Integrated Pest Management within the Agricultural Innovation Systems perspective – the case of IPM introduction in Canino's area

Introduction of Integrated Pest Management (IPM) in Canino's area (Italy), analyzed from an Agricultural Innovation System (AIS) perspective and focusing on the complementary roles of the innovation actors, their functional linkages, and the innovation impact pathway

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Integrated pest management (IPM) is an approach to crop production and protection that combines different management strategies and practices to grow healthy crops and minimize the use of pesticides. It involves the integration of appropriate measures that limit the development of pest populations and keep pesticides and other interventions to levels that are economically justified and reduce or abate risks to human health and the environment [1]. In promoting IPM, the functional relationships of different components of the system, such as plants, soils, insects, fungi, animals and water, must be considered, as well as other aspects of the environment and economy. The introduction of IPM is likely to be effective if it is realized in terms of changes in tangible components, such as agronomic practices, as well as other intangible or abstract aspects, such as new forms of social organizations within the family, the community, and/or the wider institutional environment (e.g. rules and regulations, new arrangements for provision of inputs, credits, market facilities, etc…). In other words, we need to adopt system thinking, which is a way of thinking of the whole – including abstract and tangible components and their interconnections.

Innovation, e.g. the introduction of IPM has in the past followed a top-down, supply-driven and linear ap-

proach of technology transfer, generated by research and hand over to extension services for transfer to farmers. Though the approach worked well (e.g. the green revolution), the main criticism was that research priorities identified by researchers do not necessarily match those of farmers, and technologies/recommendations developed failed to capture the diversity of farm households circumstances. The process was linear with very little involvement of other actors such as extension, development practitioners etc. in problem diagnosis and participatory development of technologies. With the increasing role of agriculture to feed the world population and the need for sustainable food systems in the context of economic globalization, climate change, financial markets instability, reducing public and private investments in research and development, the need to consider farmers as partners in research and development, the agricultural innovation system (AIS) approach has been proposed as a promising tool to understand and support processes underlying innovation, knowledge exchange and transformation of agriculture and food sectors [2].

This paper investigates the introduction of IPM in Canino's area (Italy) as described by Fadanelli in this issue of *Energia, Ambiente e Innovazione* [3] from an AIS perspective focusing on the roles of the innovation actors and the innovation impact pathway.

Agricultural innovation and agricultural innovation systems

Agricultural innovation is defined as the process whereby individuals or organizations bring existing or new products, processes and forms of organization into social and economic use to increase effectiveness, competitiveness, resilience to shocks or environmental sustainability, thereby contributing to food and nutritional security, economic development and sustainable natural resource management.

Agricultural innovation systems (AIS), defined as "network of actors or organizations and individuals together with supporting institutions and policies in the agricultural and related sectors that bring existing or new products, processes, and forms of organization into social and economic use", have been proposed to respond to the complex and wicked challenges emerged. Policies and institutions (formal and informal)

Actor	Role in AIS
Family farmers	Creating, testing and adapting new practices to field conditions; adopt innovative practices to increase agricultural productivity and market access and deal with the connected risks.
Farmer organisations and cooperatives	Represent family farmers (needs, opportunities, interests) in value chains and/or in policy arenas; brokerage of knowledge between farmers and other actors; facilitating access to agricultural inputs, credit and markets; represent family farmers' interests in agricultural research and extension agenda setting.
Advisory services (both private, non-governmental and public)	Brokerage of knowledge and practices between farmers and other actors; bringing new knowledge to farmers and other local actors; developing networks and supporting organisation of producers; facilitating access to knowledge, credit, inputs and output services; promoting gender equality; managing conflicts on resource access.
Agro-dealers	Providing (new) agricultural inputs; providing technical assistance; identifying, piloting and mainstreaming new market opportunities.
Agro-food processors, buyers	Providing (new) output markets; defining quality standards of agricultural products; developing and applying technologies; identifying, piloting and mainstreaming new market opportunities.
Researchers	Identifying the farmers' needs and priorities; identifying innovation opportunities; developing and improving technologies, practices and processes; (Joint) Testing of locally developed (indigenous) technologies and processes; documenting the way new practices and technologies are adapted and further innovated with (for both men and women, poor and rich), to feed into other agricultural research efforts and policy decisions; assessing the socio-economic and environmental impact of innovations.
Tertiary education institutes	Education and training of professionals in the agricultural sector.
Policy makers	Creation of an enabling environment and public sector that accommodates innovation; provide incentives to innovate and collaborate; enabling networks and partnerships.

