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# INNOSETA regional workshops: analysis of the needs for better dissemination of spraying innovations in vineyards and orchards

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## Summary

In the framework of the H2020 INNOSETA thematic network focused on agricultural spraying, 17 workshops were organised across Europe on issues related to the appropriation of spraying innovations by farmers. The objective of these workshops, which gathered a total of 850 people, was to foster exchanges between the various stakeholders (sprayer manufacturers, PPP companies, authorities, advisors, farmers' representatives, researchers, etc.) in a multi-actor approach; to address issues related to the dissemination of innovation; and to identify ways to improve farmers' uptake. Each workshop was organised as a technical day combining demonstrations of innovations with interactive discussions. The outcomes of the discussions highlighted in all countries are that there is still a lot to be done to enable farmers to make better use of the technologies they have or that have been available on the market for a long time. The need for better training of farmers was also a key point. This paper focuses on two cropping systems (orchard and vineyard) and summarises the results from the workshops.

**Key words**: EU Thematic network, spraying, multi-actor approach, dissemination

## Introduction

Since the 1990s, the issue of the risks associated with the use of pesticides has emerged in public opinion. There is a growing public demand for a better control of the use of PPPs, including a ban of the most dangerous products, regulations on the farmers practices, drift reduction and the establishment of buffer zones near sensitive areas, etc. The growing general awareness of the risks for health and environment (contamination of water, presence in food, exposure of operators, exposure of residents and bystanders…) has led to a strengthening of regulations at European level and in each Member State (Directive 2009/128/EC for the sustainable use of pesticides, machinery Directive 2009/127/EC, EU Farm to Fork Strategy, National Action Plans).

Despite this common European framework, a great deal of freedom has been left to the member states, where the perception of the risks associated with the use of PPPs by civil society varies and results in more or less restrictive regulatory guidelines. For example, drift was studied in Germany at a time (mid-1990s) when Southern Europe was not aware of this problem. France legislated early on pesticide reminant bioremediation systems (2006), whereas this is not yet the case in Italy, Spain or Greece.

To meet these challenges and develop low-impact agriculture, technology is a solution to consider. Many innovations have emerged in recent years from manufacturers or research institutes which can help farmers in their practices for plant protection and spraying. The shared observation is that there is a wide gap between the research carried out by public institutes, the innovative technologies proposed by the industry and their implementation in everyday farming practices (Gil *et al*., 2020).

The H2020 INNOSETA thematic network aims to make these innovations widely known by farmers to foster dissemination. Within the project, a freely accessible platform was therefore constructed (Mozzanini *et al*., 2022). The INNOSETA platform (https://platform.innoseta.eu/) is a repository of innovative spraying technologies, training materials, projects, and articles. The acronym INNOSETA stands for "Innovating Spraying Equipment, Training or Advising". A SETA is either (i) a whole sprayer that presents innovative components, (ii) the devices/tools enhancing the environmental sustainability of spraying operation, or (iii) training and advising materials referred to sprayers and spraying operations.

In addition, the INNOSETA project aims 1) to better understand the perception of the challenges linked to the use of pesticides according to the countries (Koutsouris *et al.*, 2019), 2) to identify the innovations to be promoted as a priority to meet the challenges and the means to promote them, 3) to identify the obstacles at national level to the dissemination of innovations and good practices and what could be done to improve the situation, and 4) to consider regulatory and/or organisational ways of addressing the problems.

## Materials and Methods

The INNOSETA European network brings together 15 partner institutes from eight countries (IT, SP, NL, SE, GR, PL, FR, BE). The partners belong to universities, research institutes, agricultural technical institutes, and extension services. The network covers the main cropping systems including orchard, vineyard, greenhouse and field crops (incl. field vegetables). Between June 2019 and December 2020, every country involved organized several "Regional Workshops" (RWs), each of them targeting one of the most representative cropping systems in the area. The focus on a single cropping system per workshop allowed to address the technical specificities linked to each crop. The considered cropping systems were orchards, vineyards, greenhouses and arable crops/vegetables. In total, 17 RWs were organized, as presented in Table 1.

