IPM Decisions

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1 Public Summary

The socioeconomic impacts associated with the use of IPM DSS in wheat, potato, and grape production were evaluated. Our analysis shows that using IPM DSS can provide economic benefits for farmers by reducing the treatment frequency index, thus lowering overall cost of production and total pesticide usage.

2 Executive Summary

This assessment aimed to calculate the potential impact on total pesticide usage if IPM DSS uptake were to be increased across EU agriculture as part of an integrated pest management (IPM) strategy. The analysis focused on three key crops: wheat, due to large area grown, as well as potatoes and grapes, due to the intensity of pesticide usage on these two crops. The analysis utilised data collated as part of a meta-analysis (Furiosi *et al*., 2023) in the IPMWORKS project (H2020 No. 101000339) that determined the impact of implementing DSS on treatment frequency index (TFI), yield, and disease severity. The meta-analysis drew together data from 10 papers for wheat, 31 for potatoes and 24 for grapes (from a total of 769 studies altogether), where there was a comparison between crop protection efficacy under standard agricultural practice and implementation of a DSS, with data given on treatment numbers and yield impacts (for wheat and potatoes).

The purpose of this work, within the context of the IPM Decisions project, was to quantify the benefit of increased uptake of DSS to the agriculture industry, and to identify the potential for reducing pesticide usage in key European crops.

The analysis combined the results from the meta-analysis with European and country level data on pesticide usage, crop areas and cost of pesticide applications at the per hectare level, to calculate a partial budget for the impact of implementing DSS within each of the three crops. Scenarios of different levels of DSS uptake (current practice - estimated at about 5% DSS use, and an additional 25% and 50% of crop area under DSS) were then used to scale up the hectare level impact to national level (for Belgium, Denmark, France, Germany, Ireland, Lithuania, Slovenia, and the United Kingdom) and European level to determine the potential impact on overall pesticide usage, and the potential cost savings for farmers. To enable the assessment, a number of simplifying assumptions had to be made:

- The TFI represents the total treatment frequency index across all pesticide usage (fungicides, herbicides, and insecticides).
- The percentage difference in TFI between standard practice and use of DSS has been applied to both the change in cost of pesticides, as well as total pesticide usage.
- For each crop the number of treatment applications, on average, are the same across all countries. *It is recognised that there are regional differences based on weed, pest or disease intensity and severity, however, the meta-analysis was conducted at a global level*

and therefore disaggregation of results down to differences in treatment numbers per country was not possible.

- For each crop-country combination, the average rate of pesticide active substance usage per treatment timing was calculated based on total weight of pesticide used on the crop per year, divided by the total area of crop grown in that year, to give a total rate of pesticide active substance used per hectare. This was divided by the number of treatments identified in the meta-analysis.
- For each crop country combination, the value and weight of the pesticides at each treatment application was the same. *It is recognised that the weight of pesticides will vary between different spray timings depending on the active substance used, and that the cost will also be affected by the specific active substance used. However, again the meta-analysis did not allow for this level of granularity, so broad assumptions had to be made.*
- The baseline current practice (data available for existing pesticide usage) was based on a predominance of farmers using standard pesticide application practices, with limited uptake of DSS.
- The average level of DSS usage in current practice was estimated at 5% based on literature (Shtienberg, 2013), feedback from the IPM Decisions workshops (Marinko et al., 2023), and the consortiums experience working with farmers and advisors across EU.
- Uptake of DSS was assumed to be uniform across all European countries.
- There are no changes in crop yield following the implementation of DSS. *This assumes that the main effect of using a DSS is to avoid unnecessary pesticide applications, that would not have provided a yield increase due to pest control.*

It should be noted that this assessment represents the maximum potential benefits of implementing DSS throughout European agriculture based on a 'normal' levels of pest pressure. During seasons with increased pest pressure, the assumptions used in this assessment would result in an over-estimate of the value of DSS, while in a low-pressure season, it might be an under-estimate.

