PestiRed: A Swiss on-farm approach to reduce pesticide use in arable crops

PestiRed: On-Farm-Versuche auf Schweizer Betrieben um den Pflanzenschutzmittel Einsatz im Ackerbau zu reduzieren

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DOI 10.5073/jka.2020.464.044

Abstract

The concept of integrated pest management (IPM) has proven successful, however challenges in implementing IPM strategies remain. Furthermore, detailed investigations are needed to elucidate the performance and trade-offs of combined practices along entire crop rotations. In the framework of efforts to reduce the use of pesticides in Swiss agriculture, IPM in arable crops will be further developed in an on-farm project starting in autumn 2019. The overall aim of the project is to reduce pesticide use by 75% with a maximum yield loss of 10%. Preventive and alternative practices supporting natural control of noxious organisms (pathogens, pests, weeds) such as cover crops, intercropping, flower strips and biological control agents will be implemented and investigated in different 6-year crop rotations in a network involving 75 farms. The project involves scientists, farmers and extension services in a co-innovation process in five regions of the Swiss plateau. Effectiveness of the practices on weeds, diseases, pests and beneficials will be closely monitored and evaluated along the entire crop rotation.

Keywords: Alternative pest control methods, IPM, pesticide reduction, preventive pest control methods, profitability

Zusammenfassung

Das Konzept des integrierten Pflanzenschutzes (IPM) hat sich erfolgreich bewährt. Allerdings ist es immer noch eine Herausforderung IPM Strategien erfolgreich umzusetzen. Darüber hinaus fehlen umfassende Untersuchungen zu Effekten und Wechselwirkungen kombinierter Verfahren im Verlauf gesamter Fruchtfolgen. Im Rahmen der Bemühungen den Einsatz von Pflanzenschutzmitteln (PSM) in der Schweizer Landwirtschaft zu reduzieren, wird der integrierte Pflanzenschutz im Ackerbau in einem mehrjährigen on-farm Projekt weiterentwickelt. Projektbeginn ist Herbst 2019. Ziel ist es, den PSM Einsatz um 75 % zu reduzieren, bei einem maximalen Ertragsverlust von 10 %. Es werden vorbeugende und alternative Maßnahmen umgesetzt, die vor allem natürliche Regulationsmechanismen von Schadorganismen (Pathogene, Schädlinge, Unkräuter) ausnutzen. Maßnahmen wie Zwischenfrüchte, Mischkulturen, Blühstreifen und biologische Bekämpfungsmittel werden in unterschiedlichen 6-jährigen Fruchtfolgen in einem Netzwerk von 75 landwirtschaftlichen Betrieben untersucht und umgesetzt. Es handelt sich um einen co-innovativen Ansatz, an dem Wissenschaftler, Landwirte und landwirtschaftliche Beratungsdienste in unterschiedlichen Regionen der Schweiz beteiligt sind. Die Wirksamkeit der Methoden auf Unkräuter, Krankheiten, Schädlinge und Nützlinge wird über alle Fruchtfolgen beobachtet und beurteilt.

Stichwörter: Alternative Pflanzenschutzmaßnahmen, integrierter Pflanzenschutz, vorbeugende Pflanzenschutzmaßnahmen, Wirtschaftlichkeit

Introduction

Integrated Pest Management (IPM) came up as a result of initiatives taken to reduce the complete dependence on synthetic pesticides to manage pests and mitigate damages to crops (CIANCIO and MUKERJI, 2007). In Switzerland the concept of integrated production (IP) based on IPM principles for pest management was launched around 40 years ago (BAGGIOLINI, 1990). It includes measures, mainly agronomic levers, to reduce pest population outbreaks, which leads to the reduction of the use of chemical plant protection products (PPP) (ASIAT, 1989). Besides obvious positive effects on the environment and human health, a reduced use of PPP offers ecological advantages like the promotion of beneficial organisms and soil fertility, which in turn contributes to contain pest

populations. The IP concept contributes to the practice of sustainable agriculture and has been further promoted in Switzerland (HÄNI et al., 2014). Since 1999, several IP recommendations are even part of the requirements for direct payments (Swiss agricultural subsidies). IP was established as an alternative between intensive agriculture with a high level of inputs and organic farming without chemical inputs, facing a growing number of Swiss consumers who consciously and increasingly buy organic as well as IP products. However, the use of chemical PPP has remained high and in 2017, the Swiss federal council launched a national action plan aiming at pesticide risk reduction and sustainable use of PPP. As a part of it and because of proven detrimental effects on all form of life, the use of chemical PPP for crop protection against weeds, pests and diseases is becoming more restricted, and legal as well as label requirements become more and more strict. Authorized active substances are re-evaluated and a part of them will be banned in the near future. Therefore, it is indispensable to develop, test and implement prevention strategies and alternative control methods.

