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SEED STANDARDS IN LEGISLATION : ASSESSING SEED QUALITY AND EFFECT OF SEED TREATMENT

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ABSTRACT

Specialist seeds legislation is put in place in most countries with the aim of promoting the use of high quality seed and to improve agricultural productivity. To achieve this it must protect the interests of the breeder, the reputable trader and the end user. Essentially there are two types of legislation 'Truth in labelling', such as operates in the USA, where few or no quality standards are prescribed and 'minimum standards' where a range of minimum quality standards are set, such as is the pattern for EC countries, below which seed may not be marketed. However legislation will only work if there are effective means of measuring seed quality in which everyone has confidence. The International Seed Testing Association Rules for Seed Testing 1993 provide the standard procedures for sampling and testing seeds, which are followed by most countries, so that results can be readily understood and compared. The detailed procedures for carrying out tests and for seedling evaluation result in highly reproducible germination results which show the capacity of a population of seeds to produce plants under favourable field conditions. The effects of chemical treatments, on seedling development, if present, can be recognised in these tests. However, with treatments currently in common use, except where serious over treatment has occurred, acceptable germination results are usually obtained. Classical symptoms of chemical phytotoxicity are thickening of the seedling shoot and root but not all chemicals coming into contact with seeds produce the same symptoms. Correct and consistent evaluation of tests is essential if all concerned with treating, marketing and using seed are to have confidence that the seed will usually perform satisfactorily and as expected.

INTRODUCTION

Because seeds are of fundamental importance to plant and food production and therefore to the prosperity of agriculture, specialist seeds legislation is put in place in most countries which is intended to protect the quality of the seed in use and to improve the supply available (Kelly, 1989). Effective legislation should promote the use of high quality seed and thus improve agricultural productivity. To achieve this aim it will need to protect the interests of the plant breeder and encourage the breeding of new varieties, protect the reputable trader in seed against unscrupulous competition, protect the end user against being sold seed of unsatisfactory quality and protect agriculture generally against the import in seed of pests, diseases or weeds from other areas or countries.

Essentially there are two types of seed legislation based on 'Truth in labelling' and 'Minimum standards'. Where legislation is of the former type, a seller is required to give the buyer certain information by means of a label or otherwise, but seed of virtually any quality may be marketed. The essential point is that the declared details must be true at the time of sale.

Under 'minimum standard' legislation standards of seed quality are decreed for such attributes as cultivar purity, mechanical purity, weed content, moisture content, germination by number and sometimes for specific seedborne disease. Seed has to be tested by an officially recognised laboratory, and is approved and labelled for sale only if it complies with these standards.

In the United Kingdom a system of seed quality control is in force which is common throughout the European Economic Community. Having a standardised system allows for free movement of seed between member countries. Essentially it is a minimum standard system which lays down conditions which must be satisfied before seeds may be marketed for sowing.

However well framed, seeds legislation will only work if there are effective means of measuring seed quality in which everyone has confidence. The International Seed Testing Association (ISTA) plays an important role in world agriculture in providing the basis for uniform, and reproducible assessments of the value of seed for sowing. One of ISTA's stated objectives is 'to develop, adopt and publish standard procedures for sampling and testing seeds, and to promote uniform application of these procedures for evaluation of seed moving in international trade'. These procedures are set out in the International Rules for Seed Testing 1993 (ISTA, 1993). However, it is important to recognise that ISTA is not concerned with the actual standards seed meets, only with the accurate evaluation of the qualities of the seed being tested. Standards are a matter for individual countries to set or for traders and users to agree.

Most countries apply the ISTA Rules in their seed testing. The main exception is North America but the rules used there are in many respects the same as those of ISTA and currently there are efforts to remove the small differences which still exist.

However carefully testing is carried out the result can only be of real value if it accurately represents the true quality of the sample, and by inference the seed lot, from which the actual seed tested was taken. The production of reasonably homogeneous seed lots and the application of sampling techniques which give reliably representative samples are essential to achieving this objective.

While in this symposium, apart from the efficacy of the treatment for the purpose it is being applied, the concern is with germination and its interaction with the treatment, it should be remembered that this is only one facet of seed quality.

LEGISLATION

European Economic Community and the UK

As a member of the EC the UK has to conform to the EC legislation covering plant varieties and seeds, the main requirements of which are contained in seven Council Directives:

1 Common catalogue of agricultural plant varieties
2 Marketing of beet seed
3 Marketing of fodder plant seed
4 Marketing of cereal seed
5 Marketing of oil and fibre seed
6 Marketing of vegetable seed
7 Marketing of seed potatoes

Changes to and revision of Directives are achieved through discussion in a series of committees in which all member states and the EC Commission are represented. The provisions made in Directives set out the results to be achieved within a stated period but leave the implementation to national governments. In England, Scotland and Wales the seven Directives are implemented through the provisions of the 1964 Plant Varieties and Seeds Act (as amended by the European Communities Act 1972). Northern Ireland has its own legislation, the Seeds Act (Northern Ireland) 1965 as amended by the European Communities (Agriculture) Order (Northern Ireland 1972). In most respects these are the same but for example cereal seed marketed in Northern Ireland must have a greater degree of freedom from wild oats. The detailed requirements for the marketing of seeds are contained in a number of Seeds Regulations made under the Act. These are:

The Seeds (National Lists of Varieties) Regulations 1982
The Seeds (Registration, Licensing and Enforcement) Regulations 1985 and amendment Regulations 1987
The Seeds (Fees) Regulations and amendment Regulations 1987 with annual amendment to fees charged.
The Cereal Seeds Regulations 1993
The Fodder Plant Seeds Regulations 1993
The Oil and Fibre Plant Seeds Regulations 1993
The Vegetable Seeds Regulations 1993
The Beet Seeds Regulations 1993

Each member state of the Community produces lists of varieties which, together with those of other member states, make up the EC Common Catalogues of agricultural plants and vegetables. Only varieties on the Common Catalogues may be marketed in the Community.

The five specific seeds regulations cover the marketing of seed of a limited number of species which are listed in them. Even with these species there are occasions where the regulations do not apply, such as for seed intended for export to countries outside the EC, seed used for research or experiment or seed intended for further processing, treatment or cleaning prior to marketing as seeds for sowing. The regulations also permit the marketing of seeds imported from other EC countries and from countries outside the Community which have been granted 'equivalence' which comply fully with EC rules and standards. For most kinds of seed marketed under these regulations only certified seed may be sold. Certification provides a system of checking and guaranteeing various aspects of seed quality during the period seed is being multiplied through a number of generations. EC seed certification schemes (Based on OECD schemes for varietal certification of seed moving in International Trade) specify crop and seed standards for varietal purity, mechanical purity and germination, place limits on the content of disease and seeds of other crop and weed species, and require official involvement in the verification that seed meets the marketing standards prescribed. The main exception is vegetable seed which is largely sold as 'standard seed', which still has to meet marketing standards, but for which no official examination is required. The official examinations have to show that seed meets the prescribed standards at the time the test is carried out if the seed is to be marketed. No further official examination is required and thereafter it is the responsibility of the seller that at the time of marketing the seed still meets the standards.

Traditionally in most EC countries all the official examinations have been carried out by government organisations. However in the UK a mixture of government organisations and licensed trained personnel and privately owned laboratories carry out this work. This system was in operation before our entry into the EC and other member states are now showing interest in developing along similar lines.

Apart from setting standards for seed (see Table 1 for the germination standard for a range of species) regulations lay down procedures for the taking of samples and for the sealing and labelling of packages of seed so that categories and grades of seed can be readily identified. The regulations require that if any seeds have been subjected to any chemical treatment this fact and the nature of the treatment or the proprietary name of the chemical used in the treatment shall be stated on the label or printed indelibly on the package.

<u>Other European Countries</u>

A number of European Countries in the European Free Trade Association are currently in the process of bringing their seeds legislation into line with the EC and adopting the EC seed standards. Sweden is one such country, but where its existing standards are higher, it is considering continuing with the more stringent requirements for certification of seed produced in its own territory. For cereals higher standards may possibly be retained for maximum content by number of seeds of other species and germination. While the EC has a specific standard for loose smut (*Ustilago nuda*) in barley no specific standards are prescribed for other seedborne diseases on cereals like stinking smut (*Tilletia spp*), *Fusarium nivale*, *Septoria nodorum*, *Drechslera* spp and *Bipolaris sorokinana*. These are all currently tested for in Sweden and if present over a specified percentage the seed must be treated before it may be marketed. The use of routine seed health testing for assessing the need for fungicide treatment of cereal seed has been the practice in Sweden for more than 20 years. Germination standards are given for some species in Table 1.

Switzerland is also bringing seed standards into line with the EC requirements. Trading in seed is currently carried out under VESKOF (Association of Swiss seed companies under official control in agricultural and vegetable seeds) rules. While for some impurities there are standards by number, standards for purity and germination are agreed between the buyer and seller. However treated seed must be marked as such and the active substance has to be declared and additional regulations (staining etc) have to be observed.

Finland is a third country looking at free movement of seed with the EC. It currently has seed standards which tend to be lower than those applied in the EC. Minimum germination levels for some species are included in Table 1.

In the longer term some East European countries will aim to make trade in seed with EC easier. Currently Poland has a complex set of standards for seed with three grades of seed with different standards for germination for each of the grades (see Table 1).

Norway currently has germination standards for home produced seed (see Table 1) but for imported seed quality is controlled by what the importer can obtain and will accept. However all seed entering Norway must be tested at their Official Seed Testing Station and the quality characteristics ascertained there must be shown on the label or seed package when the seed is sold. Norway has particularly stringent requirements for wild oats (*Avena fatua*, *A. ludoviciana* and *A. sterilis*) to try and avoid this becoming a serious weed problem. To avoid unnecessary fungicide seed treatment Norway has decided that all seed lots of cereals shall be subject to disease tests, following the Swedish practice, and for treatment to be applied only when results indicate that application is necessary.

