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INNOSETA - An H2020 European project to fill the gap between research and professional users in crop protection

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Summary

INNOSETA - Innovative practices for Spraying Equipment, Training and Advising in European agriculture through the mobilization of Agricultural Knowledge and Innovation Systems (www.innoseta.eu) is an EU project financed under H2020 (RUR-2016-2017) programme. Coordinated by the Universitat Politècnica de Catalunya (Spain), with an international and representative consortium of 15 partners representing all the stakeholders (research and academy, farmer's associations, sprayer's manufactures, pesticide companies, advisors). The main goal of INNOSETA is to establish a self-sustaining and innovative thematic network on crop protection and the sustainable use of plant protection products (spray equipment, training and advice) to help close the gap between research, and the use and exploitation of all this by the farmer. The project promotes the effective exchange of new ideas and information between research, industry, extension and the agricultural community so that existing commercial and research solutions can be widely disseminated and applied. The aim is to reduce/eliminate the existing gap between research and the agricultural sector, allowing a great improvement of the training skills of the involved agents.

Key words: Training, industrial solutions, European Commission, education, spray application

Introduction

Global agriculture relies on synthetic Plant Protection Products (PPP) for pest management including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others to support sustainable yield productivity. Farmers and crop advisors/ extension service personnel follow conventional crop protection strategies that were established after the Green Revolution during 1950–1960 maintaining, in general, significant use of PPPs with potential significant impact on the environment and human health. In the meantime, PPP industry and research entities have been developing more sustainable novel PPPs either biological or chemical that show high efficacy in the lab environment, but their efficacy rate is reduced significantly, when applied in field conditions with the current spraying practices. Even more, spraying technologies

developed in recent years have demonstrated an important improvement in terms of efficiency and safety, including in their development the latest advances in electronics, data management and safety aspects. New sprayers have experienced a revolutionary improvement allowing a better and safer use of PPPs.

New PPP developments and the latest advancements in intelligent sprayers have been complemented with a large list of Best Management Practices (BMP), alternative methods for dose/volume selection adapted to canopy structure, safe recommendations to reduce drift, bystander and resident exposure and point sources' contamination, development of electronic and web-based Decision Support Systems (DSS) to improve the phase-use of PPPs. But unfortunately, there is still an important gap between research developments and the actual use of the available tools and practices by the farmers, especially for this large number of small and medium producers with limited access to the information. If this gap closes, then European agriculture could become more sustainable with minimum environmental, socioeconomic and human health impact. Since new legislation has applied efforts to the use-phase of PPPs, it is now time to integrate all the available tools and practices that previous research has demonstrated to be interesting. However, there is still another key element that is absolutely needed to achieve success in the whole process: an adequate training of all the professionals involved in the process, which represents the key factor for the whole integration. Therefore, only when agricultural stakeholders gain knowledge of existing and future technological advancements in spraying technology and adequate training is achieved in all of the European territory will the system be able to implement the policies in the legal framework and to produce food in a better and more sustainable way.

Objectives of the INNOSETA Project

INNOSETA - Accelerating **INNO**vative practices for **S**praying **E**quipment, **T**raining and **A**dvising in European agriculture through the mobilization of Agricultural Knowledge and Innovation Systems

SETA *- Spraying Equipment, Training and Advising*

The main objective of INNOSETA (Fig. 1) is to set up an Innovative self-sustainable Thematic Network on Spraying Equipment, Training and Advising to contribute to closing the gap between the available novel high-end crop protection solutions either commercial or from applicable research results with the everyday European agricultural practices by promoting effective exchange of novel ideas and information between research, industry, extension and the farming community so that existing research and commercial solutions can be widely communicated, while capturing grassroots level needs and innovative ideas from the farming community. Detailed distribution of the objectives can be established as follows:

- Objective 1: Create an inventory of directly applicable spraying equipment and technologies, training materials and advisory tools available from the large stock of research results and commercial applications.
- Objective 2: Assess end-user needs and interests, and identify factors influencing adoption considering regional specificities.
- Objective 3: Generate interactive multi-actor, innovation-based collaborations among different stakeholders.
- Objective 4: Set up of an ICT tool for the on-line assessment of the Spraying Equipment, Training and Advising and the crowdsourcing of grassroots-level ideas and needs.
- Objective 5: Liaise with EIP-AGRI and its structures.