Tab. 1 Roles of a number of actors in AIS (modified from [4])

shape the way that these actors interact, generate, share and use knowledge as well as jointly learn [4].

With its emphasis on the interaction among multiple actors, AIS thinking aims to understand the contribution (knowledge and skills) of different actors, and the quality of interaction among them. The roles of conventional actors (research and extension) in agricultural development are no longer considered the sole drivers, initiators or owners of the process of agricultural innovation. While they play important roles in an agricultural innovation process, their services have to be considered in relation to the roles of other actors (see Table 1) [5]. AIS approach emphasizes that agricultural innovation is not just about new technologies but also about institutional change [2].

Canino's case study

Overview

The integrated pest management project was initiated in 1979 by the Italian National Agency for New technologies, Energy and Sustainable Economic Development (ENEA) upon the request of Oleificio Sociale Cooperativo di Canino (OSCC), an olive grower's cooperative founded in 1965. Prior to the project, pest control in olive groves has relied mainly on chemical pesticides often applied by aerial spraying. Estimates indicate that in the 1970s and 1980s large quantities of pesticides were used each year on olive production in the Province of Viterbo (central Italy) [5], representing ca. 27% of all pesticides used in agriculture in the province [6]. In Canino, control of the main olive pests *Dacus oleae*, *Prays oleae*, *Saissetia oleae* and *Cycloconium oleaginum* was done by

Actors	Role
1st phase	
ENEA	Research body, funding and management of the project
ERSAL	Technical body, field monitoring and personnel training
OSCC	Facilitator, beneficiary, mobilization of olive growers, support to research and advisory services
2nd phase	
ENEA, ERSAL and OSCC	Same roles as above
CET (Cooperativa Energia e Territorio)	Develop the decision-support system Weather monitoring Information sharing
Stazione Sperimentale Olii e Grassi di Milano	Additional laboratory analysis for quality
Osservatorio per le malattie delle piante	Additional laboratory analysis for pests
Media	Information sharing
3rd phase	
COPROVIT (Consortium between ENEA, CET, another oil mill and 3 producers' associations)	Knowledge sharing on IPM and diffusion
Ministry of Agriculture	Policy guidance, regulation and national diffusion
CCIAA (Chamber of Commerce of Viterbo)	Control for PDO certification

Tab. 2 Actors and their roles in the IPM research project in Canino [8]

6-7 insecticide sprays and 2 fungicide treatments per year (calendar-based pest control) [7]. Further, olive growers were experiencing pesticide resistance and persistent secondary infection of sooty mold. The control of these pests was critical to sustain olive production in Canino.
The objectives of the project funded by the Italian government through the Ministry of Agriculture and implemented by ENEA in collaboration with OSCC and the Regional Agency for Agricultural Development in Lazio (ERSAL, now ARSIAL) were to:

- Develop less polluting pest management techniques;
- Apply IPM in Canino's territory;
- Demonstrate the economic and environmental advantages of IPM;
- Adding value to the olive oil produced in the area;
- Validate the territory approach to improve the production system and outscale innovation [3].

