Decision-aiding tool for the management of agriculture in case of a nuclear accident

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INTRODUCTION
For several years, agricultural and nuclear professionals in France have been working on how to manage the agricultural situation in the event of a nuclear accident. This work resulted in measures at both the national (Aube nuclear safety exercises in 2003, INEX3 in 2005) and international levels (EURATOM Programmes). The European FARMING (FP5) and EURANOS (FP6) programmes strongly influenced this effort by calling upon institutional and technical professionals from the agricultural and radiation protection sectors. Their contribution consisted in assessing and completing datasheets describing different countermeasures (to protect the population and agricultural resources, to restrict the contamination of produce and the amount of waste) [Howard & al] and a European generic handbook on how best to use them. Following on from this work, ACTA1, IRSN2 and six agricultural technical institutes3 which are specialised by agricultural production and processing network (arable crop [especially cereals, maize, pulses, potatoes and forage crops], fruits and vegetables, vine and wine, livestock farming [cattle, sheep, goats, pigs, poultry]), created a resource adapted to the French context: the Decision-aiding Tool for the Management of Agriculture in case of a Nuclear Accident4. Devised for the Ministry of Agriculture services supporting state officials in a radiation emergency, this manual focuses on the early phase following the accident when the state of emergency would make discussion on countermeasures with a large stakeholder panel impossible. Supported by the Ministry of Agriculture and Fisheries and the French Nuclear Safety Authority, this project increased knowledge of post-accident management strategies (range of countermeasures, operational feasibility,...) and made an important contribution to the national think tank set up within the framework of the French Steering Committee for managing the post-event phase of a nuclear accident (CODIRPA)5. This article describes how the manual evolved throughout the project, from the initial difficulties to the development of new resources.

PRELIMINARY PHASE AND BUILGING OF A SHARED KNOWLEGDE
To prepare the investigation led by the agricultural technical institutes, ACTA and IRSN first selected a range of countermeasures applicable to farms. Only countermeasures easy to implement or similar to routine agricultural practice and achievable during the crisis and immediately after the event were retained. Any countermeasures requiring means not normally available on farms were eliminated. The countermeasures were then classified according to chronological order of implementation (preventive and early phase

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1 ACTA : network head of the agricultural technical institutes
2 IRSN : Public expert body in charge of the scientific assessment related to nuclear and radiological risks
3 ARVALIS - Institut du végétal ; CTIFL (Centre Technique Interprofessionnel des Fruits et Légumes) ; Institut de la Vigne et du Vin ; IFIP-Institut du porc, Institut de l’Elevage ; ITAVI (Institut Technique de l’Aviculture)
4 http://agriculture.gouv.fr/sections/thematiques/alimentation/securite-sanitaire/surveillance-controles-alertes
5 http://www.asn.fr/sections/espaces-professionnels/situations-d-urgence/gestion-post-accidentelle/seminaire-international-post-accidentel
countermeasures), their targets (farmhouse, agricultural land or livestock) and objectives. Questionnaires were developed for each of them to highlight important technical aspects needing further investigation (e.g. What are the risks involved in closing a silo? What are the consequences of suddenly ceasing to milk a cow?). At the same time, there were several group meetings to ensure that the agricultural technical institutes had the information and basic documentation they needed to understand the phenomena and radiological issues which have an impact on agriculture in the event of a nuclear accident [IRSN, 2004; Nisbet & al, 2005; FNSEA & al, 1991; Réales & al, 2006]. These elements were subsequently assembled in the manual’s “General Information” section and supplemented with a concise description of the different type of agricultural production studied.

FIRST RESULTS AND ANALYSIS OF DIFFICULTIES
To begin with, the agricultural technical institute agents listed the major sources of exposure relating to individuals and contamination of products on a farm. The investigation then concentrated on the extent to which countermeasures reduce their impact and on the operational feasibility and constraints (technical, agricultural, environmental ...) of implementation in an accident context. The results were formalised in technical memoranda progressively enhanced by exchanges with ACTA and IRSN.

Depending on agricultural productions, the results were very heterogeneous and not entirely satisfactory. First of all, group members found it difficult to formulate an objective technical analysis given that the various crises which have hit the different agricultural productions have demonstrated that their management does not only depend on technical criteria but involves a number of different aspects (economic, media ...). These results also showed how difficult it is to rapidly assimilate the complexity of issues linked to nuclear accident management and to farms organization, especially with their economical and technical environment. Above all, there is a real difficulty to rationalise countermeasures without quantified time or space references. Lastly, they revealed how necessary it is for working methods to evolve. The initial group meetings led to refining the manual’s structure by, for example, combining different types of productions which could be managed in a similar way. However, this type of organisation did not make it possible to identify and further investigate bottlenecks sometimes specific to a given production.