Representative consortium

The INNOSETA consortium has been established trying to cover all the sectors involved in the process. From academia to the final user, going through sprayer manufacturers, pesticide companies, advisors and farmer's associations, the main objective during the consortium creation was to cover

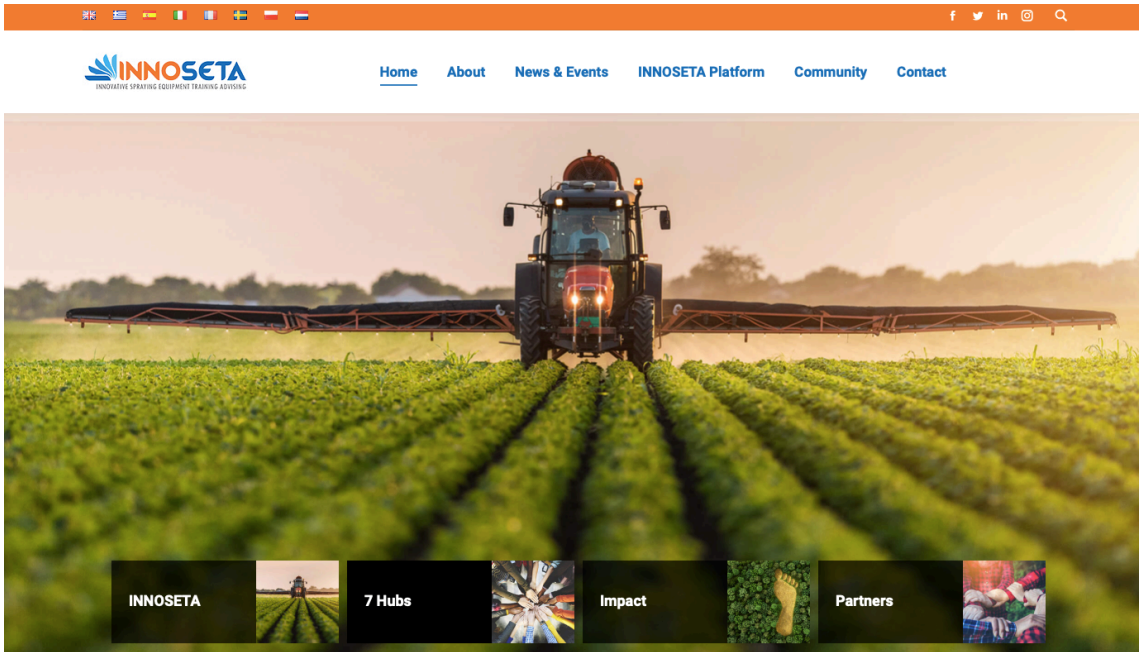

Fig. 1. Innoseta website. www.innoseta.eu.

all the strategic sectors. Fifteen partners from seven countries have been organized in different strategic hubs (Fig. 2). Main reasons for creation of INNOSETA consortium:

- INNOSETA gathers experts in both the technical part (spraying technology, extension and training), and social science and innovation to allow a holistic approach to the uptake of novel SETA and the capture of innovations.
- INNOSETA is based on a "Multi Actor Approach", including farmers/extension organizations from seven countries, which ensures that the end-users of SETA innovations are well represented.
- Industry relating to SETA will participate in INNOSETA providing the contact of this thematic network with staff from the R&D and commercial departments of multinationals and SMEs from the countries involved in the project and other EU countries. More specifically, the farm machinery industry is represented through its umbrella organization (CEMA: European Association of Agricultural Machinery), while the Plant Protection Product industry will also join forces (ECPA: European Crop Protection Association). Last but not least, COPA-COGECA will signify the farmers' industry that is the final applicator of agrochemical in the field.

INNOSETA is coordinated by Universitat Politècnica de Catalunya (https://uma.deab.upc.edu).

Why SETA solutions?