The purpose of RWs was to bring together the relevant stakeholders and to make use of the multiplicity of their expertise to identify which innovations are the most relevant to meet the challenges of the sector. The objectives were also to:

- Identify the ways to promote the development of these innovations and their dissemination,
- Identify the needs not covered by current available SETAs solutions,
- Identify policy gaps and produce recommendations and policy briefs for EU policy-makers.

To have the greatest possible diversity of expertise, a broad spectrum of stakeholders has been gathered during the workshops including representatives of the authorities, farmers, agricultural extension services, research and R&D institutes, PPP companies and SETA's manufacturers. Most of the RWs were organized as a technical day that combined demonstrations of SETAs in the field with interactive discussions in groups. From July 2020, the COVID-19 restrictions forced partners to organize the RWs online. Nevertheless, 850 stakeholders attended the INNOSETA RWs across

Table 1. *Schedule of the RWs (partner in charge of organization is indicated in the Hub column)*

| Hub<br>RW organizer | Regional Workshops<br>Orchard | Vineyard | Greenhouses | Field crops /Veg. |
|---|---|---|---|---|
| **Spain**<br>UPC | 5 Dec 2019<br>(24 attendants) | 25 Oct 2019<br>(37 attendants) | 9 Jan 2020<br>(32 attendants) | |
| **Italy**<br>UNITO | 5 Nov 2020<br>(39 attendants) | 10 July 2019<br>(58 attendants) | | 11 Oct 2019<br>(76 attendants) |
| **France**<br>IFV | 16 Oct 2019<br>(52 attendants) | 18 June 2019<br>(134 attendants) | | 2 July 2020<br>(27 attendants) |
| **NL/BE**<br>ZLTO/ILVO | 13 Aug 2020<br>(52 attendants) | | 11 Feb 2020<br>(36 attendants) | 6 Nov 2019<br>(76 attendants) |
| **Greece**<br>AGENSO | 16 Dec 2019<br>(50 attendants) | 16 Dec 2020<br>(46 attendants) | 28 Feb 2020<br>(49 attendants) | |
| **Sweden**<br>VISAVI | 20 Jan 2020<br>(21 attendants) | | | 14 Jan 2020<br>(23 attendants) |

Europe. A common methodology was used. Discussions between attendants were organized in small groups to foster exchanges. Attendants were divided into three discussion groups conducted in parallel:

1. Thematic Group 1: Optimization of spray quality and application precision,
2. Thematic Group 2: Spray drift reduction,
3. Thematic Group 3: Prevention of point sources pollution – Environmental safety and operator health

Within each group, participants were first asked to identify the priority issues and challenges related to the theme. Then, around 15 SETAs pre-selected by the organizers were presented to the attendants. Participants were asked to rank these SETAs in order of importance according to their ability to address the challenges previously identified. The two highest ranked innovations were discussed by the participants and ways to promote their use in the field, whether technical, regulatory, or organizational were proposed. The discussions subsequently focused on identifying the needs not covered by the innovations presented as well as the definition of priorities in terms of public policies at the national and European levels to address the issues.

This paper presents the results from the orchard and vineyard RWs, while the "Discussion" section of the paper contains an overall discussion including all the cropping systems addressed during the RWs. The outcomes from the RWs are described in an overall SETA report (https://www.innoseta.eu/3rd-international-event-seta-workshop/).

## Results

### *Vineyard spraying: Identification of challenges*

In total, four RWs focused on vineyard **s**praying were held in Spain, France, Italy and Greece. They gathered a total of 275 stakeholders. With regard to the identification of challenges, most participants highlighted that with most of the sprayers used in vineyards, it remains difficult for winegrowers to check the quality of spraying. Indeed, on most sprayers, the only device available for control is a manometer fitted on the machine.

It is crucial to raise awareness among farmers and their advisors about the importance of a proper and regular sprayer adjustment (distribution profile) and to train all operators involved in plant protection (farmers but also advisers, PPP sellers, sprayer distributors) on sprayer calibration.