In this project, we aim at moving up a level by applying agroecology concepts. To further reduce the use of PPP, we will use preventive and alternative measures and combinations of them as well as promote biological regulation and benefit from ecosystemic services. In order to be successful, preventive and alternative measures have to be implemented in a coherent manner. Despite a good knowledge of the effects of different alternative and preventive control measures, an overall evaluation of these measures and their combinations under Swiss agricultural conditions for the medium term and under practical conditions is missing. Moreover, there is lack of knowledge about economic performances and how to limit sanitary risks.

The farmers take the ultimate decision, which control methods to be used, with or without chemical inputs. It is up to them to make a classification and to decide whether alternative measures will be taken. In Switzerland and in the surrounding countries IP or conventional farmers are reluctant to implement new knowledge about alternative control methods in cultivation strategies (CHÈZE et al., 2020). While they perfectly know their production conditions due to years of experience, there is a lack of shared and evaluated information about the possibilities and risks of alternative control methods. On the one hand, they do not easily have access to consistent information about the successful use of alternative strategies and measures. On the other hand applied research knowledge, which investigates scientifically the implementation and the success of alternative measures in agricultural practice, is missing. Alternative measures have to be part of an overall perennial approach (cultivation system) and their efficacy needs to be assessed in the long term in a local context.

This is where the project comes into play with its co-innovation approach. From the beginning of the project, practical knowledge is combined with the findings from advice and research implicating farmers, advisors and scientists. Practical cultivation concepts and diversified crop rotations will be developed and innovative control methods will constantly be assessed and if necessary supplemented and optimized.

Objectives of the project

Alternative control strategies for arable crops will be defined together with farmers, agricultural advisors and researchers and implemented on 75 farms distributed in five arable regions of Switzerland. With around 25% of the utilized agricultural area of Switzerland, arable crops are an important target when it goes to reducing PPP use. The objective is to greatly reduce pesticide use (-75% on average within the rotation) while maintaining yield and crop quality (a maximum economic loss of 10%). The acceptance of these alternative strategies by the farmers will also be evaluated, as well as the possibilities to extend these measures throughout Switzerland.

Approach and concept

The project is based on the principles of integrated production and the aim is agroecological crop protection. Agricultural production will be based on the functionalities of ecosystems, maximizing functional biodiversity and strengthening biological regulation in agroecosystems.

Existing fragmentary knowledge about preventive and alternative control measures will be integrated in a global approach over the duration of a diversified 6-year rotation. Mutual interactions between the different measures will also be exploited.

The project is based on a co-innovative approach. Acquired knowledge and experience are exchanged between practice and research. The three groups of actors (farmers, advisors and researchers) will closely work together in order to develop and optimize the measures and strategies of plant protection in which chemical pest control will only be applied as a last solution (Fig. 1).

Finally, the effect of the alternative plant protection measures will be examined under practical agricultural conditions and the farmers will receive financial contributions to compensate the additional workload and potential yield losses.

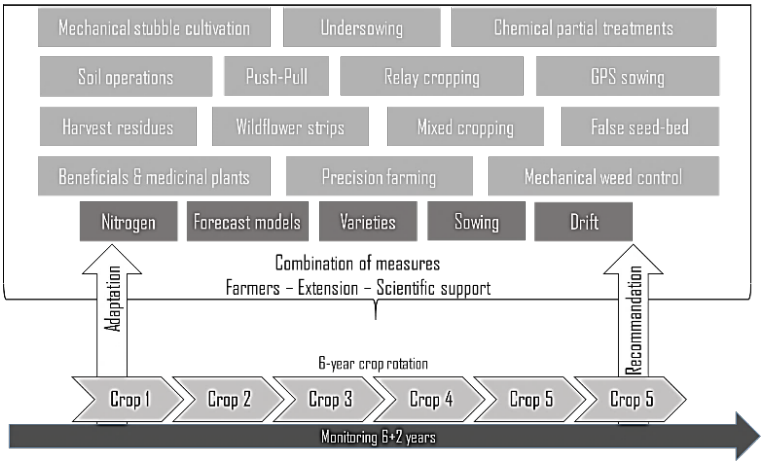

Fig. 1 Implementation concept of the PestiRed project.

