REPORT OF THE
FAO Expert Consultation on Environmental Effects of Genetically Modified Crops
16 - 18 June 2003, Rome, Italy

Executive Summary

The cultivation of genetically modified (GM) crops is changing agriculture practices in a number of developed and developing countries. The area of GM crops planted worldwide continues to increase. As agriculture is intrinsically linked to the environment, FAO invited sixteen technical experts in their individual capacities, from a wide range of countries, to a three-day Expert Consultation on "Environmental Effects of Genetically Modified Crops". The aim of the consultation was to assess the current understanding of the effects of GM crops on ecosystems, identify gaps and priorities and indicate the role of FAO in this context.

The experts discussed the environmental effects of major GM crops, including those used for pest management, drought and salinity tolerance. They evaluated the potential environmental impacts with respect to both above and below ground effects. The scale and pattern of effects were examined at the field level, for crop-associated biodiversity and in larger landscapes. The discussions led to the recognition of environmental effects that need to be considered during introduction of GM crops within a specific agro-ecosystem.

The Consultation highlighted the following important and linked aspects:

- The cultivation of GM crops with their benefits and potential hazards to the environment should be considered within broader ecosystems and their effects on the environment should be assessed on a case-by-case basis.

- The scientific understanding of the effects of GM crops at the agro-ecosystem level remains limited. This is partly due to the limited number of crop seasons and numbers of generations of crop-associated species for which data have been collected so far.

- The possible long-term and large-scale environmental effects of GM crops need to be quantified. Some of the main areas of interest would be
  - Gene flow and introgression into populations of plants other than crops,
  - Changes in agricultural inputs and practices associated with GM crops, and
  - Changes beyond agro-ecosystems (*e.g.* other biota located within common landscapes).

- Practical tools and appropriate information are needed to evaluate and address the possible environmental effects and farm-scale management of GM crops. The potential hazards of GM crops with novel traits like pharmaceutical products need to be better characterised.

- FAO has a unique role and responsibility to assist member countries with scientifically robust guidance, including in the context of standard-setting processes, information dissemination and capacity building to realize the common goals of environmental safety and sustainability.

- FAO should undertake and facilitate a consultative process, through partnerships with a wide range of stakeholders, to ensure internationally agreed methodologies, global commitment and financial resources for realising the common goals.

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I. Introduction:

1. Biotechnology and the introduction of genetically modified (GM) crops are providing new opportunities for increasing crop productivity and tackling agricultural problems, such as pests and diseases, abiotic stresses and nutritional limitations of staple food crops. Cultivation of GM crops is changing the practice of agriculture and there is an increasing trend in planting GM crops worldwide. Plants with novel traits to produce pharmaceutical products are also being generated. The safety of GM crop cultivation and use is a topic of extreme international debate. As GM crops are being adopted in various locations with different ecosystems, agriculture biodiversity and agriculture practices; a scientifically-based understanding of the environmental effects of cultivation of GM crops would assist decision-makers worldwide in ensuring environmental safety and sustainability.

2. A three-day Expert Consultation was organised by the Plant Production and Protection Division (AGP) of the FAO to examine the pattern and scale of environmental effects of GM crops on ecosystems. The main objectives were to assess the current status of our understanding in this field, identify the gaps in knowledge, indicate priority areas and explore the potential role of FAO in this context. Sixteen specialists from a range of agriculture, environmental sector and related regulatory agencies were invited to discuss the full range of environmental effects that can be expected both from the GM crops that are under cultivation and from those that are under development. They were requested for inputs that would allow FAO to continue to assist member countries on policy and technical issues in this area.

3. The Consultation was inaugurated by Dr. Louise O. Fresco, ADG, AG who welcomed the participants and emphasised the Organisation's commitment to continue providing science-based advice to member countries on policy and technical issues. She noted the broad range of scientific expertise assembled, and felt confident that inter-sectoral dialogue would provide the best way forward to examine the full range of the effects of GM crops on the agro-ecosystem. Through a better understanding, the Organization would be better positioned to assist member countries in making appropriate choices in this area.