Moreover, the cost of new technologies limits their dissemination and the use of spraying innovations, especially for small farms which remains the most popular model in Europe. It is worth noting that, on average, the largest vineyard holdings are located in France, with an average

area of 10.5 ha, followed by Germany (2.4 ha), Italy (2.0 ha) and Spain (1.8 ha). Average areas of less than one hectare are found in Greece, Cyprus and Slovenia (0.5 ha each) as well as in Portugal (0.9 ha) (EuroStat, 2015).

Looking to the future, stakeholders highlighted a real interest in the development of SETAs that increase the accuracy of PPP application. Those devices could be based on canopy sensors and/or disease detection systems and generate prescription maps that 'smart' spraying systems would be able to automatically apply with limited operator involvement. However, there is still much R&D to be done to develop these technologies and to make them technically reliable and affordable for farmers.

With respect to drift, it is also important to inform farmers and operators about the Best Management Practices and technologies for drift reduction. Attendants agree that most growers should be better aware of the impact of spray drift and they still need to be trained on how to mitigate the risks. Available and reliable SETAs able to reduce drift (e.g. sprayer settings, choice of sprayer and nozzle) still need to be widely promoted based on scientific data.

Regarding the protection of the operator and the environment, there is a need to raise awareness about the risks that point sources pollution (water courses pollution and soils contamination) represent for the environment. The operations that are most likely to generate point source pollution must be identified and explained to operators. It is also necessary to clearly demonstrate to operators that they are exposed when filling and cleaning the sprayer, and that these operations can negatively impact their health.

Table 2 presents the top-ranked SETAs for vineyard spraying during the RWs for their ability to address the identified challenges.

Table 2. *SETAs for vineyard spraying ranked highest according to their ability to address the identified challenges*

| | Spray quality and application precision | Spray drift reduction | Prevention of point sources pollution - Environmental safety and operator health |
|---|---|---|---|
| 1 | Spray quality assessment tools, apps or help from advisors for sprayer calibration | Air induction nozzles | Systems for safe transfer of PPP in the tank (e.g. Closed Transfer System) |
| 2 | Smart technologies with Variable Rate Application technologies ← mapping of vegetation | Shielded sprayers | Personal protective equipment (PPE) |
| 3 | Spraying control units for real-time monitoring of spray parameters | | Annex tank for mixture preparation (induction hopper) |

*Vineyard spraying: Ways to support winning SETAs' development and priorities for future European policies and calls for projects.*

In viticulture, the discussions highlighted that innovation is not only about bringing the latest technology to the farm, but also about teaching farmers to use their sprayers correctly. Indeed, the key point from the discussions was the need for winegrowers to be better informed and trained on the importance of sprayer adjustment and the decisive influence of sprayer calibration on the application efficacy and the risks of contamination. More training courses covering very practical aspects under real field conditions are therefore necessary. The mandatory training courses to get PPP licenses for farmers and advisers (Article 5 from Directive 2009/128/EC) could be used in this objective and could include a consistent practical part dedicated to the "correct sprayer use and adjustment". Furthermore, training should involve various stakeholders, including advisers and sprayers dealers, not only growers.

When growers purchase a new sprayer or device, it should also be ensured that sprayer manufacturers and/or retailers provide training to farmers on how to use and adjust the machine.

Scientific and technical publications aimed at proving the biological efficacy of innovative sprayers are still needed to provide an additional incentive for their adoption by users, especially in case of air induction nozzles, which are still very poorly used despite their effectiveness in reducing drift and their low cost.

It is also necessary to give growers the possibility to control the quality of spraying by monitoring of the application parameters in real time. As mentioned above, most sprayers used in viticulture are only fitted with one single sensor, a simple manometer fitted on the sprayer, far from the cabin. In addition, the data of the pressure in the spraying system is a data too indirectly linked to the relevant parameters for controlling the accuracy of spray application which are: (i) the volume rate (L $ha^{-1}$), (ii) the flow rate of the nozzles on the different sections of the sprayer (L $min^{-1}$), (iii) the forward speed (km $h^{-1}$). The monitoring systems (such spray computer) that allow the relevant spraying parameters to be displayed should become mandatory on each sprayer in Europe to facilitate spraying operations.

