AFPP – 6e CONFÉRENCE SUR LES MOYENS ALTERNATIFS DE PROTECTION POUR UNE PRODUCTION INTEGRÉE
LILLE – 21, 22 ET 23 MARS 2017

EUCLID: LEVERAGING IPM FOR SUSTAINABLE PRODUCTION OF FRUIT AND VEGETABLE CROPS IN PARTNERSHIP WITH CHINA

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ABSTRACT
EUCLID is a project funded by the EU in the context of H2020. The objective of the EUCLID project is to contribute to secure the production of food for the increasing worldwide population while developing sustainable production approaches to be used in the European and Chinese agriculture. EUCLID is coordinated by INRA and it includes 19 partners from public research and private companies (15 representatives from 6 countries of the European Union and four Chinese partners).
It started in September 2015 for a period of 4 years. The project will exploit knowledge developed in the last decades and will explore new methods of IPM to provide solutions to pest management for specific problems of European and Chinese farmers for a few important and emblematic crops that represent different production systems. These include leafy vegetables, protected tomatoes and wine grapes. The poster presents the objectives and workpackages of EUCLID.

Keywords: IPM, biological control, leafy vegetables, grapes, tomatoes.

RÉSUMÉ
EUCLID: UTILISER LA PROTECTION INTEGREE POUR UNE PRODUCTION DURABLE DE FRUITS ET LEGUMES EN PARTENARIAT AVEC LA CHINE
EUCLID est un projet financé par l'UE dans le cadre du programme H2020. L'objectif du projet EUCLID est de développer des approches de production durable utilisables dans l'agriculture européenne et chinoise afin de contribuer à la production d'aliments. EUCLID est coordonné par l'INRA et comprend 15 partenaires de l'Union européenne et quatre partenaires chinois.
Ce programme a débuté en septembre 2015 pour une période de 4 ans. Le projet exploitera les connaissances développées au cours des dernières décennies et explorera de nouvelles méthodes de lutte intégrée pour fournir des solutions pour des problèmes spécifiques aux agriculteurs européens et chinois pour quelques cultures importantes et emblématiques représentant différents systèmes de production. Il s'agit plus particulièrement de légumes à feuilles, de tomates protégées et de raisins à vin. Le poster présente les objectifs et les activités d'EUCLID.

Mots-clés : Protection intégrée, lutte biologique, légumes à feuilles, vigne, tomates.

Overall goal

For many years, society has enjoyed the benefits of using chemical pesticides to control weeds, arthropod pests and plant diseases in agriculture. Pesticides have largely contributed to boosting agricultural production and consumers have been benefiting from this extensive and large-scale use: agricultural products are now available in large quantities and sold at low prices. However, continuous use of chemical pesticides during the past decades has proved a threat to both consumers and farmers health, as well as to the environment. The development of more environmentally-sound and sustainable pest management methods followed by their wide adoption by farmers would help reduce the negative effects of chemical pesticides on human health and would also help prevent the degradation of natural resources especially in terms of reduction of the biodiversity, pollution of groundwater, etc.

EUCLID's goal is to contribute to securing food production for the increasing worldwide population while developing sustainable production approaches to be used in European and Chinese agricultures.

Among agricultural products that are of concern to both Europe and China, fruits and vegetables are key ones, considering their importance in population diets, the positive effects they have on consumers' health and their economic weight. Both regions share similar objectives of reducing chemical pesticide residues in products to be safer for domestic consumers while ensuring profitable trade among countries. China is particularly the top world producer and exporter of various vegetables and fruits that are largely consumed by EU citizens. In this context, the collaboration of European and Chinese partners in EUCLID will ensure the development of safer pest management methods for the production of healthy fruits and vegetables, i.e. with reduced chemical pesticide residues, for European and Chinese consumers.