4. The Director of AGP, Dr. Mahmoud Solh, emphasised the need to explore the current scientific understanding of environmental impacts of GM crops, and to identify the knowledge gaps so that the Organisation can provide pragmatic, field-oriented guidance in determining the best course of action for sustaining the positive impacts and mitigating potential negative environmental effects of GM crops.

5. Dr. Peter Kenmore, Chairperson of the Interdepartmental Working Group on Biodiversity for Food and Agriculture, and focal point for this Consultation, introduced the Provisional Agenda which was adopted unanimously. He briefly described the two Background Papers prepared for the consultation. Thereafter, the Chairperson of the Sessions invited the speakers to present their papers. Each presentation was followed by an initiating comment from an expert on that particular theme, to facilitate the discussions.

6. The presentations of the invited speakers and the discussions that followed are summarized below along with the Recommendations of the experts. The Provisional Agenda and List of

Participants are attached as Annex 1 and II and the two Background Papers[1] are available separately.

II. Bt –crops and their Environmental Effects

7. Prof. Fred J. Gould, Professor of Entomology, NC, USA, presented an overview of the impacts of introduction of Bt-crops in the environment. He described how the environmental risks and benefits of Bt-crops depend on a) the specific Bt-gene-construct, and the crop in which it is introduced, b) the geographical location of the crops and c) the period or timescale of its cultivation. The importance of these parameters were illustrated with specific case studies. The gene constructs make a difference because there are hundreds of different Bt-genes that produce different toxins which affect a range of pests. There are a variety of promoters that are used for the preparation of the gene-constructs. In addition, as major corn pests vary in different geographic locations, the same Bt-gene cannot be effective everywhere. For instance, cotton bollworm is the main pest in the USA, while it is boll weevil in Central America. In China, cotton cultivation is an insecticide-intensive process, and the benefit of cultivation Bt-cotton is that it has reduced sprays from 21 to 7 per crop season and has helped in a better control of the aphids by predators in cotton agro-ecosystems. It has, however, been associated with pest problems due to mites and hoppers. Therefore, the unequal regional impacts due to differences in pest pressure levels need to be considered. He emphasised that pest resistance and changes in pest pressure levels have to be documented among the potential long term impacts of using Bt-crops. Theoretical studies on resistance dynamics, based on experiments carried out using high-dose refuge approach; show an exponential increase in susceptibility in the long term. With regards to yield, he noted that the current Bt-crops have increased yield and at the same time have a high level of variance. There was a need for developing varieties that have higher mean yield stability and showed decreased variance through time.

8. The expert summarised that environmental effects of Bt-crops should be assessed on a case-by-case basis, including their potential impact on local soil micro flora and biodiversity. He indicated that scientists were at an early stage in their ability to discriminate the direct and indirect changes in such detail, but initiatives such as 'The GMO Guidelines Project[2]' was providing useful information in this area. Despite the practical challenges both for scientists and national authorities, there was a real need to conduct research on the long-term ecological effects. He called on FAO to facilitate such activities through partnerships of all stakeholders.

9. The participants discussed at length the range of practical information required for analyzing the full environmental effects of the Bt-crops. They agreed that the benefits and potential environmental hazards of the cultivation of Bt-crops should be considered within broader agro-ecosystems taking into account conventional agricultural practices. While scientific data was still limited on many of the ecological aspects related to GM crops, they emphasised that a case-by-case analysis should be the most appropriate approach. The key point from the discussion were as follows:

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[1] Background Paper I: Envisioning Futures for GMO's in Agriculture: Lessons to Date and Prospects for Consensus; P. Kareiva, S.Solie, M. Marvier' 2003

Background Paper 2: Elements of a Framework for Environmental Monitoring of Genetically Modified Crops; R.Laing, 2003

[2] GMO Guidelines Project: http://www.gmo-guidelines.info/

- Full information of the Bt-gene-constructs, the genetic background of the crop varieties and specific knowledge of the agro-ecological zones where Bt-crops have to be planted was important. Experimental designs for analysing effects of Bt and other GM crops should include ecosystem data as much as feasible.

