International Journal of Pest Management

ISSN: 0967-0874 (Print) 1366-5863 (Online) Journal homepage: http://www.tandfonline.com/loi/ttpm20

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To cite this article: Jay Ram Lamichhane, Birol Akbas, Claus Bo Andreasen, Wilma Arendse, Sylvia Bluemel, Silke Dachbrodt-Saaydeh, Annika Fuchs, Jean-Pierre Jansen, Jozsef Kiss, Per Kudsk, Jean-Claude Malet, Alberto Masci, Anabel de la Peña, Astrid S.T. Willener & Antoine Messéan (2018): A call for stakeholders to boost integrated pest management in Europe: a vision based on the three-year European research area network project, International Journal of Pest Management, DOI: 10.1080/09670874.2018.1435924

To link to this article: https://doi.org/10.1080/09670874.2018.1435924

Published online: 08 Feb 2018.

INTERNATIONAL JOURNAL OF PEST MANAGEMENT, 2018
https://doi.org/10.1080/09670874.2018.1435924

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A call for stakeholders to boost integrated pest management in Europe: a vision based on the three-year European research area network project

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ABSTRACT

Recent years have seen an increasing effort towards the development and adoption of sustainable crop protection strategies, especially in the EU. Several policy frameworks have been put in place including the EU framework Directive (128/EC/2009) on the sustainable use of pesticides. Consequently, all EU Member States developed National Action Plans to ensure the implementation of the general principles of Integrated Pest Management (IPM) by all professional pesticide users starting from January 1, 2014. On the other hand, there are also difficulties related to the adoption of IPM in Europe and worldwide which seek for a better understanding of factors hindering IPM uptake. This paper presents the potential role that each actor of the food chain may have – called here stakeholders – to ensure a higher level IPM adoption in Europe. The information reported here is a summary based on several discussions held within a three-year European Research Area Network project on Coordinated Integrated Pest Management (ERA-Net C-IPM; http://c-ipm.org/).

ARTICLE HISTORY
Received 10 November 2017
Accepted 28 January 2018

KEYWORDS
Demonstration farm; knowledge sharing; obstacles; pesticide risk perception; socio-economic drivers

1. Background

Integrated Pest Management (IPM), as defined in the Directive 2009/128/EC, can be viewed as a continuously improving system in a spatial and temporal scale in which innovative solutions are integrated and locally adapted as they contribute to reducing reliance on pesticides in cropping systems (European Commission 2009). Such improvements derive from the fact that the system responds to diverse farming situations. An optimal IPM decision process is based on sound knowledge of the entire cropping system and available information and tools which need to be combined or improved. This flexibility and resilience in space and time are strengths on one hand and challenges for IPM implementation on the other. Indeed, the rate of IPM adoption is heterogeneous across countries/regions of the world, including the EU, and is affected by different social, economic, environmental and institutional factors (Parsa et al. 2014; Lefebvre et al. 2015).

It has been reported, based on studies performed in an North American context, that farmers who used IPM for pest management (pests in *sensu lato* that includes pathogens, animal pests and weeds) faced severe pest resistance problems, while those who did not practice IPM were still achieving adequate pest control (Alyokhin et al. 2015; Beckerman et al. 2015; Owen et al. 2015). The reality is that farmers who practice IPM are controlling pests and forestalling resistance issues while those who hold onto the "old ways" are losing control of pests on their farms. Recent works performed in the EU have clearly identified the potential that IPM has to reduce reliance on conventional pesticides while preserving crop productivity and profitability (Lechenet et al. 2014, 2017). Although problems related to resistance development are of concern in the EU as well, the extent of the problem is significantly different than what has been occurring in North America (European Commission 2017). This can be ascribed to numerous efforts by research, extension and policy in the EU for the development and adoption of IPM principles (Barzman et al. 2015), as well as restrictions in use and/or banning of a large number of pesticides considered harmful to human health and the biodiversity (Lamichhane et al. 2016b).