Non European Countries

The USA is a major source of seed but the US Federal Seed Act (USDA, 1988) is a truth-in-labelling law prescribing very few standards that have to be met. Apart from vegetable seeds in small containers for sale to the home gardener no germination standards are prescribed in the Federal Seed Act Regulations (USDA, 1987). Even the pure live seed (purity % x germination %) requirements for imported seed listed in these regulations no longer apply leaving importers to determine the quality of seed which they are prepared to accept. The US Federal Seed Act has no requirements or standards relating to seedborne diseases. However, some States do have seedborne disease standards for seeds of certain crops. These seedborne disease standards are usually part of regulations designed to keep crop production areas free of specified diseases. The Federal Seed Act Regulations detail the labelling requirements for treated seed. The US Environmental Protection Agency (EPA) Regulations Section 153.155 require that all pesticides intended for use as seed treatments must contain an EPA approved dye. This results in all chemically treated seed sold in the USA being stained. The Federal Food, Drug and Cosmetic Act section 2.25 also has a requirement that all interstate shipments of treated cereal seed is coloured or stained.

In contrast to the USA, the Canadian Seeds Act and Regulations prescribe in detail standards for a range of quality attributes for all crop species of importance there. Seed may be marketed under a range of grades, each grade having its own set of standards, with one or more of the quality standards differing for each grade. Some germination standards are given in Table 1 showing the variation in requirement according to grade of seed. Very few seedborne diseases are covered by the Canada Seeds Act and Regulations, loose smut (*Ustilago nuda*) in barley, and ergot and/or sclerotia in cereals, sunflower, clovers, grasses and oilseed brassicas being exceptions. Where the barley has been treated with a registered product for controlling loose smut testing is not required.

Any seed treated with a pest control product must be thoroughly stained with a conspicuous colour to show that the seed has been treated and the container marked or labelled bearing the symbol and signal word presented under the Pest Control Products Act and the regulations made thereunder. These indicate the degree of risk inherent in that product and must be accompanied by a statement not to use the seed for food or feed and giving the common chemical name of the product.

The Republic of South Africa in its Agricultural Pests Act No 36 of 1983 provides for the effective control of pests that are deemed important. This legislation does specify particular pests and diseases for a very wide range of species. The Plant Improvement Act No 53 of 1976 as amended provides for the registration of seed processors, the recognition of new varieties, for a system of certification of seeds produced in South Africa and the control of import and export of seeds. The Act also covers other propagating material. In many respects the legislation is similar in content and effect to UK legislation. It requires the words "Poison - treated seed" to be conspicuous on the container or on its label if the seed has been treated with a controlled substance which is poisonous or harmful to humans or animals. A number of acts impinge on the use of chemical seed treatments. A very wide range of crop seeds are prescribed under the legislation with a range of seed quality requirements and different standards for prepacked and imported seed from other seed material (see Table 1 for germination standards). Israel also sets standards for purity, weed seed content and germination for the major crop species. In many instances germination standards are similar over a wide range of countries.

In many developed countries governments are seeking ways of withdrawing from direct involvement in seed production, quality control being recognised as being the responsibility of the seller, although the government often still sets standards below which seed may not be sold. In developing countries there is not always an established private seed trade and small scale farmers may need the greater protection provided by government quality - control systems. Even in these circumstances there is recognition of the advantages of the greater efficiency which usually results when private companies become involved in seed production. However legislation still needs to provide adequate safeguards for the end user as well as promoting the production of high quality seed whether by the public or private sector or a mixture of the two.

Table 1 Germination Standards

	EC	Sweden	Finland	Poland +	Israel	South Africa *	Canada +	Norway
Avena sativa (Oats)	85	90	80	94/89/83	85	80	85/75	90/88/85°
Hordeum vulgare (Barley)	85	87 or 90°	80	95/90/83	85	80	85/75	90,88,85°
Secale cereale (Rye)	85	87	80	94/89/83	75	80/70	75/65	85
Triticum aestivum (Wheat)	85	87 or 90°	80	95/90/83	85	80	85/75/70	90,88,85
Zea mays (Maize)	90	90	-	95/90/85	80	80/70	90/80/75	
Festuca pratensis (Meadow grass)	80	85	75	90/82/75	-	-	80/70	80
Festuca rubra (Red fescue)	75	85	75	90/82/75	-	-	80/70	80
Lolium multiflorum (Italian ryegrass)	75	90	75	90/80/70	80	80/50	80/70	80
Lolium perenne (Perennial ryegrass)	80	90	75	92/85/78	80	80/50	80/70	80
Phleum pratense (Timothy)	80	85	75	90/82/75	-	-	80/70	85
Medicago sativa (Lucerne)	80	75	60	85/75/65	80	80/70	85/80/70	-
Pisum sativum (Pea)	80	80	75	95/86/77	80	70/50	80/75/70/65	-
Trifolium pratense (Red clover)	80	75	60	86/78/70	-	70/50	85/80/75	80
Trifolium repens (White clover)	80	75	60	85/78/70	80	80/50	80/70	-
Vicia faba (Field bean)	85	80	-	93/84/75	80	80/70	85/80/75/65	-
Beta vulgaris (Sugar/Fodder beet)	68-80	75	80	80/65	70	70/50	75/65	-
Brassica napus (Oilseed rape)	85	80	80	95/85/75	65	(70/50)	90/80/75	85
Linum usitatissimum (Flax, Linseed)	92,85	75	80	92/84/80	80		85/70	-
Allium cepa (Onion)	70	70	70	85/80/65	75	70/50	75	80
Brassica oleracea (Cabbage)	75	80	80	90/80/70	75	70/50	80/70/60	85
Daucus carota (Carrot)	65	70	70	65/50	70	70/50	60	-
Lactuca sativa (Lettuce)	75	85	80	80/70	80	70/50	75	-
Lycopersicon lycopersicum (Tomato)	75	85	85	80/70	80	70/50	75	-
Phaseolus vulgaris (French Bean)	75	85	85	85/75	80	70/50	85/80/75/65	-

* South Africa Two standards: prepacked and imported and other seed

\+ Germination standard varies with grade of seed

° Standard varies with winter and spring sown seed

THE INTERNATIONAL SEED TESTING ASSOCIATION (ISTA) AND ASSESSING SEED QUALITY

ISTA was formed in 1924 as a result of the recognition of the need for a universally accepted single set of seed testing rules which could be followed by all countries trading in seed so that results could be readily understood and compared. While the principles remain the same, in the intervening period many changes have been introduced to the details of the tests to improve their value for assessing suitability for sowing and to increase the uniformity of results between laboratories, both nationally and internationally. The current ISTA rules came into effect on 1 July 1993.

Assessment of any quality attribute is made on a very small amount of seed taken from a seed lot. It is vital therefore that the seed is representative if the result is to be of any value in defining the true quality of the lot. The rather time consuming procedure for drawing a sample prescribed in UK seeds legislation is not time wasted if it ensures the relevance of test results. For cereal, a minimum sample size of 1000g is prescribed for a seed lot up to a maximum size of 25,000kg. Equally as important as the drawing of the sample from the lot is the subsequent handling in the laboratory to ensure the test result accurately reflects the sample and therefore the seed lot.

The Standard Germination Test

The standard germination test is designed in a highly reproducible way to show the capacity of a population of seeds to produce plants in a field under favourable conditions by exposing them to conditions in the laboratory which are optimal for germination. The germination percentage is obtained by careful examination and classification of the seedlings, at a stage of development where accurate assessment of shoot and root system is possible, and the capability (normal seedlings) and inability (abnormal seedlings) for continued development into normal mature plants can by determined. In the seed testing context, therefore, germination refers to a more advanced stage of development than would normally be described by this term in physiological studies or such tests as a malting test for barley.

The test is undertaken normally on four replicates of 100 seeds. Seed is first subjected to a purity test, an essential prerequisite to the germination test, as it determines the material on which the test will be undertaken. By following internationally agreed and very precise rules, based on the principle that any crop seed which might conceivably germinate should be tested, it is ensured that equivalent material is always put forward for germination. Some degree of arbitrariness is inevitable: thus for example only broken seeds larger than half the original size are included, no attempt being made to determine the presence or absence of an embryo. The 'pure seed' from this test is sub-sampled and planted often using a vacuum planter which must be used correctly if bias, such as the preferential selection of light seed, is to be avoided (Bould and Arthur, 1978).

A basic medium is sterile sand, free from chemicals which may affect germination and standardised in particle size so that after the addition of the appropriate amount of water the right moisture/oxygen balance is obtained for germination to proceed. For cereals each replicate is planted onto the surface of a layer of moist sand 13 mm deep in a 150 mm diameter aluminium dish and after planting covered by a similar depth layer and a lid placed over the dish to restrict loss of moisture. By careful standardisation and control of the medium and other test conditions all samples and subsequent retests, in the same or different laboratories, are provided with identical growing conditions ensuring reproducibility of result. After the appropriate period if all seeds and seedlings are assessable the test is completed but if some cannot be evaluated with reliability these are left to develop further. If seedlings in the sand test are difficult to evaluate either because of the effect of seed treatment or from some other cause, a retest may be made in a proprietary seedling compost, but with the temperature and duration of the test the same as for the sand (Tonkin, 1969).

For inclusion in the germination figure reported, cereal seedlings must have a well developed root system having at least one long white, slender seminal root and an intact plumule with a well-developed green leaf, within or emerging through he coleoptile near the tip. Also included are seedlings with certain limited defects such as superficial discolouration of the shoot and, or roots, providing development of the structures is otherwise normal, or splits in the coleoptile near the tip which do not extend down more than one-third the length measured from the tip. All other seedlings are classified as abnormal and not included in the germination percentage. All remaining ungerminated seeds are examined to check whether the seed is dormant, when a retest with more extensive pretreatment may be required, or dead.

These principles apply to the testing of all species but of course details vary for substrates, temperature for optimum growth, length of test, dormancy breaking requirement and seedling evaluation. Table 2 gives information for a number of species on substrate, temperature, length of test and dormancy breaking method. Though light is not essential for any of these species to germinate it is often provided to ensure development of seedlings which can be easily evaluated. For each species the rules define, in the same way as for cereals, what seedlings can be included in the germination percentage reported.