- Benefit or hazard analyses of Bt and other GM crops should not be extrapolated from small plots or by aggregating statistics. Broad generalisation of crop performance must be avoided to allow a free and fair assessment of the GM crop in the country.

- An over-reliance on a single GM variety could lead to the evolution of resistance. Although it was possible to alter the level of Bt-toxicity to control and decrease such incidences, resistance management was complex, and there is only a limited knowledge of the effects of single genes or stacked genes on pests and pest pressure.

- Monitoring the long term-environmental effects of GM crops, and adopting best agriculture practices are useful strategies to avert undesirable situations. However, the baseline data required for the purpose of monitoring is not yet available for the GM crops under cultivation.

- The possible effects of introducing Bt-genes in local landraces and in various climatic zones, or of growing a GM variety in the centre of origin of that crop, cannot be determined at present due to very limited scientific data available on these matters.

III. Herbicide Resistant Crops and their Environmental Effects

10. Dr. Katherine Hauge-Madsen, KVL, Denmark, presented the benefits and potential environmental impacts of herbicide resistance crops (HRC). She noted that, among the GM crops being cultivated worldwide, about 83% of the area is planted with HRC including soybean, maize, cotton and canola. HRC offer new options for herbicide use to control weeds; helps reduce tillage, prevents soil erosion and preserves soil moisture for plant production. Effective farm management and improved efficiency were the main reasons for commercial success of HRC. However, she cautioned that short-term benefits could be jeopardized by some unwanted impacts in the longer run. They could occur at field level e.g. in weed control or on the environment. Within an ecosystem, non-target species could be affected by the widespread cultivation of HRC because of shifts in weed control and in the equilibrium of population dynamics between the weed species in the field, and insects, birds and small mammals that feed on them. At the field level, ‘outcrossing’ from HRC to a weedy species or to crops without the HR trait and/or spread of HRC seeds, combined with the effects of herbicide use, are the main processes that could lead to environmental problems. Outcrossing is a natural phenomenon and requires the successful dispersal of the gene through pollen, the presence of a wild cross-compatible out-crossing species in the vicinity and overlapping flowering periods of the two species. The issues related to high selection pressure on naturally occurring resistant biotypes of weeds was a cause of concern and the first glyphosate-resistant annual broadleaf weed *Conyza canadensis* has already been detected in glyphosate-resistant soybean systems. It was emphasised that the potential effects of outcrossing and selection for resistant weeds however, should be compared to the properties of currently used herbicides, which are often less environmentally benign than the herbicides used in HRC.

11. The expert summarised that HRC offered significant benefits. Countries/regions should establish a mechanism for approval of national/regional use of HRC and ensure long term benefits for farm management and the environment. The mechanism should be based, at least in part, on assessment of agricultural and environmental effects and should be carried out prior to the release of the HRC on a case-by-case basis. Good agriculture management practices should be encouraged, which could include record keeping at the farm level, crop rotation,

maintenance of minimum temporal and spatial distance between HRC and non-resistant varieties of the same crop, regular monitoring of weed flora and its shift in order to detect the species which are evolving resistance, and quick management decisions following detection of resistant volunteers.

12. During the discussion, the participants agreed that the current range of HRC has assisted in increasing crop production by providing an effective and convenient weed control strategy and to date, no major negative environmental effects have been reported. Experts cited several ongoing large-scale studies being conducted in Canada and UK, which were assessing the impact of gene flow in canola and other crops. The experts were of the opinion that the exact cause for the emergence of the resistant weed *Conyza canadensis* in glyphosate-resistant soybean systems needed to be ascertained. The key points of the discussion were as follows:

- HRC needs to be integrated within farming systems through sound management and agricultural practices, taking into account the local agro-ecological conditions for ensuring continued benefits.
- There is incomplete scientific research or data-analysis on emergence of resistance, genetic make up of resistant weeds, and weed shifts from GM crops. More targeted research was needed.
- There is a need for more focussed discussion on the ecological concerns arising from the possible impacts of HRC on biodiversity, centres of origin of crops and issues surrounding co-existence of GM and non-GM and organic crops.