Project's objectives and results in response to end-users' needs

The EUCLID project has the ambition to deliver the simultaneous optimisation of current pest management methods and the development of novel ones, and to promote their rapid adoption through the design of IPM packages and exploitation by end-users. This will reduce the dependence of European and Chinese farmers on chemical pesticides in selected key farming systems in both regions.

The objectives of the project are:

1) **To optimise existing management methods for key agricultural pests** (WP1, WP3[1]) and evaluate them against end-users expectations to overcome the limits which currently prevent their widespread implementation. In particular the consortium will:

a. **Evaluate and optimise biocontrol agent (BCA)** in containment approaches against soil-borne and air-borne pathogens, whitefly and associated begomoviruses (on tomato and leafy vegetables) and grape canker diseases in vineyards

b. **Exploit genetic diversity of leafy vegetables** (notably lettuces, wild and cultivated rockets) in terms of resistance against soil-borne pathogens

c. **Improve cultural practices and community ecology-based approaches** for reducing chemical pesticide applications (notably on tomatoes and leafy vegetables)

d. **Optimise modelling approaches** to rationalise chemical pesticide's use (on grapes and tomatoes).

[1] WP = Workpackage

2) **To develop novel protection methods** (WP2, WP3) taking into account farmers' and agricultural businesses' priorities, consumers' preferences, and legislation related issues, notably through:

a. **the assessment of new, high potential, micro and macro biocontrol agents (BCAs)** on tomato, grape and leafy vegetables

b. **the exploitation of natural products that could be used as biopesticides**, e.g. botanical pesticides (on tomato, grape, and leafy vegetables)

c. **the development of protection methods based on novel techn**ologies; RNAi (on tomato and leafy vegetables), entomovectoring and Sterile Insect Techniques (SIT) (on tomato, grape and leafy vegetables)

d. **the identification of tactics that promote biocontrol services** through habitat manipulations, i.e. via thoroughly designed crop assemblages and cropping practices, enhancing the spilling-over of key natural enemies of pests across different fields and crops at the farm and agricultural landscape scales (on tomato, grape and leafy vegetables).

3) **To assess the innovative candidate pest management and newly designed IPM[2] solutions** under commercial field conditions in terms of reduced dependence on chemical pesticides, agronomic performances (yield, product quality), socio-economic impact (labour, product price, etc.), environmental footprint and risks to human health (WP3, WP4). The convenience to adopt IPM packages at farm level will be measured.

4) **To disseminate knowledge to key stakeholders**, create a participatory framework that will ensure a permanent dialogue between researchers, extension specialists and end-users, and provide support to policy implementation (WP5).

Overall concept

The choice of the crops of interest in EUCLID (fresh tomato, wine grape and leafy vegetables) is based on their economic importance for both European and Chinese fruit and vegetable production, but also for their exemplarity in representing different production systems (field and greenhouse vegetables and ligneous perennial); this means that the pest management solutions of the project will serve as models for developing similar actions for other crops. In addition, these crops represent productions for which mutual benefits can be expected as an outcome for both European and Chinese farmers.

A double strategy will be followed in EUCLID. From one side, the consortium will work on problems of common interest for the European and Chinese agriculture, but for which solutions are missing, poorly competitive, or relying heavily on chemical pesticides.

On the other side, with the idea of promoting exchange of information and best practices, the European teams will benefit from the knowledge and experience of the Chinese colleagues and will adapt proposed solutions to the European context. In addition, exchange of knowledge and experience as well as adaptation from Europe to China will also be ensured. EUCLID will notably benefit from building up on pre-existing strong and long-term collaborations between EU and Chinese teams involved in the project.

The choice of tomato (*Solanum lycopersicum*) is dictated by its market's importance: it is the most widely eaten vegetable in the world. It is grown worldwide and China is the main producer. From a phytosanitary point of view, tomato is among the most pesticide-polluted vegetable.

