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Greener European Agriculture? Evaluating EU Member States' Transition Efforts to Integrated Pest Management through Their National Action Plans

Florența-Elena Helepciuc ¹ and Arpad Todor ^{2,*}

¹ Institute of Biology Bucharest, Romanian Academy, 296 Splaiul Independenței, P.O. Box 56-53, 060031 Bucharest, Romania

² Faculty of Political Science, National University for Political Studies and Public Administration, 012244 Bucharest, Romania

* Correspondence: todor.arpad@politice.ro; Tel.: +40-0723-756-779

Abstract: Integrated pest management (IPM) is among the most promising approaches for transforming today's agronomical practices toward sustainable and environmentally friendly agriculture. Aiming to become a global environmental leader, in 2009, the European Union (EU) embraced the idea of making IPM practices ubiquitously used by 2014 in all EU Member States (EU MSs). Through Directive 2009/128/EC (the Sustainable Use Directive (SUD)), the EU required EU MSs to structure their transformative measures in National Action Plans (NAPs) in a comprehensive effort. These documents have a fundamental role in orienting the plans and activities of national stakeholders, such as agronomists, researchers, and local and national-level institutions. We analyze and compare the second-generation NAPs (2019–2022) of 10 EU MSs to assess their strengths and weakness and their modifications from the first generation of NAPs (2009). We advance several recommendations on how to make them more valuable instruments in structuring activities towards achieving the goals of the SUD.

Keywords: integrated pest management; European Union; Sustainable Use Directive; National Action Plan



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1. Introduction

Overcoming the era of intensive agriculture based on widespread use of harmful chemical pesticides requires a paradigm shift throughout the entire chain of activities. One of the most promising shifts is labeled under the generic name integrated pest management (IPM). IPM is defined as control over the levels of harmful organisms' populations through a complex set of diverse and appropriate measures in order to reduce or minimize environmental and human health effects. IPM implies the selection and use of measures best fitted for particular contexts to maintain acceptable levels of harmful organisms while simultaneously having a minimal environmental and health impact. In recent decades, this approach has become increasingly popular globally and received increasing attention from policymakers. In the European Union (EU), IPM was officially adopted as a critical strategy in the agricultural transition starting in 2009 through Directive 2009/128/EC, also called the Sustainable Use Directive (SUD) [1]. The SUD requires the adoption of IPM by all EU Member States (MSs), and it is considered one of the principles upon which agriculture can be transformed into a more sustainable form through the stimulation of "the expansion of IPM and alternative approaches or methods to reduce reliance on pesticides" (article 4). Each EU MS had to elaborate on two types of documents: (1) crop-specific guidelines on the introduction and use of IPM across agricultural sectors by 2014 and (2) National Action Plans (NAPs). These documents would structure the detailed measures taken by each EU MS to achieve the three overarching goals of the SUD. The first generation of NAPs was

elaborated by most EU MSs by 2009, while the second generation of NAPs was published starting in 2019 by some EU MS. Given that NAPs present an evaluation of the existing situation and represent the best case of each EU MS's intentions for the following years, in this article, we evaluate the state of the development of IPM in the second generation of NAPs.

This article continues the analysis we developed in a previous paper [2], where we analyzed the first generation of NAPs for six countries across all the goals of the SUD. Our evaluation concluded, "Also, most NAPs did not contain some elements deemed compulsory: timetables and targets, provisions regarding the application of IPM by all professional users by 2014, and crop and sector-specific guidelines". Overall, the UK had the least details on its IPM strategy, and Romania, Hungary, and Poland did not have all the necessary elements. As such, the conditions required to achieve the goals set for 2014 were simply not present, as the NAPs could be considered the best-case scenarios. We also emphasized the importance of analyzing the original documents (NAPs) instead of using an evaluation based on the questionnaires provided by EU MSs [3]. Overall, the goal of developing crop-specific guidelines across the EU was still far from being achieved.

Our analysis is structured as follows: in the remainder of the introduction, we present some historical elements of the evolution of IPM and the current definitions of IPM. In the Materials and Methods section, we present the structure of our analysis and the methodological approach. In the Results and Discussion section, we detail the results of our analysis, interpretation implications, and other recommendations from the recent literature regarding the factors that influence the adoption of IPM. We review the main findings and discuss the policy implications of our research in the Conclusion.