There is an estimated 23.8 million hectares (Mha) of wheat, 1.5 Mha of potatoes and 3.1 Mha of grapes grown in the EU27 (plus an estimated 1.7 Mha of wheat and 0.14 Mha of potatoes grown in the United Kingdom) based on 5-year average data (FAOSTAT, 2017-2021). These are treated with an estimated 22.1 million tonnes (Mt), 8.2 Mt and 46.1 Mt of pesticide active substances on wheat, potatoes, and grapes respectively on an annual basis. On average it was estimated that wheat growers spent on average €200/ha on pesticide applications (ranging from €80/ha to €342/ha in Lithuania and Belgium respectively), while potato growers spent €530/ha (ranging from £282/ha in the UK to €800/ha in Belgium). No data was found regarding the cost of pesticides for grape production.

The meta-analysis identified that on average in wheat, the use of DSS could reduce the TFI by 67%, while in potatoes it reduced TFI by 17% and in grapes the reduction was 50%. The analysis also showed that these reductions in TFI could be achieved without impacting yield in wheat and potatoes. Yield data is rarely collected in grapes, as grape quantity is not the only parameter determining the final yield, but it should be considered together with qualitative parameters.

When this data was scaled up to the European level (EU 27), it is estimated that 25% additional uptake of DSS would result in total pesticide usage in wheat reducing by 1,800 tonnes, in potatoes reducing by 1,700 tonnes and in grapes reducing by 5,700 tonnes. The biggest reduction is seen when an additional 50% of the crop area is under DSS, as these values increase to 3,600 tonnes for wheat, 3,400 tonnes for potatoes and 11,500 tonnes for grapes. This is equivalent to pesticide usage being reduced by an estimated 24% across the three crops, which results in a 28% reduction in pesticide costs, worth €4,000 million a year.

Therefore, the widespread implementation of DSS as part of an IPM strategy holds significant potential for providing substantial economic and environmental benefits throughout European agriculture.

3 Introduction

Integrated Pest Management Decision support systems (IPM DSS, hereafter "DSS") are tools that provide guidance to growers, enabling better management of agricultural pests, diseases, and weeds. DSS consider a range of factors, including environmental conditions (e.g., precipitation, soil and air temperatures), and target invertebrate, pathogen, or weed growth stages to indicate the risk from pests, diseases and weeds. Growers and their advisors can use DSS to support integrated pest management strategies, with the potential for economic and environmental benefits, primarily by reducing unnecessary pesticide applications. This is important as the European Commission has proposed that pesticide use, and associated risk, is to be reduced by 50% by 2030 (European Commission, 2022), as part of an overhaul of the existing rules set out in the Sustainable Use of Pesticides (European Commission, 2009).

While different DSS exist that provide risk indications for various pests, diseases, and weeds, this deliverable focuses on the overall impacts of using any DSS in wheat, potato, and grape production, rather than the value of individual systems for these crops. The analysis is based on a meta-analysis conducted in IPMWORKS (H2020 funded project 101000339) of all IPM DSS in these crops across weeds, pests, and diseases, with a higher proportion of DSS found for disease systems than either pests or weeds.

The aim of this deliverable is to evaluate the impacts of using DSS in European agriculture on the cost of production and yield, of three economically important crops: wheat, potatoes, and grapes.

The objectives are:

Objective 1: Define scenarios for scaling up DSS use, and collect relevant data, including changes to treatment frequency index (TFI).

Objective 2: Evaluate the impact of DSS on pesticide usage under each scenario.

Objective 3: Use a partial budget analysis to evaluate the economic benefits of DSS usage under each scenario.

In determining the value of using DSS in European agriculture, a comparison was made between crop production where these systems have been implemented, and those where traditional management practices are used. The resulting differences in yield, cost of production and treatment frequency index (TFI) were used to evaluate the overall value of implementing DSS.