[2] IPM = Integrated Pest Management

Grape (*Vitis vinifera*) is among the most cultivated fruits worldwide and Europe (notably Italy, Spain and France) is the first world producer. Moreover, China is aiming to increase its overall grapevine production in the coming years, in order to match the national wine market demand. Also, many chemical pesticides are heavily used in grapes.

The economic importance of leafy vegetables (which includes lettuces, cabbages, etc.) has grown rapidly in recent years as they occupy the ready-to-eat vegetable market. This growth has heightened awareness about the microbiological and physiological parameters associated with quality. Lettuce (*Lactuca sativa*), rocket (*Eruca sativa, Diplotaxis tenuifolia*), and spinach (*Spinacea oleracea*) are the most popular ready-to-eat vegetables, while the chemical pesticide multi-residues can be a serious threat to the health of human beings, in fact Maximum Residue Limits (MRLs) set by many countries and are becoming more and more strict.

Overall structure of the work plan

The project is structured in 3 R&D workpackages (WP1, WP2, WP3), one demonstration workpackage (WP4), one workpackage dedicated to dissemination (WP5) and a workpackage devoted to project management (WP6).

WP1 – Optimisation and adaptation of current pest management methods

A number of initiatives on pest and weed management have been funded in recent years by national, European and international programmes. The work in WP1 will take its sources from the knowledge accumulated and will have the goal to improve it, adapt it to both the European and Chinese context, and propose tailored solutions to be implemented by the end-users in WP4. The consortium has decided to focus on the following aspects: biological control, management of pest resistance, cultural practices, and modelistic approaches applied to pest management.

WP2 – Development of innovative pest management products and approaches

The goal of this WP is to develop new pest management strategies on problems that have not been tackled extensively so far, or for which unsatisfactory results have been produced (despite obvious potential) or where emerging/invasive species are reducing yields. It is the most research-focused of all workpackages. The WP will pay particular attention to: development of spill-over of biocontrol services among crops, evaluation of novel high potential micro and macro bio-control agents and natural-based products, development of RNAi-based and entomovectoring-based pest management products, and sterile insect technique against key Chinese and European pests.

WP3 – Assessment by and support to project's end-users

Partners in WP3 will analyse the benefits of optimised and innovative pest management solutions developed or adapted in WP1 and WP2 and their potential for being included in newly designed IPM packages. Through a bottom-up approach, the analysis developed by farmers, advisers, businesses and other operational groups selected for their knowledge of the European and Chinese market will be fed back to researchers in WP1 and WP2 to fine tune the proposed solutions. This knowledge exchange will generate new insights and ideas while speeding knowledge towards practical and innovative solutions. Only the most optimised methods developed through this iterative approach will be combined into IPM packages to be tested in the field demonstrations activities (WP4). The partnership in this WP includes: farmers' associations and representatives, extension services, SMEs working in the field of pest management tools, policy makers, economists, retailers and consumers' representatives (all partners of the project). WP3 too will receive inputs from the project's Stakeholders Advisory Board (SAB) which will ensure the European coverage of the project and will include other actors of the rural development.

WP4 – Demonstration and implementation by the end-users

IPM packages designed in WP3 will be tested and validated through field trials. The same partners involved in the optimisation of the pest management solutions and in the design of IPM packages in WP3 will ensure the active transfer of the knowledge and tools produced to the various end-users of their competence. Various activities are envisaged in this WP, in particular training and demonstrations in the fields at both European and Chinese selected locations. All appropriate regulatory procedures will be carried out prior to field application of all new biocontrol methods developed in the project.

WP5 – Dissemination

WP5 is dedicated to the dissemination of project results to various types of audience: scientific community, general public and various stakeholders. Networks from all EUCLID partners including Carrefour (notably China, Spain and France) will be used to achieve this objective. Communication approaches and tools will be chosen and adapted in order to efficiently target the concerned public.