Novel SETA has a real potential to deliver a more productive and sustainable agricultural production, based on a more precise and PPP-efficient approach, especially in a scenario of farming labour shortage and climate change. However, novel SETA are not widely implemented throughout Europe, except in some advanced European countries (i.e. Germany, Netherlands, Sweden and Denmark), where there are still a large number of innovations in spraying technology to be adopted. Improvement of training activities have been widely underlined as the most efficient tools to improve the application-phase of PPP in EU members with lower technological level and higher number of small and traditional farmers (i.e. Mediterranean countries), while in large agriculture systems from the North of Europe, new technological improvements and developments are largely appreciated.

The underlying reasons for this implementation gap can be deduced from empirical adoption studies that have shown that individual adoption and the wider diffusion of technological innovations and new application techniques depend on characteristics of the innovation (e.g. cost, complexity), the

innovator and his/her socio-economic background (e.g. preferences and educational level of farmer), the perceived usefulness and ease of use, the informational, social and institutional environment, and, in particular the knowledge support system in place.

Survey to EU Stakeholders

All the partners were involved in organizing surveys with farmers in seven hubs: France, Greece, Italy, The Netherlands and Belgium, Poland, Spain, and Sweden. Farmers were selected according to their cropping system (arable crops, open field vegetables, orchards, greenhouses and vineyards) and farm size class. Overall, 348 farmers were interviewed from mid-October 2018 till mid-January 2019. The questionnaire comprised sections on background (farm and farmer's) information, spraying equipment and machinery, innovative spraying equipment, adoption (and non-adoption), best management practices, information seeking and farmers' attitudes towards technology and innovativeness. A combination of multiple-choice questions, Likert-scale data, and open-ended questions were used to shed light on the abovementioned topics with emphasis on how background data, subjective perceptions and/or information sources differ between adopters and non-adopters. Data analysis has been performed at univariate (frequencies) and bivariate level (cross-tabulations; Pearson Chi-Square).

Farmers' background and (some) perceptions towards spraying equipment were found to differ according to cropping system while differences per hub (country) were also detected, as for example in terms of farmers' education, information sources and the rate farmers renew their farming equipment. In general, farmers seem interested and have favorable attitudes towards innovative spraying equipment. The main obstacles vis-à-vis their adoption according to non-adopters are farm size and affordability. Non-adopters claim that a special subsidy would be very welcome although few adopters made use of such a subsidy. Among non-adopters economic reasoning and equipment condition predominate over technological and environmental considerations. According to all the interviewed farmers the three most important spraying equipment characteristics that would make spraying equipment more relevant to farmers' needs are long term reliability, ease of use and operator safety. Adopters and non-adopters differ in terms of training, information sources, attitudes towards technology and venturesome spirit. Fig. 2 shows the dissemination or new technologies among farmers (orchards/vineyards).

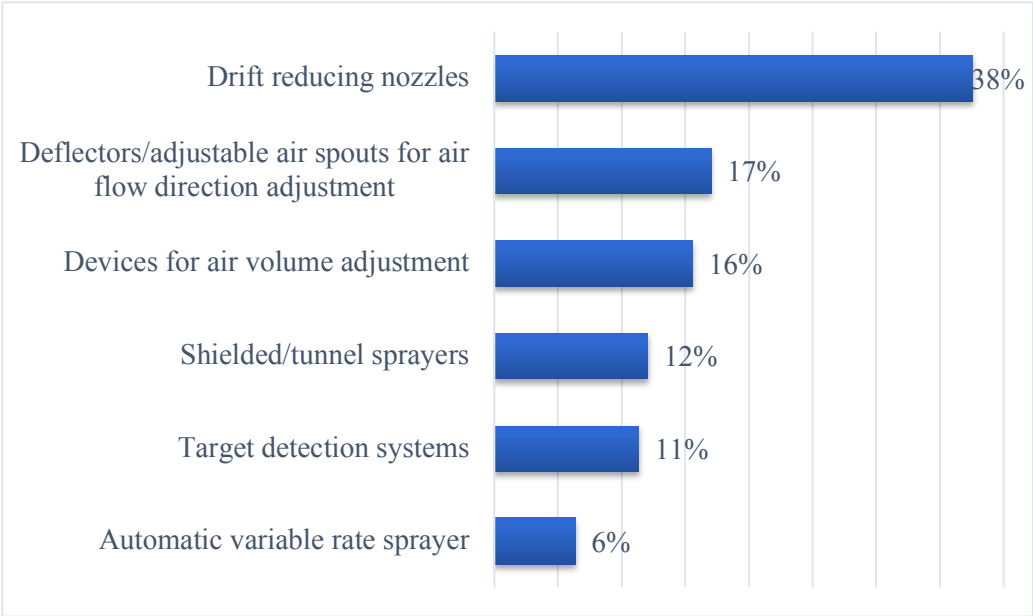

Fig.2. Main new technologies disseminated among farmers with orchard and vineyard production.