In terms of public policy priorities, participants underlined the need to encourage and promote the renewal of the sprayer fleet towards more efficient machines and to support this transition with purchase subsidies. The evolution of the fleet and orientation of subsidies should be based on a sprayer's performance classification system as for example that proposed in France by PerformancePulvé (http://www.performancepulve.fr/).

Furthermore, very old sprayers with a high drift potential and a low spraying quality should be removed from the market.

*Orchard spraying – Identification of challenges*

In total, six regional workshops about orchard spraying were held in 2019–2020 in Greece, Spain, France, Italy, Sweden and Belgium/The Netherlands and involved a total of 238 stakeholders. As with vineyard spraying, the lack of information and practical training on proper sprayer calibration was mentioned by most of the participants as a challenge. A lack of dissemination of information on new technologies, their technical value, and how they can be used was also mentioned.

A technical challenge specific to orchards due to their particular geometrical characteristics has been identified with regard to spraying precision: there is a need for easy-to-use devices, automatic or manual, to help growers calibrate and target the spray on the plant as accurately as possible, since the vertical distribution of the spray deposit on the trees is a key point for the quality of plant protection.

Concerning drift, several regulatory aspects were mentioned: (i) the current inequity and policy differences in regulation, particularly related to drift reduction practices between different European countries, resulting in a lack of standardization of Spray Drift Reduction Technique (SDRT) at the EU level, (ii) the lack of controls carried out on farms that results in insufficient information on the actual implementation of the regulations.

Participants considered that it might be useful to plan a scrappage programme for the oldest sprayers. Also with regard to drift, as in viticulture, stakeholders point out that there are not enough training courses available for farmers on SDRT, on the influence of weather conditions (e.g. avoiding windy conditions) and on how to properly adjust a sprayer to limit drift.

Concerning point sources, participants mentioned the lack of information and training for farmers concerning the Best Management Practices related to spray tank filling, PPP mixing and prevention of PPP contamination when cleaning the sprayer.

There is also insufficient information and training on the use of personal protective equipment (PPE). Note that this should not be the case as this important aspect is part of the mandatory training of professional users (Annex 1 of the SUD Directive 2009/128/EC). Regulations have evolved rapidly in recent years, and it is important to ensure that farmers understand regulatory updates. Unfortunately, the shared analysis is that most users do not read the labels, resulting in

a lack of knowledge. An identified need is to harmonize labels to make them more readable and understandable. It also appears necessary to develop PPE better adapted to the practical needs of growers (e.g. multilayer gloves) so they are accepted easier (aesthetics, comfort, ergonomics). Finally, the last challenge is related to the operator and environmental safety during the preparation stage of PPP treatments: it seems that more knowledge about techniques and tools that facilitate the filling of the tank is needed (e.g. closed transfer system, induction hopper).

Table 3 shows the top-ranked SETAs for orchard spraying during RWs for their potential to address the identified challenges.

Table 3. *SETAs for orchard spraying ranked highest according to their ability to address the identified challenges*

| | Spray quality and application precision | Spray drift reduction | Prevention of point sources pollution - Environmental safety and operator health |
|---|---|---|---|
| 1 | Canopy sensors | Air induction nozzles | Systems for safe transfer of PPP in the tank (e.g. Closed Transfer System) |
| 2 | Spraying control units for real-time monitoring of spray parameters | Cross flow sprayer and systems able to move the distribution close to the target | Annex tank for mixture preparation (induction hopper) |
| 3 | Tools/apps for sprayer adjustment (patternator) | Fan air flux control | Personal protective equipment (PPE) |

*Orchard spraying – Ways to support winning SETAs' development and priorities for future European policies and calls for projects*