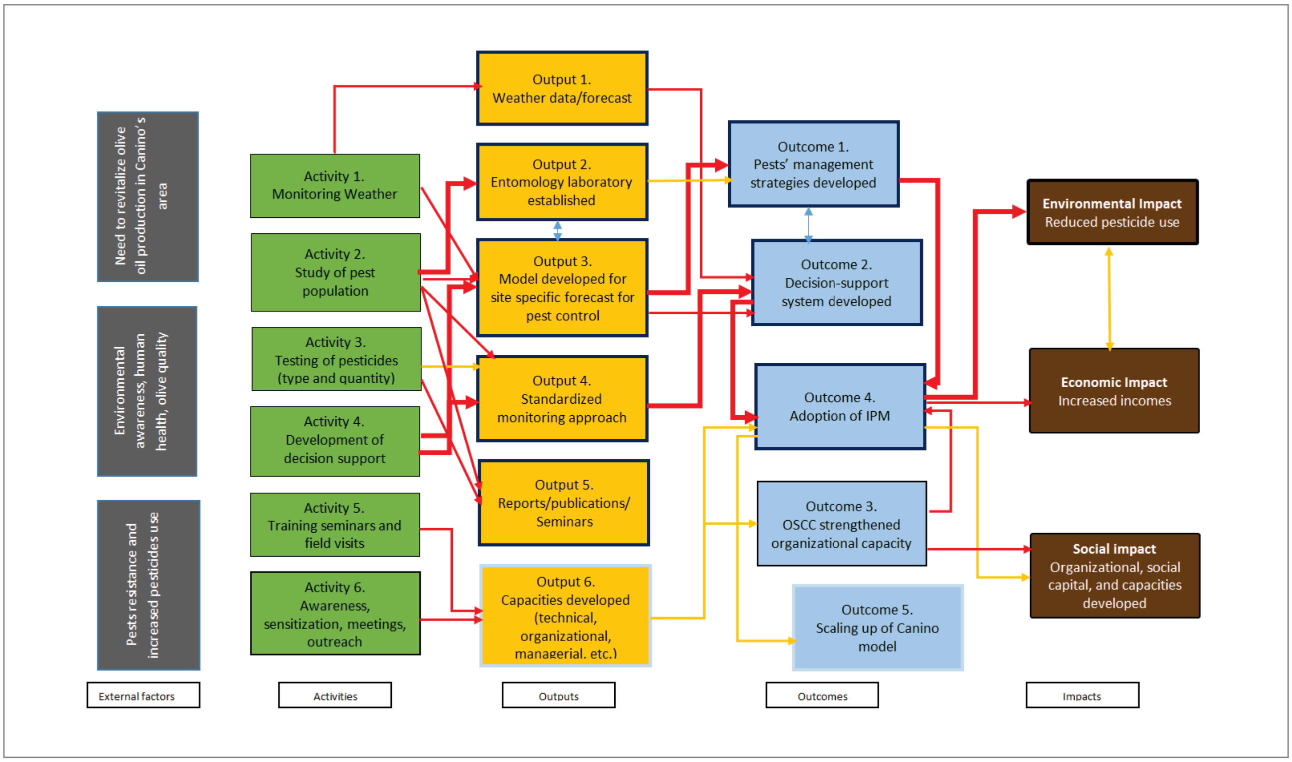
IPM main actors and roles

The project involved five main actors: ENEA, OSCC, ERSAL (now ARSIAL), Cooperativa Energia e Territorio (CET) and the Municipality of Canino. Their roles and responsibilities varied during the lifetime of the research program. Three out of these actors were the main forerunners of the IPM project (phase 1): ENEA, ERSAL and OSCC. During project implementation other actors joined the process (phases 2 and 3) playing various roles in support of the project (Table 2).

Impacts of IPM research

Using participatory approaches (interview, meetings, farm visits), and building on the comprehensive analysis of the IPM project in the context of the IMPRESA project, the following outcomes/impacts were reported [5, 8]:

- Direct result: after 4 years of testing and adoption, more than 11,000 ha were treated with IPM.
- Normative aspects: IPM became mandatory to all cooperative members and included in Protected Designation of Origin (PDO) protocol;
- Spill-over effects:
  - IPM was the starter of a virtuous circle of innovation and economic progress for the



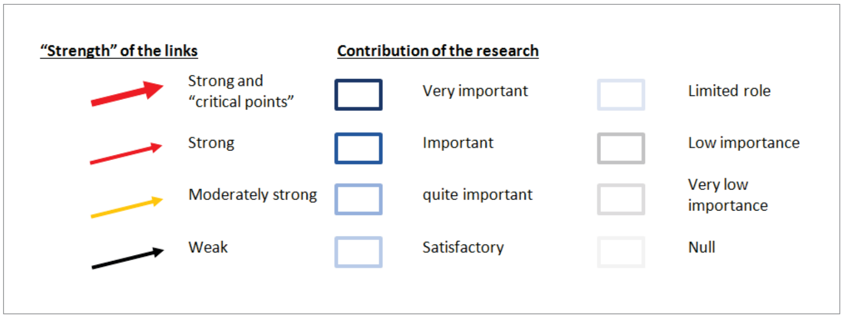


Fig 1 Impact pathways of IPM in Canino [9]

farmers and the cooperative;

- The "Canino IPM model" was spread within the province of Viterbo and in 14 other regions in Italy;

- Economic impact: higher income for olive growers due to:
  - lower production cost because of reduced insecticide use;
  - higher price on national and international markets, as a consequence of higher olive oil quality. Increased oil price, price of olives paid to farmers has increased as well.
- Environmental impact: Significant reduction of the quantities of chemicals used;
- Social impact: strengthening of the cooperative capacity and its role, improved organizational, managerial and marketing capacities, collective action and technical capacities increased.

Impact pathway

Figure 1 shows a graphical presentation of the impacts of the introduction and adoption of IPM in Canino. The legend of the figure is given below.