IV. Drought and Salinity tolerance and GM crops

13. Dr. John Passioura, CSIRO, Australia, focused on the key strategies for ensuring efficient water use by crops in an agriculture environment. He emphasized that tackling drought was a matter of resource economics and finding strategies for obtaining the best yield under fixed and limited water supply. It required expert water management along with improvement in the genetic make-up of crops. Healthy vigorous plants are best at achieving water-use efficiency. Through several examples, he showed that the genetic make-up of crops could be improved for capturing more water supply for transpiration; increasing exchange of transpired water for CO_2 for producing biomass, and for converting more biomass into grain, and raising the harvest index of crops. He stated that, by adjusting flowering time, a right balance could be struck between using water before flowering and in using water after flowering to fill the grain. Therefore, tackling drought required a combination of good agriculture management practices, and a thorough understanding of the strong interactions between genotype and highly variable environments of the crop plants. Due to the complexity of the processes, he pointed out that to date, there have been no big breakthroughs in developing ‘drought resistant’ GM crops. As there were little prospects of such crops in the near future, he considered it premature to discuss their possible environmental effects.

14. On the issue of ‘Salinity tolerance and GM crops’, the expert examined the mechanisms applied by plants to tackle salinity, and described the best agricultural practices to deal with salinity related problems. He noted that most plants, including mangroves, (with the exception of lupins and rice) excluded at least 98% of the salt contained in the water that entered the roots, because excess of salt truncates the life of leaves. Plants also sequestered salt, into vacuoles, to prevent damage to the cells metabolic machinery. Halophytes and some crop plants, for example, barley, are effective in this activity. He noted that molecular studies have shown the possibility of single gene-controlled salt transport mechanisms. Although this was valuable information, the expert was not sure how it could lead to the development of salt-tolerant transgenic plants in the foreseeable future. Plants in the fields provide a wide and diverse range of responses to the fluctuating salt concentrations. However, currently used laboratory techniques did not simulate these field situations in real time and therefore, could

not be considered plausible working models for studying salinity tolerance in a practical manner. The expert noted that some success had been achieved in tackling drought tolerance and salinity tolerance through conventional methods and through molecular technologies like marker-assisted selection. However, he strongly cautioned against expecting miracles in this sector, at least in the foreseeable future, because of the complexity of the interactions and systems.

15. During the discussion, many participants did not agree completely with the expert on the unfeasibility of generation of drought or salinity tolerant GM crops. They acknowledged the enormity of the challenge but pointed out that a steady progress was being made and that there was a distinct possibility of release of drought tolerant crop varieties within few years. The key points from the discussion were as follows:

- Developing drought or salinity tolerant crop was a huge challenge but advances were being made through a step-wise approach. Current breakthroughs in biotechnology are providing a better understanding of the mechanisms involved in drought and salinity tolerance.
- Several drought–tolerant genes have been identified. Institutes such as ICARDA were developing salt and drought tolerant wheat and barley through biotechnology and conventional means. Experiments in Egypt have successfully reduced water budget for wheat by 70% under the theme of crop per drop.
- There was a need for developing approaches and strategies for making incremental gains under drought conditions. Although difficult, field trials have to be properly designed to show the desired effects on a long-term basis. Introduction of crops with special traits in very fragile ecosystems like semi-arid zones could have adverse environmental effects in the long term. It is important that agro-ecological conditions of specific farming systems are always taken into account.
- Drought management programmes needed a multidisciplinary approach which incorporated genomics and soil ecology to assist plant breeding and crop production for better adaptation and water management.

