

GMASSURE Application of “-omics” to Biosafety Workshop

1. Introduction

GMASSURE is an action of the African, Caribbean and Pacific (ACP) Science and Technology Programme and is funded by the European Union (EU) and the Department of Science and Technology (DST) in South Africa.

The action’s objective is to assist in increasing agricultural productivity in the Southern African Development Community (SADC) region by improving knowledge about, and increasing capacity in agricultural biosafety and biotechnology, and the safe use of genetically modified (GM) agricultural crops. In order to achieve this objective, GMASSURE hosts workshops on a variety of topics.

2. About the workshop

A two-week workshop was jointly developed and presented by specialists from the University of Pretoria, the University of Johannesburg, the Council for Scientific and Industrial Research (CSIR) and the Agricultural Research Council (ARC) of South Africa to inform scientists and policy makers about the application of biotechnologies (including transcriptomics, proteomics and metabolomics) to crop plants. The workshop was presented in four modules, which were held at the facilities of the respective partner institutions in Pretoria and Johannesburg from 19 to 30 October 2015.

The implication of natural variation in abundance of transcripts, proteins and metabolites in wild plant populations, as well as between genetically modified organisms (GMOs) and their near-isogenic lines formed a strong focus of the discussions in the workshop. The modules included lectures, demonstrations, analyses and facility tours at the ARC’s Biotechnology Platform at Onderstepoort, the University of Pretoria’s Plant Sciences laboratories, the laboratories of CSIR Biosciences and the University of Johannesburg’s Biochemistry laboratories.

Despite student protest action at both the University of Pretoria and the University of Johannesburg during the second week of the workshop, alternative arrangements could be made to present the affected modules, and it did not have an impact on the presentation of the workshop.

3. Workshop programme and facilitators

Day 1: Introduction to GMASSURE, “-omics” technologies, background, delegate roles and expectations, GMOs developed for Africa

On the first day of the workshop, Dr John Becker, project leader of the GMASSURE action, introduced delegates to the project. They were provided the opportunity to introduce themselves, the roles they fulfil in their respective countries, as well as their countries’ position in terms of GMO legislation. They also reflected on their expectations of the workshop. Delegates were introduced to the facilitators of the various modules.

- *The Genomics module* was presented by Prof Jasper Rees and Dr Charles Hefer of the ARC’s Biotechnology Platform. Prof Rees is Group Executive: Research and Innovation Systems at the ARC, and Dr Hefer is a senior researcher and Bioinformatics lead researcher at the Biotechnology Platform.
- *The Transcriptomics module* was presented by Mr Nicky Olivier, an experienced scientific officer at the Microarray facility in the University of Pretoria’s Department of Plant Science.

- *The Proteomics module* was presented by Dr Stoyan Stoychev, a senior researcher at CSIR Biosciences in Pretoria.
- *The Metabolomics module* was presented by Prof Ian Dubery, a research professor in the Department of Biochemistry at the University of Johannesburg.

The facilitators each provided brief outlines of their planned workshop modules.

Delegates were introduced to the genome-wide analysis of crops by means of a presentation delivered by agricultural plant scientist, Dr Lerato Matsaunyane of the ARC's Crop Protection Division, while Dr Kingstone Mashingaidze of the ARC's Grain Crops Institute delivered a presentation on GMOs developed for Africa. He focused specifically on the Water Efficient Maize for Africa (WEMA) and Improved Maize for African Soils (IMAS) projects.

Day 2 and 3: Genomics

The first two-day module was presented by Prof Rees and Dr Hefer at the ARC's Biotechnology Platform at Onderstepoort, Pretoria.

Delegates learnt that together with the development of next generation sequencing (NGS) technologies came an explosion in the field of genomics. Genomics can be summarised as the study of an organism's genome, ranging from whole genome sequencing to genotyping targeted regions. NGS technologies have enabled scientists to generate massive amounts of genomic data, which enables the development of genomic resources such as genome sequences or genetic maps. Further analysis of these genomics resources can lead to the identification of genetic variants with large phenotypic effects in breeding populations.

The focus of the Genomics module was to introduce delegates to NGS systems and the analysis of genomes for the identification of genomic variation, and to discuss the advantages and pitfalls of the technology. The first day was spent explaining the central dogma of biology and various sequencing technologies. Delegates observed practical demonstrations in the facilities of the Biotechnology Platform and participated in hands-on tests such as DNA extractions. The day was concluded with a tour of the ARC's Robotics facility, its DNA Sequencing facility and its GMO facility.