IPM's roots can be traced a long way back in history, with the first records of cultural practices dating from 1500 BC [4]. Over time, these techniques improved, and several basic IPM practices, such as cultural, mechanical, and biological control, represented the main procedures utilized to control harmful organisms for an extended period. What changed this type of approach was the development of modern synthetic pesticides in the early 1940s. The high short-term efficiency of these products led to a decrease in interest in using and even studying other pest control measures, so the main techniques of IPM were put in a shaded corner. Only once pesticide resistance became an issue and the public became aware of the health and environmental problems caused by chemical pesticides did IPM techniques start to regain the scientific community's interest. The concept of "integrated pest management" was accepted in the 1970s, along with the adoption of its name, based on previously proposed concepts, such as "pest control", "integrated control", and "pest management" [5]. A 1979 report defined IPM as an approach that "seeks maximum use of naturally occurring pest controls, including weather, disease agents, predators, and parasites" [6]. Currently, the US Environmental Protection Agency defines IPM as "an effective and environmentally sensitive approach to pest management that relies on a combination of common-sense practices. IPM programs use current, comprehensive information on the life cycles of pests and their interaction with the environment. This information, in combination with available pest control methods, is used to manage pest damage by the most economical means, and with the least possible hazard to people, property, and the environment [7]. In contrast, the EU defines IPM as "careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimize risks to human health and the environment" [8]. While the two definitions have important commonalities in stressing the need for a complex approach and the use of all available instruments and knowledge to combat pests, the US's definition emphasizes the economic aspects. In the same line, Storkey et al. [9] define the concept of integrated weed management (IWM) as a "continuum of multiple combinations of chemical and non-chemical interventions. In this sense, IWM is not categorical but represents a gradient of increasing complexity—the so-called 'many little hammers approach'". This is

different from certified and standardized approaches, such as organic agriculture, which have defined sets of practices. Thus, IWM does not have a crop-level set of practices but a field-level approach that incorporates local conditions.

The European Commission has proposed eight principles of IPM: “(P1). The design of inherently robust cropping systems using a combination of agronomic levers is key to prevention. (P2) Local availability of monitoring, warning, and forecasting systems is a reality to contend with. (P3) The decision-making process can integrate cropping system factors to develop longer-term strategies. (P4) The combination of non-chemical methods that may be individually less efficient than pesticides can generate valuable synergies. (P5) Development of new biological agents and products and the use of existing databases offer options for selecting products minimizing the impact on health, the environment, and the biological regulation of pests. (P6) Reduced pesticide use can be effectively combined with other tactics. (P7) Addressing the root causes of pesticide resistance is the best way to find sustainable crop protection solutions. And (P8) integration of multi-season effects and trade-offs in evaluation criteria will help develop sustainable solutions” [10].

Tataridas et al. [11] have identified a range of new techniques for weed management that can be integrated into IPM: “novel cultivation techniques (e.g., intercropping, false seedbed, reduced tillage, crop rotation and diversification, adjustments on sowing densities and dates), non-chemical tools (e.g., flaming, seed coating, beneficial microorganisms, mechanical weeding, biocontrol agents and natural herbicides), competitive plant material (hybrids and cultivars, cover crops, service crops), and new technologies and precision agriculture tools (e.g., Decision Support Systems, robots, remote sensing, UAVs, omics and nanotechnology)”. Advancing the implementation of this complex and knowledge-intensive array of methods depends on the cooperation of farmers and supporting parties and increasing pressure on the application of existing regulations.

2. Materials and Methods

To better understand the state of affairs in IPM implementation across the EU MSs and the main obstacles to the widespread adoption of IPM, we analyzed the NAPs of Austria, Belgium, the Czech Republic, Ireland, Romania, Hungary, Poland, Denmark, France, and Spain, countries that have published their second-generation plans. We selected 10 of the 23 countries that published their second-generation NAP by August 2022 with relevant agricultural sectors. We based our analysis on the assumption that, while the first generation of NAPs required by the SUD were the first such plans for most EU MSs, with a few exceptions, such as Denmark and France, the second generation of NAPs should more accurately represent a good map of each EU MS's intentions towards the efforts to achieve the aims of the SUD. We used a methodological approach built on a previous article [2], adapting Barzman and Dachbrodt-Saaydeh's [10] initial approach. Each of the 10 NAPs was read in detail and analyzed using the search function for specific keywords. To assess the comprehensiveness of elaboration the measures related to IPM, we evaluated if a specific objective, or several objectives, related to IPM were present in the NAP; if there were detailed measures designed to implement IPM; and if these measures were operationalized into specific steps to be implemented. Furthermore, we assessed whether there were timetables and indicators associated with these measures and detailed steps. In the synthetic table, we present the objectives, the references to IPM throughout the NAPs, and how the IPM is discussed. In the qualitative summative interpretation, we also aimed to compare the NAPs of different EU MSs in terms of how comprehensive they are. This discussion allowed us to evaluate the degree to which EU MSs have seriously engaged with implementing IPM systematically within their agricultural practices.

3. Results and Discussion

In this section, we discuss the current evaluations of the main factors affecting the progress of the implementation of IPM in the EU MSs and then proceed with the assessment of the second-generation NAPs of 10 EU MSs.

To offer the reader a general overview of each NAP's approach to IPM, the data in Table 1 indicate the number of times that IPM is mentioned in the second-generation NAPs of each EU MS analyzed, whether the implementation of IPM is present as one of the document's objectives, and whether relevant details are present in the document. Nevertheless, given the high heterogeneity of these NAPs, an adequate comparison requires an analysis of the comprehensiveness of the measures designed to implement IPM.