The most important farmers' source of information on buying innovative spraying equipment is sprayers' manufacturers/dealers (29%) followed by farmers' own experience (17%), other farmers (16%) and private advisors (10%). All the other sources of information account for less than 10% each. More specifically, the situation per hub is as follows:

- Belgium/The Netherlands: sprayers' manufacturers/dealers (32%), own experience (14%), other farmers (14%), private advisors as well as PPP distributors/local dealers (11% each)
- Spain: sprayers' manufacturers/dealers (22.5%), own experience (20%), other farmers (20%), private advisors (17.5%), farmers' group (12.5%)
- France: public advisors (43.8%), own experience (25%), sprayers' manufacturers/dealers (18.8%)
- Greece: sprayers' manufacturers/dealers (33.3%), other farmers (29.2%), internet (16.7%), own experience (12.5%)
- Italy: sprayers' manufacturers/dealers (48.4%), own experience (12.9%), other farmers (9.7%)
- Poland: own experience (28%), internet (20%), technical press (16%), sprayers' manufacturers/dealers (12%), PPP distributors/dealers (12%)
- Sweden: sprayers' manufacturers/dealers (28.6%), other farmers (25%), private advisors (25%), own experience (10.7%)

In general, adopters state that their innovative spraying equipment are easy to work with (96%), reliable (95%) and economically justified (90%); additionally, it is easy to get technical support for their equipment (87%) and they do not require a lot of maintenance (57%). Farmers also disagree with the statement that "sharing costs with other farmers has allowed you to use this spraying equipment" (83%).

INNOSETA Platform

SETA collection process was started by all the partners in order to identify the potential information to be included in the platform. Fig. 3 shows the general procedure established to collect and implement the database. Four categories were established: 1. Peer reviewed and technical papers; 2. National and international projects; 3. Industry products; and 4. Training and advice material.

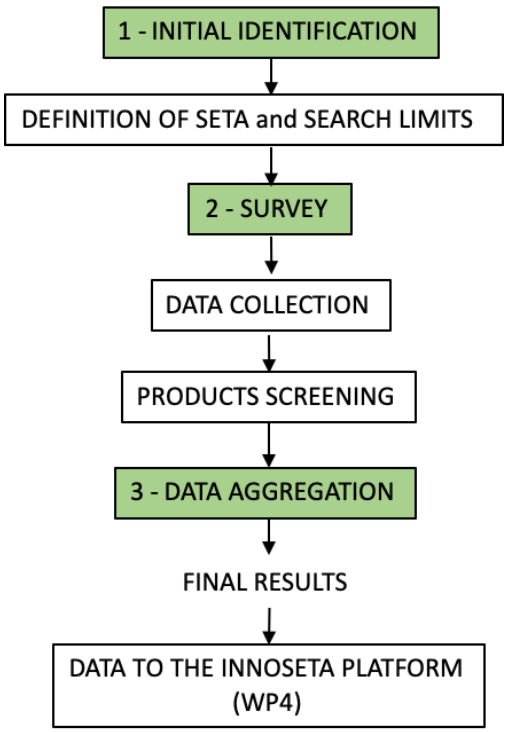

Fig. 3. Established process for SETA screening and classification.

Once the process was established, all the partners were in charge to collect SETAs corresponding all the four classes previously defined. A common agreement was arranged among the partners in order to clarify what should be/or not considered as SETA. As a common decision, a SETA is:

i. whatsoever component, device, tool etc. that can be fitted to spraying machineries,
ii. a whole sprayer that presents innovative components/accessories,
iii. devices/tools enhancing the environmental sustainability of spraying operation (e.g. closed transfer systems)
iv. training and advising material referred to sprayers and spraying operations.

This decision led to exclude from the search: technical solutions not directly connected to the sprayers or to the setting and control of the sprayers.