In tests where normal germination is shown to be depressed and there are sufficient abnormal seedlings it is often possible to indicate from the types present the reason for the loss in germination. Mechanical injury, drying at too high a temperature and the application of too high levels of chemical treatment, for example, result in characteristic types of abnormal seedlings which are readily recognised by trained seed analysts. Abrol (1978) surveyed seedling abnormality in cereals and gives clear illustrations of the wide range found in tests made at the OSTS Cambridge. No similar surveys have been published for other species but the same wide range of abnormalities are found for most species where their seed is subject to the same handling and treatment procedures.

Table 2 Germination Methods Used at OSTS Cambridge

Species	Substrate	Temperature °C	First count days	Final Count (days)	Dormancy breaking Methods
Avena sativa (Oats)	S	20	5	10	Prechill
Hordeum vulgare (Barley)	S	20	4	7	Prechill : GA_3
Secale cereale (Rye)	S	20	4	7	Prechill
Triticum aestivum (Wheat)	S	20	4	8	Prechill : GA_3
Zea mays (Maize)	S	20	-	7	-
Festuca pratensis (Meadow fescue)	TP	20-30	7	14	Prechill : KNO_3
Festuca rubra (Red fescue)	TP	15-25	14	21	Prechill : KNO_3
Lolium multiflorum (Italian ryegrass)	TP	20-30	7	14	Prechill : KNO_3
Lolium perenne (Perennial ryegrass)	TP	20-30	7	14	Prechill : KNO_3
Phleum pratense (Timothy)	TP	20-30	7	10	Prechill : KNO_3
Medicago sativa (Lucerne)	BP	20	5	10	Prechill
Pisum sativum (Pea)	S	20	-	8	-
Trifolium pratense (Red clover)	BP	20	5	10	sealed polythene envelope
Trifolium repens (White clover)	BP	20	5	10	sealed polythene envelope
Vicia faba (Field bean)	S	20	-	14	-

Table 2 Continued

Beta vulgaris (Sugar/Fodder beet)	TP	20	5	14	Prewash for 2 hours at 25°C. Followed by drying for 2 hours at 25°C.
Brassica napus (Oilseed rape)	TP	20-30	5	7	Prechill
Linum usitatissimum (Flax, Linseed)	S	20	-	7	Prechill
Allium cepa (Onion)	BP	20	7	12	Prechill
Brassica oleracea (Cabbage)	TP	20-30	6	10	Prechill
Daucus carota (Carrot)	TP	20-30	7	14	-
Lactuca sativa (Lettuce)	TP	20	-	7	Prechill
Lycopersicon lycopersicum (Tomato)	BP	20-30	7	14	KNO_3
Phaseolus vulgaris (French bean)	S	20	-	9	-

Substrate	S = Sand TP = Top of paper on Copenhagen tank BP = Between paper inside polythene envelope
Temperature	A single figure indicates a constant temperature. Two figures separated by a dash indicates a 24 hour cycle with 16 hours at the lower temperature and 8 hours at the higher temperature.
First count	A deviation is permitted but seedlings must be sufficiently well developed for assessment or counting should be delayed.
Dormancy breaking	Prechill : Prechill at 5°C for 3 to 7 days GA_3 : Use GA_3 in solution at 0.05% or 0.1% KNO_3 : Use 0.2% KNO3 solution to moisten at beginning of test

The classical symptoms of chemical phytotoxicity observed in germination tests on cereals (and on other species), have been a thickening of the shoot including both the coleptile and first leaf, and or root with in extreme cases elongation being so retarded that these structures are almost spherical in shape. Not all chemicals that come into contact with seed have quite the same effect on seedling development and glyphosate, for example, sprayed onto cereal crops to control couch grass, has been observed only to affect the geotropism of the roots which start to grow upwards. Baytan and Ferrax (Tonkin, 1987) were observed to produce seedlings with marked retardation of coleoptile elongation with no particularly obvious effect on root and leaf development. In this case sufficient elongation occurred if the tests were left two days longer, when seedlings could be evaluated as normal, and most treated tests had germinations above the marketing standard of 85%.

Sand (and filter paper) tests tend to accentuate the effect of chemicals present on the seed because there is no adsorption of the chemicals by the sand particles. Also no water is added after the initial wetting of the sand so increasing the likelihood of uptake of chemicals on the seeds. While accurately treated samples frequently show no phytotoxic symptoms in these tests, it has been established that it is appropriate to retest samples where phytotoxic symptoms are evident, in compost. Except where serious over treatment has occurred, even where the great majority of seedlings have been affected in the sand test, an acceptable result is usually obtained in compost.

Discussion

Legislation, in whatever form, sets the framework for the marketing of seed with the intended aim of supporting improved agricultural production. It must encourage the production of good quality seed but at the same time not be prohibitive in its requirements so that inadequate quantities of seed are available in the market place to satisfy growers needs. Therefore where minimum standards are prescribed these are set at levels which may be too low for specialist needs, though providing adequate safeguards against serious crop problems arising. In the EC minimum germination standards for example for sugar beet are at the highest 80% (for some classes the standard is lower) but in the UK the seed lots used for sugar beet production now show laboratory germination percentages of around 95%. Such a high level is essential to the production of the right population when sowing single seeds at spaced intervals.

With close spaced sowings such as those for cereals, where tillering can also compensate for lower establishment, such high levels may not be critical and the 85% minimum may prove satisfactory for most purposes. However in cereals many lots of seed have germinations of 95% or better. At a sowing rate of 3.0 million seeds/ha there is a very large difference (420,000) in the number of seeds being sown with the potential to produce a satisfactory plant between the best seed lots at 99% germination and those at 85%. Clearly seed with very high germination is desirable for many situations and many crops, particularly those that are wide spaced. Adjusting seed rates can compensate for low germination, but there is more risk of uneven plant distribution.

In the laboratory ideal conditions for germination are provided and all external factors such as soil fungi, insects, mice, birds and variations in soil and climatic conditions are eliminated. The grower aims for the optimum in trying to create a good seed bed and providing the best environment to support growth. The more successful he is the more closely will establishment reproduce the figure obtained in the standard germination test. However, it is not possible to achieve the ideal in the field and some depression of germination is likely. In less favourable conditions, particularly in circumstances of specific stress conditions, some seed lots in spite of above standard laboratory germination establish less satisfactorily than expected. A number of 'vigour' tests have been developed for the detection of seed lots meeting the standard for laboratory germination but showing weakness; eliminating these lots must increase the probability of obtaining satisfactory establishment when conditions are adverse. However so far such tests have not been considered sufficiently standardised to be included in ISTA rules and 'vigour' is not covered in seeds legislation. The one exception is vigour in maize using the 'cold test' which is covered in Austrian Seeds Legislation.

The correct application of seed treatments evenly applied on individual seeds should not reduce germination and may well enhance establishment in the field. Uneven application, even at the overall correct rate, may result in some reduction in germination because of phytotoxic effects on overtreated seeds, but in most seed lots this will not affect the marketability of the lot. Where legislation sets minimum standards frequently testing before treatment is permitted. This accepts that properly evaluated and correctly applied treatments rarely result in serious problems of establishment in the field. However seeds legislation frequently now stipulates identification of the treatment used and colouring of the seed so that the user is in no doubt that the seed is treated and should not be used for human or animal consumption.

For those producing new seed treatments it is important to know what standards seed has to meet, how the seed will be tested and how seedlings will be evaluated in checking the seeds suitability for marketing and sowing. The ISTA seed testing rules provide a virtually universally accepted basis for the testing. With properly trained seed analysts carrying out the tests seed can be correctly and consistently evaluated wherever the testing is carried out. All concerned with treatment, marketing and using the seed can as a result have confidence that the seed will usually perform satisfactorily and as expected.

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EFFICACY AND PHYSICAL/MECHANICAL DATA REQUIREMENTS FOR APPROVAL OF SEED TREATMENTS IN THE UK

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ABSTRACT

The scale and scope of trials and the expected level of performance required by the UK regulatory authority to demonstrate acceptable efficacy and physical/chemical properties of seed treatment products in support of approval/authorization, are presented.

INTRODUCTION

In the UK, it is a legal requirement under both The Control of Pesticides Regulations 1986 (Anon., 1986a) and the EC Authorization Directive (Anon., 1991) that applicants for approval/authorization of a plant protection product demonstrate acceptable efficacy and physical/chemical properties. The evidence required to demonstrate acceptable efficacy and physical/chemical properties for seed treatment products are generally less well-known than for foliar or soil-applied plant protection products. To address this lack of information, the official authority responsible for approval/authorization of plant protection products in the UK, the Ministry of Agriculture, Fisheries and Food's Pesticides Safety Directorate, issued guidance notes to applicants on the scale and scope of trials and the expected level of performance required to demonstrate acceptable efficacy and physical/chemical properties of seed treatment products. The guidance notes are summarized below.

EFFICACY DATA REQUIREMENTS

Effectiveness against pests/pathogens

Evidence is required (or where appropriate, a reasoned case argued) to support the proposed claims made for each disease/pest on a product label.

Scale and scope of trials

The evidence should be provided largely by conducting field experiments under conditions as near as possible to commonly accepted practice. Where soil type or geographic location can affect performance, products should be tested on a range of sites/situations relevant to the proposed area of use. This core of information can, where appropriate, be supplemented by contrived experimental situations, such as, defined artificial plots with introduced pests or diseases; or various pot or container trials under glass or in the open.

In the case of soil-borne pests, such as wheat bulb fly (*Delia coactata*), sites should be sought where pest numbers are high so that treatments under test are challenged by the problem. The pest numbers should be determined by appropriate methods. The guidelines set out in Appendix 10 of Data Requirements for Approval under the Control of Pesticides Regulations 1986 (Anon, 1986b) should be followed where trials are to be sited in fields with natural infestations of soil- or air-borne pests, e.g. wheat bulb fly and leatherjackets (*Tipula oleracea* or *T. paludosa*) on cereals; pygmy mangold beetle (*Atomaria linearis*), millepedes and other soil pests of sugar beet; aphids, thrips; and systemic fungicides for control of air and splash-borne diseases. For example, the requirement, '*to assess the performance of the product under the conditions likely to occur there during the relevant period(s) of the year*' should be provided by distributing trials throughout the appropriate national regions.