Austria's 2017 second-generation NAP [12] has the Further Development of Integrated Pest Management as the last of its objectives. According to the NAP, the guidelines for professional users of IPM are already elaborated and integrated into plant protection products (PPPs), and further steps to reinforce the information are necessary. Moreover, the drafting of guidelines on IPM for non-professional use is forecasted for 2020 (pp. 9–10). The NAP links IPM use with a reduction in PPPs and requires further development of the principles of good plant protection practice and IPM, although this necessity is not clearly defined (p. 16). The description of the measures already taken for the seventh objective details policy actions but contains no evaluation of how widespread IPM use is or the measures to promote IPM. The four measures refer to reinforcing measures to decrease the import of PPPs and plants, including monitoring; increasing funding for PP alert services; increasing funding for coverage of treatment emergencies; and EU-wide cooperation, harmonization, and network participation. Measures also refer to testing, regular meetings, and funding research for IPM and PPP alternatives, all of which are ongoing, meaning they were already implemented. Austria's 2017 NAP also contains a detailed set of 10 risk indicators for IPM (agri-environment, "organic farming", "biodiversity management", use of insecticides, limiting use of PPPs, use of fungicides, "greening of arable land", communication, a treatment frequency index, and PP equipment (pp. 21–22).

Belgium's second-generation NAP [13] mentions IPM 37 times. Its last objective is dedicated to IPM, with the set of objectives, actions, and measures centered around four pillars: promoting low-input systems, such as IPM and organic farming (8 measures); creating the conditions needed to promote the implementation of IPM (15 measures); reinforcing the general principles of IPM (9 measures); and stimulating the implementation of IPM in line with the main specific guiding principles in the sectors (3 measures). Most of the 36 measures contain a clear description of the actions required, how to monitor the activity, and the end state to be achieved. Overall, Belgium's second-generation NAP is more complex than Austria's, but it appears that many of the measures Austria already implemented are only planned in the second NAP.

The Czech Republic's NAP for 2018–2022 [14] does not use the term IPM but "integrated plant protection" (IPP) (mentioned 29 times), which is considered part of integrated plant production (IPP) (seven mentions). IPP is defined as a "set of measures that, after considering all available plant protection methods, suppress the development of pest populations, support natural pest control mechanisms, and reduce risks to human health and the environment" (p. 38). While IPP has no dedicated objective, it is mentioned on several occasions. The NAP explains that information on IPP has been available since 2014 on an institute's website and gives details of the efforts required to fully explain it to professional users and the general public. The Czech Republic's NAP also briefly further discusses the measures required to develop crop systems for IPP. The Czech Republic's NAP clearly states that the introduction of IPP should "not harm agriculture entrepreneurs" [14] and the entrepreneur is obligated to bear the costs of implementing IPP. The NAP also proposes several indicators, such as the number of authorized products usable in organic farming and IPP, informed agricultural entrepreneurs, and assumptions present in the NAP.

The 2019 Review of the Irish National Action Plan for the Sustainable Use of Pesticides [15] mentions IPM 29 times and dedicates one of the five objectives to it—"To achieve widespread adoption of IPM practices amongst end users through education and raising awareness"—which it aims to achieve through three sub-objectives, four targets, and one action and to monitor through five indicators of progress. Analyzing the five indicators shows that measures to implement IPM are in their incipient stage, since they focus on

starting to measure the number of professional users of IPM, conducting an IPM survey, and collecting data through a pesticides usage survey. Indicators also measure how growers monitor infestations and professional users' implementation of a decision support system on pest control. Unlike the NAPs of Austria or Belgium, Ireland's NAP contains fewer details on the steps to implement the actions.

Romania's second NAP [16] mentions integrated management of harmful organisms, used in the same sense as IPM, 19 times and dedicates one of its objectives to IPM. The goal of promoting IPM is to be achieved through five measures, associated with risk indicators and quantitative targets, to be completed by the end of the NAP's period. As the first two goals refer to the drawing up of crop- or sector-specific guidelines for IPM and agricultural practices for IPM (p. 10), these activities are only incipient at the second NAP's elaboration stage.

Hungary's 2019 NAP [17] mentions IPM 13 times, sets the sub-goal of 'Introduction of a training system complying with the philosophy of IPM', and also mentions it as one of the target areas of the NAP. Most mentions are present in a wide discussion of the importance of IPM in the context of the SUD. The sub-goal measures indicate that measures on education are in their incipient stage, and the only indicator refers to the number of participants. Hungary's NAPs only pay lip service to IPM, as they contain no measures, actions, targets, or indicators on implementing it.

Poland's 2018 second-generation NAP has the most comprehensive approach to IPM, as dissemination of the general principles of IPM is one of the two objectives of the NAP, and it mentions the term 77 times. As shown in Table 1, the objective is operationalized through 11 tasks covering all relevant aspects of IPM implementation, each with a clear description of the steps to be implemented. Furthermore, Poland's 2018 NAP is one of the few that contains sufficient data on assessing the measures undertaken to promote IPM during the implementation of the first NAP.

Denmark's second-generation NAP mentions IPM 34 times and discusses it within the fifth chapter: "Information, Advice, and Guidance". The forecasted measures focus on informing, educating, and training users about IPM principles and gathering data on prior progress.