4 Methods

Evaluation of the potential impact of DSS in Europe was originally intended to utilise data from the validation of the IPM DSS systems conducted as part of the IPM Decisions project. The IPMWORKS project (sister project to IPM Decisions) subsequently produced data which was better suited to the evaluation. In collaboration with IPMWORKS, we utilised the results of a meta-analysis of all DSS applied in wheat, potato, and grapes to provide a high-level understanding of the potential of these DSS to reduce pesticide usage at a European scale. The meta-analysis led by Furiosi et al. (2023) is part of the IPMWORKS work package 4 activities, determining the effect of using DSS on treatment frequency index (TFI), yield and disease severity. The TFI is calculated by dividing the total quantity of active ingredients used for each crop by the standard dose associated with each active ingredient (Kudsk, 1989; Gravesen, 2003). The meta-analysis study used data from 10 papers for wheat, 31 for potatoes and 24 for grapes (from a total number of 769 studies over 27 countries covering the period from 1983 to 2020). It focused on those papers where there was a comparison between the efficacy in crop protection under standard agricultural practice and implementation of DSS, with data given on treatment numbers and yield impacts (for wheat and potatoes).

Data was collected on total weight of pesticide active substance used at the national/European level and cost of pesticide applications at the field level, for each of the three crops. This information was used to estimate the potential scale of impact on production and costs if pesticide usage was reduced through increase uptake of the DSS on farm. Effectively, this created a partial budget calculation to understand the impact of change on the business (at a per hectare level) and then scaled up to an industry level (farm gate) at country and EU level.

4.1 Scenarios and baseline data

As data was not available on the level of DSS use in individual countries or at an EU level, in order to conduct our analysis, a series of scenarios were used to demonstrate how DSS usage may be scaled up. These scenarios were:

- Current agricultural practice (assumed that DSS is used on 5% of total crop area)
- Additional 25% of crop area previously not using DSS, now under DSS
- Additional 50% of crop area previously not using DSS, now under DSS

The scenarios were applied to both a national and European scale, to assess the economic and environmental impacts by analysing changes in cost of production and total pesticide usage.

Baseline data relating to crop areas, yields, and pesticide usage were collected for all EU member countries, including total figures for the whole of the EU, where possible from

FAOSTAT and Eurostat for the years 2011-2021. Five-year averages (2017-2021) were then calculated where possible to conduct the country-level analysis.

Data was not available for every year in each country, and therefore pesticide usage data reflects the one- or two-years' worth of data available for each country within that time period. Additionally, pesticide usage will be impacted by season, with high pest pressure years seeing increased levels of use, while in low pressure years usage will be lower.

4.2 DSS impact assessment

Data was used from a meta-analysis conducted for the IPMWORKS project (Furiosi et al., 2023), in which they analysed the impact of using various disease control methods, including DSS, on crop yield, disease severity and treatment frequency index (TFI). In order to facilitate our evaluation, the data pertaining to changes in TFI were used, supported by the yield and disease severity data. The meta-analysis provided comparisons of TFI with standard treatment programs against those using DSS. It also provided yield comparisons between the two approaches.

For each crop, partial budgets were calculated to give a cost of pesticide usage (per hectare) using average country or European level data. Data on the average number of treatment applications was taken from the Furiosi et al. (2023) meta-analysis. Due to a lack of data granularity and to simplify the calculations it was assumed that on average every treatment that was made to the crop cost same amount and applied the same rate of active substance. The European and country data was used to calculate the average total rate of pesticide applied per crop year, and this was then divided by the treatment frequency index to give average rate of application per treatment. These values were all calculated on a per hectare basis (either at European or country level). The changes in TFI were then applied pro-rata to calculate the change in weight of pesticide applied with DSS and the value of that change on a per hectare level. The scenarios were then used to scale this per hectare level up to an additional 25% and 50% of the crop area using DSS for the European or national crop area to give an indication of the scale of the change if DSS were implemented.

4.3 Partial budget analysis

In order to create the partial budget calculation we used publicly available data sources (predominantly FAOSTAT and Eurostat) for each of the three crops wheat, potato, and grapes. Data for value (€/ha) of wheat, potatoes, and grapes, as well as pesticide costs (€/ha) for these crops were gathered where possible by IPM Decisions project partners using national databases alongside their own knowledge for the following countries: Belgium, Denmark, Germany, Ireland, Lithuania, and Slovenia for the years 2017-2021. For the United Kingdom, data was gathered from John Nix Farm Management Pocketbook (Redman, 2022), as well as the Pesticide Usage Survey report (2021 & 2019).