Where activity against seed-borne diseases is to be tested, it is important to obtain seed stocks carrying moderate to high levels of disease. The proportion of seed carrying a given disease should be known and recorded. Artificially inoculated seed can be used for diseases, such as, bunt (*Tilletia caries*) on wheat. Guidance on trials techniques are given in Organisation Européenne et Mediterranéenne Pour la Protection des Plantes/European and Mediterranean Plant Protection Organization (OEPP/EPPO) guidelines on seed-borne cereal fungi (OEPP/EPPO, 1980) and seed treatments against seedling diseases (OEPP/EPPO, 1988a), the latter of which provides information on seedling diseases of larger seeded field crops, vegetable crops and beet and their damping-off diseases due to soil-borne fungi.

Numbers of trials and plot size may be limited by infected seed availability but the aim, for a major pest/disease, should be a minimum of 10 trials showing similar acceptable results. Results should be presented from tests conducted over at least two growing seasons. Preferably results should be provided from different seed batches and/or different locations. Field evidence may be supported by experiments in controlled or glasshouse conditions where it is possible to contrive challenging conditions. For pests or diseases which are extremely spasmodic in occurrence, these requirements may be reduced.

Assessment criteria

For seed-borne diseases on cereals, which have the potential to multiply rapidly from one generation to the next i.e. bunt (*Tilletia caries*) on wheat, covered smut (*Ustilago hordei*) on barley and oats, loose smut (*Ustilago nuda*) on wheat and barley, and leaf stripe (*Pyrenophora graminea*) on barley, evidence showing consistent control of >98%, is required to support a claim for 'control' on a product label. Demonstration of consistent control of 85-98% may be accepted for a claim of 'partial control' with the restriction that control is not sufficient for crops grown for multiplication.

For other pests/diseases, effectiveness of the test product will be judged in comparison to the untreated control and approved standards. Unless there are good reasons to accept a poorer level of control than that provided by a standard reference product, the level, duration and consistency of control of the test product must be similar to that provided by the standard. If no suitable reference product exists, the test product must be shown to give a defined benefit in terms of the level, duration and consistency of control.

Safety to the crop

Evidence must be provided (or where appropriate, a reasoned case argued) to support the proposed use on each crop on a product label.

Scale and scope of trials

Some guidance on trials techniques are given in an OEPP/EPPO guideline on phytotoxicity assessment, which includes a section on seed treatments (OEPP/EPPO, 1988b).

With the exception of germination tests, evidence should be largely provided by conducting field experiments under conditions as near as possible to commonly accepted practice. Where soil type, geographic location or sowing date can affect safety to crops, products should be tested on a range of sites/situations relevant to the proposed area of use.

With the exception of germination tests, a minimum requirement for other aspects of crop safety on a major crop e.g. winter wheat, should normally be 10 trials showing similar acceptable results. Results should be presented from tests conducted over at least two growing seasons and should include a range of common cultivars.

For more minor crops, these requirements may be reduced. For example, in the case of a seed treatment product for use on vegetable brassicas, provided satisfactory evidence of germination is provided on a range of varieties of each crop, the remaining requirements need only be satisfied for a single representative of each species e.g. evidence of safety on cabbage (*Brassica oleracea* var. *capitata*) could be extrapolated to cauliflower (*B. oleracea* var. *botrytis*) or Brussels sprouts (*B. oleracea* var. *gemmifera*).

Tests for crop safety should, where possible, be separated from tests for effectiveness on pests or diseases in order to remove an interfering variable. It is advisable to use certified seed in tests on crop safety. Seed should be free from infection by seed-borne diseases, which affect germination and emergence. Furthermore, in field trials taken to yield (essential information for crop safety), seed should be free from seed-borne diseases which adversely affect yield. N.B. It is important that all crop safety work should include the normal (N) recommended dose. For products where any adverse effects, however transitory, have been seen in trials at N dose, the margin of selectivity on the target crop must be established using twice the normal (2 N) dose. Doses less than twice the recommended dose should only be used where there are physical loading problems in applying the 2 N dose.

Germination

Evidence is required on the affects of seed treatment on seed germination in standard germination tests. Protocols specifying standard test procedures and assessment methods for various crop seeds are provided in the International Rules for Seed Testing (Anon., 1985). These standard tests may be supported, where necessary, with data obtained in standard soils or growing media. Normally, evidence of satisfactory germination is required from tests on a minimum of three common cultivars of each crop. Each test should consist of four replicates, each of 100 seeds.

Field emergence

Although, germination tests under controlled, artificial conditions are very challenging to a chemical seed treatment, evidence of satisfactory field emergence, which is the most important parameter for the farmer/grower, must also be demonstrated. Data may be provided using 1.0 m² plots (or larger) and records should provide comparisons with controls and standards, not only in terms of final crop stand but also speed of emergence.

Crop Vigour

Information is required on the subsequent growth and vigour of the plants. This may be done using a visual scoring system relative to untreated controls and standards. If early vigour is adversely affected by a seed treatment it is most important to provide evidence as to whether or not the treated crop recovers or gains in vigour compared with untreated and standards and the period of time over which this occurs.

Selectivity

As well as information on crop vigour, it is most important to assess the incidence and/or severity of any phytotoxic effects. It is essential that the symptoms measured and recorded are described accurately. In the absence of any observable effects, it should be clearly stated that this was the case.

Crop Yield

Evidence must be provided to show that a seed treatment does not adversely affect yield in the absence of the pest or disease. Clearly, as far as possible seed should be used which is free of seed-borne problems which affect germination, emergence and vigour of the crop. Trial design and dimensions must be suitable for yield comparisons.

Taint testing of treated crops

The requirement for taint data will depend upon the crop. Such data are normally only required for root crops e.g. carrots and radishes. However, because certain preservation processes can be sensitive to the formation of taints, discussion with the specialists, such as, Campden Food and Drink Research Association, is advised.

There are accepted procedures and numbers of taint trials required depending upon whether the crop or process is considered a major one for the food industry. Guidance on the general requirements for taint testing is given in Working Document 10/5 of Data Requirements for Approval under the Control of Pesticides Regulations, 1986 (Anon., 1986b).

Safety to following crops

Evidence or a reasoned case is required to demonstrate safety to following crops. In many instances, a case may be made for the safety to following crops based on evidence from fate and behaviour studies and results from crop screening studies.

Assessment criteria

Germination above the minimum required under the various Seeds Regulations is taken to be 'satisfactory' e.g. >85% for cereals.

For all other aspects of crop safety (emergence, vigour, selectivity, yield and quality, including, where relevant, taint), there must be no unacceptable adverse effects on treated plants or to following crops, except where the proposed label indicates appropriate limitations of use.

Biological compatibility with other seed treatments

Where the proposed label claims include recommendation for use of the product in combination with other products, whether the product is applied at the same time or before/after any other product(s), the principles for demonstration of satisfactory effectiveness and crop safety must be satisfied.

Effectiveness

In practice, evidence of effectiveness of both tank-mix / co-applied products, may often be extrapolated from evidence of satisfactory loading of active ingredients in both products.

Crop safety

Evidence of crop safety of tank-mixes or co-applications of products may often be limited to demonstration of satisfactory germination and field emergence.

Storage of treated seed

In cases where treated seed will be stored before use, the principles for demonstration of satisfactory effectiveness and crop safety after an appropriate period of storage must be satisfied. Treated seed should be stored in conditions approximating to commercial practice, e.g. in paper sacks and at ambient temperatures. The period of storage should reflect the length of time for which seed would normally be stored e.g. for most crops, 18 months should be sufficient to cover the event that sowing was missed and seed will be retained for use in the following season.

Effectiveness

In practice, evidence of effectiveness following storage, may often be extrapolated from evidence of satisfactory retention of active ingredients on stored, treated seed.

Crop safety

Evidence of crop safety following storage may often be limited to demonstration of satisfactory germination and field emergence.

PHYSICAL/MECHANICAL DATA REQUIREMENTS

Achieving and maintaining target dose

The data for a seed treatment product must cover two distinct areas. They are: (a) satisfactory retention of the chemical and physical properties of the seed treatment product in its container and (b) achieving the correct loading of seed treatment onto seed and maintaining the required loading to the point of sowing by the user. Requirements for evidence of satisfactory retention of the chemical and physical properties of the seed treatment product in its container, have already been covered in 'Guidelines for Formulation and Storage Stability Requirements for UK Registration' (Anon, 1993).

Scale and scope of trials

In general, at least one test should be carried out on seed from each crop (e.g. wheat, barley and oats) or crop group (e.g. brassicas) on which the product is proposed for use. Alternatively, the applicant may make a fully detailed case for the extrapolation of data from one seed type to another. Currently, there are few recognised standard methods for the tests described. Details of any method used should be submitted in full and include an assessment of the precision of the method.

Evidence must be provided to demonstrate satisfactory loading of the product on the seed when treatment is made by commercial seed treatment machinery. Evidence from small scale machines may be accepted *in lieu* of full-scale commercial machinery but because different seed treatment machines (both commercial and small scale) employ different mechanisms it is advisable to test a seed treatment using at least one commercially available seed treatment method. This is especially important should preliminary small scale testing show any suggestion of possible formulation/machinery problems.

Information must include actual results of the active ingredient(s) loading and observations on the uniformity of seed treatment distribution between seeds. Tests should be performed before and after storage of the product. Storage regimes should comply with those listed in 'Guidelines for Formulation and Storage Stability Requirements for UK Registration' (Anon., 1993).

A method for the determination of the uniformity of distribution of liquid seed treatment formulations is currently under consideration by the Collaborative International Pesticides Analytical Council (CIPAC).