France is one of the few EU MSs that developed a national approach to reducing pesticide use and risk before the SUD, creating the Réseau de Demonstration Experimentation et Production de references sur le systemes economies en pHYtosanitaires (DEPHY) mechanisms to advance the implementation. Its Ecophyto 2018 NAP focuses on pesticide use reduction and does not use the term "IPM" but terms such as integrated production. Nevertheless, a qualitative evaluation of the eight focuses of the NAP shows a focus on pesticide use reduction. Furthermore, most of the principles of IPM are covered to a certain extent. Focus 2, "Determination and general dissemination of agricultural systems and known methods conducive to reducing pesticide use through the mobilization of all partners in research, development and knowledge transfer", requires the identification of available integrated production and protection methods and the creation of an experimental benchmarking platform, but not widespread implementation and relevant justification and description of steps, and it includes a few indicators.

Spain's 2018 second-generation NAP [18] mentions IPM 53 times and has the promotion of IPM as one of its two general objectives. Two of its specific objectives aim to promote research, innovation, and technology transfer in IPM and to promote IPM, and it has special measures to promote IPM in four of its nine measures, which cover most areas of IPM. While Spain's NAPs do not have an evaluation of the measures and progress during the implementation of the first NAP, it contains relevant details, steps, and indicators to assess future implementation.

All in all, our analysis of the second-generation NAPs of 10 of the 23 EU MSs published by August 2022 reveals a nuanced picture of recent and planned progress in implementing IPM across the EU. First of all, the high degree of heterogeneity identified in our analysis of the first generation of NAPs [2] persists, though it has diminished. While most NAPs

are structured around general goals and objectives or focuses, the degree of elaboration of details, measures, indicators, and timetables varies widely, making a systematic comparison difficult. Second, although they are second-generation NAPs, one commonality of almost all NAPs is that they lack a consistent evaluation of the measures undertaken as a result of the first NAPs adopted after the SUD, their success, and how this success was assessed through indicators. No NAP clearly evaluated the degree to which the objective stated in the SUD was to achieve the 2014 goals of having IPM applied by all professional users and developing sector-specific guidelines. As such, it is difficult to evaluate if the second-generation NAPs build on the lessons learned at the national level. Furthermore, the absence of any inter-country comparison was expected, but it indicates the limited capacity of EU MSs to learn from other countries' experiences and to transfer good practices.

Third, while some NAPs have separate objectives focusing on IPM, others elaborate the measures related to IPM across several focuses or objectives. Fourth, while the institutions responsible for each measure are mentioned in some cases (Romania, Belgium), in most NAPs, they are not. Fifth, although the second-generation NAPs of most countries contain more indicators to assess the implementation of the proposed measures and targets, there is still huge variety among the NAPs. Furthermore, some of these indicators in the analysis indicate that data will be collected for the first time.

Based on our findings, we can elaborate some specific recommendations about how to use the NAP instrument to accelerate the implementation of IPM in the EU MSs. We start by reviewing several factors identified in the recent literature. In a discussion on the incentives and policies to adopt IPM in Europe, three types of drivers for IPM adoption are identified: "the cost-effectiveness and impact on the risk of IPM technology, the market drivers (access to market and farm-gate price for IPM products, input prices) and farmers' attitudes towards innovation, the environment, and health risks" [19]. In practice, cost gains from IPM vary significantly based on local conditions, the type of crop, and specific practices. No general guidelines have been developed, and early adopters of IPM have not received any specific economic benefits. The authors stress the important role of public intervention in promoting the adoption of IPM in combination with economic incentives and information dissemination. They also stress that, given the still limited experience in implementing IPM in Europe, there is not sufficient data on the most efficient IPM strategies, and, thus, the role of public intervention remains crucial. Incentive-based policies could maximize IPM profitability through a mix of taxes and subsidies that would reduce risks to individual farmers.

Furthermore, a recent article by Lamichane et al. [20] identifies the main obstacles to the development of the biocontrol sector, one key component of IPM in achieving higher acceleration in the transition from conventional crop protection based on the intensive use of chemical pesticides to IPM. Given that the possibility of increasing the use of IPM depends on existing alternatives, including biocontrol, the study underlines the gap between the existing biocontrol solutions and users' requirements, emphasizing the need to enlarge the array of biocontrol methods.

It is worth stressing that the SUD directive had effects beyond the EU's borders, as a recent evaluation of the introduction of IPM regulation in Norway as a response to the EU's development of legislation [21] shows that 41% of farmers increased their knowledge about and usage of IPM techniques after the Sustainable Use Directive was introduced.

Furthermore, several recent articles compare the advantages of IPM [22–24] to those of organic crop systems and other techniques, underscoring the effectiveness of IPM while supporting the importance of collaboration among different communities of practice [25].

Based on our comparative analysis of 10 second-generation of EU MS NAPs, and considering the findings and recommendations from recent literature, we have developed a series of recommendations for the implementation of the third generation of NAPs with regard to IPM. These are designed to promote the efficient use of IPM in preventing pest occurrence, monitoring pest occurrence, increases in the sensitization of framers, and incentives for IPM adoption.

