. Oder [...] nein, es ist eben gleichwohl kompliziert. Also es ist komplizierter, aber das macht es auch spannender, weil man im Biolandbau eben nicht die schnellwirksamen Mittel zur Verfügung hat. Also man muss eben vorher denken.[36] (IP6, pos. 8)

[36] Translation: Yes, well, actually it's quite simple in organic farming. There's not much you can do. Or [...], no, it's still complicated. So it's more complicated, but that also makes it more exciting, because in organic farming you don't have any fast-acting means at your disposal. So you have to think ahead.

This approach markedly differs from chemically intensive agricultural practices, which are described as reactive and interventionist: “Here is the chemical, it’s going to go and create. If you talk about biocontrol, it’s about how do you prevent the problem [from occurring]” (IP1, pos. 30). Biocontrol, by contrast, focuses on prevention and on working with ecological processes rather than responding after the fact.

Several interview participants further highlight how biocontrol reshapes farmers’ attentiveness during fieldwork. Drawing on experiences from field days and projects involving the release of beneficial insects and the establishment of flowering habitats in cherry orchards, IP7 (pos. 52) observes that farmers become more attentive to what is visible on trees and in the field. This increased awareness often leads farmers to exceed project requirements by independently adding structures, such as wooden branches or stones, as insect refuges. Similarly, IP5 (pos. 28) reports that farmers who implement such measures express strong appreciation for the increased visibility and diversity of insects in their fields, contrasting it with what they typically observe.

Biocontrol not only promotes attentiveness and ecological observation but also requires changes in routines. According to the biocontrol industry representative IP1, biocontrol demands a shift in attention and “a bit more coordination, rather than the way we have been used to agriculture” (pos. 14). As IP4 (pos. 24) explains, the effective use of biocontrol compels farmers to be more attentive, leave their machinery more frequently, and closely inspect crops, for example when monitoring potato beetle eggs or early signs of disease. Rather than relying on standardized application routines, farmers must actively observe and interpret ecological signals in the field. Farmer IP6 illustrates how biocontrol encourages adjustments in farming practices such as alternative soil cover strategies and soil moisture monitoring:

> [Der] Einsatz von Transfermulch, wo man versucht, den Boden abzudecken, und Kulturen, die eben den Boden lange offen lassen, wo viele Wirte auf den Boden lassen. Man tut mit Mulch eigentlich den Boden abdecken, also damit eben das Keimen von Konkurrenzpflanzen eigentlich nicht stattfinden kann […]. Ja, und halt auch den Boden nicht strapazieren mit Verdichten. Das ist immer ein Wunschdenken, aber trotzdem, man kann darauf achten. Wir tun die Bodenfeuchtigkeit messen, wenigstens an wenigen, an einigen Stellen, oder. Um das Gefühl zu bekommen, wie ist der Boden jetzt gerade.[37] (IP6, pos. 22)

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[37] Translation: [The] use of transfer mulch, where you try to cover the soil, and crops that leave the soil exposed for a long time, where many hosts are present on the soil. Basically, with mulch, you cover the soil to prevent the germination of competing plants […]. Also, it helps avoid stressing the soil through compaction. It’s always a bit of wishful thinking, but still something one can pay attention to. We measure soil moisture, at least in a few places, just to get a sense of how the soil is right now.

In addition to changes in agricultural practices, biocontrol is framed as requiring cognitive and normative adjustments. IP4 (pos. 28) suggests that modifications in one area of the farm may not only require adjustments across other agricultural practices but may also trigger shifts in mindsets. The representative of the biocontrol industry IP1 (pos. 20) and the interviewed farmer IP6 (pos. 24) emphasize that adopting biocontrol requires farmers, particularly those accustomed to chemical-based systems, to change their thinking. This involves overcoming skepticism (IP4, pos. 14; IP12, pos. 78), accepting higher levels of uncertainty and risk (IP6, pos. 28; IP13, pos. 30, 32), and recalibrating expectations regarding effectiveness (IP7, pos. 26; IP11, pos. 15). Moreover, IP2 (pos. 22, 40) contends that successful adoption of biocontrol depends not only on shifts at the farm level, but also on mindset changes among all actors within the Swiss pesticide complex.

Emotional Engagement and Reconfigured Human-Nature Relations

Despite the additional demands it places on practices and mindsets, biocontrol is associated with emotional rewards. For example, the representative of the environmental NGO IP5 (pos. 28) reports that farmers using biocontrol increasingly value biodiversity in their fields and describe this engagement as emotionally meaningful, even when it entails higher costs. IP7 (pos. 50, 52) similarly describes how biocontrol can foster greater attentiveness, joy, interest, and engagement among farmers. As the representative of the biocontrol industry IP4 argues, successfully using biocontrol can generate pride, satisfaction, and a sense of professional competence among agricultural practitioners who usually apply synthetic chemicals and contribute to a revaluation of agricultural expertise:

> Es ist niemand stolzer, wenn er etwas Biologisches einsetzt und es dann gut wirkt, wie der Konventionelle. Am Anfang erzählt man es nicht. Und plötzlich geht man es nachher erzählen und man meint sich nachher auch fast mit dem eigentlich. Und das löst ja auch noch recht spannende Abläufe aus […]. Du als Produzent, als Landwirt, also du musst ein besserer Landwirt eigentlich gewissweit sein […]. Ganz böse gesagt, der dumme Bauer bleibt dann […] vielleicht auf der Strecke.[38] (IP4, pos. 28)

Similarly, farmer IP6 (pos. 26) links the use of biocontrol to a sense of moral and emotional satisfaction derived from enabling natural processes, reducing environmental harm, and avoiding long-term soil degradation:

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[38] Translation: No one's prouder than a conventional farmer when they use something biological and it works well. At first, you don't tell anyone. And then suddenly you start telling others about it, almost bragging about it. And that also triggers quite interesting processes […]. As a producer, as a farmer, you really need to be a better farmer in a certain sense […]. Put very bluntly, the stupid farmer might then […] be left behind.

> Nebst verminderten Umwelteinflüssen gibt es einem einfach ein gutes Gefühl. Also, durch das, dass ich ein Produkt abliefern kann, bei dem ich davon ausgehen kann, dass es weniger […] schädliche Inhaltsstoffe hat. Es ist gewachsen, ohne dass ich den Boden langfristig strapaziere […]. Indem ich die natürlichen Prozesse laufen lasse und nicht störe, gibt es mir einfach das Gefühl, irgendwie läuft es in die gute Richtung. Es ist irgendwie gut, was ich mache, auch wenn ich es im Einzlenen nicht belegen kann.[39] (IP6, pos. 26)

This perspective links ecological practice with personal satisfaction, framing biocontrol as both responsible and emotionally rewarding, and closely connected to the ecological logic in legitimizing it (see Section 6.1).