4.4 Assumptions

Due to limited data availability, and the nature of the meta-analysis by Furiosi et al. (2023) being global rather than country specific, there was insufficient granularity of the data to create individual assumptions around TFI for different countries within the EU. The meta-analysis also identified that there was no negative yield impact correlated with the implementation of DSS, and in some instances use of DSS was correlated with an increase in yield. Therefore, the following assumptions were made:

- The TFI represents the total treatment frequency index across all pesticide usage (fungicides, herbicides, and insecticides).
- The TFI for each crop is the same for each European country.
- The percentage difference in TFI between standard practice and use of DSS has been applied to both the change in cost of pesticides, as well as total pesticide usage.
- For each crop the number of treatment applications, on average, are the same across all countries. *It is recognised that there are regional differences based on weed, pest or disease intensity and severity, however, the meta-analysis was conducted at a global level and therefore disaggregation of results down to differences in treatment numbers per country was not possible.*
- For each crop country combination, the average rate of pesticide active substance usage per treatment timing was calculated based on total weight of pesticide used on the crop per year, divided by the total area of crop grown in that year, to give a total rate of pesticide active substance used per hectare. This was divided by the number of treatments identified in the meta-analysis.
- For each crop country combination, the value and weight of the pesticides at each treatment application was the same. *It is recognised that the weight of pesticides will vary between different spray timings depending on the active substance used, the cost will also be affected by the specific active substance used. However, again the meta-analysis did not allow for this level of granularity so broad assumptions had to be made.*
- The baseline current practice (data available for existing pesticide usage) was based on a predominance of farmers using standard pesticide application practices, with limited uptake of DSS.
- The average level of DSS usage in current practice was estimated at 5% based on literature (Shtienberg, 2013), feedback from the IPM Decisions workshops (Marinko et al., 2023), and the consortiums experience working with farmers and advisors across EU.
- Uptake of DSS was assumed to be uniform across all European countries.
- There are no changes in crop yield following the implementation of DSS. *This assumes that the main effect of using a DSS is to avoid unnecessary pesticide applications, that would not have provided a yield increase due to pest control.*

It is recognised that these assumptions represent a substantial, but necessary, simplification of complex pest management programmes. In addition, it is important to note that the results of this evaluation represent the maximum potential benefits of implementing DSS throughout European agriculture based on a 'normal' levels of pest pressure. During seasons with increased pest pressure, the assumptions used in this evaluation would result in an over-estimate of the value of DSS, while in a low-pressure season, it might be an under-estimate.

5 Results

5.1 Current practice and baseline data

5.1.1 Pesticide usage by crop and country

There are an estimated 23.8 million hectares (Mha) of wheat grown throughout the EU, with 1.5 Mha of potatoes, and 3.1 Mha of grapes grown (FAOSTAT, 5-year average 2017-2021). Eurostat data (from 2011 to 2021) indicates that on average across the whole of Europe (plus the UK) 0.92 kg/ha of pesticides active substances were used in wheat, 5.26 kg/ha in potatoes and 14.70 kg/ha were used in grape production. However, where country data was available from Eurostat, it has been indicated that rates of application range from 0.04 kg/ha to 3.62 kg/ha in wheat (with Ireland being the highest user and Finland the lowest). In potatoes it ranges from 0.60 kg/ha in Lithuania to 16.82 kg/ha in France. For grapes the range is from 5.07 kg/ha in Greece to 31.65 kg/ha in France.

5.1.2 Cost of pesticide applications

Where country data was available, it has been indicated that the cost of pesticides ranged from €80/ha in Lithuania (2021 data) to €342/ha in Belgium (5-year average, 2017-2021) for wheat. In potatoes it ranged from £282/ha in the UK (2022 data) to €800/ha in Belgium (5-year average, 2017-2021). For grapes, no specific country data was available for cost of pesticides, however these are highly variable depending on the variety of grapes grown, the value of the end market and the quality implications of weed, pest or disease damage. National costs for which data was available are detailed in Table 8 and Table 9.