First, further efforts to promote a common understanding of IPM across EU MSs are necessary. The NAP analysis revealed that 2 of the 10 countries do not use the IPM terminology and that the measures to implement IPM are formulated differently, even if they approach the same problems. Thus, we recommend further efforts from the EU Commission to promote common operationalization (even if a common definition exists) of the most important measures to promote IPM. Second, to strengthen this approach, relevant efforts should be put into developing appropriate indicators to measure EU MS's progress. The EU has already developed two harmonized risk indicators (HRI) on the uses and risks of pesticides and emergency authorization; thus, the capacity to develop IPM-related indicators is present.

Third, given that IPM is significantly more knowledge-intensive than the chemical pesticides-based approach to pest control, significant efforts to disseminate knowledge on crop-specific guidelines to IPM are needed, both at the level of agronomist training and that of farmers. Fourth, to ensure that IPM practices and crop-specific guidelines are up to date with the latest scientific knowledge, significant efforts in identifying common research priorities are needed [20], combined with systematization, facilitation of easy access, and dissemination of this knowledge and best practices. Best practices should be assessed in terms of productivity and cost-effectiveness to alleviate farmers' risk aversion. Fifth, while some NAPs mention efforts to inform farmers of their obligations to use IPM, these efforts are feeble compared to the enormous needs for knowledge transfer and changes in practices to make IPM a truly compulsory approach. To adequately plan for these measures, each future NAP should contain an evaluation of the state of affairs and plan accordingly to achieve clearly defined targets for each crop (e.g., percentage of arable land with a specific crop using IPM).

Sixth, significant changes are required based on the findings of the recent European Court of Auditors' Report that IPM use is not linked with receiving payments under the Common Agricultural Policy. This linkage has to be gradual and must consider the different levels of socio-economic development in different EU MSs, market and farm-gate prices, and concerns about maintaining competitiveness. Overall, the introduction of IPM should become associated with economic benefits.

All in all, the field of IPM has received greater attention in recent years from the academic community, practitioners, and policymakers, especially in the EU. Despite the ambitious goals set in 2009 in the SUD, the 2014 goals were not achieved, and a rough road still lies ahead in fully implementing IPM across all EU MSs and cultures. These difficulties are also underscored by a recent report by the European Court of Auditors stressing that farmers still have limited incentives to adopt IPM [26] and a report by the RISE Foundation showing the lack of coherence and comprehensiveness in IPM implementation in the EU [27].

Table 1. Analysis of the second-generation National Action Plans of Austria, Belgium, the Czech Republic, Ireland, Romania, Hungary, Poland, Denmark, France, and Spain.

Country/ Year of NAP Adoption	Nr. of Mentions of IPM	Presence of Dedicated Objectives for IPM Relevant Details (Quoted)
Austria [12]—2017	19	Dedicated objectives for IPM: O7. Further development of Integrated Pest Management Relevant details p. 7 Professional users must follow the general principles of integrated pest management set out in Annex III to Directive 2009/128/EC on the sustainable use of pesticides (p. 16) Professional users must apply plant protection products in accordance with the principles of integrated pest management, using specialist staff with the appropriate qualifications (Article 5, Directive 2009/128/EC) pp. 21–23—Very detailed plan with measurements, timetables, and indicators p. 16—Reducing the risks and the quantities of plant protection products used—Further development of the principles of good plant protection practice and IPM

Table 1. Cont.

Country/ Year of NAP Adoption	Nr. of Mentions of IPM	Presence of Dedicated Objectives for IPM Relevant Details (Quoted)
Belgium [13]—2018	37	<p>Dedicated objectives for IPM: 9. Integrated Pest Management (IPM) (p. 34) Relevant details Plant protection practice and integrated pest management (pp. 15–17) <input type="checkbox"/> Promoting low-input systems such as integrated pest management and organic farming <input type="checkbox"/> Creating the conditions needed to promote the implementation of integrated pest management <input type="checkbox"/> Reinforcing the general principles of integrated pest management <input type="checkbox"/> Stimulating the implementation of integrated pest management in line with the main specific guiding principles in the sector . . . (p. 41) All four measures have clearly elaborated objectives, actions, and indicators</p>
Czech Republic [14]—2018	0 for IPM; 29 integrated plant protection (IPP)	<p>Dedicated objectives for IPM: Objective II. Optimizing the use of PPPs without limiting the extent of agricultural production Relevant details</p>
Ireland [15]—2019	29	<p>Dedicated objectives for IPM: 5. Integrated Pest Management 5a: Implementing the Principles of Integrated Pest Management 5b: Monitoring of Harmful Organisms 5c: Availability of Decision Support Systems (DSS). Relevant details pp. 25–26—The first Irish plan (2013) set out a national strategy to achieve sustainable use of pesticides, establishing objectives, targets, measures, and timeframes to reduce the risks and impacts associated with the use of pesticides on human health and the environment and to encourage the development and introduction of Integrated Pest Management (IPM). This review (2018) builds on the original NAP and consolidates the objectives set out in that document. In maintaining and reviewing the NAP, each MS must take account of the measures' social, economic, and environmental impacts and the health of its citizens.</p>
Romania [16]—2019	19	<p>Dedicated objectives for IPM: 5. Promoting the integrated management of harmful organisms Relevant details 9—The promotion of integrated management can be achieved by promoting/disseminating guidelines on the integrated management of harmful organisms in accordance with Article 14 of Government Emergency Order No 34/2012, approved by Law No 63/2013, and developing a system for the integrated management of harmful organisms that includes training designed to provide farmers with access to specialised knowledge for the development of sustainable high-performance agriculture. The main objective of integrated pest management is the use of practices and products entailing the lowest risk to human health and the environment. In order to ensure effective and economically viable protection for agricultural crops, PPPs must be applied only when strictly necessary, i.e., when there is an actual occurrence of harmful organisms as defined in the forecasts and alerts issued by the county phytosanitary offices and the advice of a phytosanitary specialist has been sought. Integrated management of harmful organisms can only be carried out if the situation regarding the presence of harmful organisms at a particular time is known.</p>