Test results of studies are required to establish the retention of the seed treatment product on seed after treatment. Tests for adhesion by means of standard 'drop' tests have been used commonly (Jeffs, 1974; Maude *et al*, 1986; Suett & Maude, 1988; and Anon., 1980).

Assessment criteria

The suggested minimum retention of active ingredient(s) is 70% of the initial target dose.

Physical compatibility with other seed treatments

Evidence of satisfactory loading is required where the proposed label claims include recommendation for use of the product in mixture with other products, whether the products are applied simultaneously or sequentially.

Seed drill tests

Evidence must be provided to demonstrate the satisfactory flow of treated seed through the relevant seed drill mechanism(s) available commercially. Comparison should be made with untreated and standard treated seed from the same batch.

Stored treated seed

In cases where treated seed will be stored before use, evidence is required on the effect of storage on seed treatment retention. Alternatively, a case for satisfactory retention of active ingredient(s) may be made based on the biological effectiveness of the product.

Treated seed should be stored in conditions approximating to commercial practice e.g. in paper sacks and at ambient temperatures. The period of storage should reflect the length of time for which seed would normally be stored e.g. for most crops, 18 months should be sufficient to cover the event that sowing was missed and seed will be retained for use in the following season.

Assessment criteria

The suggested minimum retention of active ingredient(s) after storage of treated seed is 70% of the initial target dose.

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RESEARCH-BASED IMPROVEMENTS IN THE REGULATION OF HAZARDS TO WILDLIFE FROM PESTICIDE SEED TREATMENTS

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ABSTRACT

This paper reviews the essential role of scientific research in evaluating and improving the regulation of hazards to the environment from seed treatments. Examples are given of ways in which research is improving methods of risk assessment, risk management and environmental monitoring. This helps to ensure that the regulatory system provides proper protection for both crops and the environment, without the need for unnecessary testing or undue expense.

INTRODUCTION

The formulation of pesticides as seed treatments has a number of advantages, compared to spraying or the broadcasting of pellets or granules. The chemical is concentrated on the seed which it is intended to protect, maximising its efficiency in controlling the target organism. Many of the potential risks to the user and the environment are reduced. However, the concentration of the chemical on what may be an attractive food item can present special risks to certain types of wildlife. There is a history of poisoning incidents involving grazing and seed-eating birds (Stanley & Bunyan, 1979; Greig-Smith, 1988a) which ensures that the risks to these species receive particular attention in the evaluation of seed treatments for regulatory approval. This paper reviews the contribution which research can make to improving the regulation of environmental risks, through developments in methods of risk assessment, risk management and environmental monitoring.

CURRENT REGULATORY PRACTICE

The UK regulatory system includes three components: risk assessment, risk management and environmental monitoring. The first two of these are closely interlinked, and are the responsibility of the Pesticides Safety Directorate (PSD) of the Ministry of Agriculture, Fisheries and Food (MAFF). Companies requesting approval of a pesticide submit data on its toxicity to non-target organisms including mammals, birds, aquatic organisms, non-target arthropods, honeybees, earthworms and soil micro-organisms. The data are evaluated by PSD specialists who then identify hazards to non-target organisms and assess the risks of those hazards being realised, taking into account the type of use proposed for the pesticide. Additional data will be requested if they are necessary to provide a sound basis for decision-making. Where the predicted risks are considered unacceptable, the proposed use may be modified to reduce them.

Guidance for risk assessment has recently been published by an expert panel under the auspices of the European and Mediterranean Plant Protection Organisation (EPPO) and the Council of Europe (CoE). This comprises decision-making schemes in the form of questionnaires, based on up-to-date developments in the science of risk assessment (EPPO/CoE, 1993). The EPPO/CoE schemes are compatible with the approach outlined in the final draft Uniform Principles in Annex VI of the European Community Directive 91/414/EEC. The schemes relating to terrestrial vertebrates, earthworms, honeybees, soil processes and beneficial non-target arthropods have been adopted for use by PSD, with modifications where necessary for consistency with existing PSD practice. PSD currently uses its own assessment procedure for risks to the aquatic environment, which is similar in concept to the corresponding EPPO/CoE scheme.

It is often assumed that seed treatments present a low risk to the environment compared to other pesticide applications. However, exposure cannot be ruled out, so the risk must be assessed and cannot be regarded as negligible. The risks are generally greatest for mammals and birds, and data may be required on the palatability of treated seed or seedlings. Risk to honeybees is likely to be low unless the product is both systemic and persistent, so that significant concentrations appear in nectar or aphid honeydew. Risks to the aquatic environment are also likely to be low, unless the pesticide is both mobile and persistent in soil, or unless treated seed is to be broadcast in fields adjacent to water bodies.

The third component of regulation is post-registration monitoring. In England and Wales, MAFF operates the Wildlife Incident Investigation Scheme (WIIS) to monitor the mortality of honeybees and vertebrate wildlife (Fletcher & Grave, 1992). Cases which appear to be related to pesticide use are investigated by means of field investigations, post-mortem examinations and laboratory analyses. The scheme serves three main purposes. First, it acts as a safety-net to detect mortality which was not anticipated by risk assessment prior to approval. If the actual level of risk is revealed to be unacceptable, then the Advisory Committee on Pesticides may recommend withdrawal or modification of approval. Second, the scheme provides evidence for use in prosecution, when poisonings have resulted from the abuse or misuse of a pesticide. Third, it provides data on actual risks which can be used to validate and improve risk assessment methods.

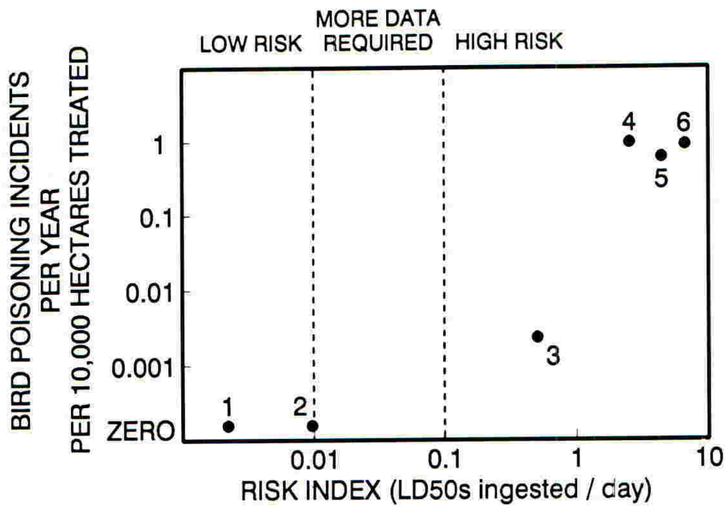

FIGURE 1. Validation of predicted risks to birds feeding on treated wheat seed, by comparison with the frequency of poisoning incidents recorded by the UK Wildlife Incident Investigation Scheme. Key to pesticides: 1, methoxyethyl mercury acetate; 2, phenyl mercury acetate; 3, lindane; 4, carbophenothion; 5, chlorfenvinphos; 6, fonofos. Dotted lines indicate the thresholds used for the initial classification of risk using the EPPO/CoE guidelines (EPPO/CoE, 1993): intermediate values usually lead to a requirement for additional data to refine the estimate of risk.

VALIDATION OF RISK ASSESSMENT METHODS

An essential and central element of research to improve regulatory procedures is the evaluation of current methods, to identify those areas in need of improvement. Risk assessment procedures should be both reliable and efficient, providing proper protection for wildlife without unnecessary testing or undue expense. Reliability can be assessed by comparing the predictions, which risk assessment produces, with data on the actual effects of pesticides in normal use. This approach has been described by Hart & Greig-Smith (1992) and has been applied to aspects of the EPPO/CoE decision-making schemes. For example, in the EPPO/CoE scheme, predicted risks to seed-eating birds from seed treatments are based initially on a risk index which estimates the number of lethal doses a bird would ingest in a day if it fed exclusively on treated seed. This risk index may be validated by comparison with data from the WIIS on the frequency of poisoning incidents involving seed treatments, expressed as a function of usage to take account of differences in the areas of land sown using the different pesticides. Results for seed treatments used on wheat show good agreement between predicted and observed risks, although the number of pesticides for which the comparison can be made is rather small (Figure 1). To complete the validation this comparison will be extended to include other crops and other types of hazard, such as that to birds grazing on seedlings.

INVESTIGATION OF BIASES IN INCIDENT MONITORING

Confidence in the regulatory system depends on the reliability of the incident monitoring scheme as well as the risk assessment procedures. The WIIS has been effective in identifying some unacceptable risks to birds and honeybees, resulting in the modification of approvals for the pesticides involved (eg. Stanley & Bunyan, 1979). However, it has been recognised for some time that only a proportion of casualties are reported to the scheme, and that the probability of reporting is likely to be lower for smaller, less conspicuous species (Greig-Smith, 1988b; Hart, 1990; Figure 2 below). MAFF has therefore funded research by the British Trust for Ornithology (BTO), in collaboration with the Central Science Laboratory, on the factors which may affect reporting rates (Baillie *et al.*, unpublished manuscript). Reporting probabilities were estimated using data on the recovery of dead or dying birds reported to the BTO ringing scheme. Probabilities for 99 species varied by over two orders of magnitude, from 0.06% for the chiffchaff (*Phylloscopus collybita*) to 16.75% for mute swan (*Cygnus olor*). Eighty-six percent of the variation in reporting rates was explained by a curvilinear relationship with body weight, confirming that small inconspicuous species are much less likely to be reported. This bias should be taken into account when interpreting data on pesticide casualties recorded by the WIIS. Consideration is now being given to how this should be done.

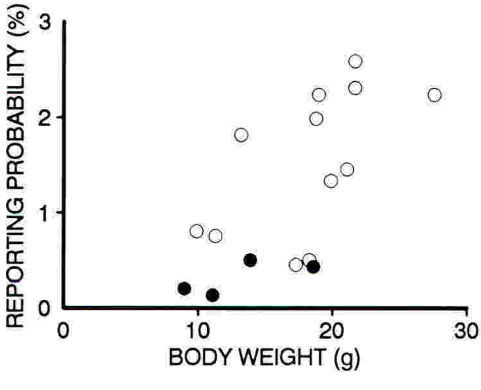

FIGURE 2. Relationship between body weight and the probability that dead birds will be reported to the BTO ringing scheme (reproduced from Hart, 1990). Each point represents one passerine species: open circles represent residents, closed circles represent summer visitors.