5.1.3 Impact of DSS on pesticide usage

The results of the meta-analysis work completed by Furiosi et al. (2023) indicate that disease severity under a DSS implemented strategy was the same, or less, compared to standard practice. Nevertheless, the use of DSS has significant potential to reduce the treatment frequency index (TFI) for key crops, with estimated reductions in TFI in wheat (by 67%), potatoes (by 17%) and grapes (by 50%). Table 1 shows the TFI for current practice and where DSS have been implemented, as well as the estimated average reduction in TFI for wheat, potatoes, and grapes.

Table 1 – The average pesticide usage for wheat, potatoes, and grapes, including the Treatment Frequency Index (TFI) for wheat, potatoes, and grapes under current agricultural practice, and the TFI when Decision Support Systems (DSS) are used.

	Pesticide usage (kg/ha)+	Current TFI*	DSS TFI*	% Change
Wheat	0.92	3	1	-67%
Potatoes	5.26	6	5	-17%
Grapes	14.70	6	3	-50%

+ *Eurostat data*   * *Data from Furiosi et al. (2023)*

5.2 Impact of DSS on pesticide use

To scale up the impacts from farm level to national and European level, the four scenarios were evaluated – current practice (assumed 5% DSS use), as well as an additional 25% and 50% of crop area under DSS.

As a result of the decrease in TFI associated with using DSS, it is predicated that reductions can be made in the weight of pesticides needed to treat crops throughout the growing season. As the proportion of growers using DSS increases, the total amount of pesticide active substance use decreases. Similarly, the reduction in TFI results in a predicted reduction in cost of production due to the lower weight of pesticides needed (Table 2).

5.2.1 European summary of impact of DSS on pesticide use

At a European level, it is predicted that the reduction in TFI would result in a decrease in pesticide active substance weight required to all three crops (Table 3). In wheat and potatoes, when an additional 50% of the crop area is under DSS, it is estimated to result in a reduction of up to 3,685 tonnes and 3,428 tonnes respectively in pesticide weight. For grape production, where the use of pesticides is more intense, when an additional 50% of the crop area is under DSS this would lead to an estimated decrease of 11,526 tonnes in pesticide weight per year. Under this scenario, the greatest reductions are seen, with pesticide usage predicted to decrease by 24% across the three crops.

5.2.2 National level of impact of DSS on pesticide use

At a national level, the reduction in TFI is predicted to have a significant impact across all countries in terms of lower pesticide weights being required to treat crops. For wheat, pesticide use is estimated to decrease by between 2 tonnes (25% increase, Slovenia) and 1,620 tonnes (50% increase, France) depending on the country and the level to which DSS is used (Table 4). The greatest impact at farm level is estimated in France, where average pesticide usage is currently 1.82 kg/ha of active substance, and total usage is 10,506 tonnes active substance per year. Therefore, pesticide usage in wheat is reduced by an estimated 1,620 tonnes per year when an additional 50% of the crop area is under DSS. In comparison, countries with a much smaller crop area are expected to see a relatively smaller impact at farm level. Under the same scenario of an additional 50% of crop area under DSS, Slovenia, where average pesticide usage is currently 0.57 kg/ha and total usage is 22 tonnes of active substance per year, reductions in pesticide usage of up to 4 tonnes per year have been predicted.

Table 2 – The average estimated reduction in both total pesticide active substance usage and cost of pesticides for wheat, potatoes, and grapes for the scenarios where an additional 25% and 50% of the crop area is under DSS, based on reductions in TFI.

	Percentage reduction in total weight of pesticide active substance used and cost of pesticide usage following different levels of increase in DSS uptake.	
	25% DSS Uptake	50% DSS Uptake
Wheat	-8.3%	-16.7%
Potatoes	-20.8%	-41.7%
Grapes	-43.7%	-48.6%

Table 3 - The crop area and weight of pesticide active substances used for wheat, potato, and grape production in the EU under current agricultural practice (based on data from 2011-2021), and the estimated reduction in weight of pesticides for the scenarios where an additional 25% and 50% of the crop area is under DSS.

