Implementing National Biosafety Frameworks in the Caribbean Sub-Region

POST-RELEASE MONITORING OF GENETICALLY MODIFIED CROP PLANTS

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Executive Summary

During the development process of a new genetically modified (GM) crop plant, the developer will repeatedly monitor and evaluate the plant's agronomic performance, its morphology and reproductive biology, and its interactions with the environment. This monitoring process has two main purposes: 1) to gather data regarding the crop plant's potential value to farmers, food processors, and consumers, and; 2) to gather data regarding the crop plant's environmental and food safety. Generally, once these purposes are met, i.e., the plant is determined to be agronomically valuable and safe, the developer may apply to government regulators for permission to release the plant as a commercial crop. Depending on the crop, the genetically modified traits, the familiarity of regulators with the specific crop/trait combination, and other factors, the regulatory authorisation for commercial release may include requirements for post-release monitoring (PRM). In addition, developers may choose to conduct PRM to collect data for their own uses. Post-release monitoring of GM crop plants is generally conducted to address one or more of three different needs:

- To ensure that products continue to meet the needs of farmers. An example of this would be monitoring for the incidence of insect resistance to a Bt toxin expressed by a GM cotton variety,
- To increase general scientific knowledge. An example of this would be monitoring to determine if farmers are changing crop management practices after adopting a particular GM crop variety, and
- To inform risk assessments and regulatory decision-making regarding GM plants. An example would be monitoring to confirm the findings of a prior environmental risk assessment.

The purpose of this document is to provide guidance, through citations to the published literature and documents developed by governmental and non-governmental organisations, regarding when it may be appropriate for regulators to require PRM and how monitoring should be conducted.

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1. POST-RELEASE MONITORING

In the Caribbean region, an environmental risk assessment is performed prior to the authorisation of the environmental release of a GM plant. The risk assessment process consists of four steps: risk identification, risk characterisation - consequence assessment, risk characterisation - likelihood assessment, and risk evaluation. The environmental risk assessment process used in the Caribbean region relies on the availability of high-quality, relevant data, and the process includes an iterative examination as to the sufficiency of the data for the assessment process. This means that as more information becomes available, it can be incorporated into the risk assessment; and it also means that the data collection process can be stopped once sufficient information is available to answer the regulatory need. The advantage of this approach to risk assessment is that is enables regulators to focus resource use on areas of greatest potential importance.

Monitoring studies are not risk assessments, even when they are required by regulators or government risk assessors, but they can be a part of the science-based risk assessment process (National Research Council, 1983; USA Environmental Protection Agency, 1992, 1998; European Commission, 2001; European Food Safety Authority, 2004). Monitoring is simply a tool to obtain information. Like all scientific tools, it is not inherently good or bad. However, inappropriate use of monitoring can expend valuable resources without providing useful information. In addition, unnecessary monitoring requirements may limit the successful release of new technologies to large companies with major products.

Regulations in the Caribbean region may require that those applying for authorisation for an environmental release of a GM plant submit a proposed PRM plan, as a part of the application, but the nature of the plan is not described in detail. This is because each plan will be tailored to the nature of the crop/trait combination, the crop production methods that may be used, as well as other factors. To assist the developer in drafting an appropriate PRM plan, a series of questions should be asked and answered. These questions can be organised into four basic areas:

- Why is monitoring being proposed?
- What data needs to be collected?
- When and where should the monitoring data be collected?
- How should the data be collected?

Although each monitoring plan may have case-specific requirements, every plan should address the questions provided in Table 1. Once the applicant has submitted the monitoring plan, regulators should address equivalent questions themselves to determine whether PRM is necessary and, if so, whether the monitoring plan proposed by the applicant would be appropriate and useful for informing the post-release risk assessment process.

