ON-FARM RISK ASSESSMENT OF AGRICULTURAL PESTICIDES

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ABSTRACT

UK Government policy is seeking to optimise agricultural pesticide use and encourage the adoption of Integrated Pest Management (IPM) techniques. An integral part of IPM is selecting pesticides that are likely to pose the least environmental risk. Environmental risk assessment is a highly technical process and is heavily data dependant making a scientifically sound approach on-farm unrealistic without a computer-based decision support tool.
Such a tool has now been developed that estimates risks to a wide range of taxonomic groups and environmental compartments using methods consistent with current regulatory assessments but also allows adjustments to reflect formulation, the local conditions and the environmental costs and benefits of varying management practices.

INTRODUCTION

UK Government policy is seeking to optimise agricultural pesticide use and to this end is encouraging the adoption of IPM techniques. An integral part of IPM is selecting pesticides that are likely to pose the least risk considering the local site, farm practices and the problem being addressed. Although the assessment of the potential risks of environmental damage that might be caused by the use of pesticides is a significant part of most registration procedures, it is highly technical in nature and is heavily data dependant making a scientific approach on-farm unrealistic without a computer-based decision support tool.

A computer-based informal environmental management tool for agriculture, known as EMA[1] has been designed for farmers and their advisers to encourage more sustainable practices across the whole farm. A new EMA module has now been developed to estimate the on-farm risks associated with crop applied pesticides. The approach replaces the former hazard-based system and is consistent with current regulatory assessments but also allows adjustments to reflect the local conditions and the environmental costs and benefits of varying management practices.

SYSTEM OVERVIEW

Potential risks are estimated from the ratio of a pesticide's toxicological properties and the degree of exposure (TER's). The approach utilises simple models of the dispersion pathways of the pesticide in the local environment to estimate the predicted environmental concentration (PEC) to which organisms will be exposed. By comparing these data with a measure of the toxicity of the pesticide to a range of different organisms an understanding of the degree of risk involved is determined.

The software includes an embedded database of all the necessary fate and ecotoxicological input data for over 350 different active substances in over 2500 different branded products. A second database holds climate and soil parameters for the UK mapped by postcode. The system also has various auxillary tools which enhance the user interface. For example database browsers and a library of advisory documents including codes of practice.

This new tool will be incorporated into the EMA software package during 2001. A more technical version (p-EMA) designed for agronomists will also be made available. Risk to human operators is currently being added to the system.

Predicting environmental concentrations

Concentrations in soil in the field and field margin

The amount of chemical arriving on the field soil surface is determined from the application rate correcting for crop interception. In harmony with current regulatory practices, the initial pesticide concentration in soil is calculated by assuming that it is uniformly spread throughout the top 5 cm of soil and has a bulk density of 1.5 g cm^{-1}. Subsequent concentrations and time-weighted averages (where required) are calculated according to first-order kinetics.

For soil in the field margin the approach adopted is that proposed by the workgroup on Terrestrial Exposure Assessment for Non-Target Arthropods[2] using the FOCUS[3] drift calculator and 50% interception by vegetation if present.

Concentrations in groundwater

Concentrations leaching to 1-m depth over a 1 year period are taken as a protective surrogate for concentrations in groundwater as in current regulatory practice. The MACRO[4] (V4.1) preferential flow model was used to predict concentrations for *ca.* 80 pairings of K_{oc} and half-life for a comprehensive range of combinations of timing, climate and soil. These predictions are held in look-up tables to avoid having to embed the model itself into the system. For a site specific prediction the system requires application date and postcode from which the site is placed into one of five climatic categories (based on winter recharge) and one of six soil types classified according to groundwater vulnerability. The four numbers surrounding the true K_{oc}-half-life pairing are read from the look-up table, interpolated and corrected to the actual application rate which itself is adjusted for any interception by the crop. No assessment is undertaken where aquifers are absent or the soil has a low vulnerability for leaching.

Concentrations in surface water

The actual dimensions of the surface water body are considered and no assessment is undertaken where surface water is not present. Concentrations feeding into the assessment are taken as the largest of those from drift and drainflow (where drains are installed).