	Crop area (Mha)	**Average rate of application Current (kg/ha)**	**Total annual pesticide weight usage (tonnes) and change in usage following DSS uptake**		
EU			**Current practice**	**25% DSS increase**	**50% DSS increase**
Wheat	24.0	0.92	22,107	-1,842	-3,685
Potatoes	1.6	5.26	8,226	-1,714	-3,428
Grapes	3.1	14.70	46,104	-5,763	-11,526

Table 4 – The crop area and weight of pesticide active substances used for wheat production in each country under current agricultural practice (based on data from 2017-2021), and the estimated reduction in weight of pesticides for the scenarios where an additional 25% and 50% of the crop area is under DSS.

	Crop area (Mha)	**Average rate of application Current (kg/ha)**	**Total annual pesticide weight usage (tonnes) and change in usage following DSS uptake**		
Wheat			**Current practice**	**25% DSS increase**	**50% DSS increase**
Belgium	0.06	6.66	413	-34	-68
Denmark	0.51	1.36	1,427	-119	-238
France	5.1	1.82	10,506	-810	-1,620
Germany	3.0	1.54	4,673	-389	-779
Lithuania	0.68	0.40	269	-22	-45
Slovenia	0.03	0.57	22	-2	-4
UK	1.7	4.11	6,690	-557	-1,115

For the production of potatoes, it is estimated that pesticide use can be reduced by between 2 tonnes and 1,360 tonnes depending on the country and the level to which DSS is used (Table 5). Similar to wheat, the countries with larger crop areas for potatoes (i.e. France and the UK) are expected to see the greatest reductions in pesticide use. In France, average pesticide usage is currently 16.82 kg/ha of active substance, and total usage is 3,265 tonnes of active substance per year. When an additional 50% of the crop area is under DSS, pesticide usage is expected to be reduced by 1,360 tonnes per year. Whereas, in Lithuania where average usage is currently 0.60 kg/ha of active substance and total usage is 11 tonnes of active substance per year, pesticide usage could decrease by an estimated 5 tonnes per year when DSS is used on an additional 50% of the crop area.

There was limited data available for pesticide use in grape production and therefore, only three countries have been analysed (Table 6). France has the largest grape production area and uses 31.65 kg/ha of active substance with a total usage of 23,791 tonnes of active substance per year. It is predicted that pesticide use in France will decrease by up to 5,948 tonnes per year when an additional 50% of the crop area is under DSS. Whereas in Germany, which has a much smaller grape vine area, total usage is currently 1,974 tonnes of active substance per year. When an additional 50% of the crop area is under DSS, it is estimated to reduce by up to 740 tonnes per year.

Table 5 - The crop area and weight of pesticide active substances used for potato production in each country under current agricultural practice (based on data from 2017-2021), and the estimated reduction in weight of pesticides for the scenarios where an additional 25% and 50% of the crop area is under DSS.

Potatoes	Crop area (Mha)	Average rate of application Current (kg/ha)	Total annual pesticide weight usage (tonnes) and change in usage following DSS uptake		
			Current practice	25% DSS increase	50% DSS increase
Belgium	0.09	17.66	2,693	-561	-1,122
France	0.21	16.82	3,265	-680	-1,360
Ireland	0.01	10.26	211	-44	-88
Lithuania	0.02	0.60	11	-2	-5
UK	0.14	10.53	1,493	-311	-622

Table 6 - The crop area and weight of pesticide active substances used for grape production in each country under current agricultural practice (based on data from 2016-2021), and the estimated reduction in weight of pesticides for the scenarios where an additional 25% and 50% of the crop area is under DSS.

Grapes	Crop area (Mha)	Average rate of application Current (kg/ha)	Total annual pesticide weight usage (tonnes) and change in usage following DSS uptake		
			Current practice	25% DSS increase	50% DSS increase
France	0.75	31.65	23,791	-2,974	-5,948
Germany	0.10	19.65	1,974	-247	-494
Italy	0.69	23.76	16,011	-2,001	-4,003

5.3 Partial budget analysis

5.3.1 European summary of partial budget analysis

At a European level, the average cost of pesticides per hectare is forecast to decrease following the uptake of DSS (Table 7). The greatest reduction is seen in grape production, where costs are expected to decrease by between €35/ha and €71/ha when DSS is implemented on an additional 25% and 50% of the crop area, respectively. However, there is still significant potential for cost reductions in wheat and potato production, with possible savings of up to €15/ha and €57/ha respectively when an additional 50% of the crop area is under DSS. These pesticide cost reductions translate into an estimated saving of up to €4,094 million per year throughout Europe for wheat, potato, and grape production from reduced pesticide inputs. We have not accounted for any increase in costs associated with DSS implementation and monitoring.