Air induction nozzles, a basic device in terms of technology and cost, topped the list in four of the six countries (SP, FR, SW, IT) as SETA able to address the challenges faced in spraying application. Participants identified several ways to develop the use of this device, which is a simple and effective way to reduce drift but it is still seldom used in practice in these countries. RW participants underline the need to increase communication towards farmers about the advantages of air induction nozzles. In addition, tests should be carried out at EU level to prove their proper functioning and their biological efficiency. Many farmers are still reluctant about producing larger droplets as practices have been to spray with small droplets/mist since decades to visually obtain a good coverage. Including air induction nozzles in biological efficacy trials during PPP registration processes would allow to obtain quantified results as evidence of their proper functioning.

Cross flow sprayers development has been identified as a major stake for three countries (SP, FR, SW). This category of sprayers improves spray quality and reduces drift significantly compared to conventional axial sprayers. To facilitate the implementation of these sprayers, technical institutes should work on the adaptation of orchard training systems to this type of sprayers as they are currently not usable in orchards trained in gobelet (stone fruits). Since it is technically complex to adapt the sprayers to the orchard, the solution might be the opposite, meaning it might be more appropriate to configure orchards into fruit hedges or into axes, as it has already been done for vineyards, pome fruits and intensive olive growing. Such growing practices would also allow a better use of the filter effect of vegetation compared to orchards where trees are isolated from each other and where spraying is not stopped between trees.

Canopy sensors able to characterize vegetation is the innovation that has been identified as a priority for five of the six countries (SP, FR, GR, SW, IT). The range of vegetation sensors has grown significantly in recent years with the development of vision technologies and computing capabilities (3D imagery, LIDAR, hyperspectral imagery, etc.). Different types of sensors can be used to provide vigour maps, but it is still necessary to further develop ways to translate

viticulture, R&D is still needed for the development of these tools that will be contribute to the implementation of precision spraying in the future.

As with viticulture, the need to fit sprayers with control units was identified as a priority in four of the six countries. Attendants stressed that spraying would gain in precision with the possibility of verifying the quality of spraying in real time during the application by monitoring of application parameters. Most sprayers used in orchards are insufficiently equipped (a single manometer) and do not guarantee the precision of the application. A real time monitoring systems (control panel displaying the different parameters) should become mandatory on each sprayer in Europe to facilitate spraying operations.

Closed-Transfer Systems (CTS) were at the top of the vote for most of the countries (SP, FR, SW, IT NL). Although they are currently limited to liquid formulations, CTS facilitate spray mixture preparations, secure filling processes and limit the risk of point source pollutions. Following the RW outcome, in order to ensure the development of CTS use, this device could be included in the European Machinery Directive requirements (Directive 2009/127/EC). The other ways identified to support the development of CTS are i) integrate the use of these devices into an European certification scheme (e.g. High Environmental Value), (ii) impose at national regulatory level the use of closed-transfer systems, as will be the case in Denmark and the Netherlands in 2024.

Despite their undeniable interest, induction hoppers are still not well-known by farmers due to a lack of knowledge: advisers, machinery manufacturers and resellers are often not active enough in promoting this kind of technology. Making the presence of induction hoppers mandatory on brand new sprayers, their inclusion in the national Rural Development Programmes as a suggested tool, along with economic incentives, may improve their dissemination. Information on the advantages of this technology should be integrated at every level in the training of farmers.

The use of personal protective equipment (PPE) results were not widespread, despite the fact that they are not very expensive. Most of the operators do not use it because they find it uncomfortable. To expand their use, it is necessary to consider user's needs. Research projects should take into account not only the ergonomic and technical aspects, but also the sociological aspect of PPE and their social acceptability (e.g. the colour of the PPE). It is therefore necessary to develop R&D on textiles, among other things to improve comfort, including the warmth felt when wearing equipment in summer. In addition, it is essential to increase the dissemination of good practices for the protection of operators through seminars, workshops and training. A decision support tool, to select the right PPE according to the spraying situation and the product used, has been suggested to be developed by Crop Life International Association and/or national PPP producer associations. This tool could be inspired by the multi-stakeholder initiative launched in France by https://epiphyto.fr/ or by Bayer initiative *DressCode*, which is however limited to the products of the brand.