With the aim of fostering IPM in the EU, recent works have dealt with several aspects of IPM, their importance

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in European agriculture and the current move towards a reduced reliance on pesticides (Lamichhane et al. 2016b; Lamichhane 2017; Lescourret 2017), major problems in terms of IPM research and innovation (R&I) and importance of networking beyond boundaries to address current IPM R&I challenges (Lamichhane et al. 2015, 2016a). Nevertheless, to our knowledge, there is limited information in the literature with regard to the role of stakeholders to promote IPM adoption in Europe. Additionally, the widespread uptake of IPM methods remains heterogeneous or confined to particular crops or cropping systems. Here we describe the major points we identified concerning practical issues hindering IPM adoption and the role of stakeholders to overcome such obstacles. A detailed debate on IPM or discussions about obstacles to IPM adoption on a global scale will not be addressed. The issues discussed here are a summary based on the outcomes of workshops, conferences and annual meetings held within the frame of the European Research Area Network on Coordinated Integrated Pest Management (ERA-Net C-IPM; http://c-ipm.org/) which intended to contribute via coordinated knowledge sharing and research efforts to overcome those impediments. Most of the reported statements and findings in this paper are original conclusions and therefore only few and EU-centric references are cited throughout the paper.

2. How stakeholders can promote IPM?

2.1. Policy frameworks

In the context of IPM, the policy frameworks in the EU are formed by three decision-making levels: European, national and local/regional. The efficient integration and harmonization of these levels play an important role in promoting IPM adoption.

While the implementation of the general principles of IPM is mandatory in the EU, the adoption of crop specific guidelines remains voluntary. This may increase the risk of slow IPM adoption and therefore crop specific guidelines need to be developed in Member States (MS; Lamichhane and Messéan 2016). In addition, a high heterogeneity in the level of commitment and circumstances among the EU MS further increases the potential disparity in terms of IPM adoption across the EU. In such a situation, appropriate stakeholder networks need to be put in place to harmonize the level of IPM adoption across the EU MS.

Another important issue is that there is a need to articulate the speed of pesticides withdrawal from the market and the pace of IPM development. It is obvious that the farmers might face major problems if widely used pesticides are removed from the market faster than IPM strategies are developed. Consequently, detrimental to the desired effect of changing management practices to build resilient systems and reduce the overall pest pressure, farmers continue to use pesticides and possibly applying other pesticides to obtain the same pest control level which may also trigger problems related to resistance development and higher environmental risks. An additional problem is due to the differences in pesticide availability among the EU MS because of specific national legislations. Farmers are aware of the fact that some pesticides banned in their own countries can be legally applied in neighbouring countries. This – in addition to promoting illegal trade of pesticides across borders – creates further confusion and thus limits the suite of tools and effective pest control.

Biocontrol is part of IPM strategies to achieve sustainable pest management. However, the lengthy and expensive registration process of plant protection products is a main obstacle to develop effective biocontrol solutions in the EU (Lamichhane et al. 2017). This is one of the reasons why there is a gap between the market offers of biocontrol solutions and the demand of farmers in the EU. Thus, appropriate policy frameworks are needed to remove legal burdens and encourage industries to invest in the development of effective and reliable biocontrol solutions for a broad range of crops.

Understanding the drivers of IPM adoption requires a broader multidisciplinary approach because IPM covers a large set of principles and is, by far, not solely limited to reducing pesticide use. Thus, obstacles related to IPM adoption should be the focus of policy (Lamichhane and Messéan 2016). There is a widespread consensus that IPM relies on the thorough understanding of cropping systems which requires broad knowledge, decision making priorities and processes for the use of appropriate tools are complex and maybe more costly than crop protection based on chemicals. But even if IPM measures do not cost more, not every farmer may desire to follow each individual principle (e.g. action thresholds) due to risk perception or habits or insecure yields. Beside technical incentives and the accessibility of knowledge, governments, stakeholders and the market partners have to increase the motivation of farmers. A recent study (Buurma and van der Velden 2017) highlighted that the motivations of the farmers and the support of their value chain partners play an important role in IPM adoption. In particular, the possibility to access high market segments with higher product prices has been reported as a primary motivation for farmers to adopt a new IPM technology as it allows obtaining higher revenues.

The retail and the social environment of the farmer and the public opinion are also important drivers in the choice of plant protection measures (Lamichhane and Messéan 2016). To this aim, policy makers and farmers' organizations should aim to mitigate those ever increasing requirements of the retail chains (see

below) and engage with them in discussion to foster IPM. As for the social environment of farmers, if a farmer is able to show that, in addition to only focus on securing the harvest in the short term, it is worth to also take into account the long-term consequences of the farming practices (e.g. of resistance development, health issues), this could be an effective way for other farmers to learn and adopt IPM solutions. Such issues are central to the success and evolution towards sustainable farming and to encourage adequate policy frameworks that help improve IPM adoption in Europe.