Abb. 1 *Implementierungskonzept des PestiRed Projekts.*

Preventive and alternative plant protection measures

The measures will build on the principles of the integrated plant protection pyramid. Preventive measures (avoid or reduce initial populations of pest organisms) are given priority, followed by curative non-chemical measures such as biological regulation, the use of natural substances and mechanical/physical regulation (Tab. 1). Chemical control will only be used if the measures employed do not allow a satisfactory harvest. The optimization of the combination of measures will be an important innovative element of the project at the interface between research and practice.

The catalogue of measures currently consists of 23 measures. Five are basic mandatory measures and 18 are specific measures, which vary from one region to the other. The catalogue of measures will evolve over the whole project period in the framework of the process of co-innovation.

Tab. 1 Areas of action measures, mechanisms of action and objectives to be achieved.

Tab. 1 *Maßnahmengebiete, Wirkmechanismen und zu erreichende Ziele.*

Areas of action		Mechanism of action and objectif of the field of action
preventive	Measures aimet at the reduction of initial pest populations	Reduction of the use of PPP with agronomic measures, like diversified crop rotation and adequate soil cultivation against intitial pest populations, such as weeds (soil seed bank), plant dieseases (inoculum) and insect populations.
	(5 measures)	
	Measures of avoidance	Reduction of the use of PPP with optimized cultural measures such as optimized sowing (date, density, distance), intermediate crops,soil cover, associated crops, under sowing, competitive varieties, less susceptible varieties, push-pull technique. The preventive measures create inappropriate conditions for the developement of pest populations.
	(11 measures)	Promotion of natural antagonists by measures of habitat management.
curative (non-chemical)	Non-chemcial control measures	Reduction of the use of PPP with biological regulation measures (antagonists), based on natural substances, physical (thermal processes) and/or mechanical control measures.
	(4 measures)	Curative non-chemical control measures are given priority.
curative (chemical)	Chemical control measures (3 measures)	The targeted and reduced use of PPP based on the use of damage thresholds and forecasting systems. Chemical measures must only be used once all non chemical control measures have been exhausted.

Monitoring and scientific support

A semi-experimental network of 75 farms was built. Agronomic, ecological and economic performances will be monitored for 6 years on two fields per farm. Innovative plant protection strategies based on a combination of the above mentioned measures have to be implemented on an innovative field and will be compared to a) a control field with the same crop grown conventionally and b) to the performances obtained from 2015 to 2018 with the same crop on the same farm.

On the innovative fields and on the control fields each farmer will accurately record all agricultural practices applied and in particular those concerning the use of PPP and harvest characteristics (yield and quality). Agroscope guarantees an accurate monitoring of weeds, plant diseases, insect pests as well as antagonists at field level and in the surrounding environment.

The diminution of the use of PPP will be measured with the help of three indicators: a) treatment frequency index, b) number of interventions and c) amount of active ingredient per ha.

Profitability and acceptance of alternative plant protection measures

From an economic viewpoint, the adoption of alternative plant protection measures by farmers mainly depends on the expected profit, i.e. costs, benefits and corresponding risk. Furthermore, social (norms and motives) and dispositional factors (such as moral or environmental concern) are also important parameters (Dessart et al., 2019). Based on detailed data provided by all farmers via electronic field calendars and additional surveys, we will analyze the profitability and the acceptance of alternative plant protection measures.

To evaluate the profitability, we assess the costs and benefits for the innovative and the control field on each farm. To compare the two fields, we apply an extended contribution margin, covering variable costs of production as well as machinery and tillage costs and benefits. The aggregation of the economic data per crop and crop rotation on farm and regional level allows a detailed economic evaluation.

Dispositional factors, such as individual farming objectives, the resistance to change and moral or environmental concerns are twice collected via surveys of participating farmers: at the beginning of the project and to its end. Merging the results from the economic and social analyses allows analyzing and better understanding the acceptance and adoption of single measures. This is important for the upscaling of promising measures to a Swiss level and beyond.

Timeline and funding

The project start is 2019 and it will end in 2026. It will be carried by IP-Suisse, the Swiss farmers association practicing integrated production, in close collaboration with agricultural services, extension services and agricultural advisors of the three participating cantons (Vaud, Geneva and Solothurn). The project is funded by the Swiss Federal Office for Agriculture, IP-Suisse, the three implicated cantons and two private partners.

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