

2. Thematic workshop C-IPM. June 15<sup>th</sup> 2015 at the IBIS Hotel at CDG airport in Paris.

## **Novel and innovative IPM tools and/or technologies**

As part of the C-IPM Eranet, 57 scientist, governmental officials, policy makers, company representatives and agriculture advisors met to discuss the possibilities and opportunities for innovative tools and technologies to support the implementation and development of IPM in Europe.

Three speakers were invited to give plenary talks on the subject and additional six speakers were asked to give shorter introductory talks for the World Café discussion.

### *Plenary talks*

#### **“Role of robotic technologies to boost IPM”**

*Ard Nieuwenhuizen, PROBOTIQ BV, the Netherlands*

Why implement robotic technology in arable farming? There are several benefits, incl. replacement of labour intensive tasks, timeliness of management tasks and improvement of sensors and applicators. The application area and benefits can be magnified by adding autonomous steering to the robots. Through all steps of implementing IPM in the management practices there are technology, which can improve efficiency, accuracy and timeliness.

A wide variety of robotic systems and autonomous machinery is developed and some is already on the market. Adding an autonomous steering system to the equipment has the big advantage of freeing man hours for other tasks. When the tractor driver becomes superfluous for repetitive, labour intensive tasks, there is more time for the farmer to spend on more complex tasks. This will be a great advantage in increasing the implementation of IPM, which by definition requires a more flexible management practice.

Some examples of used robot technology are robotic phenotyping, where robots monitor seeds or starting plant material, air sampling of spores and collection of traps, growth season monitoring, e.g. for scouting growth stage, crop health, insect traps, catch plates etc. and airborne measurements by drones, satellites and planes. Finally, soil potential measurements are highly relevant for robotic technology but not yet a major focus area for use of robots. The challenge is to get the most out of the data sampled. Big data analyses are a developing area.

Compared to arable farming, other sectors of agriculture have been adopting the robotic technology faster, e.g. dairy farms for milking. The technology for arable farming has to be more flexible and able to adapt to changing soil and climatic conditions. This sets high demands for sensors and monitoring equipment for real time measurements and precision application. For the largest farms the adoption of intelligent autonomous robots is a way to move forward from a trapped situation, where they have limited labour available and thus no possibility of implementing mechanical weeding or other labour intensive methods in IPM.

It is important to keep the balance between a push and a pull strategy in developing new technology. The best experiences are made with a pull strategy, where the farmers report a problem to the researchers/developers and the technology is developed to fulfil this need. This way it is a bottom-up

process. The other way around (push strategy), where technology is developed first and then the developers try to find relevant uses and marked opportunities for it, can be difficult. The driving force for farmers is the farm economics and this spurs entrepreneurship, which drives adaptation and changes in farming systems. Other factors, which can induce changes, are climatic changes, environmental awareness and technology development in other sectors, which can have relevance for farming. Often a global perspective is employed by the developing companies in the development of technology, but local adaptation is needed and the solutions need to be as diverse as the cropping environment.

The vision is an autonomous farm within 5-10 years. The technology is there for most uses, but it is not adopted yet. It is important that farmers are aware of the fact that they can change their farming system if they want to adopt autonomous solutions.

### **“Innovative and user-friendly technologies for pest detection and monitoring”**

*Jean-Yves Rasplus, INRA, France*

It is highly needed to improve our knowledge on insect pest life cycles and biology as the published literature is often inaccurate and/or inadequate. Tools to better identify the insect pest or complex of pests are being developed. A database has been built for barcodes of agricultural and quarantine insects. The database contains data for 6500 arthropod species, 65000 sequences and 800 photos. There are taxonomic, biological and distribution information along with sampling information, geo-localisation, and host sequences (multigenic).

There are some drawbacks in mitochondrial sequencing, which is currently used and sequencing COI alone is not a panacea. It can be a rough but good estimate of the species diversity. However, it is difficult to study closely related species using only classical genes as these genes are not informative enough or can be misleading through mitochondrial introgression. This is a problem when deciphering closely related species that still exchange genes or when thelytokous parthenogenesis occurs (females are produced from unfertilized eggs). To study complexes of closely-related species, we develop RAD-sequencing, a powerful tool for characterization of insect species. It offers in depth characterization between and within species in complexes. It can lead to better assess hybridization between released strains and natural populations and identify the genetic basis of traits. Similar to other methods RAD-seq can be dependent on DNA quantity that can be extracted from very small insects (i.e. *Trichogramma*). To overcome this problem, whole genome amplification (WGA) can be used, and appears a reliable method that generates no artefacts. RAD sequencing is also a helpful tool to characterize biological control species/strains bred in biological resource centre before release, assess hybridization between released strains and natural populations and identify the genetic basis of some interesting traits (dispersal, efficiency of BCA). Furthermore, it is useful to bridge taxonomy, population genetics, phenotypes and genomics of traits. This has implications for IPM and can aid in a control strategy targeted on specific species, using their inherent traits and life cycles.