2.2. Research and knowledge transfer

Overall, the adoption of new knowledge, methods and technologies into practice is a challenge in agriculture (Moore 1991). The European Commission outlined this challenge as "closing the research and innovation divide" (CORDIS 2014). Indeed, it clearly emphasized that rather than the continued knowledge generation via scientific projects, research results are often not sufficiently exploited into practice. Likewise, the Standing Committee on Agricultural Research recently concluded that the current model of technology transfer from science to end-users is "linear and outdated" which should be replaced by an interactive model of networking systems capable of integrating knowledge production, adaptation, advice and education (SCAR 2016). All this information emphasizes the fact that there is a need to find an alternative way to increase the effectiveness of research and knowledge transfer into practice.

Instead of a narrow focus on specific crop-pest relationships, IPM adoption will benefit from a broader system approach in research. For many crops we already have substantial knowledge of the individual crop-pest relationships, and what lacks is the overall research to combine them into system guidelines or the updating of existing guidance documents. Those system guidelines enable farmers to make sound decisions and weighting between benefits and shortcomings. More importantly, machine learning and other decision making approaches, such as analytical hierarchy processing, may play an important role in the IPM adoption process although these issues were not discussed within the ERA-Net.

Based on the discussions held during the ERA-Net C-IPM, lack of fast, timely and efficient knowledge transfer between research and practice appeared as one of the key obstacles to IPM adoption (Lamichhane and Messéan 2016). Driving research by practical questions and via an in-depth understanding of the entire production chain may help reduce the existing gap between research and practice thereby providing a better basis for farmers towards IPM adoption. Access to the available knowledge is another leverage for farmers towards IPM adoption, although the supply of knowledge and technologies alone is not enough for adoption of IPM innovations (Buurma and van der Velden 2017). However, in some countries the gap between research and practice is still large. Extension services are crucial and demand from science solutions based on a holistic approach. The advisors have an important role to play both to confer the research results into practice and to communicate the practical management problems from the farmers to the research community.

The adoption of IPM will be impaired by the lack of proper knowledge transfer into practice. Therefore, these aspects have to be integrated into the IPM research projects. The incorporation of IPM knowledge in the education system is another potential means to ensure that farmers are better prepared to handle the challenges that IPM poses (Lamichhane et al. 2016a). Taken together, knowledge transfer should be accompanied with a broader capacity development of farming communities to find appropriate solutions for future pest or farming problems.

The economic aspects related to IPM adoption are poorly addressed to date, but crucial to the farmer (Buurma and van der Velden 2017). One of the key reasons behind a slow adoption of IPM, as given by farmers, is the lack of robust evidence of an economic benefit it may offer compared to conventional crop protection system (Labussière et al. 2010). IPM has to be cost-effective for farmers – as they depend on securing the harvest, a high productivity, high quality of the produce and making a profit – otherwise the IPM strategies are not perceived as a realistic alternative to pesticides. This issue has been poorly addressed by research until now.

The farmers and advisors are dependent on effective communication channels from research and advisory services. The development of online platforms with all useful information available and guidelines for a variety of crop management situations must be readily available for the farmers. Information flow and education and/or training for all concerned groups of the food chain are needed for an improved IPM adoption (Lamichhane and Messéan 2016). Farmers should have access to education and initial training on IPM methods, as well as about the added value of adopting IPM for human health and the environment. Better information, training and education on IPM approaches and its value in sustainable production is of importance to overcome perceived risk and better understanding of the production process for all concerned groups.

Most of the present research approaches focus on specific research questions, and specific crop-pest interactions, and do not always consider the practical dimension, where farmers often face a combination of factors. Applied research can play a pivotal role to

bridge the gap between fundamental research and farming realities. In addition, an indicator – which informs on the societal, environmental and economic benefits in the easiest way possible – should be developed to help assess pros and cons of IPM.

Overall, a two-track planning – one focussing on existing problems and the other trying to anticipate possible future problems– will be beneficial for IPM adoption. The existing problems might be solved with specific crop-pest approaches, whereas the holistic approach is essential for the long term pest management.