Such emotional engagement can also be tied to changes in human-nature relations. According to IP4 (pos. 24) and IP5 (pos. 26, 28), increased attentiveness and ecological observation deepen farmers' connections to their land. For example, IP1 illustrates the broader consequences of biocontrol not only as treating nature as something separate from us, but as treating human health and "for that sense, I'm treating myself" (pos. 14). In this way, biocontrol can contribute to alternative ways of relating to nature, which contrasts with the logic of chemically intensive agricultural practices. Biocontrol practices challenge the mechanized and distanced modes of interaction characteristic of chemically intensive agriculture and foster alternative plant protection practices grounded in observation and ecological responsiveness.

Collective Coordination and Alternative Networks

Another aspect that embeds biocontrol discursively in alternative agri-food arrangements relates to the creation of new forms of collaboration and collective organization beyond dominant agricultural structures. As the effective implementation of biocontrol often requires coordination among actors within the pesticide complex (see Section 5.2.4), as well as with nature, it can contribute to the formation of alternative networks.

An illustrative example of collaboration and the establishment of alternative networks is the use of pheromone-mediated mating disruption techniques in viticulture. According to IP4 (pos. 16, 28), this approach requires coordinated implementation across neighboring farms. In several Swiss wine-growing regions, such coordination has led to new collective structures that extend beyond individual farms. As IP4 explains, joint activities such as installing dispensers collectively and social gatherings afterward helped rebuild trust and communication among

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[39] Translation: Besides reduced environmental impacts, it simply feels good. So, because I can deliver a product that I can assume contains fewer [...] harmful ingredients. It has grown without me causing long-term damage to the soil [...]. By letting natural processes take their course and not interfering, it just gives me the feeling that things are somehow moving in the right direction. It somehow feels good what I do, even if I cannot prove it in detail.

farmers, with spillover effects into other areas such as machinery sharing and land consolidation:

> Das hat dazu geführt, dass in gewissen Gebieten, wo man zum Beispiel keine Bewässerungsgenossenschaft hat, wo man miteinander zum Beispiel das Wasser teilt, dass man plötzlich auch etwas hat, was man gemeinsam gemacht hat. Und das hat zum Beispiel bei Güterzusammenlegungen nachher auch geholfen, weil man plötzlich wieder eine Organisation hatte, wo man zusammen etwas gemacht hat […]. Und vielleicht hat man dort miteinander geredet und dann plötzlich gemerkt, ja gut, wir brauchen nicht zwei Maschinen, eine reicht.[40] (IP4, pos. 28)

Further collaborative projects similarly underscore the network-building potential of biocontrol, as observed in other alternative agri-food initiatives. For instance, IP7 (pos. 36) describes a project addressing cockchafer grub infestations in the Canton of Grisons that brings together a biocontrol company, a farmers' self-help organization (Maschinenring Graubünden), and a research institution. Beyond improving plant protection outcomes, this cooperation fosters social exchange and collective learning, thereby embedding biocontrol within broader networks of alternative knowledge and practices.

7.2 Biocontrol within Chemically Intensive Agriculture

I now turn to the discursive framings that embed biocontrol within chemically intensive agricultural structures. Unlike many other projects of alterity, biocontrol is neither economically marginalized nor situated outside dominant economic structures; rather, it is actively incorporated into them. Whereas alternative agri-food initiatives, such as food cooperatives or solidarity-based agriculture, often develop distinct economic models that operate outside of, or loosely connected to mainstream markets, biocontrol is integrated into prevailing market structures governed by industrial logics.

Economic Integration and Market Embedding

The discursive framings articulated by the interviewed representatives of the agricultural industry, the policymaker, and the Swiss Farmers' Union position biocontrol as a component of mainstream plant protection rather than as an economically alternative project. Although IP4 (pos. 22) notes that biocontrol historically occupied a niche largely ignored by major agrochemical companies, its contemporary development increasingly aligns with dominant market

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[40] Translation: This has led to a situation where, in certain areas – such as where there is no irrigation cooperative, and people share water collectively – people suddenly have something they've done together. And this, for instance, later also helped with land consolidation projects, because there was suddenly an organization where things were done collectively […]. And perhaps through that, people talked to one another and suddenly realized, well, we don't need two machines, one is enough.

logics. Within this framing, biocontrol is expected to meet profitability criteria. As IP2 (pos. 22) explains, biocontrol must ultimately be profitable to someone in order to be viable.

Accordingly, biocontrol is governed and positioned within the dynamics shaped by neoclassical economic principles such as economies of scale and market growth. The representative of the biocontrol industry IP1 (pos. 40) and the agricultural economics and policy researcher IP13 (pos. 36) invoke the concept of economies of scale, projecting declining average production costs as output increases, to argue that biocontrol will become increasingly economically viable over time. They suggest that accumulated experience and scaling effects will reduce costs and facilitate the broader diffusion of biocontrol within chemically intensive agricultural systems. Although IP1 (pos. 20) notes that biocontrol would require a different economic model than synthetic chemicals, the interview participants do not associate biocontrol with alternative economic forms such as cooperatives, solidarity economies, or social enterprises, which are common in other projects of alterity within the agri-food sector.

From the perspective of the representative of the Swiss Farmers' Union IP9 (pos. 48), the successful diffusion of biocontrol depends on its alignment with existing commercial structures: Biocontrol needs to operate "hand in hand" with dominant market arrangements rather than outside them. This alignment, for instance, is visible in the distribution of biocontrol products. As farmer IP6 (pos. 36) explains, access to and distribution of biocontrol products follow the same commercial channels as synthetic chemicals: Biocontrol products are purchased through established distributors such as "Landi"[41] and are often supplied by the same companies that sell synthetic chemical inputs. Even if products are approved specifically for organic farming, they remain widely available and integrated into the mainstream market. This integration underscores biocontrol's status as a market commodity rather than as part of alternative economic structures.

Institutionalization through Governance Frameworks

Regulatory frameworks further institutionalize biocontrol within chemically intensive agricultural structures rather than as an alternative approach. The representative of the biocontrol industry IP1 (pos. 20) highlights that agricultural support mechanisms are largely designed for chemically intensive farming and offer limited incentives for biocontrol applications. This policy

[41] Landi is a nationwide cooperative retail network owned by the agricultural cooperative Fenaco, supplying agricultural inputs and operating hardware stores (Landi, n.d.).

bias contributes to framing biocontrol as an auxiliary tool rather than as a foundational element of an alternative agricultural practice.