Table 7 - The average cost of pesticides per hectare for wheat, potato, and grape production in the EU under current agricultural practice, and the estimated reduction in cost following an additional 25% and 50% of the crop area being under DSS.

EU	Units	Current practice*	25% DSS Uptake	50% DSS Uptake
Wheat	€/ha	88	-7	-15
Potatoes	€/ha	137	-29	-57
Grapes	€/ha	283	-35	-71

**European Parliament (2021)*

5.3.2 National level partial budget analysis

At a national level, the total cost of pesticides for growers is expected to decrease as a result of less pesticides being required in crop production. For wheat, it is estimated that the cost of pesticides will decrease between €7/ha and €57/ha, depending on the country and the level of DSS uptake (Table 8). The country that will see the greatest reduction in cost is Belgium, where the cost of pesticides is €342/ha under current agricultural practice and is predicted to decrease by up to €57/ha when an additional 50% of the crop area is under DSS. In comparison, in Lithuania where the current cost of pesticides is comparatively lower at €80/ha, when DSS is implemented on an additional 50% of the crop area, a €13/ha reduction in cost has been estimated.

For the production of potatoes, it is expected that the cost of pesticides will decrease between £59/ha and €333/ha, depending on the country and the level of DSS uptake (Table 9). Potato production requires a more intensive pesticide programme compared to wheat, which is reflected in the increased cost of pesticides. For example, in Belgium where the average cost of pesticides is currently €800/ha, by implementing DSS the cost of pesticides is estimated to decrease by up to €333/ha, assuming that implementing DSS on an additional 50% of the crop area is achieved. Therefore, following the implementation of DSS at a national level, the savings on cost of pesticides for potatoes are likely to be greater than for wheat as a result of the higher overall usage and therefore cost of pesticides.

Table 8 - The cost of pesticides per hectare for wheat production in each country under current agricultural practice, and the estimated reduction in cost following an additional 25% and 50% of the crop area being under DSS.

Wheat	Units	Current practice	25% DSS increase	50% DSS increase
Belgium	€/ha	342	-29	-57
Denmark	€/ha	114	-10	-19
Germany	€/ha	271	-23	-45
Lithuania	€/ha	80	-7	-13
Slovenia	€/ha	129	-11	-21
UK	£/ha	232	-19	-39

Table 9 - The cost of pesticides per hectare for potato production in each country under current agricultural practice, and the estimated reduction in cost following an additional 25% and 50% of the crop area being under DSS.

Potatoes	Units	Current practice	25% DSS Uptake	50% DSS Uptake
Belgium	€/ha	800	-167	-333
Denmark	€/ha	500	-104	-208
Slovenia	€/ha	500	-104	-208
UK	£/ha	282	-59	-118

6 Discussion

The aim of this evaluation was to estimate the impacts of using DSS in European agriculture. The results demonstrate the economic and environmental value of implementing DSS at farm level, as well as when scaled up to national or European level.

6.1 Scenarios for scale up of DSS use in Europe

The reduction in both pesticide usage and costs that can be achieved through the uptake of DSS highlights the importance of platforms like the one developed by the IPM Decisions project. The IPM Decisions platform enables users to assess the risks associated with weeds, invertebrate pests, and diseases in a variety of crops across Europe, though integrated and linked DSS. As the platform takes regional climate conditions into consideration, it provides the user with tailored information regarding the risk to crops.

The results of this evaluation indicate that supporting growers and their advisors in the use of DSS is likely to see widespread environmental and economic benefits as a result of reduced pesticide applications and costs. This is important in the context of current and forthcoming targets and regulations initiated by the European Commission, which include reducing the use and risk of pesticides by 50% by 2030, as well as measures to ensure that growers are using IPM practices (European Commission, 2022). In addition, the associated meta-analysis found that these reductions in pesticide usage could be achieved without negative impacts on crop yields. Therefore, widespread implementation of DSS has the potential to significantly contribute towards meeting these EU targets for reduced pesticide usage, whilst maintaining food security.