2.3. Farmers and demonstration farms

Any tool that allows demonstrating the sustainability (all economic, environmental and social) of a system may help IPM adoption. Because farmers are the key actor of the IPM adoption process, demonstration farms are one of these tools to show farmers that the IPM adoption can ensure yields and may lead to long-term benefits (Lamichhane and Messéan 2016). The idea of demonstration farms cannot be materialized without full involvement of real farmers and detailed analyses of financial security/stability of farmers. Several countries in Europe have established demonstration farms, used for several purposes – including validation of IPM tools, farmers meetings and dissemination through videos, booklets and agricultural platforms. In particular, demonstration farms establishing actual trials with predetermined protocols may act as research supporting and research disseminating services.

Demonstration farms have large potentials to be innovative and test cutting-edge technologies. To this aim, innovative tools or approaches that pose certain risks in their adoption are tested on-farm, reflecting that there is a large aspect of "learning by doing" in IPM. Consequently, even "economically risky" but innovative strategies should be tested to determine their feasibility across different pedo-climatic situations. The interest of a farmer increases once they begin to see the logic in IPM. Over time, this can lead to increasing interest of other farmers in IPM. Taken together, in addition to other stakeholders, the involvement of pioneer farmers (early adopters) in such initiatives is of paramount importance. The latter group of farmers are a driving force behind the innovative farming system designs and thus have a large influence on other farmers at the local level.

Demonstration farms implementing and testing specific IPM elements can, generate relevant information to cope with existing problems. To put in place more system-oriented approach, demonstration farms will help develop highly advanced IPM strategies. At the same time, they will be a source for foreseeing the future problems and help addressing more complex issues. In countries with limiting budget, this means allocating the IPM efforts in fewer demonstration farms, but with a more experimental focus on IPM development.

There are many possibilities for collecting data from demonstration farms including i) retrieving data from present and past large and long-terms field experiments, ii) reviewing already existing economic data from farmers (groups) over the years, and iii) using data from the large reference farms networks (also of agro-chemical industry). A meta-analytical approach of these data may be of good scientific value as well to understand potentiality of demonstration farms to foster IPM adoption.

2.4. Communication

All possible communication channels and media should be engaged in producing clear and simple messages for the general public (Lamichhane and Messéan 2016). The real risk vs. the perceived risks of consumers should be explained by science via "easy-to-understand" messages. Social networks have a good potential in this context, especially to reach the young generation. The media people should be better informed and educated via appropriate public policy frameworks to avoid a simplified good or bad vision of complex topics such as IPM especially to consumers. Creating an understanding along the food chain enables IPM methods to become widely adopted in practice and not be impeded by retail chain requirements. Therefore, farmers need to be proactive rather than reactive and be empowered to produce according to IPM guidelines, while responding to the requirements of the retail chain.

IPM, per definition, includes a more sustainable pesticide use which is not always an easy message to communicate to consumers. IPM can be a marketing solution to address certain market problems (e.g. sustainability, water usage etc.), and can be used by marketing specialists to cope with retail demands. In addition, the use of certain new genetically modified techniques in new breeding programs should be made transparent to the consumers through marketing.

More effort needs to be put into communicating the value of IPM for the general public in improving sustainability of food production without jeopardising food security. General public, including children, should be informed about food production methods, comprising IPM, and how difficult it can be to produce foods, especially with regard to plant protection measures. The general public should be educated about the consequences of what no crop protection would mean, as it is unlikely that conventional or organic farmer will grow their crop without any protection. That means addressing global food security and to show how difficult it is to address this issue in the total

absence of pesticides may help increase awareness raising of the general public.

One of the difficult tasks is to convey the message to the consumers concerning the fact that IPM is the compromise between environmental, sustainability and global food security. Although farmers seek to use nonchemical tactics whenever possible, pesticides still play an important role in IPM. There is a wide spread perception of the general public, especially in Europe, that all pesticides have the same negative effects on human health and the environment. The use of the Environmental Impact Quotient may help distinguish different toxicity level of pesticides currently used in agrioculture.

There is a great challenge in turning farming into an attractive profession for young people so that they can become a new type of "societal rewarded farmer", who manages their farms with sustainability as the main focus. Organic farming organizations have had success in attracting young farmers, by focusing on the positive image among consumers but also by highlighting the professional challenges and its social and financial benefit that organic farming poses compare to conventional farming.

2.5. Retail chains

Overall, marketing companies could negatively or positively affect IPM adoption via the requirements they can impose to producers from whom they buy the agricultural products. In particular, these companies can seek that the production process of an agricultural product complies with IPM production standards via adoption of best cropping practices.