Table 1. Cont.

Country/ Year of NAP Adoption	Nr. of Mentions of IPM	Presence of Dedicated Objectives for IPM Relevant Details (Quoted)
Hungary [17]—2019	13	<p>Dedicated objectives for IPM: No</p> <p>p. 38—6.1.1—Introduction of a training system complying with the philosophy of integrated pest management</p> <p>Objective: In plant protection education, efforts must be made to spread the philosophy, skills and practices of integrated and organic plant protection, taking into account the objectives of the National Action Plan.</p> <p>Relevant details</p> <p>5—introduction of integrated pest management and of alternative approaches or techniques in order to reduce agricultural risks posed by the use of plant protection products.</p> <p>p. 19—5.2.4. Introduction of integrated crop management techniques . . .</p> <p>Accordingly, establishment of a legal framework for integrated farming serves as a basis for sustainable production in Hungary as well. A decisive element of this objective is the requirement laid down in Directive 2009/128/EC on the sustainable use of pesticides which states that from 1 January 2014 onwards, all farmers have to respect the provisions on integrated pest management (IPM) set out in special legislation.</p> <p>Changes in production techniques across several tiers are necessary to disseminate integrated farming methods, taking into consideration that the introduction of integrated pest management is compulsory:—respect of mandatory provisions on integrated pest management as from 1 January 2014 in accordance with Directive 2009/128/EC</p>
Poland [28]—2017	77	<p>Dedicated objectives for IPM: 10. Action 10. Promoting Integrated pest management—</p> <p>Task 1. Dissemination Of Knowledge In The Field Of Integrated Pest Management 25</p> <p>Task 2. Maintaining An Internet Platform Dedicated To Integrated Pest Management 25</p> <p>Task 3. Preparation, Updating And Dissemination Of Integrated Pest Management Methodologies For Individual Crops . . . 26</p> <p>Task 4. Running A Pest Monitoring System 26</p> <p>Task 5. Providing Decision Support Systems In Pest Management 26</p> <p>Task 6. Providing Integrated Pest Management Programmes 27</p> <p>Task 7. Dissemination Of The Results Of The Assessment Carried Out Within The Framework Of Post-Registration Variety Testing 27</p> <p>Task 8. Promotion Of The Integrated Plant Production Scheme 27</p> <p>Task 9. Providing Advice In Plant Protection 28</p> <p>Task 10. Ensuring Safety Of Pollinating Insects During Plant Protection Treatments 28</p> <p>Task 11. Monitoring And Limiting Resistance Of Pests To Plant Protection Products 29</p> <p>Relevant details</p> <p>p. 5—According to data from the State Plant Health and Seed Inspection Service, in 2014, 71.8% to 95.3% of professional users of PPPs complied with the various requirements of integrated pest management. In 2015, this was from 69.2% to 97.2%, while in 2016 from 67.3% to 95.7%</p> <p>Detailed evaluation of the implementation of measures present in the first NAP and implemented</p>
Denmark [29]—2017	35	<p>Dedicated objectives for IPM: No</p> <p>Relevant details</p> <p>p. 19—Fund research projects that contribute to the development of alternative pest control and pest prevention methods, pesticide resistance prevention and the further development of Integrated Pest Management (IPM)</p> <p>p. 20—5. Information, advice and guidance</p> <p>5.1 Integrated Pest Management (IPM)</p>

Table 1. Cont.