In Switzerland and beyond, biocontrol is formally integrated into IPM strategies and is subject to registration procedures that largely mirror those applied to synthetic chemicals. Although IP7 (pos. 30) explicitly contests this equivalence, arguing that biological products require different regulatory treatment, the prevailing regulatory logic reinforces the perception of biocontrol as merely another functional category of plant protection products. Consequently, regulatory integration further normalizes biocontrol as embedded within industrial plant protection regimes.

Strategic and Commercial Drivers

A central factor in biocontrol's economic embedding is its integration into the portfolios and core business models of major agrochemical companies. This integration reflects both historical patterns and strategic considerations. As IP9 (pos. 8) explains, biocontrol products have long been used within chemically intensive systems, particularly in fruit production, where residue limits and market pressures encourage the use of non-synthetic inputs. In such contexts, spray programs routinely combine biological and chemical products, reflecting a logic of functional substitution, whereby biocontrol is adopted insofar as it enhances performance within existing production models.

Beyond historical use, the contemporary integration of biocontrol into agrochemical portfolios follows two strategic rationales (see Section 6.4). First, the growing biocontrol market represents a business opportunity. Although biocontrol currently accounts for only a fraction of the global pesticide market, it is framed as a rapidly expanding future market. Second, biocontrol helps manage resistance and extend the effectiveness of synthetic chemicals. As IP13 (pos. 22) explains, the declining availability of synthetic substances and rising resistance pressures necessitate expanding the "toolbox" of plant protection.

Within the business logic, the limited effectiveness of biocontrol is reinforced to position biocontrol as a complement rather than a substitute for synthetic chemicals. While the representatives of the agrochemical industry recognize biocontrol as an important future market, they explicitly reject the notion that it could replace synthetic chemical products. As IP12 states: "Also es ist für uns ein Zukunftsmarkt. Aber, und das möchte ich auch ganz klar gesagt haben, aber es ist nicht der Markt, der dann das andere substituiert" (pos. 18).[42] IP1 (pos. 26) and IP11 (pos. 19) reinforce this view, noting that many plant protection challenges cannot be addressed by biocontrol alone.

Framing biocontrol as complementary preserves the perceived indispensability of existing synthetic chemical products while simultaneously legitimizing its commercial potential. By emphasizing complementarity, industry actors reinforce the stability of established business models while introducing new market segments. Gaps created by bans on synthetic chemical substances present market openings for biocontrol (IP4, pos. 18), and integrating biological agents with chemical inputs helps manage pesticide resistance (see Section 5.1.2), thereby extending the commercial lifespan of existing synthetic chemical products (IP1, pos. 18). In this sense, from a business logic, biocontrol is legitimized not only as generating new business opportunities but also enhancing the longevity and profitability of synthetic chemical plant protection products.

The embedding of biocontrol within chemically intensive agriculture is driven not only by investments from agrochemical companies but also by specialized biocontrol companies actively pursuing it. From their perspective, engagement with dominant agricultural markets is motivated by two primary factors. First, it is essential for the economic viability of specialized biocontrol companies. The representative of a company specialized in biocontrol IP4 (pos. 16) emphasizes that sales into chemically intensive agricultural arrangements are indispensable for achieving the volumes necessary to cover research, development, and registration costs. Second, IP4 (pos. 10), in line with researcher IP13 (pos. 34), argues that broader market penetration enhances biocontrol's environmental impact. Replacing even small proportions of synthetic chemicals at scale can generate significant aggregate effects. This dual rationale, economic necessity and environmental leverage, reinforces biocontrol's strategic alignment with chemically intensive agricultural arrangements.

Advisory Services and Knowledge Mediation

Agricultural advisors and advisory services play a key role in embedding biocontrol within chemically intensive agricultural arrangements by shaping how it is introduced and practiced on farms (see Section 5.2.4). The representatives of the companies specializing in biocontrol describe advisory work as part of their mandate, particularly in instructing farmers on how to

[42] Translation: So it's a future market for us. But, and I want to make this very clear, it's not the market that will replace the other one.

combine biocontrol products with synthetic substances. As IP4 (pos. 16) explains, such advisory activities are often provided without direct financial compensation, motivated instead by the interest to ensure that biocontrol products function effectively alongside other plant protection measures.

At the same time, advisory services affiliated with agrochemical companies actively promote the integration of biocontrol into chemically intensive arrangements. According to the agricultural advisor IP11, biocontrol is typically introduced as an additional component within existing spray programs. This strategy is readily accepted by farmers, as it aligns with their efforts to manage and reduce production risks:

> [Ich] probiere […] natürlich auch an einem Bauern oder Produzenten, der konventionell spritzt, einen solchen Baustein einzubauen und zu sagen, hey, nimm das dort dazu, weil wir haben dann ein Mechanismus mehr, oder. Und das wird sehr stark auch angenommen, weil das Risiko nehmen die Produzenten auch explizit wahr […]. Aber so findet eigentlich der Transfer oder die Übernahme auch von biologischen Mitteln für den nicht-biologischen Markt statt.[43] (IP11, pos. 59)

However, the role and influence of advisory services in shaping biocontrol adoption vary considerably depending on their institutional affiliation. As the environmental NGO representative IP5 (pos. 28) highlights, the nature of advisory support – who provides it, how it is organized, and whether it is delivered by an external contractor or a company offering ready-made packages – can strongly affect outcomes. In the context of biocontrol, advisory services thus not only mediate knowledge transfer but also determine whether existing chemically intensive systems are reinforced or whether space is created for alternative plant protection practices.

This chapter has examined how biocontrol is discursively positioned in relation to both alternative agri-food arrangements and chemically intensive agriculture. On the one hand, the representatives of the Swiss pesticide complex associate biocontrol with alterity through its natural origin, alignment with organic farming, holistic approach, and potential to reshape farming practices, social relations, and collaborative networks. On the other hand, they describe biocontrol as embedded within chemically intensive agricultural structures and integrated into mainstream markets governed by regulatory and corporate logics.

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[43] Translation: [I] also obviously try […] to introduce such a component with a farmer or producer who sprays conventionally, and say, hey, add this there, because then we have one more mechanism, right. And this is very well received because the producers explicitly perceive the risk […]. And in this way, the transfer or adoption of biological products into the non-organic market actually takes place.

8 Discussion

In the following sections, I discuss the empirical findings presented in the preceding chapters by situating them within the existing literature reviewed in Chapter 2 and linking them to the theoretical frameworks outlined in Chapter 3. I start by synthesizing the potentials and limitations of biocontrol as articulated by the representatives of the Swiss pesticide complex in Section 8.1, with particular attention to the structural conditions specific to the Swiss agricultural context. In Section 8.2, I discuss the legitimation logics through which these actors legitimize their positions on biocontrol. Finally, in Section 8.3, I consider how the discursive positioning of biocontrol in relation to chemically intensive agriculture and alternative agri-food arrangements could contribute to more sustainable agricultural plant protection practices in Swiss agriculture.