Presently, retail chains often represent a constraint for IPM because of their demand for zero residue levels or below the legal maximum residue level of some pesticides that are often chosen following a public debate on specific pesticides rather than on a scientific basis (Lamichhane and Messéan 2016). Such retail standards can be counterproductive to the IPM concept with regard to pest resistance management, to the use of selective pesticides, treatment thresholds and environmental sustainability. Therefore, there is a need that, retail chains and other stakeholders of the food chain jointly engage to put in place frameworks that help adopt IPM.

2.6. Consumers

Consumers are a stakeholder group that partially impacts on production schemes and market opportunities (Lamichhane and Messéan 2016). A recent study showed that information on IPM guidelines increases IPM products purchases (Lefebvre et al. 2017). The purchase behaviour of consumers, however, is often affected by economic reasons. To extend the focus of the consumers on IPM-based products, there is a need for producers to actively engage with the retail sector.

The social aspects of IPM adoption are largely a matter of perception and buying behaviour of consumers (Lamichhane and Messéan 2016). Consumers are highly influenced by headlines in the news and the interactions on social media, which leads to increment focus on certain issues related to agricultural production in the short term. The behaviour of the consumers, however, does not reflect the public dissatisfaction with regard to the environmental effects of agricultural production. For example, many consumers choose organic products because they are perceived to be healthier and of higher quality. However, little is known as to whether IPM products would be accepted by the consumers since the retailers do not put sufficient effort to develop "a third brand" given that they already invested a lot in promoting organic products. As a result, IPM products have difficulties to be distinguished from products from conventional farming. While the sociological aspects of IPM acceptance by consumers are very important, without full adoption and acceptance of IPM practices by farmers, the chance for working together across farmer-consumer platform could be difficult to achieve.

There are some emerging trends among consumers who are becoming more interested in "local production", "the farmer behind the products", having their own production (e.g. vegetable garden, mini-plants) and the nutritious value of the products (e.g. "vegetables are my pharmacy"). In addition, the perceived risk of pesticides by consumers is a clear driving force to minimum residue levels settings below the legal thresholds which, however, could be counterproductive to IPM.

3. Conclusion

IPM, if developed separately from broader aspects, will remain a theoretical discussion confined among IPM specialists without any real and practical progress. In contrast, IPM being part of Integrated Crop Management and Integrated Farming represents one of the most effective means towards a sustainable agriculture, which is environmentally friendly, economically viable and socially responsible. In such a way, IPM allows to address the increasingly evoked issue of global food security, on one hand, and environmental sustainability, on the other.

The concept of IPM has often been criticized. The authors group, however, considers that IPM *per se* is neither a wrong nor a static concept. If stakeholders of the food chain are not able to evolve IPM and fully exploit the full range of options, perhaps a more thoughtful reflection is needed on our capacity to adapt this system to our current need. It is clear that if problems of pest resistance evolution have risen in

agriculture, it is not due to the IPM concept nor because of the type and number of pest management tools it assembles. The problem is simply due to how those tools and concepts have been poorly applied for pest management. We recognize that the effectiveness of current IPM programs can be improved using a more holistic approach so that the combination of all IPM tools has a higher effect compared to separately applied individual pest management tools.

As for any system, the success of IPM depends on the joint effort that will be put in place by all stakeholders of the food chain. The information reported in this paper – based on discussions held with a large group of stakeholders – may help reflect where the future efforts should be directed to improve IPM adoption. Most of the obstacles related to IPM adoption reported in this paper are in agreement with a very recent overview report published by the Directorate-General for Health and Food Safety (European Commission 2017) on the adoption rate of IPM measures as well as main obstacles encountered in the implementation of the sustainable use Directive. In addition, a key point of criticism reported in the report is the lack of tools to measure the adoption of IPM by farmers. Therefore, research and policy should focus to develop simple and easily applicable tools/indicators that could measure the rate of IPM adoption in the EU which will further help increase the confidence of consumers and retailers in IPM.

Acknowledgements

The authors thank all partners of the ERA-Net C-IPM and all those who directly or indirectly contributed to C-IPM activities, through their active and valuable contribution to the discussion. The ERA-Net C-IPM is funded by the EU under the 7th framework programme (Grant agreement number 618110).

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The EU [grant number 618110].

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