Country/ Year of NAP Adoption	Nr. of Mentions of IPM	Presence of Dedicated Objectives for IPM Relevant Details (Quoted)
France [30]—2018	0	<p>Focus on pesticide reduction. IPM is integrated to a certain extent in all measures. An integral part of its DEPHY mechanism</p> <p>Relevant details</p> <p>FOCUS 2—Determination and general dissemination of agricultural systems and known methods conducive to reduce pesticides use through the mobilisation of all partners in research, development and knowledge transfer</p> <p>p. 14—The dissemination of innovative, low-plant protection product practices will depend in large part on providing support to 30 000 holdings as they move over to agro-ecological systems that make little use of plant protection products. The DEPHY mechanism will serve as an initial foundation, by sharing knowledge gained on supporting farmers in reducing the use, risks and impacts of plant protection products and on the engineering aspect of the role of the network engineer. The 3000 DEPHY farms will provide points of reference and resources for designing low-use and high-performance systems</p> <p>p. 20—7. ESTABLISH A NATIONAL RESEARCH AND INNOVATION STRATEGY</p> <p>The Ecophyto II national strategy for research and innovation set out in the roadmap will identify priority actions around four objectives:</p> <ul style="list-style-type: none"> o Guide and support research with a view to promoting integrated pest management; limit dependence on plant protection products; reduce the risks and impacts linked to the use of those products; identify and address socio-technical and economic barriers to a shift in practices and support changes in practices and sectors
Spain [18]—2018	53	<p>Dedicated objectives for IPM: The general objectives of the NAP are as follows:</p> <p>1- To promote integrated pest management (IPM) to ensure the farming, forestry and food sector remains prosperous and to make a positive contribution to the environment through a sustainable production model that is compatible with the rational use of plant protection products.</p> <p>1.3 Improve knowledge of integrated pest management in local administrations</p> <p>(2) Promote research, innovation and technology transfer in integrated pest management and the sustainable use of plant protection products 22</p> <p>2.1 Promote the establishment of operating groups enabling research, innovation and technology transfer projects to be started up in the sector 23</p> <p>2.2 Promote research, innovation and technology transfer projects in the sector . . . 25</p> <p>3 Promote integrated pest management to ensure a rational use of plant protection products . . . 27</p> <p>3.1 Draft nationwide harmonised guidelines on integrated pest management . . . 28</p> <p>3.2 Strengthen plant-health monitoring networks to facilitate decision-making when applying integrated pest management 29</p> <p>3.3 Setting up information and/or support systems for applying integrated pest management 30</p> <p>3.4 Promoting integrated pest management advisory systems</p> <p>8.1. Establish a methodology for assessing the effectiveness of the recommendations set for protection zones in relation to integrated pest management</p>

4. Conclusions

The NAPs adopted by EU MSs are key instruments for structuring the complex sets of actions required by the SUD towards achieving the objective of implementing IPM across the EU MSs and across all types of crops. The recent evaluations analyzed in this article show that limited progress has been achieved so far and that the 2014 goals set by the SUD have been totally missed. Our comprehensive study evaluated the second generation of NAPs to assess the progress from the first generation of NAPs and what progress needs to be achieved in the near future. Positively, with the notable exception of Hungary's NAP and some specificities (France's NAP focuses on pesticide reduction), IPM implementation is treated seriously in most NAPs. Nevertheless, the details of the steps need to indicate the measures, timetables, indicators, and institutions responsible for the evaluation of recent progress, as the results of the implementation of the first generations NAPs differ dramatically and, thus, make comparisons difficult.

Given that the NAPs are an instrument for national stakeholders and an EU-level instrument, we recommend that they should be elaborated in a much more structured and comparable way to allow comparisons of progress and transfer of good practices across EU MSs.

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References

1. European Parliament and the Council Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 Establishing a Framework for Community Action to Achieve the Sustainable Use of Pesticides. Available online: <https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A32009L0128> (accessed on 13 April 2020).
2. Helepciuc, F.-E.; Todor, A. Evaluating the Effectiveness of the EU's Approach to the Sustainable Use of Pesticides. *PLoS ONE* **2021**, *16*, e0256719. [[CrossRef](#)] [[PubMed](#)]
3. DG Health and Food Safety. *Overview Report on the Implementation of Member State's Measures to Achieve the Sustainable Use of Pesticides under Directive 2009/128/EC*; DG Health and Food Safety: Brussels, Belgium, 2017.
4. Abrol, D.P.; Shankar, U. History, overview and principles of ecologically-based pest management. In *Integrated Pest Management: Principles and Practice*; CABI: Wallingford, UK, 2012; pp. 1–26.
5. Kogan, M. Integrated Pest Management: Historical Perspectives and Contemporary Developments. *Annu. Rev. Entomol.* **1998**, *43*, 243. [[CrossRef](#)] [[PubMed](#)]
6. Bottrell, D.G. *Integrated Pest Management*; Council on Environmental Quality: Washington, DC, USA, 1979.
7. US Environmental Protection Agency. Integrated Pest Management (IPM) Principles. Available online: <https://www.epa.gov/safepestcontrol/integrated-pest-management-ipm-principles> (accessed on 2 June 2022).
8. European Commission. Integrated Pest Management (IPM). Available online: https://ec.europa.eu/food/plant/pesticides/sustainable_use_pesticides/ipm_en (accessed on 16 December 2020).
9. Storkey, J.; Helps, J.; Hull, R.; Milne, A.E.; Metcalfe, H. Defining Integrated Weed Management: A Novel Conceptual Framework for Models. *Agronomy* **2021**, *11*, 747. [[CrossRef](#)]
10. Barzman, M.; Bärberi, P.; Birch, A.N.E.; Boonekamp, P.; Dachbrodt-Saaydeh, S.; Graf, B.; Hommel, B.; Jensen, J.E.; Kiss, J.; Kudsk, P.; et al. Eight Principles of Integrated Pest Management. *Agron. Sustain. Dev.* **2015**, *35*, 1199–1215. [[CrossRef](#)]
11. Tataridas, A.; Kanatas, P.; Chatzigeorgiou, A.; Zannopoulos, S.; Travlos, I. Sustainable Crop and Weed Management in the Era of the EU Green Deal: A Survival Guide. *Agronomy* **2022**, *12*, 589. [[CrossRef](#)]
12. Federal Ministry for Agriculture, Forestry, Environment and Water Management. *National Action Plan for the Sustainable Use of Plant Protection Products 2017–2021 (Austria)*; Federal Ministry for Agriculture, Forestry, Environment and Water Management: Wien, Austria, 2017.
13. Federal Public Service for Health, Safety of the Food Chain and the Environment. *Programme 2018–2022 of the Belgian National Action Plan (NAPAN)—Revised on May 2020*; Federal Public Service for Health, Safety of the Food Chain and the Environment: Brussels, Belgium, 2020.
14. Ministry of Agriculture of the Czech Republic. *National Action Plan on the Safe Use of Pesticides in the Czech Republic 2018–2022*; Ministry of Agriculture of the Czech Republic: Prague, Czech Republic, 2018.
15. Department of Agriculture, Food and the Marine of Ireland. *Review of Irish National Action Plan for the Sustainable Use of Pesticides (Plant Protection Products)*; Department of Agriculture, Food and the Marine of Ireland: Dublin, Ireland, 2019.
16. Romanian Government. *Decision No 135 of 12 March 2019 Approving the National Action Plan on Reducing Risks Associated with the Use of Plant Protection Products*; Romanian Government: Bucharest, Romania, 2019; Volume 135.
17. Ministry of Agriculture of Hungary. *National Plant Protection Action Plan 2019–2023*; Ministry of Agriculture of Hungary: Budapest, Hungary, 2019.
18. Government of Spain—Ministry of Agriculture and Fisheries, Food, and the Environment. *National Action Plan for the Sustainable Use of Plant Protection Products*; Government of Spain—Ministry of Agriculture and Fisheries, Food, and the Environment: Madrid, Spain, 2017.