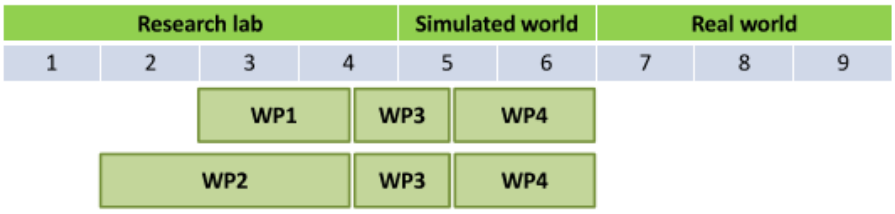
WP6 – Project and innovation management

At the strategic level, the WP will aim at steering the project so it remains relevant considering the changes that may occur in the subject area, be they of a scientific, technological, environmental, or political nature. At the operational level, WP6 will ensure that the project progresses in conformity to the work plan, in particular with regard to the milestones, the deliverables, as well as to the planned resources. The management will also pay particular attention to all the legal aspects and the technology transfer issues that may occur during the project's lifespan.

Positioning of the project

With respect to the Technology Readiness Level (TRL) scale, the project will cover the levels 2 to 6 (see image below).

Figure 1 : Positioning of Research and Technical WPs in the TRL scale (Positionnement des "Workpackage" sur l'échelle TRL)



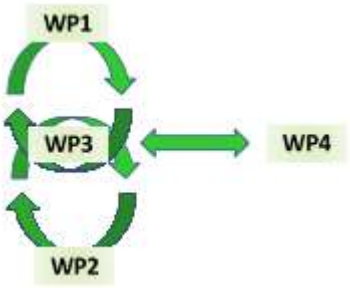
In particular:

- **WP1 (current pest management methods)** will include the adaptation and optimisation of tools and methods which have been developed previously but that could not effectively be transferred to the end- users. These solutions will be re-analysed, refined and optimised based on end-users expectations (WP3). Methods developed in WP1 will be tested under controlled conditions i.e. experimental greenhouses and experimental fields.
- **WP2 (novel pest management approaches)** concerns concepts which are still at an early stage of development. Novel pest management methods will be designed, developed and tested at increasing scales i.e. laboratory-greenhouse-field; tests at field scale will be done owing to results obtained at lowest scales.
- **WP3 (stakeholder analysis and evaluation)** ensures the link between the academia and the real world, i.e. between scientists and the stakeholders. Pest management methods developed in WP1 and WP2 will be evaluated in WP3 according to stakeholders' indicators (developed in WP3) before

being combined as IPM packages (targeting the best trade-off efficacy – economic competitiveness) and the field trials of these packages (WP4).
- **WP4 (demonstration)** will provide a verification/ validation of the solutions in relevant environment (field, supermarkets).

Approach and methodology
The project shaped in the format of a double interactive innovation loop. On one hand (WP1↔WP3↔WP4), Interactive Innovation Loop EUCLID will focus on the optimisation of existing methods to provide more efficient, cost-effective WP1 and low-pesticide input solutions.

Figure 2: Interactive Innovation Loop between WPs in EUCLID (Boucle de l'innovation dans le projet EUCLID)



On the other hand (WP2↔WP3↔WP4), EUCLID will develop novel crop protection methods. In both cases the loops are based on a multi-actor approach to ensure the identification of stakeholders' priorities and their active WP4 WP3 participation in the development and demonstration of the tools and approaches proposed in the project. This will ensure that the projects' output will need little (or none) adjustment, as they were shaped to fit to WP2 real life conditions and stakeholders' needs.

