A Farmer's Toolbox for Integrated Pest Management Practices

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The German model project "Demonstration Farms for Integrated Pest Management"

Abstract

The German model project “Demonstration Farms for Integrated Pest Management” was set up to speed up the process of knowledge transfer and actively engage in knowledge exchange between growers, advisors, and researchers.

The main goals were the implementation and demonstration of IPM on selected farms, the analysis of indicators for IPM implementation and exchange on the acquired knowledge and information of a wider audience.

The project achieved a sound implementation and improvement of IPM practices. Depending on the crop and regional conditions, it is possible to reduce pesticide use in case-specific approaches. In arable crops preventive measures such as adapting crop rotation, choice of resistant or tolerant varieties, tillage or sowing times as well as monitoring and the use of decision support systems were improved. The close collaboration with the state advisory services is essential for the uptake of IPM at field level.

1. Introduction

Germany engages intensively in fundamental research and applied scientific activities to find pest control solutions for integrated pest management. However, many of the research results are adopted only at a low rate by the farming community. In acknowledgement of this fact, the Federal Ministry of Food and Agriculture (BMEL) has set up the model and demonstration project “Demonstration Farms Integrated Plant Protection” to speed up the process of knowledge transfer and actively engage in knowledge exchange between growers, advisors, and researchers. A network of demonstration farms implemented and demonstrated integrated pest management in the best possible way, identifying the possibilities and limitations under practical conditions and demonstrating the "best practice" in integrated pest management and innovations that contribute in particular to limiting the use of chemical pesticides to the necessary minimum.

The aim was to optimize the implementation of the IPM by adapting preventive measures such as the choice of variety, sowing time and crop rotation, the demonstration and testing of non-chemical and alternative methods, as well as the expansion of stand and pest monitoring directly in the field and indirectly through the use of decision support systems, thus reducing the dependence on pesticide use.

The project was embedded in the measures of the “National Action Plan for the Sustainable Use of Plant Protection Products”, which was decided by the Federal Cabinet in 2013 (ANONYMUS, 2013).

2. Research theme

This case presents the objectives of the initiative, its implementation and the results obtained to data. In more details, the reports addresses:

1. **Implementation and demonstration of IPM on selected farms**
    - introduction of innovative IPM methods, supported and supervised by project advisors;
    - implementation of project related crop- or sector specific IPM guidelines;
    - use of chemical pesticides limited to the necessary minimum;
    - reduction of risks that may result from the use of plant protection products.
2. **Analysis of indicators for IPM implementation**
    - adaptation and use of non-chemical measures;
    - costs for monitoring and advise;
    - intensity of pesticide use (treatment index);
    - economic and environmental impact (SYNOPS risk indicator).
3. **Knowledge transfer and public relation work**

3. Methodology

The case study was conducted through an extensive literature review and completed by interviews, including especially the actors of the network and the official authorities in charge of developing and monitoring the activities of the network.

4. Activities and results

4.1 Inception of the initiative

The project was embedded in the measures of the "National Action Plan for the Sustainable Use of Plant Protection Products", which was decided by the Federal Cabinet in 2013 (ANONYMUS, 2013). The project received an average annual funding of 1 Mio. € from the Federal Ministry of Food and Agriculture (BMEL).