METHODS FOR REGULATING ACCIDENT MANAGEMENT
A concise description of essential information in crisis management
Following these conclusions, individual interviews of each agricultural production helped to remove bottlenecks and increase management option information. Through these exchanges, it was possible to identify information essential to rapidly understand the main concerns and phenomena linked to contamination of products and the implementing countermeasures (contamination pathways, transfer kinetics, spatiotemporal variation of contamination risks, agronomical or zootechnical constraints induced by countermeasures, ...). All these elements, essential to crisis management, have been collected in “Decision aiding” datasheets to help decision-making specific to each production under consideration.
Zoning: adapting and fine-tuning the response in terms of time and space

To regulate a nuclear accident and its consequences in its spatiotemporal dimension, while avoiding preconceptions linked to a given scenario, ACTA and IRSN have proposed a generic zoning (figure 1) of an area contaminated by a radioactive deposition based on two main criteria: the implementation of countermeasures to protect the population during the emergency and/or post-accident phase (sheltering, evacuation…); and the level of agricultural products contamination compared to levels prohibiting consumption and/or commercialisation and contamination detection thresholds. In each zone, two strategies meeting different objectives can be envisaged: (1) valorization of the current production (e.g. milk, standing crops,...) and/or farm assets (e.g. livestock, greenhouses, ...); (2) destruction of the production and/or abandonment of agricultural assets in the short, medium or long term.

In each zone, strategy can be predefined or should be the result of a multicriteria analysis linked to the accident (date and extent of the accident, land use, ...). This method helps the decision-maker to adapt his response with respect to space and time and is an important operational element in the decision-making procedure.

**Figure 1: Generic zoning of an area affected by a radioactive deposition**

**Zone 1 (a, b, c):** From the pre-release phase (if there is one), the main issue is to protect the population. During the emergency phase, the population in Zone 1 is sheltered. If the period between warning and the beginning of the release is short (< 6 hours), Zone 1 is probably restricted to an area within a radius of several kilometres around the facility. If the period is longer, calculations define a smaller area.

When discharge has ceased, if protective measures for the population are necessary (evacuation ...), products contamination is probably substantial, so consumption and commercialisation will be prohibited, at least temporarily. If this is not the case, the food production management strategy will be linked to the strategy applied in Zone 2.

**Zone 2:** During the emergency phase, calculations define a zone (dotted line) within which the population runs no significant risk of exposure even when the radioactive cloud passes over. On the other hand, products contamination levels could rise beyond consumption and commercialisation thresholds. During the post-accident phase, this zone’s limits are fine-tuned by means of increased radioactivity measurements in the area which sometimes reveal some critical points. Apart from the food chain, no protective measures of the population are necessary, at least, not during the first few hours. And so in theory, it is possible to begin protective measures of agricultural assets as soon as the emergency phase begins. In the post-accident phase, the choice of strategy will depend on numerous parameters linked to the agricultural context and the extent of the accident.

**Zone 3:** During emergency and post-accident phases, there is no risk to extend intervention levels for the protection of population or for the prohibition of agricultural products consumption or marketing. Therefore, no protective measures for the population are necessary. In an effort to optimise the situation, contingency measures may be initiated at the outset of the emergency phase to minimise land, farm and food chain contamination.

**Zone 4:** At the outset of the emergency phase, measurements made in the area demonstrate that the zone has not been affected by discharge. No population or agricultural asset protection measures are necessary.

**Methods for organising and describing countermeasures**

The above two strategies are described in the manual in a “STRATEGIES” datasheet using diagrams and explanations to describe the possible countermeasures for attaining the required objectives, organising them logically in time and space. And finally, each possible countermeasure is explained in a “Management option” datasheet setting out objectives and targets, constraints and precautions associated with their implementation, elements for evaluating its efficiency and the observations of agricultural and radiological experts (cf. figure 2).
CONCLUSION
The Decision-aiding Tool for the Management of Agriculture in case of a Nuclear Accident is based on the results and dynamics instigated by the FARMING and EURANOS European programmes. This manual can rightly be considered as an example of how to adapt the generic European manual to France [Nisbet & al]. However, the working group wished to go further and respond to all the recurrent technical issues which until now have limited work to general considerations and had to adapt its working methods and create specific procedures. This project led to increasing technical knowledge of countermeasures and developing a more operational tool. Nevertheless; it is a first step. Some elements of the manual (e.g. zoning criteria) need to be updated following changes in national doctrine. In future, all those participating in crisis management, from experts responsible for evaluating the situation to operators in charge of implementing countermeasures, not forgetting the decision-makers, should have their own manual, adapted to their specific role and needs.

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