In order to propose an effective solution to be rapidly adopted by the European and Chinese end-users for each pest-crop pair treated in the project, the following approach will be adopted:
1) **WP1 or WP2**: (i) **adaptation/optimisation of existing pest management methods**, and development of new pest management methods respectively, (ii) **validation at the field scale of the pest management methods optimised and/or developed** by the WP1 and WP2. All appropriate regulatory procedures will be carried out prior to field application of all new biocontrol methods developed in the project.
2) **WP3**: (i) **identification of the priorities in terms of needs and preferences** for farmers, market potential and IPM tool development for companies, health benefit for consumers, environmental sustainability, EU directives and requirements for policy makers, (ii) **design of new IPM packages** (encompassing methods from WP1, WP2 and other already available methods) and socio-economic evaluation: assessment of cost effectiveness of solutions and IPM packages, selection of methods showing best trade efficiency/cost and highest feasibility, perception of consumers, etc.
3) **WP4: demonstration at the field level of the IPM packages** previously designed in WP3 and knowledge transfer to end-users. All appropriate regulatory procedures will be carried out prior to field application of all new biocontrol methods developed in the project.

We foresee that the "adaptation/optimisation" cycle (WP1↔WP3↔WP4) will take 3 years; a refinement of the solutions reaching the demonstration WP4 at year 2 is envisaged, and by the end of the project optimised solutions demonstrated in the field will be ready for exploitation by end-users.

We foresee that the "novel protection methods" cycle (WP2↔WP3↔WP4) will take 4 years; then at the end of the project novel methods demonstrated in the field will be ready for exploitation by end-users. Adoption will be very likely as the solutions developed in EUCLID will be shaped from the beginning of their development to take into account the stakeholders requirements.

Optimisation and adaptation of pest management strategies and IPM packages are key to the project. At present, different cropping habits, facility conditions and knowledge of farmers result in various crop management patterns. Therefore, the selection of methods and their integration for the selected plant-pest systems have to be optimised according to the region considered as well as to the knowledge of producers. The regional differences (both at European and Chinese levels) will be taken into account throughout the project in the various WPs. This EU-China approach is strengthened by the EU-China co-leadership for R&D and demonstration WPs.

Sustainable cropping systems go beyond technical changes and refer to organisational and even strategic change. Integrating economic, environmental and social goals into the design of agricultural production systems requires broad multidisciplinary cooperation. EUCLID is a perfect example of such a multidisciplinary approach, as the consortium integrates various skills covering the innovation project and allowing to take end-users needs into account.

Communication activities

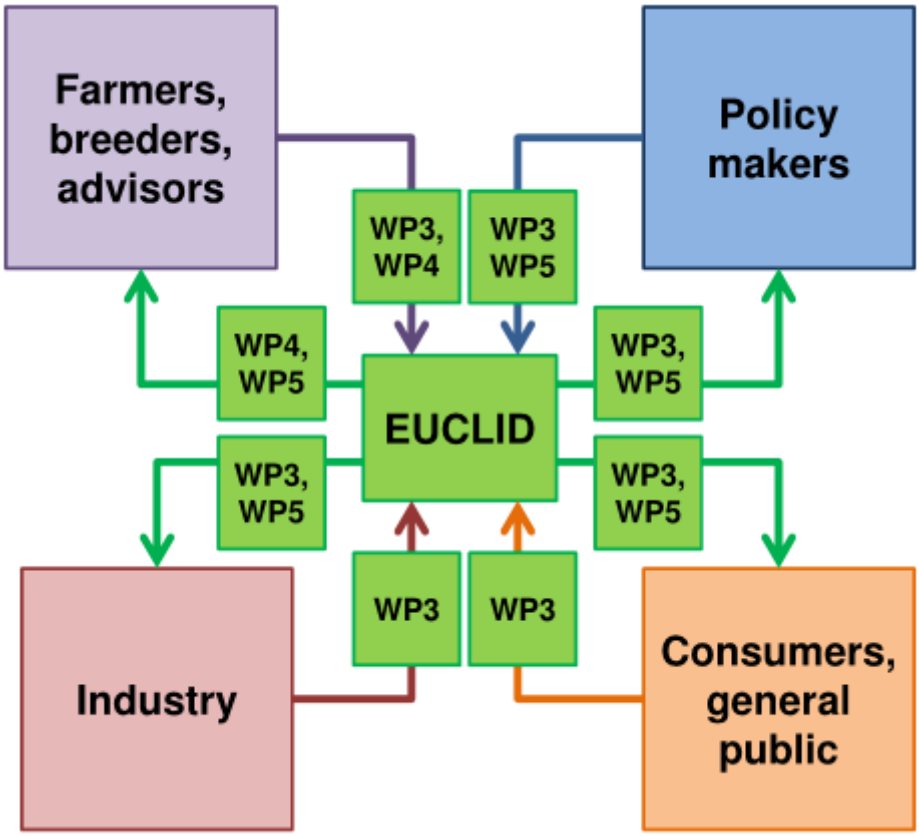
Communication activities will be handled through a number of WPs. Pure dissemination activities (intended as making people outside the consortium aware of the project) will be handled in WP5; but more technical communication activities, like training, or bi-univocal exchanges with stakeholders, will be handled by WP3, WP4, and WP5. The project will carry out a dynamic programme to ensure dissemination towards all the stakeholders: scientists working in academia or industry, farmers/growers, agricultural advisors, breeders, consumers, policy makers in order to fulfil their information needs. A dedicated WP has been set-up (WP3) to include from the very beginning the project's stakeholders in the discussions concerning the relevant actions and strategic decisions to be taken. The consortium will take advantage of the stakeholders being partners of the project (multi-actor approach) as well those invited to be part of the Stakeholder Advisory Board (SAB) that will ensure outputs coming from outside the project and covering a wider geographical area.