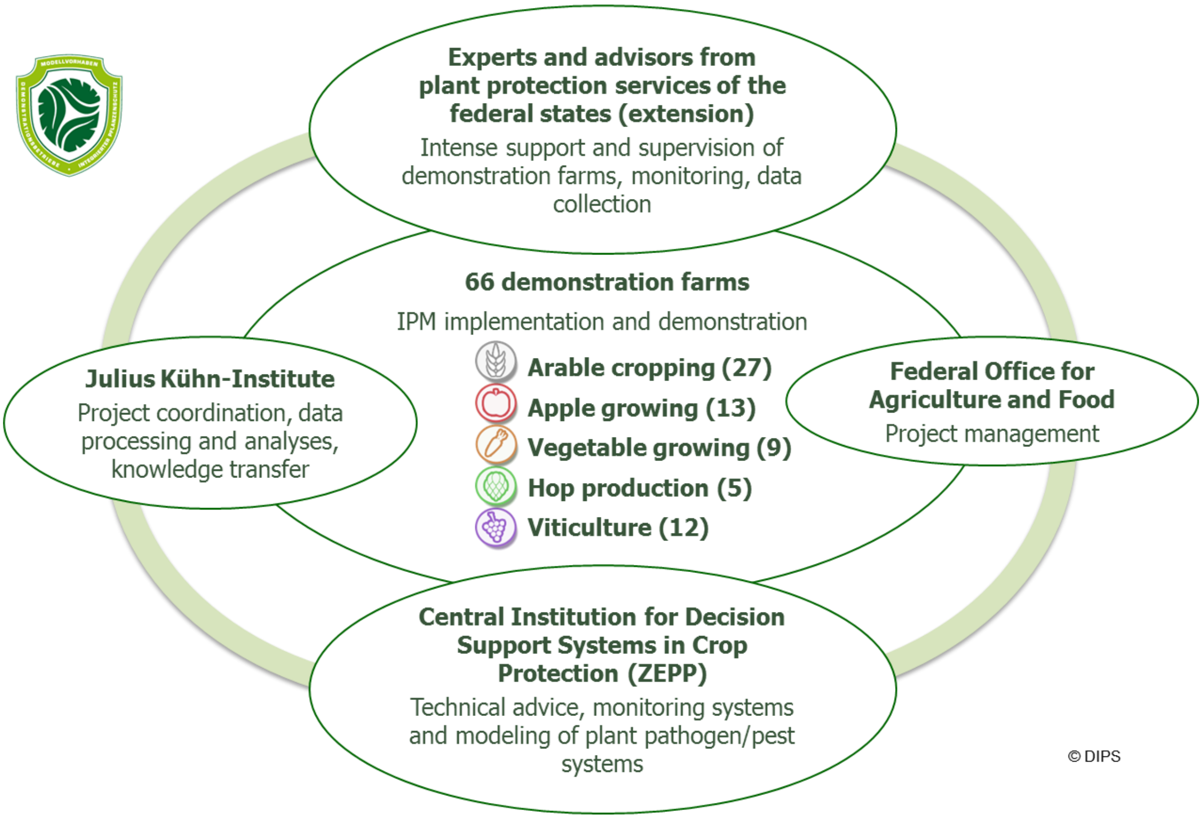

Figure 1: Collaboration of partners in the model and demonstration project "Demonstration Farms Integrated Plant Protection" (Gummert, 2016)

The close collaboration of partners in project ensured a smooth exchange of knowledge and innovations between especially the experts and scouts from the plant protection services, farmers and JKI researchers. Especially the organisational settings and expertise of the advisors as well as the intensive advisory support are decisive and conducive levers for the implementation of IPM at farm level.

4.2 Implementation

In the project, 66 farms in total participated over the project period from 2011 – 2018. Each farm participated for five years contributing three demonstration fields/crop, one farm reference field/crop and also the management data of two years prior to the project start from one field/crop.

Demonstration farms were established representing the main production sectors: arable field crops (29 farms in 7 regions), apples (14 farms in 3 regions), field vegetables (9 farms in 3 regions), vine grapes (12 farms in 3 regions) and hops (5 farms in 1 region).

Each farm provided the full data sets from their demonstration fields for the agronomic, monitoring and pesticide treatment data as well as economic analyses.

In return for their collaboration farmers were supported in their field-monitoring activities and decision making as well as with general advice form the demo-farm scouts. The scouts were responsible for five farms each and employed by the state advisory services as to ensure close links to the regional applied research and advisory services.

All farm data were collected in a data base, the monitoring data were recorded online using mobile devices and a front-end for data submission and direct submission into the database.

Statistical analyses covered in particular the assessment of the treatment frequency index (TFI) (developments on individual farms and regions), as well as its dependence on varying factors such as regional (soil-) conditions choice of varieties, sowing/planting dates/periods, cultural methods, farm size, etc.

Further, non-chemical methods were evaluated based on farmer/advisor assessments; time need for in-field monitoring; the use of prognosis and decision support systems as well as the evaluation of the uptake of IPM according to a checklist.

The risk indicator SYNOPS-GIS was used to assess environmental impacts. The assessment of the economic effects included total pesticide costs (cost for pesticides dose rates, application costs, monitoring costs) and gross margin per crop and region or in total per crop across all regions.

4.3 General outcomes

The main general conclusions of the project read as follows:

- Demo farms do not only implement IPM but they also motivate other farmers to adapt their practices via meetings, demonstration activities on farm days, dissemination through the project website and publications.
- IPM-practices and strategies which worked well, are easily adopted by farmers, or exceeded expectations. Intensive monitoring and comprehensive data collection have been recognised as helpful for decision making.
- Depending on the crop and regional conditions, it is possible to reduce pesticide use in case-specific approaches. The results of the demonstration farms in arable crops will be described in more details below.