8.1 Structural Conditions Influencing Biocontrol in Switzerland

The representatives of the Swiss pesticide complex describe several potentials and limitations of biocontrol. On the one hand, environmental and human health benefits, resistance prevention, and relatively high social acceptance are emphasized as key advantages of biocontrol in Swiss agriculture (see Section 5.1). On the other hand, limited product availability, regulatory hurdles, operational complexity, high knowledge requirements, and economic constraints are identified as challenges to its broader adoption (see Section 5.2). While these assessments largely mirror the benefits and challenges discussed in the scientific and industry literature (see Section 2.1), the interview participants also highlight several factors specific to the Swiss context. In particular, market size, price level, and the policy and regulatory framework emerge as decisive structural conditions shaping the role of biocontrol in Switzerland.

The Swiss agricultural **market size** constitutes a central constraint on the development and availability of biocontrol products. The representatives of both a global biocontrol company, IP1 (pos. 24), and a global agrochemical company, IP12 (pos. 37), characterize Switzerland as a marginal market with limited strategic relevance for product development and commercialization. High development costs, combined with limited market volume and price sensitivity, reduce companies' incentives to prioritize the Swiss market. This perception has concrete consequences for the range of biocontrol products available domestically. As IP9 (pos. 28) notes, corporate research and development efforts tend to focus on internationally significant cash crops such as soy or maize rather than on crops more specific to Swiss agriculture, including rapeseed, sugar beet, and specialty cultures. Consequently, Switzerland's small market size reduces companies' incentives to invest in biocontrol products tailored to national agricultural needs, thereby constraining product availability.

Switzerland's comparatively high **price level** serves both as an enabling condition and a structural constraint to the adoption of biocontrol. On the one hand, higher agricultural product prices imply that Swiss farmers generally possess greater financial capacity to invest in plant protection measures, a condition that IP10 (pos. 27) identifies as favorable for the uptake of biocontrol products. In principle, this pricing environment could allow farmers to absorb higher input costs or experiment with alternative plant protection strategies. On the other hand, even in a high-price context, willingness to pay remains limited. As IP1 (pos. 24) notes, farmers are often reluctant to accept the higher and less predictable costs associated with biocontrol. This tension is further exacerbated by Switzerland's high labor costs, which intensify one of the central challenges of biocontrol-based approaches: their comparatively greater labor intensity. IP1 (pos. 12) explains that increased labor requirements, such as more frequent monitoring and manual interventions, translate directly into higher production costs. Consequently, while Switzerland's high price level may facilitate access to biocontrol inputs, it simultaneously intensifies the economic pressures linked to their practical implementation.

Finally, the **policy and regulatory framework** exerts an ambivalent influence on the feasibility of biocontrol in Swiss agriculture. Regulatory procedures for biocontrol agents in Switzerland closely mirror those for synthetic pesticides, a pattern observed in many other countries (Bullion, 2023). The Swiss approval process is described as lengthy, complex, and costly, limiting the speed and scale at which new products can enter the market. This regulatory burden is not unique to Switzerland but reflects broader European trends (Wyckhuys et al., 2024). Bullion (2024) notes that the absence of tailored regulatory frameworks constitutes a major obstacle to the market uptake of biological products in general. However, Switzerland's agricultural policy introduces compensatory mechanisms that can partially mitigate these challenges. Targeted direct payment schemes, for instance, provide financial support that offsets production risks associated with less intensive plant protection strategies. As IP11 (pos. 36) observes, such payments can compensate farmers for potential yield losses, thereby reducing the economic uncertainty tied to biocontrol adoption. As a result, while regulatory constraints limit the development and market introduction of biocontrol products, agricultural policy measures create conditions that may encourage their uptake by reducing farmers' financial and risk-related barriers.

8.2 Legitimation Logics Shaping Biocontrol Discourses

The representatives of the Swiss pesticide complex draw on multiple logics to legitimize their positions on biocontrol, reflecting different priorities and underlying conventions. As analyzed in Chapter 6, these logics include ecological responsibility, functional pragmatism, food security imperatives, and market-oriented business rationales. Drawing on the sociology and economics of conventions, these logics can be understood as different conventions that actors mobilize to legitimize, critique, or negotiate biocontrol adoption within the broader agricultural context.

The **ecological logic** is invoked to legitimize supportive positions toward biocontrol, particularly by representatives of the biocontrol industry (IP1, IP4), the environmental NGO representative (IP5), and the interviewed farmer (IP6). From their perspective, biocontrol is framed as less harmful to soils, non-target organisms, and ecosystems, and as a way to reduce environmental externalities associated with chemically intensive agricultural inputs. Biocontrol is thus positioned as a means to restore ecological balance and enhance agricultural resilience under climate change. This ecological reasoning establishes biocontrol as a legitimate response to environmental degradation and frames its adoption as an ecologically responsible course of action.

Closely linked to ecological reasoning, moral logics introduce a normative and affective dimension to the legitimation of biocontrol. Beyond environmental benefits, biocontrol is framed as a moral responsibility toward nature and future generations, while also providing practitioners with personal satisfaction. It emphasizes the duty to protect natural systems while simultaneously recognizing the positive emotional experience derived from producing in harmony with ecological principles. The interviewed farmer IP6 (pos. 26), for instance, describes ethical fulfillment and emotional well-being derived from reducing harm through biocontrol practices. These moral and emotional considerations deepen ecological legitimation by framing biocontrol not only as environmentally sound but also as an ethically and personally meaningful choice aligned with broader ethical values and personal convictions. This combination of ecological and moral reasoning underscores the role of affect and ethical responsibility in shaping actors' discourses and decisions regarding biocontrol.

Ecological and moral logics appear across all interviews, yet they are uniquely mobilized to support biocontrol, rather than to critique it. In contrast to other legitimation patterns, ecological reasoning is not used to oppose biocontrol. Nevertheless, it is often subordinated to competing considerations. As Diaz-Bone and De Larquier (2024) note, actors strategically mobilize alternative conventions as resources for both justification and critique. In the context of the Swiss pesticide complex, this dynamic reflects a broader tension: ecological ideals are acknowledged but frequently constrained by functional, economic, and food security logics.

The pragmatic and **functional logic** emerges as a dominant reasoning pattern among actors expressing more cautious or critical positions toward biocontrol. The policymaker (IP3), the representative of the Swiss Farmers' Union (IP9), and agrochemical industry representatives (IP10, IP11, IP12) emphasize the practical requirements of intensive agricultural systems. The functional logic reflects a shared understanding that such systems, often organized as monocultures, create structural vulnerabilities to pests, thereby necessitating continuous intervention. This reasoning aligns with the notion that pesticides serve a dual function within the GPC: they not only enable and drive agricultural intensification but also mitigate the socio-natural effects that such intensification produces (Werner, 2025).