As illustrated in the flowchart in Fig. 2, the last step of SETAs selection is data aggregation, with the aim to provide the final data for the launch of the INNOSETA interactive platform. In general, the effort was to categorize SETAs in a harmonized category, group and subgroup system, which emerged from the screening itself. This was carried out so that the INNOSETA platform can be effectively used by the end users (farmers, contractors, advisors, suppliers) for finding out information about projects and papers dealing with the latest innovations in the PPP application sector. Such categories, and sub categories and description are summarized in Table 1.

Table 1. *Categories, groups and subgroups of SETAS identified to classify the records into homogeneous sets of data*

CATEGORY	GROUP	SUBGROUP	DESCRIPTION
Components			Generally any mechanical/electronic component of the spraying machine.
	Nozzles		Anti-drift nozzles, caps and accessories that facilitate and /or optimize the PPP application
	Nozzles Accessories		
	Valves		With sensor guided or automatic shut-off
	Fans		New types of distribution fans
	Sprayer Booms		Booms with innovative design
	Cleaning Systems		Cleaning nozzles and innovative systems to clean the tank or the exterior of the sprayer
	Filling Systems:		
		Closed transfer systems	Components that allow to pour the PPP in the mixing tank without dispersing the product, protecting the operator and the environment from contamination
		Direct Injection	Direct injection of PPP in the mixing tank
		Filling level monitoring	Allows to easily check the filling level of the tank and avoid spillage/overfilling
		Pre-mixers	Mixer tanks directly applicable to sprayers that allow to prepare the mix directly onto the machine, without transporting it from a prep bench. This reduces the risk of spillage and exposure of operators and contamination of the environment.
Sensors			
	Canopy Sensing		Sensors that are capable to scan and perceive the dimension of the canopy and its density. This is essential for the dose/volume expression of PPPs and avoid over/under treatment.
	Target detection:		--

Table 1 (cont'd)

		Weed detection Disease detection	Ultrasound or LIDAR imaging systems that accurately detect weeds and or signs and symptoms of diseases in order to determine a precise target to be treated
Integrated Systems			Articles/projects dealing with systems that integrate a sensor component that guides a mechanical actuator.
	Boom height control		Adjusts the position of the boom following the characteristics of the ground detected by a sensor. This allows a more uniform application.
	Control Units		These include automation devices for automated spraying, computers that allow adjustments of the machine
	Nozzle Control:		
		Variable rate/ PWM	Recent technology (2016) that employs the duty cycle of a pulsing solenoid instead of spray pressure to control nozzle output. It ensures constant droplet size, ability to change pressure with instant response and doesn't drip.
		On/Off section or single nozzle	Control of single nozzles allows to more precisely apply PPPs where needed. For example, this technology can be combined with Weed detection systems to treat only unwanted weeds.
		GPS based nozzle control	A GPS system detects where the PPP has to be applied, following prescription maps or operation data to avoid overlaps with already treated areas. It controls the nozzle activity
Support systems			Articles/projects dealing with systems that support the farmer in the application process, to reduce stress of decision making and operations.
	Guidance:		
		Automated guidance	Guidance of machinery automated following prescription map / pre-determined path
		Assisted Steering	Steering is made easier thanks to an automated system which reduces the stress for the operator
	DSS		Decision support System, might be a online page, software or an app for smartphones and/or tablets which help the farmer decide when/how much PPP to apply.
	Monitoring		Monitoring operations is important to avoid overlapping of treatments
		Single/Multiple operation monitoring	One or more operations are monitored and registered.
		Sprayer position via GPS	GPS system that allows to know where the machinery is located / has applied PPP
		Nozzle activity monitoring	Sensors that detect the activity and adjustment of the sprayer and its parts (e.g. nozzle pressure, eventual clogging, speed)
	Mapping/recording		
		Field operations (automated data collection)	Software and apps for smartphones and/or tablets that keep track of treatments (area, date and time, product used), products in stock.
		Field mapping (Drones/Satellite)	Prescription maps obtained by Satellite or Drone imaging systems

Table 1 (cont'd)