Sequencing of Multiplexed Amplicon (SMA) can also be a powerful tool for IPM research. We take advantage of new sequencing method such as high-throughput Illumina MiSeq sequencing as an alternative to SANGER sequencing. SMA sequencing appears fast, cheaper and user subjectivity has no impact. This method enables concurrent identification of host and microbiome or vector and transmitted bacterial disease. This way it is possible to identify the proportion of vectors carrying a certain bacterial disease or to

study how microbiomes affect life-history traits and fitness of their host. Co-sequencing the host and its prey (on multiple genes) enables the identification of whole food-webs through the identification of an insect plus gut content (though the food is degraded, so it is a one-moment picture). This further enables description of how different changes affect the food preferences, e.g. changes in agricultural practices. Thus we can compare the structure of food webs under different conditions. It is possible to study the infraspecific geographic and genetic structures and to identify the main infraspecific lineages. We can study the adaptation of specific lineages to biotic and abiotic conditions.

The taxonomic resolutions should be accounted for in pest risk analyses as the differences within a certain species might infer differences among the optimal control strategy. When we try to project the risk of invasive species, we often forget that a given population is a pool of different entities (populations, mitochondrial lineages etc.) with different traits. Using this information in Species Distribution Modelling (SDM) can enable better, more accurate risk assessment of invasive species. So far only a few studies on biogeographic structures of pest species have been published; and only 23 insect species has been documented accurately. This is a very poor basis for insect risk assessment and management that need to be implemented in the next years. To develop SDMs, different tools have been developed, e.g. R-functions to datamine and georeference published occurrences for invasive pests, which enable validation and correction of reported occurrences. Other tools are the possibilities of using standard search engines to follow invasive species: GEEK ([Google trends network and pest outbreak](#)). Google streetview can be used for larger specimens, e.g. dead trees due to specific insects.

### **“Advanced biotechnologies to breed resistant and/or tolerant plants”**

*Mark Tepfer, INRA, France*

RNA interference (RNAi) is a biological process in which RNA molecules inhibit gene expression, typically by causing the destruction of specific mRNA molecules. In plants, nematodes, and insects, RNAi plays an important role in controlling invasive nucleic acids (viruses, transposons). In its simplest form, we can increase virus resistance by boosting RNAi HIGS (Host-induced gene silencing): create resistance by silencing essential genes of plant pathogens and pests. Conferring resistance via RNAi builds on the natural biology and boosts the natural process of e.g. insect virus resistance. The method is authorised for virus resistant biotypes of plants and proofs of principle are available for nematodes, insects, fungus, parasitic plants and bacteria resistance. Specific uses are authorised in US and Brazil. There are, however, still some unresolved issues with this method; it does not work for all organisms and the durability in field is unknown.

Using RNAi to silence host genes, which are essential for the target pathogen HIGS, requires that the target organism take up the dsRNA or siRNA. There may be cases where this does not occur efficiently. An alternative would be to silence host genes that are essential for the pathogen, but not the host (e.g. down-regulate EIF4e for resistance to potyviruses). There is the opportunity of applying RNAi as a type of pesticide, where antiviral RNAi can be induced by inoculation with dsRNA. Further exploration of this was the purpose of a COST project FA0806 “Plant virus control employing RNA-based vaccines: a novel non-

transgenic strategy". Since the inoculated plants are not modified, would this be a way to bypass the constraints and prohibitive costs of the GMO regulatory system?

What are the potential impacts of RNAi-mediated resistances? The potential harms are equivalent to those related to GM plants. Furthermore, there are some RNAi-specific potential harms; Off-target effects on the target organism, deleterious effects on non-target organisms, ingested siRNAs have siRNA- or miRNA-like effects on expression of human genes, saturation of the RNAi machinery, stimulation of innate immunity. The key question related to the possibilities is dose: is enough siRNA absorbed to have an effect?