Role and influence of the various actors on the olive IPM innovation systems

Using the agricultural innovation system approach lens, results from the IPM analysis in Canino revealed that the roles of the innovation actors involved overlapped during the lifetime of the project. The figure below summarizes the roles of the innovation actors. Some actors undertook research, were involved in training activities and served as bridging institutions to producers, while the cooperative was both involved in agribusiness but also served as facilitator between farmers and research (Figure 2).

Research and training components of IPM innovation systems in Canino's area were mainly undertaken by ENEA, ERSAL and to a lesser extent CET. The research focused on a) the study of the population dynamics of major pests in different microclimates (ENEA and ERSAL), and b) the development of a model to predict insect population and to establish thresholds for treatment (CET). Two external laboratories, Osservatorio delle Malattie delle Piante della Regione Lazio (Plant Pest Observatory of Lazio Region) and Stazione Sperimentale Olii e Grassi di Milano (Experimental Station of Oils and Fats in Milan) contributed to the research by studying the behaviour of pests populations and analysing olive composition and quality before and after the application of IPM, respectively.

Research played a critical role in *facilitating and brokering* the partnership between the various actors at the onset of the project. Analysing the impacts of this project, the following crucial points were identified as key milestones that led to its success:

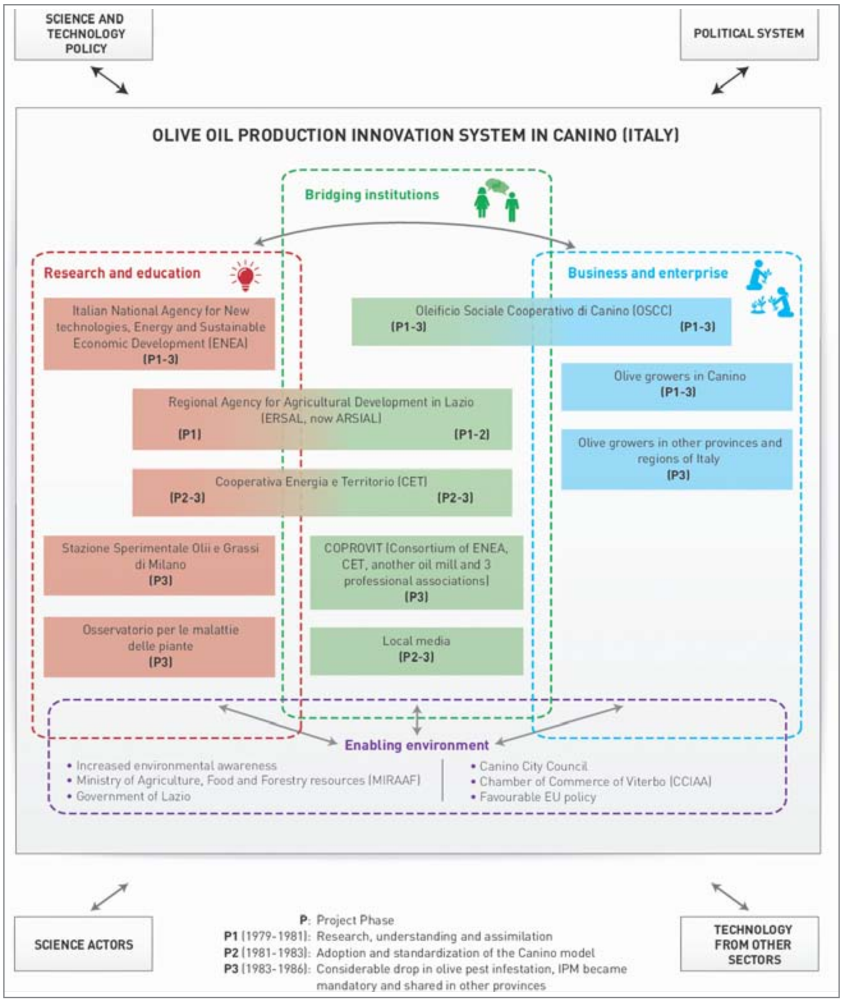


Fig. 2 Olive oil production innovation system in Canino (Italy)