Innovative sprayers		
	Sprayers for field crops Sprayers for arboreal crops Sprayers for greenhouses	In these subgroups were included articles/projects dealing with sprayers that carry an innovative element (component or sensor) but were presented as a whole new innovative machine by the manufacturer. They were divided by crop type of use.
Best Management Practices		
		In this macro-group were included articles and projects dealing with Best Management Practices
Other SETAs		
		In this macro-group were included articles and projects dealing with innovations useful to reach the goal of the INNOSETA project, but belonging to any of the previous categories

The INNOSETA platform has been already created with all the SETA collection previously classified. Results can be seen at https://platform.innoseta.eu where users can easily obtain detailed information about the collected SETAs. Fig. 4 shows the main screen of INNOSETA platform while Fig. 5 shows an example of a certain SETA.

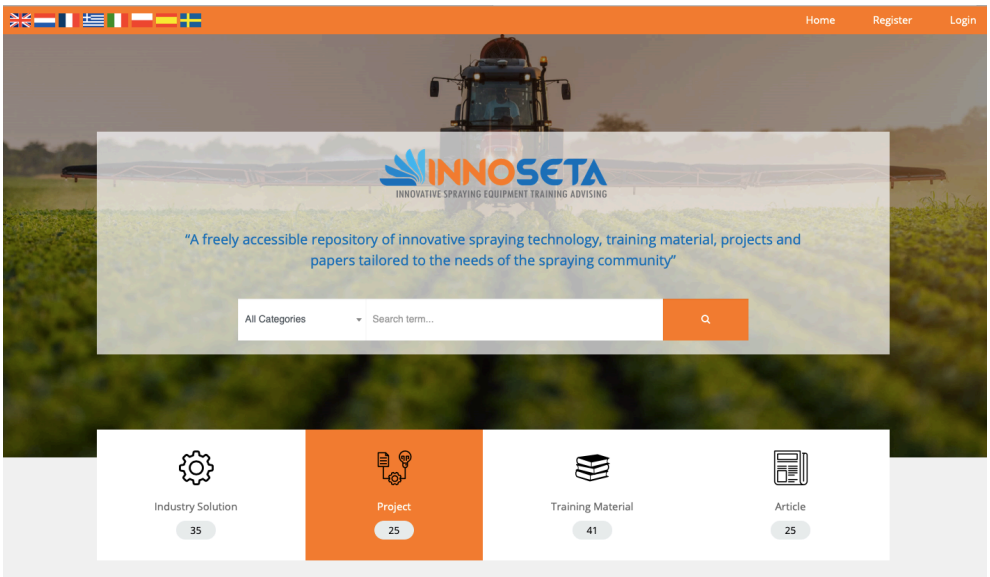

Fig. 4. INNOSETA platform (https://platform.innoseta.eu) with the four SETA classes: industry solutions, projects, training material and articles.

INNOSETA Regional Workshops

Among other actions, included in the project were the organization of several transnational and regional workshops at the different hubs. The process already started in France and Italy. The activity was organized with the aim to catch the interest, opinion and importance of different stakeholders on the whole activity of the project. The objective of this workshop was to bring together the different actors (sprayer manufacturers, PPP manufacturers and suppliers, regulatory authorities, technical

advisors, farmers, farmers' unions, media, researchers, etc.) in order to address issues related to innovation in pesticide application and identify the keys to its appropriation by farmers in the field.