Does this technic have a future in Europe? The potential benefits of RNAi-mediated resistances are enormous, and they could lead to major reductions in pesticide use, but most are at the proof-of-concept stage and may not prove sufficiently effective in the field. They are based so far entirely on GMOs that synthesize novel RNAs, so going forward to unconfined use of these resistances may prove difficult. The cost of going through the regulatory process is high. In Europe, the GMO authorization process is going through drastic changes, for which the endpoint is difficult to predict today. In Europe, the critical issue is, and will be, public acceptance of the products stemming from this technic.

Another novel method is genome editing with CRISPR/Cas9. This method creates targeted mutations, which can disrupt a specific gene coding for susceptibility of a pesticide thus creating resistance without being transgenic. The method can also make repair genes. The result may be a simple mutant, indistinguishable from the naturally occurring one. Since they bear no transgenes, will they be considered GMOs? Selecting host genes will be more delicate than for HIGS: Resistance will be created by mutating or inactivating a host gene that is essential for the pathogen or pest, but not essential for the host. But this will not take long, there are in many cases excellent candidate genes. Similar to the RNAi method the potential benefits of resistances created by CRISPR are enormous, and they could lead to major reductions in pesticide use, but what will be their regulatory status in Europe? Paradoxically, although CRISPR technology is in its infancy, whereas RNAi is relatively mature, we may see dissemination of CRISPR-mediated mutants in Europe sooner than HIGS organisms modified to resist pathogens or pests. It all depends on the regulatory climate.

*Short plenary talks to spur the discussion in the World Café session.*

*Topic A*

### **Robotic technologies for weeding – Norwegian activities**

*Nina Trandem and T. W. Berge, Bioforsk, Norway*

The project SMARTCROP aims at developing proven and practical IPM tools for farmers to use, as well as a relevant policy for a successful implementation of IPM. One of the developed tools is sensor-based harrowing of annual weeds in cereals. The harrowing intensity is adjusted according to weed level and soil properties by the angle of the teeth.

Another project applies "drop on demand" herbicide application in row crops by image recognition of weeds.

The third project, MULTISENS, focus on map-based control of perennial weeds in cereals. A robot is used for capturing images of the weed patches in the field during harvest. As glyphosate applications in maturing crops are not legal in Norway, the images can be used for patch spraying after harvest.

*Topic B*

### **Automated insect monitoring system**

*Matej Stefancic, EFOS, Slovenia*

“Trapview” is pheromone traps with sticky plates to trap the insects.

The traps are independent with solar energy batteries and contain a camera, which automatically process and analyse the images via a Cloud-based system. There is automatic image recognition, but the identification can be corrected manually as it is not completely accurate. The system is learning by these manual corrections. The counting is added up from previous images until the sticky plate is changed. The situation can be monitored by smart device, which enables a fast reaction to a change in insect infestation. It is now possible to recognise almost 30 species. It is also possible to upload pictures from smartphone manually and get identification.

### **LIFE Agroiintegra DSS**

*Alberto Lafarga, INTIA, Spain*

Agroiintegra combines innovative and new pest and diseases monitoring tools and decision support systems (DSS) for insects and diseases. The system is based on areas of homogeneous behaviour and relates monitoring data with meteorological measurements through insect and disease models. The overall risk is assessed both with regard to frequency and severity. Effective control measures are evaluated and a subsequent risk is assessed. The calculated risk can be viewed on a regional (areas of homogeneous behaviour) or a local (field unit) scale.

### **Mobile services for pest monitoring, data storing and sharing**

*Jussi Nikander, LUKE, Finland*

Smart devices can provide location specific advice for tasks specific tools. The farmer is interested in assessing locally relevant information and is observing the local development of pests. The farmer’s observations can be uploaded via the smart device in the field. The processing of this information, however, requires quality assurance. The accumulated observations from farmers can then be distributed via pest management services. There are several constraints to consider when making smartphone Apps; limited screen space and the difficulties of handling the sensitive touch screen under field conditions. The Finnish “Viljavahti” app is an example of a successful mobile service for pest management.