V. Soil Ecosystem and Environmental Effects:

16. Dr. George Kowalchuk, IBED, Netherlands gave a comprehensive overview of soil ecosystems, and the below-ground effects of microbial-plant interactions, the current knowledge status in understanding the effects of GM plants of soil-borne communities, and identification of possible indicators. He highlighted the existing gaps in assessment of GM crop-induced effects on soil ecosystems and provided suggestions for assessment of current and future GM crop introductions based upon present knowledge and technology. Soil microbes are the greatest source of biodiversity on the planet and soil-borne microbial communities are the engines driving numerous key ecosystem functions. Important soil functions include decomposition, nutrient cycling, disease suppression and groundwater purification while plants provide the major input of energy and carbon to soil-borne microbial communities. He noted that in some cases, the impact of microbial groups and/or processes that were likely to be susceptible to the introduction of GM crop could be assessed or predicted. However, there was only a limited understanding and lack of base-line reference which limited the possibility of predicting tentative effects of GM crops on soil ecosystems. Therefore, all new challenges associated with risk assessment of GM crops needed to be documented. This was particularly important for those GM crops with entirely novel traits like pharma-crops and neutraceuticals. He noted that recent advances in molecular techniques provided a way for meaningful assessment of GM crop-induced effects on soil-borne micro-organisms and processes for the first time. These included broad-targeted and group-specific nucleic acid-based fingerprinting methods for the detection of shifts in the microbial community, measurements of general enzyme activities, community structure with

phospholipid fatty acid analysis and measurement of general soil fungistasis. There is still an absence of a full understanding of GM crop-induced effects. However, to date all available evidence revealed only very minor effects of GM crops; effects that pale in comparison to other sources of variation in soil-borne ecosystems. However, the knowledge base for existing crops was growing, thereby providing a good frame of reference for future evaluations. However, such a knowledge base did not exist for the new crops under development in particular those engineered for the production of pharmaceuticals. Under the circumstances, he recommended a two-pronged approach for environmental assessment of GM crops; incorporation of information on what is known, and an indication of other relevant information that needed to be ascertained.

17. The discussion revolved around the environmental impacts of GM crops on soil microorganisms, and the nature of these interactions. Studies conducted on Bt and its impact on rhizosphere and the persistence of Bt in soil at a level higher that the natural background of Bt organisms were mentioned. Queries were raised on the need and means of detecting the interactions especially for regulatory purposes. It was argued that agriculture practices, not any single gene-construct, affects soil systems. In general, the experts agreed that so far, no real impact on soil ecosystems had been detected from the cultivation of GM crops. However, there was a need for better tools for assessing the changes in functions of the soil communities and a better documentation of the results. At present there was no reason to believe that GM crops present any undue risk to soil ecosystems, but as new crops and products are developed, it is important to have monitoring schemes, provided that they were practical and feasible.

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VI. Scale of Effects: Patterns and Responses

18. Dr. Peter Kenmore, Senior Officer, Integrated Pest Management, FAO, introduced the theme and presented a matrix (Fig1) showing the inter-linkages between the scale of effects and the level of responses. He noted that agriculture, which included forestry, fisheries and farming covered roughly 40% of the surface of the globe and provided some of the best studied systems from the viewpoint of ecosystem functions, trophic-level interactions, community assembly and energy flows. Agriculture and the associated biodiversity are key components of environment and biodiversity as recognised in the Convention of Biological Diversity[3]. While the scale of environmental effects of GM crops could be categorised under three levels namely the crop-field, crop associated biodiversity and the natural landscapes; the environmental issues arising from them can be clustered under three separate but interconnected themes depending on their scope and impacts. These are hazards (mostly direct effects), ecological resilience (mostly indirect effects); and agricultural practices. He looked for scientific guidance from the experts that would assist FAO and member countries to provide practical methodologies for assessment of the environmental effects holistically and in an integrated manner.

19. Dr. Paul Jepson, Oregon State University, USA, discussed the importance of selecting appropriate temporal and spatial scales in the design of experiments and monitoring programs that seek to quantify the hazards and benefits associated with new agricultural technologies including both pesticides and GMOs. The expert pointed out that real-world scale of agriculture more closely matches the scaling of population processes in pest and beneficial species than does the scale of conventionally designed experimental studies. Significant ecological effects, including local extirpation of beneficial species, may only be detected when the practice is adopted on a large scale that intersects with the scaling of critical factors that govern local persistence of pests, and their predators and parasites. Examples were provided from long term farming systems studies in Europe and USA, particularly those that measured

[3] The Programme of Work on Agricultural Biodiversity of the CBD (COP decision V/5). http://www.biodiv.org/programmes/areas/agro

local persistence of beneficial species in sprayed agricultural systems. Systems vary in their sensitivity/resilience in the face of new agricultural technologies, and experiments/observations that capture the intrinsic characteristics of a given system were likely to provide realistic predictions of ecological impacts. Experiments like the on-going multi-site farm-scale assessments of GM crops being carried out in UK, would capture trends associated with treatments applied in many farms that span a complete agroecosystem. The expert felt that there was a need to consider monitoring through properly designed experiments to provide data and general surveillance of possible eventualities.