Drift is calculated according to the proposed FOCUS methodology with reductions for use of LERAP star-rated nozzles and correcting for the actual distance between sprayed area and surface water. Losses via drainflow have been considerably adapted from a tier 1 calculator derived by Pesticide Safety Directorate (PSD) from data for Brimstone Farm. Six standard soil types have been derived to represent those drained under arable cultivation. The MACRO model was first used to simulate Brimstone data for pesticides within each of the Koc categories in the PSD calculator. Comparison with measured values gave correction factors (all within a factor of 3 for compounds with Koc <4000 ml g^{-1}) to account for model inaccuracy. The model was then used to predict concentrations for the standard soils and predictions were adjusted using the correction factors. Multiple applications are considered for both drift and drainflow and time-weighted average concentrations are calculated according to first-order kinetics and the most rapid dissipation process from surface water (including partition to sediment).

Predicting risk

A basic risk index is determined based upon the methods used in the initial UK regulatory assessment. It is impractical to use data from higher-tier studies directly as they are too variable in nature to incorporate in to a standard calculation. Instead it has been assumed that, if a pesticide use has been approved under EU procedures, any concerns indicated by the basic risk index must have been satisfactorily resolved by a more detailed ('higher-tier') assessment. In such cases the basic index is adjusted to the level used as a threshold in the EU procedures (e.g. TER = 10 for acute risk to birds).

Mammals and birds

TER's for mammals are determined based on the acute oral LD_{50} for rats or mice (the lower value taken) and an estimation of the amount of pesticide which is likely to be consumed depending upon the pesticide formulation and application technique. The worst-case TER between centre-feeding mammals and edge-feeding mammals is taken as the risk indicator.

For birds the acute oral LD_{50} is taken for either mallard duck or quail. Exposure is based on the amount of pesticide consumed by both edge-feeding and centre-feeding species, the worst-case TER is then used as the risk indicator. Granular and pelleted formulations are treated as special cases: 'poor' scores being assigned if the LD_{50} value is < 1 per particle based upon a typical average weight of 0.015g per particle.

Site factors which are taken into consideration include the amount of alternative feeding habitat: amounts of natural habitat, hedgerow and conservation headlands. Adjustments are also made for spray drift control and the incorporation and removal of spills.

Honeybees

For honeybees a 'hazard ratio' is used based on acute LD_{50} (lowest of contact and oral values) for sprays and the application rate. It is assumed that there is no risk from other formulations or from applications made between October and February inclusive. The index is also adjusted according to the crop's attractiveness to bees, the presence of flowering plants or weeds in the crop and the field margin and the presence of bees foraging at time of application.

Earthworms

The risk to earthworms is only considered in the soil below the crop. Exposure outside the crop is not considered likely to be significant. The TER is calculated from the acute LC_{50} and the predicted concentration in the field soil. The crop type and growth stage (or % canopy cover) determines the interception of the spray.

Aquatic Organisms

Risk to aquatic organisms is determined from toxicity data and the initial concentration in exposed surface waters. The LC_{50} and NOEC were used for acute and chronic risk to fish respectively. Similarly, the EC_{50} and NOEC were used to determine acute and chronic risk to daphnia. Only acute risks are determined for algae and lemna using their EC_{50}. It is assumed that there is no risk if the field is not adjacent to surface water. Contamination of water bodies with chemical or used containers increases the risk.

Non-target arthropods

The approach taken for non-target arthropods is different to that used for other taxa. As regulatory studies are not generally dose-responsive it is not possible to determine variation in risk due to variable dosage or variable drift zone. Therefore a scoring system has been devised based on the pesticide type (insecticide/other and selective/broad spectrum), the time of year the application is made (assuming a low risk before 1st April) and the presence of unsprayed buffer zones.

Risk communication

Risk communication is seen as an important part of the software system. The system has been primarily designed for use by farmers and growers. TER's ideally need experience and expertise to intrepret, therefore TER's have been converted to a scoring system which lies on a defined scale. EU regulatory thresholds are used as reference points linking the risk indices to the system categories 'good average practice', 'review recommended' and 'poor', e.g. an acute avian TER of 10 would fall just above the boundary between 'poor' and 'review recommended'. Index values between the reference points are converted using a straight-line relationship on a log scale.

In order to aid the interpretation of the large amount of data generated, an icon alert system is utilised at farm and field summary level. However, the more detailed information on TER's, eco-scores and predicted environmental concentrations are also available for all active substances and at all levels of aggregation: product, field and farm, if required by the user.

The accuracy of the determined risk is highly dependant on the quality of the input data. Data confidence is determined using a scoring regime considering the data source, reliability and, as data is aggregated, on the proportion of missing information.

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