### **Vite.net – A decision support system for sustainable viticulture**

*Sara Legler, HORTA, Italy*

Horta Srl was founded in 2008 with the mission to increase the value of research by transferring the technological innovation to practical agriculture at national and international level. This is obtained through development of decision support systems, management of a certified agro-meteorological network, development of technical tools and participation in research projects. All of these activities increase the speed of IPM implementation. A variety of crops are targeted by the DSS from Horta SRL, e.g. Vite.net, which is a DSS for viticulture. The DSS is web-based and data is continuously fed into the system from a variety of monitoring systems and sensors, e.g. weather data and pest observations. It considers all aspects of management practices and provides reliable and prompt decision support. The final responsibility for decision still lies with the manager, but the DSS provides supportive information.

*Topic C*

## **Monitoring Phytophthora on emerging resistance using a SSR-marker set**

*Piet Boonekamp, DLO, The Netherlands*

Late blight (*Phytophthora infestans*) caused major losses in potatoes in the 1840s Europe. The disease was imported from America.

The disease is a major problem for potato growers and the resistant cultivars mutate to form non-resistant cultivars. Therefore, resistant gene stacking is a possibility to decrease the need for spraying. In the Netherlands, fungicides against this disease account for 50% of the total amount of fungicides used.

The stacking of resistant genes might, however, not be enough to keep the infestation under control and precision spraying and careful monitoring have to be part of a sustainable IPM strategy. The development of late blight is monitored through the EuroBlight project and the diversity of potato blight strains is analysed.

World café

*Topic A*

## **Role of robotic technologies to boost IPM**

*Moderator Jozef Kiss and Wolfgang Zornbach, minute taker Mette Sønderskov*

The general opinion was that new technology incl. robotics is welcomed by the farmers as long as the costs are reasonable and increase IPM efficiency and profitability. There is spatial scale (and also socio-economic) dependence as large farms will have the opportunity to buy the equipment for themselves and thus save labour costs. For smaller farms, which often exist in heterogeneous landscapes, there are some difficulties in economic capability of buying the equipment and for using the autonomous robotics. An example is from Switzerland, where many farms are located in mountain areas with small fields. Here autonomous equipment is challenged by the topography. A diverse crop rotation will also limit the possibilities of small farms to have the most relevant equipment for all crops. In this context buying service from external companies using the technology or working in cooperation with other farmers are highly relevant. A rule of thumb for developing companies is that it cannot take more than 3-4 years to cover the costs of new equipment. Subsidies for implementation of robotics were suggested by some participants in order to speed up the process.

In greenhouse production robotics are implemented to a large degree already, often for highly specific purposes, which rely on specific measurements of conditions and some application depending on the measurement. This is a highly specific use and might apply to specialised productions in the arable land as well. There is a large potential for technology to take over some of the more tedious soil and pest sampling tasks, which is necessary for precise application of both fertiliser and pesticides.

It is important the companies developing the technology consider that machinery can have multiple functionalities, e.g. some monitoring device, which collects data while harvesting. It is also important that there is a solid support for farmers on equipment maintenance as the more complex machinery limits the possibilities for farmers to repair it themselves. There are different perceptions of the technology being a barrier or not for implementation. This is probably somewhat cultural affected and there might be large geographical differences. This led to a discussion of the education of farmers. It is important to make it

clear that the technology is there and how to use it. A tool to disseminate the knowledge and increase the capacity of farmers is demonstration farms, which can be used as validation of the methods for the farmers. The practical visualisation of technology can help farmers to see the opportunities in changing their growing systems for the technology to work. Farmers are often eager to implement new technology; if it is proven that it works.

The effect of autonomous technology on agronomic knowledge of the farmers was discussed and some of the participants drew the analogy to map-reading abilities and use of GPS in cars. There was a concern that farmers will rely solely on the technology to determine the necessary actions and lose some of the agronomic knowledge. A contrasting viewpoint was that technology can only take over the repetitive tasks, and the data sampled by the equipment needs to be interpreted before any management decisions are made. The increased possibility to collect data will give the farmers a better basis for their decisions. The increased data mass will, however, also increase the need for DSS, as the decisions become more complex. DSS are by nature supportive for management decisions, but need the human factor as final evaluator. The technology might require specific plant growing patterns or other practical management changes and therefore there is a need for farmers to be flexible and rethink their management systems. This is an inherent characteristic of IPM and it is highly relevant for farmers to incorporate new technology when they change their cropping systems to more integrated systems. Here the technology can add new possibilities, e.g. intercropping, which previously have been restricted by the harvesting methods. Robotics is considered a tool in the toolbox for IPM as it does not inevitably mean increased IPM implementation to invest in this new technology. It can be a helpful tool to free time of the farmers for the more complex planning and management, which is a build-in characteristic of IPM. The future development of robotic technology must be driven by the farmer's needs.