Fundamental scientific results will be freely disseminated through appropriate channels: scientific publications in peer-reviewed journals and books, presentations at international conferences and workshops.
Dissemination of the scientific results will also be performed taking advantage of the international conference organised by the project; other international conferences, workshops, and seminars will be explored throughout the project.
Among the researchers involved in the project there are professors, teaching to undergraduate and graduate students; these researchers will ensure the dissemination of the main scientific achievements and the training on the tools developed to young scientists.
A dedicated website and informative leaflets will be used to reach the main stakeholders, with a special eye on general public, farmers and breeders. The website will present the state of the art of integrated pest management, pesticides problems and solutions, the objectives of the project and the consortium partners and will disseminate information on the project activities and achievements.
Publication and communications in general public journals and press, magazines, exhibition where farmers, breeders, consumers, are participating, will be used to disseminate.
Next to the website, there will be an intranet site where the consortium partners will be able to log in and share resources such as files and data dissemination documents. An electronic newsletter will be prepared and distributed to the partners of the consortium and also to all the stakeholders who will contribute to the discussion groups.

Because the project takes a multidisciplinary approach, the integration of the various groups and their mutual understanding is essential to ensure its success. For this reason, workshops and training will be organised during the four years of the project in order to promote exchange among partners and strengthen their relations.
The project will adopt an active knowledge interaction approach to improve the exchange of information and experiences with various stakeholders in order to get advice and feedback from them and to assist in the research and dissemination process and to ensure an effective transfer of knowledge. Discussion meetings will be organised. Data and useful information made available by the project will be used to interact. The tools developed by the project will be provided especially to farmers and extension services.

The bi-univocal communication (to the project and from the project) activities in EUCLID are rationalised to exploit interactions between end-users and project members at best. In the image below it is drafted how the flux of information from the stakeholders will be channelled into the project, mainly through the various activities organised in WP3. The project results will reach the end-users through dedicated tasks in WP3, WP4, and WP5. The management (WP6) will play a key role in ensuring that the project stays permeable to any useful opportunity coming from outside the consortium and will carry-on activities associated to technology transfer and intellectual property management, thus regulating any exchange with the outside.

Figure 3: Flux of integration of information from the stakeholders into the project (Flux d'intégration des données dans le projet provenant de différents acteurs)



You can follow EUCLID project on http://www.euclidipm.org/ to access to all information and results from it.