MINI REVIEW

Interactions between pesticides; a review of reported effects and their implications for wildlife risk assessment

HELEN M. THOMPSON

Central Science Laboratory, MAFF, London Road, Slough, Berkshire SL3 7HJ, UK

Received 9 March 1995; accepted 23 June 1995

Reviews of pesticide usage survey data and vertebrate wildlife and honeybee poisoning incident schemes in the UK show that there is considerable potential for wildlife to be exposed to combinations of agricultural pesticides. According to the published literature the toxicity of many pesticide combinations is at least additive. In some cases pesticide mixtures, particularly those involving insecticides, have been shown to be synergistic, with reported increases in toxicity of up to 100-fold. However, these effects are species, time and dose dependent and are therefore difficult to predict routinely. It is suggested that risk assessments should routinely take additive toxicity into account and those based on synergism should be targeted at those mixtures for which a further defined increase in toxicity would result in a high-risk classification. In order to support this risk assessment approach there is a need to develop and validate a standard in vivo test in order to confirm the interaction in those cases where additive or synergistic toxicity results in a high-risk classification.

Keywords: pesticides; synergism; risk assessment; wildlife.

Introduction

Concern has been expressed in recent years that exposure of non-target species to more than one pesticide in a short period of time may result in unpredicted toxic effects (Johnston et al. 1994a,b,c). Multiple exposure of wildlife can occur through applications of tank mixes or co-formulations, through sequential application to the same crop or by wildlife travelling between treated fields.

Data collected for the MAFF Pesticide Usage Survey of arable crops in England and Wales in 1990 (Davis et al. 1991) showed that over 25 000 different combinations of two active ingredients had been sprayed as tank mixes or co-formulations on the 761 farms surveyed, though only a small proportion had been used on significant numbers of farms. A more detailed analysis of spray applications has been carried out using data from the 1992 survey of arable crops in England, Scotland and Wales (Davis et al. 1993). This showed that tank mixes and co-formulations were applied to 10.9 million ha, implying a mean of over two mixtures per crop. Fifty-nine different combinations of two or more active ingredients were applied to 30 000 ha or more. The concentration of pesticides on seeds can present particular risks to grazing and seed-eating animals (Hart and Clook 1994). Eighteen combinations of pesticides (fungicides and insecticides)
were approved for use as seed treatments in 1994. These statistics demonstrate the high frequency of use of mixtures which are not usually considered in their own right in risk assessment.

In order to assess whether interactive effects resulting from multiple exposure to pesticides should be considered in risk assessment for vertebrate wildlife, this paper aims to identify the following.

1. The scale of increase in toxicity resulting from multiple pesticide exposure which may alter the risk classification
2. The basis for chemical interactions resulting in increased toxicity as reported in the literature
3. The most appropriate way to address interactive effects in the risk assessment process

Multiple exposure and risk assessment

In Europe, terrestrial vertebrate environmental risk assessments for plant protection products are based on decision-making schemes incorporating risk classifications. Risk assessments are directed at protecting the individual, although the conclusions can also be used to indicate the proportion of animals in a population that are likely to be affected (EPPO/CoE 1994). There are no commonly used criteria for the significance or acceptability of effects for populations. Within the EPPO/CoE (1994) risk assessment guidelines for vertebrate wildlife, decisions are guided by risk classifications based on estimated daily intake/LD50 quotients (dose/toxicity \((D/T)\)). Data on laboratory surrogates or selected indicator species in the field are normally used. Low risk (no further action required) is defined for \(D/T\) values less than 0.01, high risk (potentially non-approval) is defined for \(D/T\) values greater than 0.1 and medium risk falls between these values. The EC Directive 91/414 Annex VI defines toxicity (LD50) – exposure (dose) \((T/D)\) ratios for high risk classification and non-approval (unless it is established that no unacceptable impact occurs under field conditions) as 10 or less. This is equivalent to the EPPO/CoE guideline high risk ratio of 0.1. From these dose–toxicity quotient-based risk classifications it can be seen that any increase in toxicity due to combined action could potentially increase the risk classification. However, if the effect is sufficient to increase the \(D/T\) ratios by more than 10-fold, this could cause reclassification from low to high risk.

Classification of interactions between xenobiotics

There is potential for any combination of chemicals to show no increase in toxicity, a decrease in toxicity (antagonism), a simple addition of toxicity or a more complex synergy. Macek (1975) reported that tests with bluegill sunfish showed that of 29 two-chemical combinations of organochlorine (OC), organophosphorus (OP) and carbamate pesticides, over one-third showed greater than additive toxicity and the remainder showed additive toxicity. This paper focuses on additive and synergistic (also termed potentiation) effects because of their greater potential to cause underestimation of the risk posed to wildlife by combinations of pesticides. In this paper effects on toxicity refer to mortality-based measures unless otherwise stated.