2. WHY IS THE MONITORING BEING PROPOSED?

The most critical step in conducting a monitoring study is a clear definition of need and purpose. The purpose of the monitoring plan should be specific, with the goal of the plan being to collect data that will be used to test one or more specific risk hypotheses. Vaguely articulated purposes such as **“to investigate potential effects on the ecosystem”** or **“to reduce uncertainties associated with the risk assessment”** are not testable risk hypotheses and will inhibit the collection of data that will be useful in a risk assessment.

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On the other hand, a testable risk hypothesis such as **"a change from conventional to Bt cotton will have less of an effect on populations of pollinators than the effects of commonly practiced insect control techniques"** clearly indicates the data that needs to be collected and will facilitate the risk assessment process.

Once a risk hypothesis is formulated, the next step is to characterise the severity of the hazard and likelihood of the hazard occurring. This is a critical step because risks with an insignificant probability of occurring do not justify the time and resources that may be expended in the PRM process. The risk evaluation step should include a review of data available from previous studies, including confined field trials and past PRM processes. These data can help clarify the significance of the risk and determine whether PRM is necessary, or whether another approach, such as risk management, may be the best approach to achieve the protection goal.

Table 1.

Key questions in developing a PRM.

General Question	Specific Questions
Why is the monitoring being proposed?	• *Is there a science-based risk hypothesis that can be tested using data collected during PRM?* • *Has existing hazard and exposure data been evaluated to determine whether there is a need for PRM?* • *Is the potential risk significant enough to justify the resources needed for PRM?*
What data needs to be collected?	• *Are appropriate positive and negative controls available for comparison?* • *Is baseline data available?* • *What types of data are needed to test the risk hypothesis?* • *Which statistical methods and significance levels will be used?*
When and where should the monitoring data be collected?	• *Is there an appropriate number of study locations?* • *Should sampling occur only once or at multiple times during the growing season?*
How should the data be collected?	• *Under what conditions should samples be taken?* • *Are validated methods available for analysing the samples?* • *What training will be needed for field workers?* • *How will samples be preserved, stored, and transported?* • *How will the data be processed and communicated in a monitoring report?*

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3. WHAT DATA NEEDS TO BE COLLECTED?

A key factor in any monitoring study is the decision of what controls will be used as a part of the study. Because crop cultivation produces highly manipulated and artificial ecosystems, monitoring studies involving GM crop plants differ from many basic ecological studies. Effects due to the GM crop may be trivial or non-detectable against the background of agro-ecosystem variability, due to factors such as crop variety differences, crop rotation and cultivation practices, and abiotic factors such as soil composition.

Positive controls, such as treatments with conventional insecticides or conventional cultivation practices (compared with a GM insect-resistant or herbicide-tolerant crop, respectively), may provide a useful comparison of the GM crop with the conventional crop. Negative controls, such as near isolines or similar varieties, can be used to focus the evaluation of the effects of the GM crop trait. Care should be taken to make sure that all of the study areas are treated in an equivalent manner (cultivation, irrigation, fertilisation, different pesticide sprays, etc.). Baseline data may be useful to understand the normal variability of the agricultural system that is being studied. However, due to differences in weather patterns from year to year, baseline data is more useful for comparing the effects of GM crop cultivation over multi-year time spans.

To ensure that PRM is carried out in a resource-efficient way, the specific data needed to test the risk hypothesis should be identified as part of the problem formulation and PRM plan design phase. The required data and the study design will depend on the purposes of the study. For example, a study designed to evaluate the potential for an increase in resistance amongst pest populations will focus on the pest species, while a monitoring study designed to evaluate potential effects on non-target organisms will likely require a much more complicated data collection process, involving different sampling locations, multiple data collection times, and species-specific methods.

A key consideration for the collection of data is the need for the data to be amenable to statistical analysis. Appropriate statistical methods and interpretation should be utilised in

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data analysis. The advantage of field monitoring is a greater level of realism as compared to laboratory tests. However, the disadvantage of field monitoring studies is the higher level of variability in the test systems, large amounts of data and potential covariance and other confounding factors in the dataset that may need to be considered during the analyses. In monitoring studies where large amounts of data are collected, there will be apparently "statistically significant" differences found simply due to the high natural variability of the natural systems being studied. These should be expected and are not necessarily indicators of biological significance. GM crops have been designed to have effects. For example, plants that have insecticidal proteins will have effects on some types of insects. Herbicide-resistant crops will alter cultivation and herbicide application patterns, which will then alter population structures of organisms living near the field. These are not unexpected effects and one must guard against the conclusion that any change from the status quo is a negative or adverse result.