One of the important challenges for the development of new technology is the integration of monitoring networks and IT-systems both nationally and transnationally. This will increase the possibility of early detection and shorten the time between observing something and getting the advice. The easier the systems communicate the more efficient they will be. This will also increase the likelihood of farmers adopting the technology.

*Topic B*

### **Innovative and user-friendly technologies for pest detection and monitoring**

*Moderator Piet Boonekamp, minute taker Wilma Arendse*

There is a large potential for technologies to support detection and monitoring of pests. Good integration with decision support systems and advice on more than pesticide application is possible and needed. DSS integrating crop rotation, sowing densities and timing along with economic parameters will make the management decisions easier for the farmers. Furthermore, a better integration of autonomous monitoring can make the time spent on registering more acceptable. When the detection and monitoring is made autonomous the farmer, however, still needs to combine the interpretation of the data with the knowledge of local conditions and previous cropping history. If the farmer relies solely on models and forecasting for the management some issues might remain unsolved and the farmer will lose confidence in the systems. The methods for detection of pests are different for diseases, insects and weeds. Traps are used for insects, forecasting for diseases and manual detection for weeds as it is necessary to identify the individual species.

Identification is also necessary for insects, but this can be achieved by cameras in the traps. Automatic identification of weeds is highly needed to make the weed management more autonomous.

A question was raised to whether it is possible to monitor signal plants instead of the crop/whole system?

The follow up of such signal plants in the field might be much easier than full field screening, and early warning better possible. Examples exist for susceptible cultivars for virus diseases.

The main groups of pests, which are monitored, are diseases and insects, but what about weeds and soil factors and soil organisms? Only few examples were known among the participants on soil monitoring. The fertiliser level can be monitored and in some areas nematode levels are monitored. But the integration of soil monitoring with DSS is rare. One reason for the low degree of integration might be lack of knowledge of the interactions between soil conditions and pest, hence difficulties in using the soil conditions in support of management decisions. In order to develop the integration of soil conditions with DSS, research is needed to determine what indicators for soil health are relevant. Weeds are less often monitored at a larger geographical scale, except for invasive species. Yet, the mapping of weeds on a farm level is highly relevant.

When we develop monitoring programmes it has to be a balance between what is possible and what is relevant for research and farmers. In principle we can monitor everything, but the costs can be larger than the benefits. Pests should only be monitored at relevant stages and where we can use the measurements. There is a difference between relevance for research and farmer's management. When we talk about costs there is also the issue of subsidies, as these can affect the balance between what is economically beneficial and what is not. The fact that in order to comply to the subsidies farmers have to consider a vast amount of rules, which is stricter than the IPM rules, is interesting.

Biogeographical information is needed to monitor bioresistance. Lineages of origins of pathogens/pests can, with modern genomics tools, be discovered and it will become possible to model the risks if pathogens/pests invade somewhere in EU.

The connection between data sampling/ processing and the practical management is crucial.

Because we are able to monitor a vast amount of factors the farmers need very sophisticated programs to process all the input. It also has to be a system that is able to integrate the management of all parts of the crop rotation. The individual farmer does not have the time to process input from a variety of systems. The program has to be easily understood and the farmer has to be able to add the special knowledge of the specific farm, e.g. soil and climatic conditions.

To gain the full advantage of extensive monitoring programmes and early detection, the exchange of information between the monitoring system and farmers has to be quick and easy. One problem is that not all people involved have the same agenda. For instance in NL (private) advisors are paid by the farmers and don't want technologies to replace themselves. A certain level of trust is required between stakeholders. There is also the question of how to reach the farmers; is communication via smart devices the answer?

Gigantic data sets are easily collected with autonomous sampling technic and network monitoring, but how do we use 'big data'? For example, farmers have to monitor prevalence's of pests in Spain. Why not have access to this information and analyse this together with geographical information for each region? A problem might be that the information is private and cannot be shared. Possible solution might be to use anonymous data. Participants had mixed experiences with this. It is important to standardize how data is exchanged and stored. Even between regions within one country it can be a problem to connect monitoring systems.



Another question is who is to pay for the system development and maintenance. This will depend on the national decisions and funding. It is possible to make it a public-private funded system. User's payment is another possibility.