INVESTIGATION OF EFFECTS AT POPULATION LEVEL

The reporting rates for pesticide casualties are likely to be lower than those estimated from ringing data, except when large numbers occur in a single incident, because the estimates are based on birds marked with a leg ring bearing an address for reports. Therefore the relationship between the frequency of reported incidents and the true level of mortality in wild populations remains uncertain. This relationship needs to be understood because of the importance of the incident scheme as a safety net, and as a means of validating risk assessments. Research is therefore underway to estimate the level of pesticide-related mortality in a wild population of woodpigeons (*Columba palumbus*) in an area of Cambridgeshire where there is extensive use of fonofos, and more limited use of chlorfenvinphos, as seed treatments for winter wheat. Radio-tracking techniques are used to monitor a large sample of birds, and those which die are recovered for autopsy and residue analysis. This will provide an estimate of the contribution of these pesticides to overall mortality, which can then be compared to estimates based on data from WIIS for the same pesticides. Together with the analysis of reporting rates for ringed birds, described above, this will provide a greatly improved basis for regulatory decisions about the ecological significance of pesticide casualties.

INFLUENCE OF REPELLENCY IN THE WILD

The ability of birds to detect and avoid food contaminated with pesticides has been demonstrated in laboratory studies, and such studies are increasingly being used to argue that exposure will be limited in the wild (Grau *et al.*, 1992; Avery *et al.*, 1993). However, it has yet to be demonstrated conclusively that low palatability in the laboratory is a reliable indicator that a formulation will be avoided in the wild. Research is therefore being conducted to investigate the occurrence and significance of avoidance behaviour by woodpigeons in relation to the use of seed treatments, in conjunction with the radio-tracking study described above. This includes systematic observations of the behaviour of woodpigeons visiting fields of wheat sown with different seed treatments. Preliminary results indicate significant differences between the treatments, though differences in feeding rates are difficult to interpret (Hart *et al.*, unpublished). Most substantial are the differences in the proportion of time spent with the head withdrawn, a posture which is often adopted by resting birds but which is also symptomatic of intoxication with organophosphorus pesticides (Hart, 1993). On the first day after drilling, increased time was spent in this posture by birds on fields treated with fonofos, but not for chlorfenvinphos (Table 1). It is possible this may be related to the fact that fonofos is microencapsulated, whereas chlorfenvinphos is not. Our studies are continuing to confirm and elucidate this result, and to assess directly the relation between the repellency of seed treatments in laboratory and field. The results will provide a much improved basis for regulatory decisions in risk assessments involving evidence of repellency.

TABLE 1. Percentage of time spent in head-withdrawn posture by woodpigeons observed on fields of winter wheat sown with different seed treatments. The difference between fonofos and the other treatments is statistically significant (regression analysis, $F_{1,6}$ = 23.6, P = 0.003). There is a significant interaction between fonofos and days after drilling ($F_{2,6}$ = 10.9, P = 0.01), reflecting the fact that the difference is largely restricted to the first day after drilling.

Days after drilling	1	2	3	4
Untreated	0	-	11.9	-
Fungicide only	6.0	13.3	2.6	0
Fungicide plus chlorfenvinphos	0	7.5	-	-
Fungicide plus fonofos	32.2	11.8	6.0	-

RISK MANAGEMENT

Risk management techniques are important in enabling regulators to approve the use of products which, while offering substantial advantages to the grower, would otherwise present an unacceptable risk to wildlife. Research has a major role to play in developing new risk management techniques, and ensuring the reliability of existing ones. Current risk management for seed treatments includes general precautions imposed by the Code of Practice for the Safe Use of Pesticides on Farms and Holdings, which has statutory force in Great Britain. The Code includes a general requirement to take reasonable precautions, including preventing contamination of non-crop land. There is also a specific requirement to clear up or cover any treated seed which is spilt. In addition, the approval of particular seed treatments may include label instructions specifying that the seed should be incorporated into the soil, as opposed to being broadcast on the surface where they would present greater risks to birds and other wildlife. Some organophosphorus seed treatments, which are highly toxic to birds, are approved for sowing only in autumn. This is because in spring birds are thought more likely to concentrate their feeding on newly-sown crops, as the availability of other foods is reduced. Depth of drilling is recognised as a factor which may influence risk to birds, but label instructions for organophosphorus wheat seed treatments specify drilling depths designed to maximise germination. Research could be conducted to investigate whether significant reductions in risk could be obtained by increasing drilling depth, without causing unacceptable reductions in germination. Adding colourings or flavourings which reduce the attractiveness or palatability of treated seed may also provide a means of improving risk management, and has already been the subject of some research (eg. Greig-Smith, 1988a).

CONCLUSIONS

The examples which have been presented illustrate the importance of scientific research in evaluating and, where necessary, improving the reliability and efficiency of methods used for risk assessment, risk management and environmental monitoring. Substantial progress has been made already, through the efforts of regulators, scientists and industry, both in the UK and abroad. Continued progress will help to ensure that the regulatory system provides proper protection for both crops and the environment, without the need for unnecessary testing or undue expense.

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OPERATOR EXPOSURE DURING SEED TREATMENT

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ABSTRACT

Operator exposure to pesticides and other hazardous substances may occur at various stages during the seed treatment process. The paper discusses the potential for exposure during both mobile and static seed treatment operations and the measures taken to control it.

INTRODUCTION

Operator exposure to pesticide may occur at any stage in the seed treatment cycle. That exposure, together with exposure to other hazardous substances, such as dust and micro-organisms needs to be assessed. Although the main focus of the paper is exposure to pesticides, the Control of Substances Hazardous to Health Regulations (COSHH) 1988 apply to all substances and to all stages in the procedure, from reception of the pesticide to dispatch of the treated seed and disposal of the pesticide container.

Both hazard and risk should be considered. The collection and filing of chemical data sheets is just the beginning! The actual risk of exposure to pesticide during each constituent operation must be actively assessed, the assessment acted upon and the situation regularly reviewed.

The Control of Pesticides Regulations 1986 (made under the Food and Environment Protection Act 1985) are the principal Regulations concerned with pesticides and apply in addition to COSHH. It is a duty under these regulations that users of seed treatment equipment who were born after 31.12.64 or those treating seeds as contractors have National Proficiency Test Council Certification (NPTC). Some farmers treat their own seed with or without assistance of their families or employees. Provided these operators were born after 31.12.64 or are working under the direct supervision of a certificate holder they will not require a certificate. Those involved in the sale, supply and storage for supply of seed treatment chemicals (classed as agricultural pesticides) need British Agricultural Standards Inspection Scheme (BASIS) certification. Presently approved pesticides are exempted from classification and labelling for supply under the Classification, hazard, information and packaging (CHIP) regulations.

HOW AND WHEN DOES EXPOSURE OCCUR?

The potential for exposure must be assessed during both routine and non routine operation. The routes of exposure ie inhalation (of vapour, dust and aerosol) and skin absorption should be considered at all stages. Key activities during routine operation can be identified as follows;

Reception of pesticide

Transport of pesticides on mobile treaters

Moving pesticide from store to treatment equipment

Introduction of pesticide into seed treatment equipment

Calibration

Application of pesticide to seed

Any adjustments to calibration or change over of chemical during treatment

Bagging

Sampling

Disposal of container and waste

The next step is to identify the actions of the operator during each of these activities and the ways in which exposure may result from these.

Non-routine operations include handling events such as breakdown or spillage and machinery maintenance. Unusual or small batch treatment may bring in to use otherwise little used plant which due to age and design may have inferior standards of control than other frequently used plant.

Persons carrying out maintenance or cleaning of the plant must be aware of the potential for exposure to organic dust and pesticide. This is important for those involved in changing filters, stripping plant or any other activities involving direct contact with surfaces that may have pesticide on them. Pesticide build up may occur on areas that are not normally accessed eg inside machinery housings and dust containing pesticides may be generated when these are dismantled. Better machine design should reduce the amount of pesticide and seed build up that occurs on internal surfaces. In order to maintain genetic purity of batches of seed, plant is generally cleaned out prior to a different type of grain being treated. Large tonnages of the same genetic type of grain may be treated successively but a variety of pesticides may be used. This means that when the plant is eventually cleaned out, exposure to other pesticides as well as the last one used must be considered. If cleaning and maintenance is carried out by outside contractors, it is the responsibility of the employer to ensure that the contractors are aware of the risks that they may be presented with.

FACTORS INFLUENCING EXPOSURE

Factors to be taken into account when assessing exposure include the likelihood of exposure occurring, the duration and frequency of exposure and the consequences of that exposure. The likelihood of exposure depends on the physical form of the pesticide and the method of handling. The consequences depend on the toxicity of active ingredient and of any solvents present and the duration of exposure. It must also be borne in mind that seed treatment chemicals, unlike most other pesticides which are applied in a dilute form, are mainly used in their concentrated form. Climatic conditions, eg increases in temperature which can influence the rate of volatilisation of the product and also the suitability of some personal protective equipment (ppe) must also be considered.

Companies who undertake COSHH assessments centrally should be aware of regional variations in treatment regimes. For example the use of organophosphorous products against wheat bulb fly which occurs only in certain regions may require biological monitoring for those workers.

CONTROL OF EXPOSURE

After elimination or substitution and enclosure the next choice of control in the COSHH hierarchy is engineering controls (use of personal protective equipment is a last resort). More effective engineering controls especially at the design and build stage mean less reliance on ppe and given that the conditions in seed treatment are often hot and the work physically hard, anything that avoids the operators being burdened with ppe is beneficial. As old plant is phased out or modified reliance on ppe for control should reduce.

