

Introduction

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Published online: 21 October 2008

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The introduction of genetically modified (GM) crops provide potential opportunities for increasing crop productivity by tackling some of the persistent agriculture problems arising from weeds and pests, abiotic stresses, water-shortages and nutritional limitations of staple food crops. Several GM crops with novel traits for insect resistance or herbicide resistance are being cultivated in many countries around the world. While this is an increasing trend, these novel crops have also raised the need to better understand the impact of these new crop varieties on agricultural resources practises and inputs and on the local ecosystems in order to ensure sustainable production intensification. The possible environmental effects of GM crop cultivation, scale of effects and the pattern of responses whether at the level of the field and its surrounding agrobiodiversity, or in the natural landscapes need to be examined to gain knowledge and develop effective guidelines that could assist decision making.

To better understand and analyse these kind of questions and find a way forward, FAO provided a

forum for two consultations on the subject of 'Environmental Effects of GM Crops'¹ and 'Methodologies for Monitoring the Environmental effects of GM crops'.² Specifically the objective was to assess current scientific understanding on the subject, identify knowledge gaps and through multi-disciplinary participation, develop guidelines for designing and carrying programmes for monitoring the environmental effects of GM crops.

The consultations lead to the recognition that a broad range of environmental and agro-effects needed to be considered on introduction of GM crops within a specific agro-ecosystem. At the same time, the scientific understanding of the specific effects arising from GM crops at the field, agro-ecosystem or natural landscape level was sparse, in part, due to the limited number of crop seasons and some what lack of initiatives for data collection for numbers of generations so far. The gaps in scientific data had to be overcome through more focussed research on the potential effects of GM crops on the agro-ecosystem, integrated pest management, soil ecosystem and agriculture practises. It was also highlighted that cultivation of a GM crop with its benefits and potential hazards to the environment, should be considered within the broader ecosystems. Effective monitoring methodologies and environmental indicators should

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¹ [ftp://ftp.fao.org/docrep/fao/field/006/ad690e/ad690e00.pdf](http://ftp.fao.org/docrep/fao/field/006/ad690e/ad690e00.pdf)

² [ftp://ftp.fao.org/docrep/fao/008/ae738e/ae738e00.pdf](http://ftp.fao.org/docrep/fao/008/ae738e/ae738e00.pdf)

be adopted to understand their medium to long term impacts. Two areas of particular interest could be to monitor (a) gene flow and introgression into non-crop plant populations and, (b) impact on local agricultural practises.

Knowledge gaps

- Baseline and reference data knowledge of potential effects on in situ genetic resources.
- Diagnostic tools, protocols and techniques for measuring environment linked changes.
- Technical strategies to study synergies and combinatorial, non-additive effects.
- Methodologies to predict long term trends or perform long term contained field trials.
- Good indicators related to ecosystem functions, both for above and below ground.
- Data on selection pressures on weeds and native plants.
- Evolution of pest resistance in especially tropical ecosystems.
- Water-use efficiency of many crops plants.
- Knowledge of local ecosystems where GM crops are introduced.
- Ecological perspectives in risk assessment criteria for GM crop applications.

Monitoring environmental effect on GM crops

Monitoring could provide a way to better understand or predict the possible impact of use of GM crops, and detect unexpected outcomes. It could assist in predicting potential environmental impacts and designing preventive or mitigation strategies. The challenge however, is to establish a working programme within limited knowledge and resources but full stakeholder engagement. As it was emphasised during the consultation, GM crop deployment must comprise the whole technology development process; from pre-release risk assessment to biosafety considerations and monitoring post-release. The positive and negative effects of GM crops on the environment are shaped by location and context, and monitoring programmes should recognise that there are important sources of variation within and among farming systems. It should inform decision making

and provide feed back to the regulatory process and policies that support the development of sustainable practises. Wherever possible, the objectives of such a programme should be nested within processes that address broader goals. A set of key actions for designing and carrying out a monitoring programme developed during the consultation is shown below.

Key actions for a monitoring programme

Set monitoring programme goals and immediate objectives

- Consult stakeholders, including farmers and managers, regarding the natural resources to develop the goals and immediate objective.

Identify potential barriers

- Prioritise and develop plans to overcome or minimise potential field barriers or otherwise.

Identify potential risks and benefits

- Use stakeholder and expert knowledge of potential risks/concerns and benefits of GM crops, and ways and indicators to measure these factors.

Develop a testing hypothesis to guide actions and decisions

- Ensure that the hypothesis is simple, robust and can be easily tested in the field.

Identify a limited number of potential indicators

- Ensure that the indicators meet the basic requirements of scientific rigour;
- Reflect key elements of the hypothesis tested;
- Compare with control sites and/or baseline values prior to GM crop release; and
- Estimate the status and trends in indicator values.

Determine appropriate trigger values for decision making and action

- Anticipate the range of decisions and actions if triggers are exceeded; and
- Prepare a follow-up action plan.

Cultivate a transparent and effective process

- Ensure follow-through continued involvement of stakeholder;

- Maintain clarity in analysis and reporting, and identify needs; and
- Build linkages with policy development and capacity building.

The capacity to undertake monitoring varies globally; therefore, these actions should not be adopted as an inflexible, linear process. Several developed countries have undertaken large-scale, long term research and post-release monitoring programmes for GM crops that have provided an effective basis for decision making. Monitoring programme development is, however, a greater challenge in the developing world, where possible hazards are less clearly understood and the stakeholders are less well defined. In addition, opportunities for engagement in public debate are limited, environmental protection measures are less effectively enforced, and there are insufficient resources for research and development or for strengthening local expertise. The core values of the monitoring programme are the serious commitment to engage with people with a stake in the final outcome, a judicious selection of indicators that meet scientific rigour and address stakeholder concerns, and can trigger appropriate management or regulatory responses. In this, the international community has a major responsibility-through commitment for overcoming the knowledge and resource gaps, assistance in establishing effective procedures for post-release monitoring of GM crops through understanding country needs.

In the five accompanying papers an overview of general features of risk assessment of genetically modified crops (Craig et al. 2008) and how the legal and conceptual framework for the implementation of monitoring can be assessed (Züghart et al. 2008) are presented. Furthermore, three practical examples which deal with research and field monitoring on

transgenic maize (Hoisington and Ortiz 2008), bio-safety implications for deployment of GM potatoes (Scurrah et al. 2008) as well as identifying indicator species for post-release monitoring of genetically modified, herbicide resistant crops (Hilbeck et al. 2008) are presented.

Acknowledgments This work would not have been possible without the wealth of knowledge and enthusiasm brought by the experts who participated in the consultations hosted at the Food and Agriculture Organisation in Rome.

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