Within this functional legitimation pattern, biocontrol is considered legitimate only to the extent that it performs reliably under real-world farming conditions. The recurring metaphor of the "toolbox" illustrates this perspective: biocontrol is positioned as one instrument among many, complementing rather than replacing synthetic chemicals. While this framing facilitates broad acceptance of biocontrol across actor groups, it also risks reinforcing the very system it is sometimes expected to transform more profoundly, thereby revealing tensions between short-term functionality and longer-term agricultural transformation towards more sustainable agricultural arrangements to reduce pest pressure (see Section 8.3).

Food security considerations constitute another central legitimation logic shaping actors' assessments of biocontrol's potential. The representatives of the agrochemical industry (IP10, IP11, IP12) and the interviewed farmer (IP6) refer to the **food security logic** to legitimize their positions on biocontrol. For the agrochemical industry representatives, food security concerns are primarily framed around short-term productivity risks, reflecting a cautious approach that prioritizes immediate yield stability. By contrast, IP6 emphasizes the long-term potential of biocontrol to contribute to food security. This temporal distinction resonates with findings by Möhring et al. (2025), which demonstrate that the benefits of sustainable pest management become particularly pronounced in the long run.

Market-oriented **business logics** further shape how biocontrol is evaluated and legitimized within the Swiss pesticide complex. Representatives of both the biocontrol industry (IP1, IP4) and the agrochemical sector (IP10, IP11, IP12) frame biocontrol as a strategic business opportunity driven by internal business considerations and external, market-side demands for low-residue products. At the same time, they emphasize structural constraints that limit commercial viability, including high registration costs, as well as the tension between consumer demands for fewer residues and flawless product appearance. These economic considerations align with research on commercialization barriers for biological products (Glare & Nollet, 2023). Business rationales legitimize biocontrol to the extent that it aligns with established economic imperatives, stabilizes existing business models, and opens avenues for revenue growth in emerging market niches. Thus, while supporting biocontrol in principle, this logic situates biocontrol within the boundaries of commercial feasibility.

Overall, the representatives of the Swiss pesticide complex draw on multiple legitimation logics that overlap and, at times, conflict. The plurality of justification logics exemplifies a core insight of the economics and sociology of conventions: rather than operating in isolation, multiple evaluative principles can coexist, intersect, and sometimes compete, producing dynamic and context-dependent patterns of legitimation. In the context of biocontrol, the representatives of the Swiss pesticide complex switch between different logics and mobilize alternative conventions as resources for critique and justification. In line with the theoretical foundations of the economics and sociology of conventions, these logics can be understood as shared rules that are culturally established and taken for granted: they are constructed through discourse within the Swiss agricultural complex, reflecting collective understandings of what counts as legitimate action.

The legitimation logics mobilized by the representatives of the Swiss pesticide are patterned justifications that closely align with the "worlds" of worth as defined by Boltanski and Thévenot (2006). Market-oriented business rationales resonate strongly with the market world, insofar as they foreground competitiveness, price, and profitability, while simultaneously invoking elements of the industrial world through an emphasis on efficiency and technical performance. In contrast, the personal and moral dimensions articulated within ecological logics align with the inspired world, which values what is described as spiritual or moral elevation through passion. Finally, the ecological responsibility rationale reflects what Lamont and Thévenot (2000) conceptualize as the green convention, in which worth is grounded in the protection of nature and ecological integrity, and actions are justified by linking them to nature and ecological preservation.

While the logics invoked by the representatives of the Swiss pesticide complex broadly mirror considerations identified in the scientific literature, they exclude social equality and security concerns related to distributional effects and uneven exposure to pesticidal risks. This absence of a social justice or equity-oriented logic contrasts with frameworks such as those proposed by Möhring et al. (2025), which explicitly integrate social equality and security alongside economic, environmental, human health, and food security dimensions in assessing potential effects of transformations toward sustainable plant protection practices. However, the omission of social justice or equity-oriented logics does not indicate permanence: as the economics and sociology of conventions stipulate, conventions are not fixed or universal but evolve over time. Therefore, the current patterns of legitimation observed in the Swiss pesticide complex represent historically and culturally situated configurations that may transform in response to evolving circumstances within the pesticide complex.

8.3 Biocontrol's Role in the Swiss Agricultural Context

The synthesis of the empirical findings shows that biocontrol can contribute to more sustainable plant protection practices, but does not function as a stand-alone solution. Biocontrol does not simultaneously and comprehensively address all three pathways for reducing reliance on synthetic chemicals as identified by Finger (2026), namely, increasing efficiency, substituting chemical inputs, and redesigning agricultural systems (see Section 2.3). Instead, biocontrol operates selectively across these dimensions.

With regard to **increasing the efficiency** of pesticide use, biocontrol contributes primarily by diversifying plant protection strategies within integrated systems. By introducing additional modes of action, biocontrol products can complement synthetic chemicals, improve overall efficacy, and slow or mitigate the development of pest resistance. As Marrone (2024) emphasizes, biocontrol strategies are most effective when combined with other crop protection tools such as crop rotation, soil health measures, and habitat management, reflecting farmers' longstanding practice of mixing and rotating interventions rather than relying on a single solution. In this sense, biocontrol enhances efficiency not by replacing existing practices but by extending the functional repertoire of IPM approaches.

Beyond efficiency gains, biocontrol can also **substitute for synthetic chemical inputs**, albeit in a limited and conditional manner. The interview participants consistently stress that biocontrol is unlikely to fully replace synthetic pesticides in the foreseeable future, but rather to complement them as part of a "toolbox" approach to plant protection (IP2, pos. 52; IP5, pos. 6; IP8, pos. 22; IP10, pos. 49, IP11, pos. 19). Strengthening biocontrol can nevertheless reduce overall chemical use by reserving synthetic inputs for situations where other measures fail (IP2, pos. 52; IP5, pos. 6, 24), in line with IPM principles. As illustrated by IP10 (pos. 33), combined strategies that sequence chemical and biological interventions are already becoming common practice in Switzerland, underscoring biocontrol's role as a partial substitute rather than a comprehensive alternative.

A holistic approach to plant protection, however, extends beyond efficiency and substitution toward the **redesign of agricultural production systems** to reduce pest pressure structurally. This dimension raises the question of whether biocontrol merely reproduces and stabilizes current chemically intensive agricultural structures or opens pathways toward more fundamental transformation to alternative agri-food arrangements. To address this tension, the following subsections examine biocontrol's dual positioning: first, as a practice increasingly embedded in dominant agricultural structures, and second, as a potential catalyst for alternative practices. The following discussion draws on the theoretical concept of alterity (see Section 3.3), specifically on three interrelated dimensions: alternative products, alternative networks, and alternative economies (see Table 1).