The extent to which local exhaust ventilation (lev) is used varies. On both mobile and static plant it is applied at the grain cleaning stage for dust removal and on most static plants at the pesticide application stage. Some mobile treaters have lev at the application stage. Mobile treaters have the advantage of more natural ventilation provided that this is managed properly. One of the elements of NPTC is to ensure that the mobile is positioned so that the wind takes away pesticide and dust rather than blowing it onto the operator.

It is essential that the exhaust from these controls is either collected in a suitable collection device or that particularly in the case of mobile units, where direct dispersal to atmosphere is more likely, the hose from the fan is long enough not to return dust to the work area.

Setting up and calibration

When introducing pesticides to the treater, exposure to pesticide can occur when removing lids and inserting bungs, tubes etc or in the case of powders when the powder is fed into the treatment equipment. Engineering controls such as 'snap on' attachments with non drip seals and valves and specially designed lids have been developed with the aim of making connection much cleaner and easier. Careful handling is also important. Treatment plants with large throughput are able to use bulk containers and multi product applicators which reduce the number of times that handling is necessary. Often, simple improvements such as having pipes short enough so that they are easy to handle and result in less splashing will reduce exposure. If containers are well sealed entry of contaminants that cause blockages will be avoided as will the need for filters that require cleaning.

However, leaks, spills etc may still occur during setting up or calibration and as it is a concentrate that is being used it is therefore essential that gloves, faceshield and suitable respiratory protection are worn.

It may be necessary to wash the plant with both solvent and water when using certain products. Care must be taken to avoid contact with the solvent as well as the rinse water.

Application of pesticide to seed

During the actual treatment, unless the machine has to be entered to clear blockages (in which case ppe must be used), exposure to pesticide and dust is generally prevented or controlled due to the enclosed nature of the process. However, the plant must be maintained in good condition to prevent emission from seals and joints.

Bagging

The ideal system is where bagging is performed by automatic means. However where such facilities are not available, exposure both by inhalation and skin absorption to pesticide at the bagging stage can be reduced by ensuring that the seal between the mouth of the bag and the chute is good. Also the use of good techniques, for example when closing the bag folding it away from the operator, can reduce exposure to any pesticide contamination that may come up off the treated seeds. It must also be borne in mind that if a final visual check of treatment is given by looking into the bag, exposure to pesticide by inhalation could occur. Bags of differing sizes may be used so that an adequate seal cannot be made, in this case suitable respiratory protection may be necessary. If the sticher fails and improperly sealed bags are thrown onto the pallet, grain spillage results. Precautions must be taken when cleaning up because at this stage the grain is still not dry and the pesticide would easily be removed from the seed by handling.

Cleaning and maintenance

Since primary control methods are usually not applicable during these activities personal protective equipment (ppe) must be worn by those working on the plant (if it is still contaminated) and also by those carrying out the cleaning. Items such as respiratory protection, gloves and faceshield will probably be necessary during both routine and reactive maintenance.

CHOICE OF PERSONAL PROTECTIVE EQUIPMENT

Because ppe plays such a major role in controlling exposure it is important to ensure that it is chosen, used and maintained properly. Training in these aspects is a crucial part of an effective ppe strategy.

At present the approved pesticide label does not specify the actual type of ppe to be used except in broad generic terms. The choice depends on the pesticides in use and this should take into account both the active ingredient and the solvent in the product. The comfort and other individual requirements of the user eg beard, facial size and shape must also be considered. Equipment must also be suitable for the job, for instance gloves must not be made so unwieldy either by their size or material of construction that it is not possible to undertake the job. Gloves suitable for use when cleaning out the plant may not be suitable for use when dismantling pumps.

Advice should be sought from distributors and manufacturers of the pesticide. In many cases more detailed guidance on the specific types of ppe appropriate to that product can be found either on a non-approved section of the product label or in the safety data sheets provided to the seed treatment facility. Respiratory protection should be chosen to protect against dust and organic vapours where appropriate.

It is also essential that the ppe is used, stored and maintained properly ie away from sources of contamination when not being used. When gloves become contaminated they should be washed on the outside before removal. If this is not possible they should then be removed carefully to prevent contamination of hands with any residue that may remain on the gloves. Flock linings may be comfortable but should be avoided as these are difficult to decontaminate.

Overalls should be worn to protect clothing and skin. It is essential that overalls are kept clean because absorption of small doses may occur if there is repeated contact with contaminated clothing.

Arrangements should be made for cleaning, storage, maintenance and regular examination of respiratory protective equipment. Some disposable ppe is designed for more than one shift use and also requires examination and possibly maintenance.

Good washing facilities and eyewash are important to deal with any accidental contamination.

CONCLUSIONS

Exposure during routine operation of seed treatment equipment can be and is being controlled by engineering means backed up by the personal protective equipment. More reliance is placed on the use of personal protective equipment to control non-routine exposure. Control of exposure has to be underpinned by training (both formal and informal) in the use of all control measures and importantly the correct choice, care and maintenance of ppe.

REGULATORY CONTROLS ON FUNGICIDAL CEREAL SEED TREATMENTS - PAST EXPERIENCE AND FUTURE PROSPECTS

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ABSTRACT

The development of non-mercurial cereal seed treatment products and seed treaters has progressed in the Federal Republic of Germany since the ban of mercury in plant protection in 1982. Problems and trends in chemical treatment of cereal seed against fungal diseases since the change-over are described.

INTRODUCTION

Testing and authorization of plant protection products has been mandatory in the Federal Republic of Germany since 1968. Seed treatments are an important group of these products. The Biologische Bundesanstalt (BBA) is responsible for the authorization of plant protection products in Germany. In the former German Democratic Republic the situation as to seed treatment products was different up to October 1990 and is not described here.

Seed treatment of cereals (wheat, barley, rye and oats), in particular to control seed-borne fungal diseases, is one of the most effective forms of chemical plant protection. The quantities of products required are small, thus minimizing the environmental risk. Chemical treatment of cereal seed, especially basic and certified seed, is carried out as a routine precautionary measure. Like most European countries Germany has strict regulations on cereal seed which make seed treatment necessary, because certain seed-borne fungal diseases (e. g. *Ustilago* and *Tilletia spp.*) cannot be controlled by fungicides applied later to the growing crop.

The use of mercurial seed treatments has been prohibited since 1 May 1982. The main reason for the ban was their toxicity to users. The only significant environmental hazard concerned the danger to bird species eating treated seeds. The development of mercury-free products was boosted by the ban, resulting in a substantial increase in the number of authorized products. It was only after this ban came into force that mercury-free products for cereal seed began to be used on a large scale. But the change-over caused some problems concerning these products and their application in seed treatment machinery. The problems and consequences are described.

PRODUCTS FOR CEREAL SEED TREATMENT

These products should be effective, not phytotoxic to cereals and not hazardous to man, wildlife (especially seed-eating birds) and the environment. In addition they should be easy to apply and adhere strongly to the seed. These prerequisites have to be fulfilled and be proved by submitting sufficient data together with the application form for authorization.

Table 1 shows the range of ingredients in authorized cereal seed treatment products and their fungicidal activity (situation 1993).

In contrast to mercury compounds many non-mercurial ingredients are systemic. Products containing such ingredients are also effective against loose smut (*Ustilago nuda*) of wheat and barley as well as foliar diseases (e. g. *Erysiphe graminis* on young plants) which cannot be controlled by mercury. But the risk of resistance to fungal diseases using mercury-free products is higher than that of mercury. Non-mercurial products often contain more than one active ingredient in order to match or exceed the fungicidal efficacy of mercury and to prevent resistance. Mercury-free ingredients have a lower vapour pressure than mercury compounds. So vapour movement of such ingredients as a factor of distribution within treated seed batches can be neglected. The amount of products needed for disease control is usually higher than that of mercury-based products (300 - 500 ml or g/dt seed instead of 200 - 300 ml or g/dt).

Cereal treatments are liquid or dry formulations. Mainly liquid formulations are used for fungicidal treatment of cereal seed in Germany. They are based on water or an organic solvent. Preference is given to waterbased products (FS) because solventbased liquids (LS) are more difficult to apply than FS-formulations due to the quick evaporation of the solvent. The adhesion of LS-formulations is so fast and their viscosity so low that no secondary distribution during mixing occurs. It is, therefore, crucial to achieve optimum distribution and most uniform loading of each seed at this first meeting between seed and product.

Powder formulations (DS) are easier to distribute from seed to seed than liquid ones. But their disadvantages can be insufficient adhesion to the seed and occurrence of dust during treatment and handling of seed. Addition of a sticking agent during application helps to overcome these adverse effects. Certain new sophisticated powder formulations for cereal seed treatment have been authorized in Germany without these disadvantages, but overall the trend is against powder treatments.

Water dispersible powders for slurry treatment (WS) are as to their physical properties (adhesion and distribution) similar to FS-formulations. However during preparation of the slurry dust may be generated. The importance of slurries for cereals is limited.

TABLE I. Ingredients in authorized cereal seed treatment products and their fungicidal activity.

INGREDIENTS	WHEAT							BARLEY						RYE			OATS	
	Tilletia caries, *T. tritici* (bunt)	*T. controversa* (dwarf bunt)	*Ustilago nuda* (loose smut)	*Fusarium nivale* (snow mould)	*F. culmorum* (seedling blight)	*Septoria nodorum* (seedling blight)	*Erysiphe graminis* (powdery mildew on young plants)	*Drechslera graminea* (leaf stripe)	*D. teres* (net blotch)	*Ustilago spp.*	*Fusarium nivale* (snow mould)	*Rhynchosporium secalis* (leaf blotch)	*Erysiphe graminis* (powdery mildew on young plants)	*Urocystis occulta* (stripe smut)	*Fusarium nivale* (snow mould)	*Erysiphe graminis* (powdery mildew on young plants)	*Ustilago avenae* (loose smut)	*Drechslera avenae* (seedling blight)
Bitertanol	x	x	x	x										x	x		x	
* Carbendazim	x		x	x											x		x	
* Carboxin			x							x							x	
Difenoconazole	x	x	x			x												
* Ethirimol													x					
* Fenfuram										x								
Fenpiclonil	x			x	x	x					x			x	x			
* Fuberidazole				x							x							
* Guazatine	x			x										x	x			
Iprodione				x				x							x			
* Imazalil								x	x									
Metsulfovax	x		x							x				x				
Nuarimol										x	x		x					
Prochloraz	x			x	x			x	x					x	x			x
Propiconazole	x			x											x			
Tebuconazole																	x	
Triadimenol	x		x	x			x			x		x	x	x	x	x	x	
Triaxozide								x										

* Ingredients in authorized cereal seed treatment products when mercurial treatments were banned (1 May 1982). These products are still authorized.