The second day included a session on genome engineering principles and techniques with a focus on the detection of GMOs using NGS technologies. Delegates learnt more about sequence data analysis, genome variation, and genome editing and modification. The day was concluded with a group discussion.

Day 4 and 5: Transcriptomics

The second module was presented by Mr Olivier of the University of Pretoria's Microarray facility.

In the first session, delegates were introduced to gene regulation at the transcript level. After explaining to delegates the flow of information inside a cell, Mr Olivier explained that gene products (RNA) increase when genes are activated. He then evaluated the advantages and disadvantages of RNA sequencing and hybridisation.

With RNA sequencing, one can detect absolute levels of products/transcripts, one can find all transcripts present, and one can detect at least five order of magnitude differences. However, RNA sequencing is expensive and needs special instrumentation, various statistical methods are used, it is difficult to quantify alternative splicing, one may need to wait a long time for the results, and there is great reliance on computing infrastructure and bioinformatics.

Hybridisation (microarrays), on the other hand, gives ratio values for gene products, it is a relatively fast procedure, well-studied statistical methods can be used, and there is less reliance on computing infrastructure. However, it is expensive and needs special instrumentation, a sequence of required genes is needed, detection is limited to the genes on the microarray slide or chip, and one can only detect in the region of three orders of magnitude differences.

Due to circumstances on the campus of the University of Pretoria on Day 4, the facility tour and demonstration of laboratory procedures had to be postponed until the final day of the workshop.

Day 6 and 7: Proteomics

The third module was presented by Dr Stoychev and colleagues from CSIR Biosciences. It included lectures, round table discussions and demonstrations at the facilities of the CSIR. This component focused on the application of high-resolution proteomics workflows for elucidating both the intended and unintended effects of GMOs. The module was divided into a theoretical component (Day 6) and a practical component (Day 7).

The first day began with an overview of proteomics, and how it fits into the world of “-omics”. This was followed by a lecture on mass spectrometry, focusing on its application to large biomolecules such as peptides and proteins, as well as a lecture on experimental design, sample collection and sample preparation, which are all crucial components in any proteomics workflow. The major workflows that are applied to global proteome profiling in light of GMO screening were also highlighted. The day was concluded with a seminar on data processing and interpretation.

The second day was dedicated to practical work. Delegates were divided into small groups and exposed to various aspects of proteomics workflows. These included protein extraction and clean-up methods, setting up and running two-dimensional gel electrophoresis (2DGE), as well as subsequent gel processing and interpretation. Further aspects that were covered included in-solution and in-gel protein digestion approaches, methods and reagents used to automate sample preparation, as well as setting up and acquiring data using matrix-assisted laser desorption ionisation time of flight mass spectrometry (MALDI-TOF MS) and liquid chromatography tandem mass spectrometry (LC-MSMS).

Day 8 and 9: Metabolomics

The fourth module was presented by Prof Dubery of the University of Johannesburg. It included both lectures and demonstrations.

Metabolomics is a scientific approach or discipline that aims at the comprehensive identification and quantification of all cellular metabolites within a biological system (primary and secondary metabolites). With the development of GMOs, possible unintended effects can be addressed by conducting a comparative analysis of the metabolite composition of GM plants in comparison to non-GM cultivars.

The need for adequate testing is also important to show substantial equivalence between a GM and non-GM variety. Studies on substantial equivalence are often required within current regulatory frameworks to prove that the intended, beneficial genetic modification did not result in any unintended effects that could have affected the metabolite composition.

In addition to these topics, the module also covered metabolomic technologies used to investigate intended and unintended changes in GM crops. The techniques that were presented (gas chromatography, liquid chromatography and mass spectrometry) form the cornerstone of the expertise in plant metabolomics of the research group at the University of Johannesburg, and enabled delegates to learn more about the application of metabolomics in plant sciences.

During the demonstrations that were performed, delegates learnt about different extraction methods, as well as targeted and untargeted analyses, complementary profiling approaches and analytical platforms. The acquisition and interpretation of metabolomic data and analysis of the data by multivariate statistical tools were explained against the background of the assessment of GM food safety.