8.3.1 Reinforcing Chemically Intensive Agricultural Structures

As described in Chapter 7, biocontrol is increasingly integrated into chemically intensive agricultural structures through economic, regulatory, and corporate mechanisms. This reflects a broader process of conventionalization, whereby alternative practices are absorbed into mainstream markets, reinforcing dominant agri-food industry logics (see Section 3.3). While historically associated with organic niche markets, biocontrol products are now widely adopted in chemically intensive agricultural production systems, dissolving the distinction between biological and synthetic chemical plant protection. Biocontrol is thus subject to industrial, regulatory, and market logics that shape its development and deployment. This integration signals a shift from biocontrol as an alternative practice toward biocontrol as a component of mainstream agricultural production.

This process of conventionalization is driven by both the biocontrol and agrochemical industries, each pursuing market expansion and strategic positioning. While specialized biocontrol companies leverage chemically intensive agricultural markets to ensure economic viability and environmental impact, agrochemical corporations incorporate biocontrol to expand business opportunities and stabilize the effectiveness of synthetic chemicals. Within this process, advisory services emerge as a crucial arena of influence, mediating how biocontrol is framed and applied in practice. As Bertomeu-Sánchez (2019) highlights, the involvement of expert and advisory services is one of the most debated issues in pesticide research. Empirical evidence from Switzerland underscores this influence and shows that advisory affiliation significantly affects farmers' plant protection strategies: Swiss fruit producers advised by public extension services are more likely to adopt preventive plant protection measures, whereas those advised by pesticide company-affiliated services rely more heavily on synthetic insecticides (Wuepper et al., 2021).

The mainstreaming of biocontrol entails both opportunities and risks for the transformation towards more sustainable plant protection practices. On the one hand, broader adoption can accelerate the diffusion and institutional acceptance of biocontrol products. On the other hand, premature market expansion, combined with variable efficacy, risks undermining trust in biocontrol as a whole, because ineffective products may damage its credibility (IP7, pos. 54). Additionally, from the perspective of the GPC, conventionalization fosters biocontrol's embedding within what Werner (2025) describes as "geographically extensive, functionally coordinated production networks" (p. 10). Like synthetic chemicals, biocontrol products are not isolated objects but shaped by global actor constellations, regulatory frameworks, and capital accumulation dynamics. While biocontrol's biological nature opens conceptual space for re-engaging with localized, place-based, intergenerational environmental knowledge, it may similarly increase farmers' dependence on external inputs and industrial expertise.

Within chemically intensive agricultural arrangements, biocontrol is often framed as a technical complement to synthetic chemicals rather than a driver of systemic transformation. To ensure compatibility with dominant practices, biocontrol products are explicitly formulated to function alongside synthetic chemical inputs and within existing application regimes (IP11, pos. 61). In this framing, biocontrol becomes a functional necessity for sustaining the performance of chemically intensive systems rather than a pathway toward alternative agricultural futures. Conventionalization thus situates biocontrol within the industrial pesticide complex and reproduces the prevailing logic of the agrochemical sector, supporting productivity, profitability, and system stability.

By stabilizing chemically intensive production systems, biocontrol can paradoxically reinforce the structures it is often portrayed as challenging. Although substituting synthetic chemicals may reduce certain risks, biocontrol does not address the root causes of pest pressure inherent in simplified, chemically intensive agroecosystems (Finger, 2026). As IP13 aptly summarizes, biocontrol can be "part of the solution" while simultaneously remaining "part of the problem" (pos. 12). Without structural changes to chemically intensive production systems, biocontrol risks mitigating symptoms rather than enabling transformation. This dual positioning highlights the ambivalent consequences of biocontrol conventionalization: it simultaneously enables alternative plant protection practices to become more present while reinforcing dominant market structures shaped by chemically intensive plant protection practices.

8.3.2 Creating Entry Points toward Alternative Agri-Food Futures

The process of conventionalization – also observed in other projects of alterity, such as organic agriculture, fair trade, and local food (Allaire, 2025) – tends to reproduce and stabilize existing chemically intensive agricultural structures. Biocontrol, in particular, is integrated into dominant economic arrangements, yet it remains closely linked to alternative products and networks. This positioning raises the question of what role biocontrol can play in advancing alternatives to chemically intensive agriculture.

As described in Section 7.1, the representatives of the Swiss pesticide complex associate biocontrol with alternative agri-food arrangements through its natural origin, links to organic farming, and reliance on ecological processes. Moreover, biocontrol practices often require closer observation, attentiveness, and collaboration, fostering new relationships between farmers, advisors, and other actors within the pesticide complex. These relational aspects reflect the multifaceted understanding of pesticidal products as stipulated by the GPC framework. Biocontrol is more than a technical, standalone input, but operates within a complex socio-technical assemblage. In this sense, biocontrol aligns with broader efforts to cultivate ecological engagement in agriculture. From this perspective, it aligns with the notion of alternative products and networks as stipulated in the alterity framework by Rosol (2020).

From an alterity perspective, biocontrol's significance lies in demonstrating that alternatives to synthetic chemicals are possible and practicable. Biocontrol can initiate incremental adjustments within chemically intensive systems by creating alternative options and imaginaries. For example, IP5 (pos. 26) argues that increased appreciation of agrobiodiversity can have transformative potential. Rather than narrowing pathways for transformation, biocontrol thus expands the repertoire of possible futures by adding diversity to plant protection strategies. As IP13 (pos. 24) notes, biocontrol offers practical pathways for reducing the use of synthetic chemicals rather than merely imposing abstract demands.

The interview participants refer to projects where biocontrol is selectively integrated to modify existing practices rather than replace them entirely. A case in point is pesticide-free, non-organic production systems, which give rise to a "third-way" of agricultural practice (Finger & Möhring, 2024). As IP10 (pos. 29) describes, such an approach rejects both full chemical intensification and strict organic standards in favor of context-sensitive, environmentally compatible practices. In this way, biocontrol contributes to agricultural arrangements that challenge binary distinctions between chemically intensive and organic agriculture.

According to Carolan (2013), transformative change does not depend on singular, fully developed, or universally applicable solutions, as these can be counterproductive and risk narrowing the very diversity and plurality on which transformative change depends. The historical dominance of synthetic chemicals underscores the risks of relying on one supposedly universal approach. Biocontrol, in contrast, contributes to more diversified and flexible landscapes of agricultural practices. It introduces alternative ways of doing, thinking, and relating to plant protection by foregrounding the plurality of substances, knowledge systems, and ecological relations involved. Biocontrol contributes to practices of "doing agri-food differently" by promoting cooperation, learning, and collective action. While these transformations are limited in scope, they nonetheless open spaces for experimentation and reflexivity. Biocontrol can thus be understood as one component within the diverse and plural approaches upon which transformative change in agri-food systems depends.