19. Lefebvre, M.; Langrell, S.R.H.; Gomez-y-Paloma, S. Incentives and Policies for Integrated Pest Management in Europe: A Review. *Agron. Sustain. Dev.* **2015**, *35*, 27–45. [[CrossRef](#)]
20. Lamichhane, J.R.; Bischoff-Schaefer, M.; Bluemel, S.; Dachbrodt-Saaydeh, S.; Dreux, L.; Jansen, J.-P.; Kiss, J.; Köhl, J.; Kudsk, P.; Malausa, T.; et al. Identifying Obstacles and Ranking Common Biological Control Research Priorities for Europe to Manage Most Economically Important Pests in Arable, Vegetable and Perennial Crops. *Pest Manag. Sci.* **2017**, *73*, 14–21. [[CrossRef](#)] [[PubMed](#)]
21. Kvakkestad, V.; Steiro, Å.L.; Vatn, A. Pesticide Policies and Farm Behavior: The Introduction of Regulations for Integrated Pest Management. *Agriculture* **2021**, *11*, 828. [[CrossRef](#)]
22. Gómez-Guzmán, J.A.; Sainz-Pérez, M.; González-Ruiz, R. Monitoring and Inference of Behavioral Resistance in Beneficial Insects to Insecticides in Two Pest Control Systems: IPM and Organic. *Agronomy* **2022**, *12*, 538. [[CrossRef](#)]
23. Morelli, R.; Roman, T.; Bertoldi, D.; Zanzotti, R. Can Comparable Vine and Grape Quality Be Achieved between Organic and Integrated Management in a Warm-Temperate Area? *Agronomy* **2022**, *12*, 1789. [[CrossRef](#)]
24. Scavo, A.; Mauromicale, G. Integrated Weed Management in Herbaceous Field Crops. *Agronomy* **2020**, *10*, 466. [[CrossRef](#)]
25. Baker, B.P.; Green, T.A.; Loker, A.J. Biological Control and Integrated Pest Management in Organic and Conventional Systems. *Biol. Control* **2020**, *140*, 104095. [[CrossRef](#)]
26. European Court of Auditors. *Sustainable Use of Plant Protection Products: Limited Progress in Measuring and Reducing Risks*; European Court of Auditors: Luxembourg, 2020.
27. Buckwell, A.; De Wachter, E.; Nadeu, E.; Williams, A. *Crop Protection & the EU Food System. Where Are They Going?* RISE Foundation: Brussels, Belgium, 2020.
28. Minister of Agriculture and Rural Development of Poland. *National Action Plan to Reduce the Risk Associated with the Use of Plant Protection Products 2018–2022*; Ministries: Warsaw, Poland, 2018.
29. Ministry of Environment and Food of Denmark. *Danish National Action Plan on Pesticides 2017–2021*; Ministry of Environment and Food of Denmark: Copenhagen, Denmark, 2017.
30. French Ministry of Agriculture and Food. *The Ecophyto 2018 Plan for Reduction in Pesticide Use over the Period 2008–2018*; French Ministry of Agriculture and Food: Paris, France, 2018.