20. The key points of the discussion in this session were as follows:

- The purpose, scope, benefits and associated problems of monitoring environmental effects of GM crops needed to be considered in a thorough and careful manner.
- Monitoring was useful because it helped prepare for the unexpected. However, monitoring would be impossible without baseline data.
- Validation of assessments and identification of advantages are equally and absolutely essential for a monitoring scheme.
- The possible areas that could be considered for monitoring are gene flow and introgression, especially in the context of the centers of origin of crops; and the changes in agricultural practices associated with the planting of GM crops. Non-agricultural systems like field borders and migratory bird populations may also need to be considered in due course.
- Partnerships and stakeholder commitment and ownership are essential for successful monitoring schemes.
- There are inherent difficulties in carrying out crop monitoring related activities in developing countries, where little extra capacity or resources can be devoted to such an activity.

VII. Regulatory Issues

21. In this session participants continued their discussions on monitoring and the pros and cons of incorporating a short-term monitoring strategy, with a minimum set of criteria, in GM crop regulatory systems. They also discussed pre-release/regulatory issues vs. post-release monitoring. Several experts strongly felt the need to build ecological concepts into regulatory processes. They emphasised that such an initiative would help in gathering the much needed field data from the registrants including all stakeholders and industry partners. They felt that even short-term data from large scale GM crop fields when collected from various geographic locations would be very useful in understanding the scale and effect of GM crops on the environment. It was important that all monitoring data was publicly available for further research and assessments. Post-planting monitoring needed partnerships and incentives which had to be built in, for farmers and stakeholders. The concepts of shared responsibility for monitoring by registrants or using independent crop consultants, as practiced in the USA were mentioned.

22. Some experts pointed out the difficulty of including ecological and long-term evaluation in a regulatory system, which by nature has defined targets and deliveries. They were of the view that an over-emphasis on setting up a monitoring system could make the release of GM crops even more stringent and thereby, defeat the purpose. While GM crops could be monitored for expected effects, one may have to monitor non-GM varieties, general farm practices and the specific agro-ecosystem for the unexpected effects; which would be a very difficult task. It is possible that registrants had some post-release responsibility, but a comprehensive ecosystem monitoring responsibility would be unfeasible. Therefore, a more practical approach had to be explored. The associated legal and related financial issues also merit more attention. The experts felt that although monitoring would be useful, all the issues surrounding it needed

further clarification. The experts suggested that FAO consider holding a Consultation solely on monitoring to take the ideas forward.

VIII. Knowledge Gaps and Research Priorities

23. Participating experts agreed that the introduction of GM crops in the agro-ecosystem has added a new and interesting dimension to ecological and environmental research. They felt that although several new initiatives have been launched for the long term assessment of the environmental impacts on GM crops at the field level, many gaps remain. Scientific knowledge was limited in a number of key areas and especially those that are listed in Table 1. Experts stressed that the gaps in scientific data had to be overcome through more focussed research in order to provide better understanding of the potential effects of GM crops on the agro-ecosystem, and on agriculture practices.

TABLE1. KEY 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; especially for the tropical areas growing GM crops.
- 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 tropical and temperate ecosystems.
- Water-use efficiency of many crops plants.
- Adequate knowledge of local ecosystems where GM crops are introduced.
- Ecological perspectives in risk assessment criteria for GM crop applications.
- Information on next generation crops, performance of the new products and novel traits.