Against this background, biocontrol is not an alternative per se but rather an entry point toward alternative agri-food futures. It holds the potential to incentivize transformations from within existing agricultural arrangements. This reflects a pragmatic approach to alternatives, as proposed by Maye (2013), in which agri-food alternatives are not positioned in direct opposition to dominant arrangements but are understood as coexisting with them. This perspective also resonates with van der Ploeg's (2015) conception of alternatives as practices that operate in the interstices of the dominant "empires" of the global agri-food complex, spanning their inherent structural gaps. Rather than eroding the distinctiveness of alternative practices such as biocontrol, this perspective acknowledges their uniqueness while simultaneously recognizing the persistence of dominant agri-food structures (Allaire, 2025). Accordingly, biocontrol should not be understood as an oppositional project but as an entry point through which new forms of knowledge, practices, and relations can be introduced into dominant systems, thereby creating possibilities for incremental change from within.

9 Conclusion

In this thesis, I examined the potentials and limitations of biocontrol in Swiss agriculture as perceived by the representatives of the Swiss pesticide complex. Beyond identifying these opportunities and constraints, I examined how the interviewed actors legitimized their positions and discursively situated biocontrol within broader agricultural arrangements. The following research questions guided this analysis:

What potentials and limitations do representatives of the Swiss pesticide complex attribute to biocontrol in Swiss agriculture?

a. *How do the representatives legitimize their positions on biocontrol?*
b. *How is biocontrol discursively positioned in relation to chemically intensive agriculture and alternative agri-food arrangements?*

Drawing on expert interviews with 13 representatives of the Swiss pesticide complex and an analysis of scientific literature, policy reports, and official documents, I discursively analyzed the resulting narratives. The thesis pursued two complementary aims: first, to provide insight into how the representatives of the Swiss pesticide complex construct and legitimate their positions on biocontrol; and second, to evaluate the potential of biocontrol to contribute to alternatives to chemically intensive agriculture through the lens of alterity.

The empirical findings indicate that the potentials of biocontrol in Swiss agriculture particularly regard environmental protection, human health, resistance management, and social acceptance. The representatives of the Swiss pesticide complex consistently emphasized that biocontrol reduces chemical residues, protects soils and non-target organisms, and provides alternative modes of action that help mitigate the development of pest resistance. However, the adoption and effectiveness of biocontrol are constrained by multiple, interrelated challenges. These limitations include limited product availability, complex and lengthy regulatory processes, operational complexity, knowledge-intensive requirements, and economic risks associated with biocontrol. Specifically, the preventive nature of biocontrol, its often rapid degradation, and the need for close collaboration and coordination among farmers, advisors, industry, and educational institutions complicate implementation. Economic considerations, including high costs and limited shelf life, add another layer of difficulty.

Regarding the first sub-question, the representatives of the Swiss pesticide complex legitimize their positions on biocontrol in multiple ways, reflecting complementary and competing priorities. Ecological and moral reasoning is frequently mobilized to frame biocontrol as a responsible choice that supports environmental integrity and provides practitioners with personal satisfaction. Functional and food security logics emphasize the pragmatic need for effective pest management in intensively farmed agricultural systems, highlighting biocontrol as one tool within a broader integrated approach. Business and market-oriented rationales further shape legitimation, with biocontrol positioned both as a commercial opportunity and as a strategy constrained by production costs, regulatory barriers, and market expectations for high-quality, low-residue products. Overall, the analysis shows that these justificatory logics are not mutually exclusive but frequently intersect. While ecological and moral reasoning predominantly support biocontrol, functional, economic, and food security considerations are mobilized both to legitimize its adoption or to articulate its perceived limitations.

The findings further indicate that, with respect to the second sub-question, the discursive positioning of biocontrol in relation to chemically intensive agriculture and alternative agri-food arrangements is ambiguous. On the one hand, biocontrol is increasingly integrated into chemically intensive systems, aligning with industrial logics and globalized production structures. This process of conventionalization underscores biocontrol's status as a market commodity integrated into dominant agricultural structures rather than as part of an alternative economy. By embedding biocontrol within existing market and regulatory frameworks, dominant plant protection practices are stabilized. Through conventionalization, biocontrol risks reproduce the structural dependencies of chemically intensive agriculture.

On the other hand, biocontrol can function as an entry point for alternative agricultural practices. Its natural origin, alignment with organic production principles, and integration into collaborative advisory and farmer networks foster ecological awareness, attentiveness to biodiversity, and experimentation with context-specific plant protection strategies. The interview participants highlight biocontrol's capacity to support combined approaches that reduce synthetic chemical use without fully abandoning chemically intensive practices. From an alterity perspective, biocontrol is significant because it demonstrates that alternative pathways exist, even when not fully embedded in distinct economic or institutional structures. By offering concrete, practical strategies to reduce reliance on synthetic chemicals, biocontrol provides entry points for pluralistic plant protection practices, incentivizing incremental change from within existing agricultural arrangements.

This dual positioning underscores the ambivalent status of biocontrol: while conventionalization positions biocontrol as a stabilizing component within dominant agricultural structures, it simultaneously holds the potential to serve as an entry point for alternative practices. Rather than presenting a comprehensive solution for fundamentally transforming production systems or creating fully autonomous alternative agri-food economies, it creates space for experimentation, ecological engagement, and diversified plant protection practices. Its relevance, therefore, lies not in universality but in its capacity to support differentiated, holistic, and context-specific approaches. In this sense, biocontrol emerges as a meaningful, if partial, contributor to alternative agricultural arrangements oriented toward more self-reliant and resilient food futures.

The limitations of this research concern the restricted examination of the regulatory dimension, despite its perceived importance for biocontrol adoption among the representatives of the Swiss pesticide complex. A more detailed analysis of regulatory frameworks and processes of regulatory innovation could yield valuable insights into how institutional structures enable or constrain the implementation of biocontrol in Swiss agriculture. Furthermore, the analytical focus on chemically intensive agriculture, in contrast to alternative agricultural arrangements, entails a degree of simplification. While I tried to avoid reproducing the dichotomy between "conventional" and "alternative" agriculture, I nonetheless relied on a binary framing that does not fully capture the diversity and hybridity of farming practices and plant protection strategies. This reduction may overlook the full spectrum of context-specific approaches and strategies for plant protection that characterize agricultural practice in Switzerland.