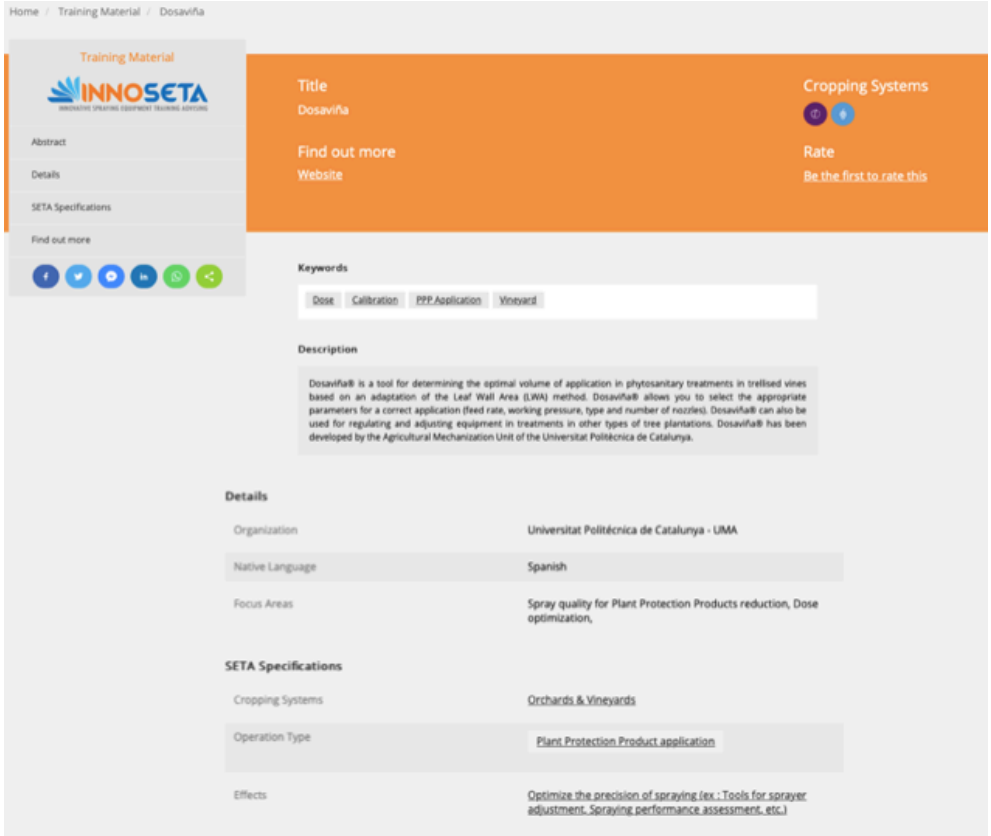

Fig.5. Example of SETA and information available.

As conclusions, it was underlined how the diffusion of information plays a key role in the adoption of innovations. According to the audience, diffusion of information should be promoted by i) manufacturers themselves (e.g. by a higher presence to specific fairs and by offering training courses for farmers, consultants and retailers), and by ii) public institutions to guarantee impartiality and to raise awareness about economic advantages and better safety for both the operators and the environment derived from the use of SETAs. The technology advancement gap between farmers and available technology was also acknowledged. Law framework was recognised to likely be of great help in the attempt to cover the gap (e.g. by RDPs). Limits to the diffusion of innovations at farm level were recognised in: the economic investments (purchase prices of innovations), bureaucracy and, sometimes, limited post-sell assistance offered by the manufacturers: often local assistance is not available, but farmers often need their equipment fixed promptly to fit the field operations requirements and time of interventions.

Expected Outcome of the INNOSETA Project

The strategic impact of INNOSETA is based on:

1. Its relevance to current needs to improve crop protection process and plant protection management.
2. Its timeliness, as SETA poses a crucial part of crop production to improve the efficiency of pesticide application process, generating technical, economic and environmental benefits.
3. Its multi-actor consortium, combining interdisciplinary spraying experts and rural sociology researchers, extension services, farmers' organizations in 8 EU countries, three umbrella European Associations having an extended network to farmers, sprayers manufacturers and

pesticides companies, which will allow for broad and intense dissemination of the project outcomes

4. Its systemic and interactive approach to innovation, including the social dimension, that will allow addressing all aspects related to the generation, introduction and diffusion of agricultural innovations to achieve the necessary shift to innovation-driven research in the area of SETA and a greater user acceptance.

INNOSETA will adopt strategies that will ensure long lasting impact on the spraying application of PPPs in agriculture beyond the project's lifespan. This will be achieved through:

i. the commitment by the core project partners to allocate own resources for maintaining the Thematic Network as a stable collaborative platform (following i.e. the ENDURE model)
ii. the maintenance of dedicated working groups within the three participating European associations (ECPA, CEMA, COPA-COGECA) which will allow mainstreaming the multi-actor and interactive innovation approaches in the implementation and innovations of SETA both by industry and research;
iii. the cross-fertilization and in-depth collaborations achieved among actors in the SETA domain, which will lead to the sustainability of the knowledge flow and the mutual learning processes elicited;
iv. and the link of SETA Platform with EIP-AGRI SP that will make all SETA solutions available at EU level.

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