- A first critical point was the initiation of the study of the insect population dynamics to provide information on their biology and reproductive cycle as well as their harmful effects on olive trees. The aim was to develop research-based solutions to the challenges faced with increasing quantities of pesticides used in the area. For example, the research carried out evidenced that the overuse of pesticides favoured the development of the sooty mold caused by *Saissetia oleae* but did not reduce the real attack to the olive trees caused mainly by *Bactrocera oleae*. For this reason, the research was fundamental to know when and how to apply the pesticides treatments.
- A second critical point was the development by CET of a model for forecasting insect populations and to establish thresholds for treatment. ERSAL collaboration was needed for the analysis of the entire dataset and its relationship with the stage of development of the insects. Alongside the study of insect population dynamics, the CET model allowed farmers to better understand and link the application of pesticides to the thresholds resulting from the modelling.
- A third critical point was the tripartite partnership between OSCC, ENEA and ERSAL at the onset of the project. ENEA and ERSAL worked together in conducting the surveys. This was a very critical factor that enabled

the testing and adoption of IPM by olive growers and at such a large scale that would have not been possible without the full partnership with OSCC.
- A fourth crucial point was the role played by ENEA and ERSAL in developing the capacities of OSCC and farmers for IPM application. Technicians and olive growers were trained on IPM principles, as well as involved through participatory research in monitoring and studying insect dynamics.

OSCC was crucial for the initiation of the research because it established contact with ENEA and demanded solutions for the overuse of pesticides in olive cultivation in Canino. OSCC facilitated linkages between research and olive growers, supported the on-farm research, provided technicians for monitoring of pest infestation and established laboratory facilities for regular pest monitoring close to farmers' fields with support by ENEA and ERSAL. These measures facilitated a fast IPM adoption in Canino.
COPROVIT (Consortium between ENEA, CET, another oil mill and 3 producers' associations) was the mechanism in the last phase of the project to share experiences and to roll out the IPM olive cultivation to other communities in Lazio and other olive oil producing regions in Italy. Until 1992, a part from Lazio, regional projects in IPM in olive cultivation were initiated in Tuscany, Umbria, Puglia and Calabria later also the other olive producing regions. The Local media also played a role in awareness raising and information sharing on IPM facilitating its adoption.
A number of factors and policies provided an enabling environment for the IPM innovation systems in Canino. The public opinion was supporting adoption of eco-friendly practices that reduce the environmental footprint of agricultural production and improve food safety and quality. The political commitment towards more sustainable food production systems allowed to achieve the necessary funds and the active involvement of public organizations (ENEA and ERSAL). Farmers in Canino follow a long tradition of olive cultivation. OSCC was established in 1965, by olive producers and, since then, the Cooperative ensures a social context favourable to collective action, including common reflection and shared learning. At the time the project started almost 900 olive producers were members of the OSCC. A small group of innovative risk takers (5 out of 897) joined the IPM project in '80/81 and agreed to on-farm research. Their participation in the research process was essential for establishing the systems and to create trust between the late adopters. Convinced by seeing the positive effect of using IPM by the early adopters ("seeing is believing"), many other farmers joined. Within only 5 years of the introduction of IPM, 904 out of 926 members of the cooperative collectively adopted IPM [6].

Conclusions

The introduction of IPM in Canino's area yielded some expected and unexpected economic, environmental and social impacts. However, impact evaluation was not included in the project design and no systematic monitoring and evaluation system was established at the onset of the project to continuously document, assess and adequately report on achieved results. Impact evaluation is therefore hampered by scarcity and unreliability of available data [8].
Nevertheless, some lessons can be drawn from the experience in Canino. The adoption of IPM was instrumental in increasing olive productivity, reducing pesticide overuse and enhancing olive growers' income. Some factors seem to have played a key role for the success of the project and sustainability of its results, including:

1. The project was demand-driven (initiated by OSCC) and adopted a participatory approach of on-farm research and benefitted from an enabling context;
2. the cooperative was involved as a full partner from the very early stages of research planning and implementation;
3. the cooperative played the important role of actual owner of the results of the project and this was one of the main elements that contributed to the relevance, uptake and continuity of the results;
4. the initiation and implementation of the research project involved a wide network of actors with partnerships developed throughout all the project phases;
5. the different actors of the network played complementary roles;
6. the research organizations played a pivotal role not only in producing the required knowledge and technology, but also in brokering linkages between the different actors and ensuring leadership and accountability;
7. the project combined research

activities, advisory services and training for olive growers and co-operative staff in order to ensure sustainability at the end of the project;
8. the positive effects obtained after only few years of experiments generated a snowball effect of rapid spread of IPM application within the province of Viterbo and elsewhere. Lack of data does not allow to evaluate breadth, speed and scale of adoption.

In conclusion, the IPM research in Canino was conducted with a wide range of actors including research, advisory services, producer cooperatives and the private sector in a favourable policy environment facilitating the fast and wide adoption of IPM. The IPM innovation process was dynamic (actors and roles changing in various stages of the project), collaborative with actors open to learn, adapt and building trust. Actors with different experiences and roles were able by working together, joint learning and reflection to co-create new knowledge that led to social, economic and environmental impacts of the IPM research.

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