In conclusion, this thesis demonstrates that within the Swiss pesticide complex, positions on biocontrol are legitimized through a combination of ecological, moral, functional, food security, and business logics, each shaping how its potentials and limitations are understood. Situating biocontrol within the GPC and assessing its alterity potential reveals both the structural constraints it faces and the avenues it offers for more diversified agri-food futures. Biocontrol is neither a panacea nor a fully autonomous alternative; rather, it constitutes a complementary approach that can enhance sustainable plant protection practices and support context-sensitive agricultural practices. Recognizing and addressing its context-specific limitations while mobilizing its identified potentials is therefore essential – not only for its effective adoption, but also for its capacity to open pathways toward alternative agri-food futures in Switzerland.

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Appendix A: Interview Guide

This interview guide presents exemplary questions used during the interviews. While a common structure was maintained across all interviews, the questions were adapted to the participants' backgrounds and areas of expertise.

1. Introduction
   - Welcome and thank the participant for their time.
   - Briefly introduce the thesis topic and research purpose.
   - Outline the structure of the interview.
   - Explain confidentiality, anonymity, and how data will be used.
   - Indicate the expected duration (approximately 45 to 60 minutes).
   - Invite any questions before starting the interview.
   - Request permission to audio-record the interview.

2. Background
   - 2.1. To start, I'd like to learn a bit more about you and your role. Could you please briefly introduce yourself and describe your role within XXX?
   - 2.2. Could you also give a short overview of XXX and its main activities?

3. Definition and Classification of Biocontrol
   - 3.1. How would you define the term "biocontrol" from your perspective?
   - 3.2. What types of products or methods would you include under this concept?
   - 3.3. What role does biocontrol play within the broader area of crop protection?
   - 3.4. What role does biocontrol play for XXX?

4. Biocontrol in Switzerland
   - 4.1. How would you describe the Swiss market for biocontrol?
   - 4.2. How would you assess the regulatory framework for biocontrol in Switzerland?
   - 4.3. How do farmers, distributors, and advisors in Switzerland perceive biocontrol products?

5. Potentials of Biocontrol
   - 5.1. From your perspective, what are the main potentials of biocontrol?
   - 5.2. What role could biocontrol play in reducing synthetic chemical pesticide use in Switzerland?

5.3. What instruments, incentives, or framework conditions could help to further strengthen these potentials?

5.4. Which of these factors do you consider most influential in the Swiss context?

5.5. What specific developments do you find particularly promising?

6. Limitations of Biocontrol

6.1. What do you consider to be the main limitations or constraints of biocontrol?

6.2. Considering the entire lifecycle of a biocontrol product – from development to application – where do you see the biggest hurdles?

6.3. How do you think these challenges differ between Switzerland and other countries?

6.4. How does XXX address these challenges?

6.5. What strategies or measures could help to overcome these barriers?

7. Outlook

7.1. How do you see the future development of crop protection in general?

7.2. Which trends do you think will shape the development of biocontrol over the next 5 to 10 years?

7.3. How is XXX preparing for these developments?

8. Final Questions

8.1. Is there anything we haven't discussed that you think is important for understanding biocontrol in Switzerland?

8.2. Would you recommend any other experts or actors I should speak with on this topic?

9. Closing

- Thank the participant again for their time and for sharing their insights.
- Offer the token of appreciation (small present).

Appendix B: Code System MAXQDA

- **Codes** **1044**
  - Anonymized Data 143
  - Strong Quote 73
  - Definition of Biocontrol 0
    - Biocontrol 0
      - Beneficial Organisms 8
      - Biopesticides 8
    - Natural Source 10
    - Conceptual Vagueness 14
    - Organic Agriculture 9
    - Compared to Synthetic Chemicals 21
  - RQ1: Potentials and Challenges of Biocontrol 0
    - Potentials of Biocontrol 0
      - Environmental Impact 12
      - Degradation / Residues 16
      - Resistance 8
      - Efficiency 6
      - Human Health 8
      - Attentiveness 6
      - Collaboration 4
    - Challenges of Biocontrol 0
      - Mode of Action 21
        - Specificity 12
        - Effectiveness 14
      - Biological Safety 12
      - Know-how 29
      - (Mis-)Information / (Dis-)Trust 24
      - Shelf Life 9
      - Business Model 14
      - Crop Yield 7
      - Availability 13
      - Price / Costs / Expenditure 36
      - Registration / Regulation 66
  - Plant Protection Issues in Switzerland 0
    - Contextual Approaches 4
    - Advisory Services 15
    - Balancing of Interests 13
    - Climate / Climate Change 8
    - Collaboration 13
    - Showcase Examples 12
    - Transparency / Data 9
    - Social Acceptance / Awareness 37
    - Economic Incentives 11
    - Disruption as Opportunity 2
    - Integrated / Combined Approaches 40
    - Policy Incentives 12
    - Research and Innovation 31
    - Relation with EU 20
    - Market Characteristics 18
    - Bans 30
    - System Transformation 15
  - RQ1a: Legitimation 0
    - Market Logic (Competition / Economic Rationality / Consumer / Price) 22
    - Fuctional Logic (Technical Performance / Effectiveness) 25
    - Food Security Logic (Ensuring Agricultural Production) 28
    - Ecological Logic (Less Damage / More Balance) 21
  - RQ1b: Alterity 0
    - Conventionalization 12
    - Alternative Economies 8
    - Alternative Networks 11
    - Alternative Products 11
    - Alternative Impact 13
- **Sets** **0**

Figure 4: Code system used in MAXQDA.

Appendix C: Interview Transcripts

The interview transcripts were submitted to the supervisor and will not be made publicly available.

Table 3: Abbreviations used in the transcript data.
The notation system is adapted from Hay and Cope (2021).

Symbol	**Meaning**
[hh:mm:ss]	Timestamp
IPX	Interview participant
HT	Interviewer
(…)	A self-initiated pause by a speaker
XXX	Anonymized data
//	Speaker interrupted by another speaker or event
(word)	A best guess at what was said

Declaration of Artificial Intelligence-Based Tools

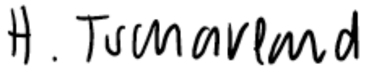
In this Master's Thesis, artificial intelligence-based tools have been used as follows:

- Language and structural improvements using ChatGPT (version GPT-5.2)
- Correction of language errors and formulation enhancements with Grammarly (version 1.148.0)
- Translation and stylistic refinements with DeepL Translator

All text parts created by AI have been checked by me, the author of this thesis. I take full responsibility of this text.

Personal Declaration

I hereby declare that the submitted thesis is the result of my own, independent work. All external sources are explicitly acknowledged in the thesis.



Zurich, 29 January 2026

Hannah Tscharland