6.2 Impact of DSS on pesticide use and economic benefits under each scenario

6.2.1 Wheat

At European level, the average pesticide usage is 0.92 kg/ha under current agricultural practice. This is equivalent to 22,107 tonnes of pesticide active substance required to treat wheat crops throughout the EU. Assuming DSS uptake in an additional 25% of the crop area, it is estimated that the total annual weight required would decrease by 1,842 tonnes, decreasing by 3,685 tonnes for an additional 50% of the crop area under DSS. This translates to an estimated reduction in spend on pesticides ranging from €176 million to €352 million when DSS is implemented on an additional 25% and 50% of crop area, respectively. At national level, this predicted reduction in pesticide usage is greatest in countries with larger areas of wheat. For example, in Germany a reduction of up to 779 tonnes in pesticide weight usage has been predicted when an additional 50% of the crop area is under DSS, equivalent to a decrease of up to €137 million in pesticide costs.

6.2.2 Potatoes

At European level, the average pesticide usage is 5.26 kg/ha under current agricultural practice. This is equivalent to 8,226 tonnes of pesticide active substance applied to potato crops throughout Europe. Assuming DSS uptake in an additional 25% of the crop area, it is estimated the total annual pesticide application would decrease by 1,714 tonnes, decreasing by 3,428 tonnes for an additional 50% of the crop area under DSS. This translates to an estimated reduction in spend on pesticides ranging from €45 million to €89 million when DSS is implemented on an additional 25% and 50% of crop area, respectively. At national level, this predicted reduction in pesticide usage is greatest in countries with larger areas of potatoes. For example, in the UK a reduction of up to 622 tonnes in pesticide weight usage has been predicted when an additional 50% of the crop area is under DSS, equivalent to a decrease of up to £29 million in pesticide costs.

6.2.3 Grapes

At European level, the average pesticide usage is 14.70 kg/ha under current agricultural practice. This is equivalent to 46,104 tonnes pesticide active substances applied to grapes per year in Europe. Assuming DSS uptake in an additional 25% of the crop area, it is estimated the total annual pesticide active substance use would decrease by 5,763 tonnes, decreasing by 11,526 tonnes under a 50% increase in DSS uptake scenario. This translates to an estimated reduction in spend on pesticides ranging from €111 million to €222 million when DSS is implemented on an additional 25% and 50% of crop area, respectively. At national level, this predicted reduction in pesticide usage is greatest in countries with larger areas of grape production. For example, in France a reduction of up to 5,948 tonnes has been predicted when an additional 50% of the crop area is under DSS. Although no data was available to calculate the cost of pesticides, it can be assumed that it would decrease significantly following the use of DSS.

6.3 Assumptions and limitations

There are limitations to this evaluation as a result of the limited and inconsistent data available on pesticide usage and cost of production for each country. As a result, only a small selection of European countries had sufficient data to complete the assessment, and an estimation of the specific value of DSS to every country was not possible within this evaluation study. In order to conduct the analysis, several assumptions were made. For each crop the TFI was assumed to be the same for each country, while the value and weight of pesticides were assumed to be the same for each treatment in each country. However, it is recognised that in practice, these would all vary considerably between countries based on weed, invertebrate pest, and disease pressure, local regulations and the standard agricultural practices used by growers. This evaluation also only considers three crops: wheat, potatoes, and grapes, and therefore it is highly likely that the scale of impact of using DSS in the production of other crops will differ.

7 Conclusion

The use of DSS provides growers with the opportunity to reduce their pesticide usage, which when scaled up to a national or EU-level, results in significant estimated savings both in terms of pesticides required, as well as total cost. This demonstrates the value that the IPM Decisions Platform has to European agriculture by providing access to a variety of DSS for the major outdoor crops. An increase of application of IPM DSS by 25-50% in wheat, potatoes and grapes would make a substantial contribution towards the European Commissions targets to reduce pesticide use, and risks associated with pesticide use.

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