Day 10: Combined closing meeting

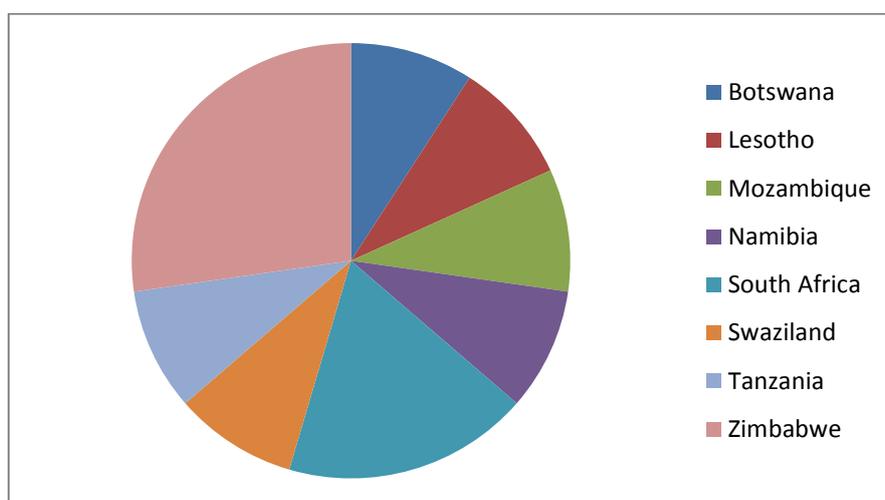
The final day of the workshop involved combined discussions. Delegates had the opportunity to provide feedback to the presenters, and to express the extent to which the workshop had fulfilled their expectations.

Dr Dean Oelofse of the ARC's Crop Protection Unit in the Vegetable and Ornamental Plant Institute (VOPI) also delivered a presentation on the role of the Organisation for Economic Cooperation and Development (OECD), especially with regard to biosafety considerations internationally. He represents South Africa on the OECD Task Force for Novel Foods and Feeds, as well as on the OECD Working Group on Harmonisation of Regulatory Oversight in Biotechnology.

4. Delegates

Some 16 delegates from Botswana, Lesotho, Mozambique, Namibia, South Africa, Swaziland, Tanzania and Zimbabwe attended the workshop. Most of the delegates were involved in scientific research and policy making in the field of biotechnology, particularly as it is applied to GMOs and food safety.

Delegate distribution by country



In addition to hailing from different countries, the following institutions were also represented:

- Ministry of Agriculture, Botswana
- Ministry of Tourism, Environment and Culture, Lesotho
- Ministry of Science and Technology, Higher Education and Professional Training, Mozambique
- University of Namibia, Namibia
- Biosafety South Africa, South Africa
- Agricultural Research Council, South Africa
- University of Swaziland, Swaziland
- Tropical Pesticides Research Institute, Tanzania
- National Biosafety Authority, Zimbabwe
- University of Zimbabwe, Zimbabwe

5. Delegate feedback

On the final day of the workshop, delegates were given the opportunity to provide feedback on the extent to which the workshop had fulfilled their expectations. They considered whether they had learnt something useful that they could take back to their country of origin, how they thought they would be able to apply what they had learnt, what they had found particularly interesting about the workshop, and whether there were any gaps that they felt could have been addressed. Some delegates also provided suggestions for future interventions, and expressed their impression of this workshop in relation to other GMASSURE workshops they had attended in terms of knowledge dissemination and capacity building. Overall, the delegates were unanimous in their commendation of the workshop and felt that it had surpassed their expectations.

Dr Derick George and Charles Mazereku of the Ministry of Agriculture in Botswana are confident that they will be able to apply what they have learnt to a particular challenge in Botswana: finding ways to acclimatise the *Jatropha curcas* tree. They found the demonstrations in the laboratories of the various partner institutions to be exceptionally interesting. Mr Mazereku highlighted the workshop's open-question format and learning through a collaborative approach as a particular benefit.

Maboi Mahula, who is involved in the development of a Biosafety Framework in the Ministry of Tourism, Environment and Culture in Lesotho, felt that he had benefited from the knowledge he gained in the use of “-omics” techniques, particularly in terms of determining the unintended effects of GMOs. He felt that a particular advantage of the workshop was the practical component. He is confident that he will be able to disseminate the knowledge he obtained through this workshop at ministerial level.