IX. Role of FAO: Recommendations of the Experts

23. The experts emphasised that agriculture and farming systems were central to cultivation of GM crops and FAO has a unique role and responsibility to assist member countries in understanding their environmental impacts. They emphasised that FAO should provide science-based guidance, facilitate dialogue including within related standard setting processes, and continue capacity building activities through effective partnerships. A set of recommendations under five specific themes was developed by the experts. The recommendations to FAO were then discussed in the final plenary session and are as follows:

i. **Development and Integration of GM crops**

- Adopt a holistic approach for integrating GM crops into production and ecological systems by assisting countries in relation to biosafety, food safety and social considerations.
- Assist communication between GM crop designers and users world wide, so that GM crop development is are geared toward addressing local needs and concerns.
- Assist member countries in formulating needs-demand driven assessment for GM crops and an action plan for their development and deployment.

- Promote an integrated and coordinated approach for research and development of high priority crop traits, such as drought-tolerance. Facilitate partnerships between institutions in research and development of such crops.
- Design research strategies with the appropriate time/space frames, to evaluate the effect of new GM crops and their associated technologies on the agro-ecosystem.

ii. **Assessment and Regulation**

- Provide guidance on risk assessment of GM crops. Establish a framework, such as a scientific committee to provide advice and guidance on this matter.

- Provide information on minimal standards for best available techniques and practices for GM crops through Toolkits. They could be prepared for

  - Developing and implementing procedures and methodologies to assess environmental effects of GM crops, and meet national and international obligations, including the Cartagena Protocol.
  - Establishing a systematic framework for assessment of positive and negative effects, at the field level, for crop associated biodiversity and natural landscapes

iii.**Monitoring**

- Initiate a process for monitoring the environmental effects of GM crops

- Facilitate intergovernmental discussions on the development of standards for pre-commercialization and post-commercialization monitoring.

- Facilitate adoption of relevant monitoring procedures within the risk assessment process.

- Distribute guidance and advice concerning the use of post-commercialization monitoring to provide validation of risk assessment procedures.

- Provide guidelines and assistance for coordination of personnel for monitoring purposes.

iv.**Capacity Building**

- Guide safe use of modern biotechnology tools to protect natural resources and the environment, and undertake capacity building activities at the policy development, institutional and technical level to assist developing countries.

- Strengthen national scientific and managerial skills to develop regulatory and legal frameworks consistent with international requirements, especially in developing countries.

- Provide a range of technical training to farmers, extension workers and other stakeholders on basic biotechnology, evaluation of experimental data, and changes in agronomic practices.

- Expand partnerships both in public and private sectors, to carry out meaningful capacity building activities without duplicating efforts.

v. **Information Acquisition, Evaluation and Dissemination**

- Consider developing a decision support system, through consolidation of available information to provide factual information on the environmental benefits and hazards of adoption of GM crops.

- Conduct a feasibility study of an information system which can include a broad set of databases and background information on general agricultural practices and monitoring data.

- Provide a forum for further regional consultation and for increasing stakeholder collaboration to stimulate research designed to diminish data gaps with respect to useful indicators and the normal operating range of environmental parameters.

X. Concluding Remarks:

24. In the Final Session, the Chairperson thanked FAO for having organized such a broad-based inter-disciplinary consultation to address the potential environmental effects of GM crops holistically. He summarised the discussion emphasising that the wide-ranging discussion over two days, lead to the recognition of the full range of environmental effects that needed to be considered on introduction of GM crops within any specific agro-ecosystem. It was stressed that when GM crops were grown, their benefits and the potential hazards to the environment needed to be considered within the context of the broader ecosystem. There was a defined need for understanding the environmental effects of GM crops and it was very important that these effects were assessed locally, on a case by case basis. The group recognised that advances in molecular biology were providing new and innovative tools. However, there were several key knowledge gaps in this area that needed attention. The experts felt that monitoring could be a useful way forward; however, its challenges and constraints needed to be addressed thoroughly. However, lack of resources, inadequate regulatory frameworks and limited technical capacity in many countries where GM crops were being adopted also need immediate attention. There was an urgent need to establish effective collaborations and partnerships with all stakeholders in order to ensure sustained benefits to agriculture and its environment. It was emphasised that FAO had an enormous responsibility in facilitating and coordinating collaborations, technical assistance and capacity building as well as continuing the dialogue that has been initiated.