## Discussion

The overall analysis of RWs outcomes hardly shows any tangible differences between countries. On the contrary, many similarities appear despite the different levels of concern regarding the use of pesticides expressed in the public opinion of the different EU Member States. The overall analysis also reveals many similarities between cropping systems beyond their technical differences.

Indeed, for all cropping systems and all of the thematic groups, the issue of the lack of (appropriate) training was the main identified bottleneck. The identified need is to strengthen training and information for farmers but also for all the actors involved in plant protection (advisers, PPP dealer, sprayers distributors…).

The need to highly improve the awareness on the necessity to wear PPE in order to promote uptake by users was also widely underlined during the workshops.

Similarities between crops also appeared concerning the SETAs identified by the stakeholders as the most able to address the challenges. For example, air injection nozzles appeared to be the top priority of the SETAs to be promoted in all the countries where the RW has been made and for all the examined crops in order to reduce drift. In terms of prevention of point sources pollution and protection of health operators, the same SETAs for vineyard, field crops and orchards topped the list of priorities (Closed Transfer System, induction hopper, use of PPE). It is interesting to note that these SETAs are not part of the most advanced technologies since they have been available on the market for many years. However, they are still adopted very little, either due to the lack of knowledge or because of cost issues.

The high-end technologies that were discussed the most in overall cropping systems were those in the field of precision spraying where the dose is adapted to the conditions of the environment (spot spraying, variable rate application based on vegetation sensors, and nozzle control technologies [e.g. PWM]). The numerous exchanges allow us to identify the hope placed in such emerging technologies for which R&D work is still lacking in order to translate the information read by the sensors into relevant agronomic information (dose recommendation maps). Moreover, the economic model and added value of these devices still need to be proven and refined for those devices to find their place at European farms.

Another aspect is the financial and/or organizational support needed to facilitate the purchase or overall use of spraying technologies that meet both agronomic and environmental issues. These technologies are either efficient sprayers, devices allowing better control of the precision of the application, tools contributing to the limitation of the risks for the environment and the operator (drift, point sources), data tools for more informed decision making related to pest control, or spot specific and variable rate technologies. Sprayers have an average lifespan of almost 15 years. Together with the training of growers, the evolution of the sprayer fleet is a key point for the EU. The orientation of subsidies should be based on a sprayer's performance assessment system drawn in a multi stakeholder approach. Common elements also emerged repeatedly in the discussions concerning the need for harmonisation of regulations on PPP application and sprayer requirements at European level. Such a harmonisation would help to improve the dissemination of spraying technologies and good practices. In many discussions, the lack of uniform European guidelines (drift reduction technologies, authorised PPPs, sprayer requirements, buffer zone rules, etc.) was identified as responsible for an unfair playing field for farmers around the EU. This request for harmonized rules is legitimate, but again comes up the necessary adaptation of regulations to the local contexts and to the decentralization movements desired by most Member States. This undoubtedly reflects a need for simplicity of the rules implemented and the challenge for authorities to make the different layers of regulation clear for end users, which is a prerequisite for their proper application.

The use of pesticides has unfortunately become one of the emblematic images of agriculture in recent years. Although initially remote from the subject, the relationship between the agricultural community and civil society has been the subject of many discussions during INNOSETA RWs. The shared observation is that the social acceptability of using a sprayer (regardless of conventional or organic farming practices) is decreasing year after year. The challenge of social acceptability about spraying was thus addressed and stakeholders identified a real stake in developing operations of communication dedicated to reconnecting with their fellow citizens all around Europe. Concerning the growing tension between farmers and residents, there is a need to increase communication, using for example tools such as neighbourhood charter, information meeting with residents, and SMS alerts to inform the neighbourhood before spraying.

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