Marcelino Xavier of the Ministry of Science and Technology, Higher Education and Professional Training in Mozambique was able to improve his network of specialists through the people he met at this workshop. He felt that the workshop met his expectations, and that he will be able to take the knowledge he obtained back to his country. He also considered the practical component and the laboratory demonstrations a particular benefit of the workshop. He suggested that the workshop should be presented in different countries on a rotational basis in order to train more people.

The Namibian delegates hailed from both government and academia. Filemon Shindume, an advisor in the Ministry of Agriculture, Water and Forestry, mentions building a network of specialists as a value-adding benefit of the workshop. He also felt that he had obtained a better understanding of the Southern African landscape by interacting with specialists working with similar challenges in different countries in SADC. Dr Ronnie Bock and Dr Emmanuel Nepolo of the University of Namibia agreed that the collaboration between the different institutions that had presented the modules was very impressive. Dr Bock stated that the workshop had exceeded his expectations, and he had found it to be very rewarding.

Dr Liezel Gouws, a project manager at Biosafety South Africa, is responsible for the coordination, management and sourcing of biosafety projects, regulatory dossiers and resources. As she has a PhD in Plant Biotechnology, she already had in-depth knowledge of a number of the topics that were dealt with in the various modules. However, she felt that she learnt a lot about how technologies have developed, as well as the databases and open-source software that are available to researchers. She found the networking with other delegates to be a particular benefit of the workshop, particularly as it enabled her to learn about the challenges experienced on the subcontinent, as well as the need to collaborate with other countries.

Dr Wilna Jansen van Rijssen, a GMO specialist who has spent many years with the South African Department of Health, found that the workshop had provided her with greater insight into the

processes involved. She found the workshop presentations to be of an exceptionally high standard, and that they explained the processes step by step – making even complex concepts easy to understand. She commented on the excellent organisation of the workshop, as well as the collaboration between the different partner institutions, which she felt added value to the workshop.

Dr Elliasha Hajari, a researcher in the ARC's Institute for Tropical and Subtropical Crops in Nelspruit, South Africa, felt that after attending the workshop she was better equipped to communicate with the general public about GMOs. She found it particularly interesting to meet the operators of the laboratory equipment at ground level. However, she suggested organising a simplified “-omics” workshop to accommodate delegates without a scientific background, as she observed that some of the topics that were discussed were too technical for some of the delegates. Overall, she considered the workshop to have been a success.

Phindile Shongwe, an economist from the Africa Cooperation Action Trust, had no prior knowledge of the technologies discussed in the workshop, but still felt that she benefited from it, as she developed a keen interest in biotechnology. She liked the fact that it focused specifically on GMOs. She now has a better understanding of biosafety as it relates to GMOs, especially as a result of environmental changes. This has increased her confidence to participate in conversations about GMOs. She would, however, have liked to have looked at more field trials.

Ramadhan Kilewa, a researcher in the Tropical Pesticides Research Institute (TPRI) in Tanzania, felt that the workshop improved his knowledge and skills, particularly in the use of biotechnologies to test for the safety of food. At the TPRI, he has access to some of the instruments that were demonstrated during the workshop, and will now be able to make better use of them. He also learnt some new techniques that he will be able to implement in his research. He suggested including case studies in the practical component of the workshop, with examples of methods that have been used successfully.

Rose Masekesa, a lecturer in Plant Biotechnology at the University of Zimbabwe, enjoyed every aspect of the workshop, and found there to be a good balance between theory and practice. The workshop exceeded her expectations, and opened her mind to several new technologies and methods of testing for GMOs. She believes that the workshop has provided her with additional knowledge, which will add value to the course material she presents to her students, and thereby improve the misconceptions that exist about GMOs.

Nyasha Mutsau and Rudo Mazarura from the National Biosafety Authority in Zimbabwe benefited from their exposure to the various technologies presented in the workshop. They believe that the knowledge they acquired would assist them in their work at the country's points of entry, where they are involved in issuing biosafety permits.

6. Workshop evaluation

Upon conclusion of the workshop, the delegates were asked to evaluate it in terms of the logistical and administrative arrangements, the workshop venue, the delivery methods and quality of the presentations, and the presenters themselves.

Delegates were all satisfied with the logistics and administration of the workshop, and commented that it was very well organised. They found the workshop venue to be comfortable and well located, and the food and refreshments to be adequate. The diverse environments in which the respective modules were presented also made for an interesting workshop.