25. Dr. Louise O. Fresco thanked the experts and all the participants for the interesting discussions and for indicating the next steps to be taken. Dr. Mahmoud Solh delivered a vote of thanks to conclude the session.

Annex I

Expert Consultation on Environmental Effects of Genetically Modified Crops
16-18 June, 2003, FAO Headquarters, Rome

AGENDA

16 June – Monday **Mexico Room (D211)**

08:30 - 09:15	Registration	
09:15 – 09:45	Opening	Louise O. Fresco *Assistant Director General Agriculture Department*
		Mahmoud Solh *Director* *Plant Production and Protection Division*
	Self-Introductions	
9:45 – 10:00	Chair and Organizational Matters and Adoption of Agenda	Peter Kenmore *Senior IPM Officer,* *Plant Production and Protection Division*
10:00 – 10:15	Coffee	

SESSION I:	**Tolerance to Biotic Stress**	Chair
10:15 – 10:30	Presentation 1: *Bt* traits	F. Gould
10:30 – 10.40	Remarks on Presentation 1	P. Jepson
10:40 – 11:20	Discussion of Presentation 1	Experts
11:20 – 11:35	Presentation 2: Herbicide Resistance	K H Madsen
11:35 – 11.45	Remarks on Presentation 2	H. Beckie
11:45 – 12:25	Discussion of Presentation 2	Experts
12:30 – 14:00	Lunch	

SESSION II:	**Tolerance to Abiotic Stress**	Chair
14:00 – 14:15	Presentation 3: Drought and Salinity	J. Passioura
14:15 – 14:25	Remarks on Presentation 3	A.Ochieng
14:25 – 15:05	Discussion of Presentation 3	Experts
15:05 – 15:20	Presentation 4: Soil Ecosystems	G. Kowalchuk
15:20 – 15:30	Remarks on Presentation 4	HJ Tassara
15:30 – 16:10	Discussion of Presentation 4	Experts
16:10 – 16.25	Coffee	

SESSION III:	**Key Issues, Gaps and Next Steps**	Chair
16.25 – 17.30	Discussion and Summary	Participants
17:30 – 19.00	Recess followed by group dinner	

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17 June – Tuesday **Mexico Room (D211)**

Session IV: Scale of Environmental Effect of GM Crops		Chair
09:00 – 09:15	Scale of Environmental Effect of GM Crops: Finding Global Patterns	P Kenmore
09:15 – 10:30	Discussions on effects on Fields, on Crop-Associated Biodiversity, in Neighbouring Habitats and on Ecosystem and Landscapes.	Experts
10:30 – 10:45	Coffee	

Session V: Research Priorities, Regulatory Issues		Chair
10:45 – 12:30	Research Priorities, Regulatory Issues and Practical Methods of Monitoring	Experts
12:30 – 14:00	Lunch	

Session VI: The Road Ahead		Chair
14:00 – 16:00	Challenges and Opportunities	Experts
16:00 – 16:15	Coffee	

Session VII: Report of the Expert Consultation		
16:15 – 17:00	Report Outline	Chair
17:00 – 17:30	Team Preparation	Teams/ Rapporteurs

Expert Consultation on Environmental Effects of Genetically Modified Crops
16-18 June 2003, FAO Headquarters, Rome.

18 June –Wednesday **Mexico Room (D211)**

8:30 – 10:45	Team Work on Report	Teams
10.45- 11.00	Coffee	
11.00- 12.30	Reports from Teams and Consensus Approval	Rapporteurs
12.30 – 14.30	Lunch	
14.30 – 15.30	Report Presentation	Chair
15.00 – 15.30	Concluding Remarks	Louise O. Fresco
15.30 – 16.00	Formal Closing	Mahmoud Solh

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* Registration will be at the FAO Reception Hall, Building A.

**A mini-bus will depart from FAO premises at 19.00 hrs for dinner on the 16th of June.

Annex II

	FAO Expert Consultation Environmental Effects of Genetically Modified Crops **16-18 June 2003, FAO Headquarters, Rome** **LIST OF PARTICIPANTS**		
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