The project was launched to promote the implementation of new integrated plant protection methods at farm level in representative German growing regions aiming at the reduction of pesticide use. Major parameters for the investigations in **arable crops** was use of resistant winter wheat varieties combined with intense monitoring and the use of prognosis systems and DSS, efforts to mechanical wed control in row crops (partly in combination with herbicide application), better adoption of monitoring and prognosis systems for the control of insect pests and fungal pathogens in winter oilseed rape.

The efforts in winter wheat resulted in a reduction of fungicide use (13 - 19 %) and growth regulators (18 %). Different mechanical weed management techniques such as mechanical pre-sowing weed management or combinations of mechanical weeding and herbicide use were tested (e.g. for black grass control: combination of straw hoeing and pesticide use) and resulted in optimal cases in a reduction of herbicide use between 6 – 30 % (depending on soil type and climatic conditions).

In winter oil seed rape the main factors were enhanced monitoring efforts for pests and the strict applications of thresholds, options for mechanical weed management, intercropping and under sowing (legumes) as well as the critical scrutinisation of pesticide use in general. The farms achieved an on overall reduction of pesticide use intensity. The largest potential for reduction of pesticide use could be observed for insecticide use (29 %) and the use of growth regulators (19 %). In one case the combination of hoeing with band spraying herbicides in winter oilseed rape achieved up to 60 % herbicide use reduction.

Monitoring is a key principle in IPM and was mainly conducted jointly by farmers and the scouts of the state advisory services. The time required for the field specific monitoring efforts were recorded. On average of all demonstration-fields in the respective crops monitoring required 147 min/field in winter wheat, 111 and 170 min/field respectively in winter barley and winter oilseed rape with an average of 8, 6 and 10 assessment dates during the season.

The **risk assessment** for aquatic, soil and non-target organisms was conducted by SYNOPS and highly dependent on the location of the farm and choice of pesticides. The achieved reduction of pesticide use did not result in significant changes of risk.

The **economic assessments** were based on the cost-benefit-analyses of the pesticide applications due to a lack of consistent data for farm-specific cultural and preventive or alternative methods. Thus, the plant protection costs refer explicitly to the costs of the pesticides used including the costs for application. The average costs for the pesticide use in winter barley were about 20%, in winter oilseed rape 11% and in winter wheat 17% lower on the demonstration farms compared to the farms of the network of reference farms for plant protection in the same area. The main reasons were lower pesticides use and the associated reduction of application costs. Those savings were possible due to choose of resistant or tolerant varieties and delayed sowing dates, intense monitoring, use of application thresholds and advisory support which were not included in the cost calculation. Therefore, the dimension of the cost reduction can be seen only as an indication and rough reference values.

In summary, the farms actively participated and demonstrated the benefits, engaged intensively in peer discussions and exchange on technical experiences. Further demonstration activities were conducted and discussed at regular farm days in the different sectors and covering different subjects. Publications and articles in farmer magazines were welcomed by the wider audience. https://demo-ips.julius-kuehn.de/index.php?menuid=81.

In more details, the following conclusions per crop or group of crops can be made:

- **Apple:** Farmers who participated in the project already produced under integrated production scheme and therefore on a high level of IPM. In the project they tested several additional IPM measures such as traps for mice, mowing of ditches especially for the control of common green capsids *(Lygocoris pabulinus*), pheromones as a confusion technique against codling moth (*Cydia pomonella*), ptimisation of mechanical weeding or pruning and row cleaner to prevent infestation of fungal pathogens (*V. inaequalis*).
- **Hops:** Farmers apply already several IPM measures such as tolerant varieties which are important to save in fungicides, although there is little room for manoeuvre as the quality is the major criteria for marketing the produce. Other methods used were catch-crops, mechanical weed control and hop-cleaning or control of spider mites. Many of the mechanical methods are labour-intensive and weather-dependent, but still practicable and effective and will be continued after the end of the project.
- **Horticulture**: Farmers increasingly grow more tolerant varieties. The highest potential for disease and pest control contributed cultivation breaks and the cultivation of break/pre-crops, biological fungicides (e.g. Contans WG) and others are used in carrots against soil-borne pests and mice. Intensive monitoring clearly contributes to reduce pesticide use as well as nets for protection against insects (vine and vegetable) but entails large costs. There is a potential of mechanical weeding, but it is already applied frequently.
- **Vine**: Mechanical weeding can be applied successfully but is not applicable for every vineyard as well nets for protection against spotted wing drosophila. Reduction in the application of insecticides due to confusion of grape moth with pheromones (RAK 1 + 2), application sequences that are benign on predatory mites saved acaricide treatments and the use of fungicides could be reduced because of preventive IPM measures such as the reduction of leaves or thinning of the grapes.