As far as the content of the modules was concerned, delegates found the information presented to be relevant, comprehensive and easy to understand, and the objectives clear. One delegate remarked that the facilitators were able to pitch the lectures at the right levels to satisfy all participants. Some delegates felt that the content was too intense for such a short period of time (referring to the individual modules), and that certain aspects (such as metabolomics) could have been condensed into a single day. Another delegate felt that two consecutive weeks were perhaps too long, and that one could perhaps consider splitting the workshop into two separate weeks.

With regard to the delivery methods and quality of the workshop, the general consensus was that the workshop was well structured to achieve the learning outcomes (there was a good balance between lectures and practical activities), the methods used to convey the content encouraged participation, delegates' interest was stimulated, the pace of the workshop was appropriate, and ideas and concepts were clearly presented.

The delegates perceived the presenters to be good communicators, knowledgeable about the topics they were presenting, well prepared and responsive to participants' questions. One delegate commented that the presenters were very dedicated, and impressed with their passion for their respective disciplines.

Finally, with regard to the length of the workshop and the level at which the workshop was presented, the responses were varied. Although the majority of the delegates were satisfied with the length of the workshop, one delegate found it to be too short, while four delegates considered it to be too long.

In general, the delegates felt that they benefited from the laboratory visits and the opportunity to use the instruments, which enhanced their knowledge of the application of the various technologies, as well as the linkages between them. They also found it useful to learn what could be achieved if the correct biological questions are asked. Other positive experiences of the workshop included the networking and collaboration opportunities provided and getting to know what is happening in Southern Africa with regard to GMO/biosafety regulations. The environment that was experienced in the facilities of the partner institutions was deemed to be conducive to learning. However, one delegate remarked that the organisers should consider widening the scope of the workshop to industry and not limit the activities to academia.

Another delegate summarised the workshop as follows: "It adequately brings the reality of the situation of GM biosafety on the subcontinent to the fore. This is because a lot of African countries are involved and the interaction between the delegates is good. The lectures were well detailed and provided great information on the possible applicability of "-omics" technologies in GM regulations."

In terms of suggestions for improvement, one delegate commented that he would have liked more hands-on work regarding data analysis and the interpretation of the various workflows, but he understood that there were some constraints to including this in the workshop. Some delegates would have liked more time in the laboratories and also more field visits. A suggestion was made to include more delegates from each country, and for a workshop such as this to be presented in other SADC countries as well, in order to enhance the knowledge of all stakeholders. Another suggestion was that the facilitators who deal with the issue of GMOs should present dossier and risk assessment documents that can be used as case studies to understand the methods used for assessing the molecular characterisation and food safety of products derived from biotechnology, and for stimulating discussion by comparing these case studies with current techniques (non-targeted techniques).

When asked whether they would recommend this workshop to a colleague, the delegates were all unanimous in their responses that the workshop had been very informative and a real eye-opener. A workshop such as this is important to strengthen the region, and is very relevant in empowering researchers and regulators to make informed decisions with regard to GMOs. One delegate remarked that this workshop would be particularly valuable to someone new to the “-omics” field who has some experience, otherwise it might be overwhelming. Another delegate commented that his recommendation would be based on the fact that the workshop provided important information to research scientists and biosafety regulator officers, including targeted techniques for the safety assessment of food that contains both GM and non-GMO content.

The delegates were grateful for the financial support that enabled them to attend this workshop.

7. Conclusion

The GMASSURE Application of “-omics” to Biosafety Workshop held in Pretoria and Johannesburg from 19 to 30 October 2015 aimed to equip researchers and policy makers from SADC with information about the application of biotechnologies to crop plants. The workshop included lectures, demonstrations, analyses and facility tours at the ARC’s Biotechnology Platform at Onderstepoort, the University of Pretoria’s Plant Sciences laboratories, the laboratories of CSIR Biosciences and the University of Johannesburg’s Biochemistry laboratories.

The facilitators agreed that the feedback received reflected the success of the intervention, and that good relationships were built between delegates from different countries.

According to Dr John Becker, project leader of the GMASSURE action, the workshop was long and knowledge intensive, but he considered this essential to presenting the content in sufficient detail to enable the delegates to engage in meaningful debate around the topic of GMOs, and to gain practical exposure to laboratory work.