The development and integration of biocontrol is a possibility, which has yet to be explored to a large extent. There are a range of measures to consider to increase the density of natural enemies for insect pests e.g. through margins with flowering plants. The natural enemies are hard to manipulate in terms of timing and we need to better understand the amount of banking crops/flowers/strips to have optimal bio-control system. For biopesticides applied directly, we need to develop robust recommendations for farmers. Biopesticides are more specific than many regular pesticides and it requires more precise application to be equally efficient. Applying thresholds for biopesticides is different than for the regular pesticides. The use of biopesticides is considered more preventative. Monitoring has a different role to play and other things needs to be monitored. An example was given for Switzerland, where drones are used to drop *Trichogramma* in maize against certain maize pests. Nowadays it is more effective. The farmer's system must have more resilience to all kind of pathogens. In such a resilient and well buffered system careful monitoring of each individual pest/disease will become less important.

### *Topic C*

#### **Advanced biotechnologies to breed resistant and/or tolerant plants**

*Moderator Silke Dachbrodt-Saaydeh, minute taker Jay Ram Lamichhane*

During the discussion, the participants asked about the national situation concerning the question whether the use of RNAi technology is considered GMO or it is simply perceived as an innovative approach as the RNAi technology involves modifying the plant (introduction of transgenes into the plant genome). From the research point of view, it was clarified that RNAi currently involves modifying plants, while RNAi products (use of RNAi products to spray on plants) are not yet a reality. Participants argued that, overall, the use of RNAi to modify plants will face obstacles in Europe in terms of practical implementation, as they might be considered GMOs. In contrast, the potential of this technology was recognized if RNAi were available as pesticides, since they would not modify the plant genome and thus would not be seen as GMOs. However, the cost of this technology would be an issue.

A communication gap was mentioned as an important barrier to the adoption of new breeding technologies in agriculture in Europe. For this reason, there is a need for thorough studies to understand how this barrier can be overcome. It will be important to consider socio-economic issues in presenting the potential benefits as well as the potential risks in conveying clear messages regarding the use of RNAi and other advanced biotechnology strategies.

In the majority of countries a moratorium of GMO exists and only field experiments for research purposes are possible, while for example in the UK currently field trials with GMO can be conducted. This represents an important obstacle for RNAi research in Europe. It cannot be tested, and validated, whether the RNAi technology, which is to-date developed and tested under laboratory conditions, offers effective and durable pest or pathogen control without conducting field trials under different environmental conditions. Many laboratories in Europe that study the potential of RNAi technology have candidate R-genes they are unable to test under field conditions. Testing these genes only under laboratory and/or greenhouse conditions is not sufficient, since effectiveness in controlled conditions may not adequately predict

behaviour under field situations. In order to go beyond “proof of principle” in the lab, there is a need for conditions more favourable for small-scale field trials. A conducive framework for research to further test and assess the potential of the technology would be a coordinated system to conduct field trials in different countries under different climatic conditions.

Regulatory constraints have been described as a main hindrance preventing these technologies from being available in the European market. It was argued that the EU regulation giving freedom of choice to each MS in accepting or rejecting GMOs and potentially other advanced biotechnologies (so-called devolution) may lead to acceptance of these technologies in some MS that are less reluctant (UK was mentioned as an example).

During the discussion a question was raised about the needs from research and coordination to favour moving forward with the evaluation of such technologies. It was argued that especially those sectors or crops need to be identified where there is a need and potential for new technologies.

It was also stated that the situation in Europe is now changing, in terms of the adoption of new biotechnologies. This is due to several factors, such as the decreasing number of pesticide modes of action available in the market for crop protection, and increasing problems related to the evolution of resistant pests and pathogens. Growers tend to be more open to innovation, and may like to adopt technologies that offer improved pest or pathogen management. What really counts for growers is the cost-benefit analysis. If a given technology has the potential to increase various benefits (profits, less pesticide use, more free time, etc.) combined with lower risks, they tend to adopt that technology. For this reason, the possibility to produce demonstration field trials going beyond “proofs of principles” would be ideal to make available new pest management alternatives if traditional approaches prove to be ineffective.

Another point of discussion was how to best raise awareness about the new technology. It was agreed that neutral and pro-active communication and education in a stepwise approach is necessary to create an intelligent discussion and acceptance by the public.

The concluding question whether breeding technologies and novel approaches to that should be part of IPM approaches was agreed to and supported by the participants.