4. WHEN AND WHERE SHOULD THE MONITORING DATA BE COLLECTED?

Monitoring studies should be located and designed to best answer the study purpose. Usually, in order to obtain the greatest use of study data, monitoring studies should be conducted at locations that are representative of regions where the GM crop is grown commercially. Studies should contain the appropriate replicates and controls at each location. In most cases, results from well-designed studies conducted in one area are applicable to other areas with similar agriculture practices, soil characteristics, and climate.

The appropriate timing and locations for sampling can be determined based on the hazard and exposure data gathered during the develop phase of the GM plant, including data collected from glasshouse studies and confined field trials. For insecticidal traits, a study strategy that links sampling to periods of highest exposure will increase the ability to achieve the purpose of the study while at the same time conserving resources. For herbicide-resistant crops, it would be more appropriate to sample during the period when the herbicide is having its greatest effect.

Sampling during a monitoring study should be focused on both the time and location of greatest likely effect. For example, if the GM trait causes novel protein expression in the roots, but not in the foliage or pollen, then soil sampling would be appropriate. Alternatively, if a Bt protein produced by the plant is effective on the larvae of certain organisms but not on the adults, then sampling of larvae should receive a greater amount of attention. Prioritisation of sampling in time and space will collect key samples most effectively and allow the study to use available resources most efficiently.

5. HOW SHOULD THE DATA BE COLLECTED?

As the PRM plan is developed, careful consideration should be given to what data are really needed, how the data will be used, and what methods are best suited to obtaining the necessary data in a time frame that will inform regulatory decision-making. Once the data types are identified, then appropriate methods must be found to gather the required information. In most cases, monitoring methods can easily be adapted from ecological and agro-ecological studies, for example, pitfall and sticky traps, visual observations, and various

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soil or plant debris sampling methods are available. In any case, the selected methods should be thoroughly validated in the published literature. Experimental data collection methods should be avoided as they will likely collect data that cannot be easily compared to existing baseline data and will not lend themselves to standard statistical analysis.

Concurrent with the identification of data collection methods, the plan should also consider the needs for field worker training. Data quality can be compromised if workers are not fully trained in the collection methods, including the correct handling of the samples (labelling, storage, and transport). In addition to trained personnel to conduct monitoring studies, trained personnel are also needed to provide meaningful interpretation of study results.

Lastly, consideration should be given to the methods used to evaluate the data and communicate the conclusions drawn from the data in a monitoring report. The purpose of the report is to assist regulatory decision-making, a type of communication significantly different from the style of communication in a scientific journal article. The developer should therefore return to the problem formulation approach to assist in the organisation of the report, beginning with the identified protection goals and risk hypotheses associated with those goals. Once the risk hypotheses have been discussed, the types of data collected to test those hypotheses can be presented and evaluated. Finally, the significance of the test results can be presented in a way that informs regulatory decisions on such matters as appropriate risk management methods and whether further monitoring is necessary.

6. CONCLUSION

The decision to undertake PRM of a GM crop plant is a complicated one, and it is crucial that the decision be informed by a carefully prepared monitoring plan. Without a good plan, it is very unlikely that the appropriate data will be collected, and without good data, it is impossible to conduct a valid risk assessment. In addition, a thoughtfully developed plan may modify the scope of monitoring or obviate the need altogether, thereby saving resources without compromising biosafety. Although each plan should be developed on a case-by-case basis, a systematic approach to plan development, beginning with the questions outlined here, will help ensure that the PRM plan is scientifically sound and will effectively inform regulatory decisions about the commercial use of a particular GM crop plant.

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