Feedback rounds with the farmers provided substantial evidence that they integrated a selection of new and improves methods in their farming systems. Some methods were not integrated to full extent such as monitoring.

The IPM Demonstration farm project will not be continued due to limited project funds. In the frame of the German Arable Farming Strategy 2035 a new project is under preparation which addresses the challenges of integrated crop protection. The project will be conducted in several regions of Germany and farm demonstrations will cover at least three of the eight core themes of the arable farming strategy.

4.4 Barriers (to implementing the project)

The main challenge for the project was the limited financial background, i.e., funds were only available for the period 2011 – 2018 and the participation of the farms was therefore limited to five years. This is a barrier as regards to implementation of preventive measures such as crop rotation and mechanical weed management. The effects of e.g., resulting in lower pest, disease, weed pressure and respectively lower pesticide use or improved biodiversity only become apparent only after several years in the assessment of a/several full crop rotations.

Such assessments toward long-term sustainability could not be addressed within the limited project period.

Another general challenge throughout the different crops is the lack of availability of sustainable biological, physical and other non-chemical measures which provide satisfactory and efficient pest control.

For example: the application of Contans WG (*Coniothyrium minitans*) in winter oilseed rape against stem rot (*Sclerotinia sclerotiorum*) only gains sufficient control results at higher infestation levels but is also cost intense. In the project, control of stem rot during flowering achieved better control and was economically more efficient.

The use of netting to prevent infestation and damage caused by insects was tested in carrot and cabbage as well as in the vineyards and apples. The nets can provide sufficient control especially in vineyards and cabbage but entails high financial investments, additional workload and sometimes even additional fungicide treatments due to changing microclimate below the cabbage nettings.

5. Discussion and conclusions

The main conclusion of this project is that IPM works based on the implementation (and full exploitation) of the general principles. Also, a certain degree pesticide use reduction can be achieved. Although the impressive results of the project should not hide the fact that the success different methods is highly farm dependent or even field specific and to a large extent depends on annual (weather) conditions. Thus, there a standard cannot be applied for all farmers. They must have a choice of methods at hand and be able to apply different combination of methods (also over the years). For example, the cultivation of legume under sowing in winter oilseed rape depends on sufficient precipitation in autumn for its establishment, freezing temperatures in winter for its destruction in order to avoid herbicide use in autumn and/or spring.

A lot of effort was put into the demonstration and testing of mechanical weed control. This included repeated post-harvest cultivations, ploughing, the use of the straw harrow before sowing and the harrow in cereals, the use of the hoe-belt-sprayer combination (in optimal cases achieving up to 60% herbicide use reduction) in row crops as well as the introduction of legume under sowing in winter oilseed rape and mulching the maize stubble.

In most of the farms, the intensive monitoring of project scouts was supported by the state advisory services in order to ensure situation-specific, damage threshold-based decision-making process. The monitoring and also the use of forecast models was better established and trust in the systems enhanced in the farms. For economic reasons (time allocation and work force), however, most companies stated that they would not be able to continue monitoring to the same extent as carried out in the project.

The optimization of the IPM in arable farming requires an intensive, continuous infestation survey on the field and the use of current forecast models and thus the strengthening of independent, situation dependent and self-confident decisions by the farmer. During the project, it was possible to raise awareness, increase confidence in prognosis systems and decision support system (DSS) as well as to reduce risk aversion.

A potential has been identified for the reduction of costs for mechanical weed control, but the higher workload is a major obstacle for many farms. Furthermore, the machinery with high performance rates on large fields requires considerable additional costs or financial investments. In the event of poor operating results, however, this would mean an additional economic risk.

More efforts are needed especially as regards to the development of economically and ecologically viable alternatives for all sectors. Also, alternative measures and the use of synthetic chemical pesticides should be evaluated comparatively with regard to their environmental impact (CO_2 footprint, emissions of other environmentally relevant substances).

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