DATA REQUIREMENTS FOR SEED TREATMENT PRODUCTS

The amended German Plant Protection Act of 15 September 1986 provides the legal basis for demanding more data mainly on environmental effects of plant protection products and on the application machinery. That is why the range of this type of testing has been extended considerably in recent years.

Applicants seeking authorization for cereal seed treatment products have to

- describe the composition of the product, the content of active ingredient(s) and formulants and the physico-chemical properties of the product and its active ingredient(s) (e. g. vapour pressure, solubility in water, log Pow),
- specify the use pattern of the product (fungal pathogens, cereal species, recommended rate of application - and the minimum effective dosage, i. e., the lowest dose rate for sufficient disease control; if required the amount of water for some liquid formulations or the amount of sticking agent for powders, application technique),
- describe the mode of fungicidal action of the active ingredient(s),
- provide information on the susceptibility of the product to the development of resistance to pathogens.

In addition to this the applicants have to submit sufficient data on

Efficacy:
The trials are carried out by the companies themselves and on their behalf by the official plant protection stations of the federal states throughout Germany in order to obtain a balanced proportion of test reports from industry and official bodies (Ehle and Menschel, 1993).
Snow mould resistance on an economically significant extent to carbendazim and fuberidazole was recorded after seed treatment in winter wheat and winter barley after the severe winter in Northern Germany early in 1979 shortly after snow melting. Whereas mercury treated wheat and barley had little snow mould attack. Consequently, efficacy trials have been more stringent ever since and are carried out mainly with winter cereal seed infected with methyl 2-benzimidazole carbamate (MBC) resistant strains of *Fusarium nivale*.

Phytotoxicity:
Effects of seed treatment on germination, seed vigour and damage to seedlings are tested in the laboratory or glasshouse. If efficacy trials are conducted in the field, phytotoxicity of seed treatment products to cereal seedlings is also assessed. It is a well-known fact that some active ingredients especially triazoles (e. g. triadimenol) may affect crop emergence under unfavourable conditions during germination. Effects of seed treatment on germination and phytotoxicity are usually more pronounced in the field than in vitro. However, these effects are mostly transient.

Application properties:

After the ban of mercurials the application properties of fungicidal seed treatments are tested prior to authorization. The tests are carried out in at least one suitable seed treater approved by the BBA. In addition to this seed samples are taken to determine the adhesion of the product by means of an abrasion test. Moreover the quality of treatment (i. e. the ratio of actual to target dose of a product on seed) is measured by quantitative colourimetric single seed analysis. Measurements of extracted dye from treated seed are related to the amount of product on seed. They are possible because all fungicidal cereal treatments contain a distinct dye. This range of tests for a new product is carried out by the applicant or an official plant protection station. The BBA conducts additional laboratory tests with new products prior to authorization. Cereal seed is treated in laboratory treaters either in the "Hege 11" or in the "Mini-Rotostat" which can apply liquid and dry formulations equally well as commercial treaters. Both treaters are described by Jeffs and Tuppen (1986). These further studies concern the properties of products as to adhesion and the seed to seed uniformity of distribution.

Toxicity:

Full toxicity data must be available for all compounds in seed treatment products. The authorized non-mercurial fungicidal cereal seed treatments are classified as non-toxic. But some furan compounds (e. g. methfuroxam) caused cancerogenic effects on these rodents in long-term studies. Seed treatments containing these compounds are not authorized any more for that reason.

Residues:

Residue behaviour after fungicidal seed treatment is investigated in the growing crop and later on in straw and grain. Residues exceeding maximum residue levels are usually not found in straw and grain.

Soil:

Information required includes studies on adsorption / desorption, degradation and metabolism of the active ingredient(s) and on leaching of the product.

Water:

Hydrolysis of the active ingredient(s) is studied.

Non-target organisms such as

Birds:

Studies on the acute toxicity of seed treatments to Japanese quail and if necessary also to another species (e. g. pigeons or pheasants) are required. In addition to this palatability tests are necessary for products being toxic to birds in order to study their repellency properties on Japanese quail, pigeons or pheasants. Products containing the ingredients listed in Table 1 are not acutely toxic to birds except bitertanol which is moderately toxic only to pigeons.

Aquatic organisms:

Studies on the acute toxicity of seed treatments to fish (mainly rainbow trout) and *Daphnia* as well as the chronic toxicity to algae are required since 1987. Like most plant protection products fungicidal seed treatments are toxic to fish.

Earthworms:

Studies on the acute toxicity of seed treatment products to *Eisenia fetida* are required since 1989. Some fungicidal active ingredients are acutely toxic to earthworms. Carbendazim is one of them. However, up to now there is no evidence that earthworm populations in fields might be affected by fungicidal seed treatments.

Beneficial organisms:

Laboratory studies on the effects of seed treatment products on carabids and staphylinids are required since 1989.

APPLICATION TECHNIQUE AND SEED TREATMENT MACHINERY

There is a very close relationship between the product and the application technique in seed treatment. It is important to achieve uniform distribution of the product over the whole surface of the cereal seed. This is not easy because there may be problems in dosing and distributing the product in the seed treater. It is therefore necessary to consider which treater can be used for a given product.

Mercury containing products were more or less uniform as far as their content of active ingredients and dosages per 100 kg cereal seed were concerned. The non-mercurial products have made higher demands on seed treatment machinery because their physico-chemical properties vary and higher dosages are usually needed for a sufficient disease control.

Some widespread application problems encountered during the change-over to non-mercurials were as follows:
- inadequate flow properties, thus affecting the operation of the treaters and drilling of treated seed,
- some dry formulations had a poor adhesion to the seed and some liquid ones could not be distributed evenly,
- some solvent based products attacked plastic components of treaters,
- treaters frequently had to be adapted for the application of non-mercurials,
- cleaning of treaters had to be more frequent and thorough than after the application of mercurial products (Kohsiek and Jeffs, 1986).

Progress in the development of seed treatment machinery has been considerable since 1982. Most of the commercial seed treaters were tested and approved by the BBA after the ban of mercurials (Table 2, situation 1993).

The procedure of declaration of plant protection equipment includes seed treaters. Since 1 July 1988 such machinery can

TABLE 2. Approved and registered machines used for treating cereal seed.

name of machine (manufacturer)	method of application and mixing process	suitable for type of formulation	output in t/h
approved machines:			
* W.N.-4 (Niklas)	spinning disc and auger mixing	liquid	0.5 - 5
W.N.-7 (Niklas)	spinning disc and auger mixing	liquid and slurry	1 - 7
W.N.-12 (Niklas)	spinning disc and auger mixing	liquid and slurry	2 - 12
W.N.-20 (Niklas)	spinning disc and auger mixing	liquid and slurry	5 - 20
* BA 101-4F (Röber)	spinning disc	liquid	1 - 4
BA 101-8/F (Röber)	spinning disc	liquid	2 - 8
BA 101-12 FD (Röber)	spinning disc	liquid	2 - 12
BA 101-22 FD (Röber)	spinning disc	liquid	4 - 22
GB S 3/F-A (Goldsaat)	mist nozzle and auger mixing	liquid	0.5 - 2
Trans-Mix 45 (Amazone)	auger mixing	liquid and powder	treatment period of 30-60 s for 100 kg
registered machines:			
Macox-S (Mantis)	spinning disc	liquid	2 - 4.5
Feuchtbeizer Typ S.30 (DENIS-PRIVE)	lattice/distributor and auger mixing	liquid	0.3 - 3

* Already approved machines before mercurial treatments were banned (1 May 1982).

only be marketed in Germany "if it is designed such that when it is used correctly and in accordance with its intended purpose for the application of plant protection substances it does not produce any harmful effects on human and animal health or on the groundwater or does not have any other harmful effects, particularly on the environment, which, on the basis of the current state of the art, are avoidable."

Manufacturers, distributors or importers of new plant protection equipment have to declare to the BBA that these requirements are fulfilled and have to supply the declaration with detailed documentation and data. Registration will be granted if the requirements are met. If not, the BBA can demand the testing of the equipment concerned and can even withdraw the registration.

Furthermore according to German plant protection legislation plant protection equipment including seed treaters can be tested voluntarily. Testing is carried out by the BBA and the official plant protection offices of the federal states. It comprises complete treaters. Data on these tests allow an evaluation of the suitability of the treaters. Approval will be granted if they perform well.

Since 1987 the BBA prepares and publishes features for evaluating the maintenance of legal requirements on plant protection equipment including seed treaters.

Important features concerning seed treaters are as follows:

- They have to work reliably to ensure proper dosing and an even distribution of a product on the seed.
- They have to be manufactured in such a way that they can be filled up in a safe manner. Maximum and minimum limits of filling levels in the tanks can be determined easily and products cannot be released unintentionally.
- Full and easy to read dosing instructions have to be fixed at the treaters.
- The dosage of the product has to be adjustable at an easily accessible plaze. The adjustment of metering mechanisms has to be easily visible.
- During treatment the seed and the product have always to be in a correct ratio.
- With continuously working treaters the dosing of the product has to be interrupted automatically when the flow of seed stops and vice versa.
- At the outlet of the treater the product has to adhere to the seed with a tolerance of not more than ± 7 % of the mean value. The mean value must not deviate more than 10 % from the target dose.
- The applied amount of the product on at least 80 % of single seeds must not deviate more than 50 % from the mean value.
- Treaters have to be easy to clean.
- Parts of wear have to be accessible and changeable in an easy way.

LABEL INSTRUCTIONS AND PRODUCT INFORMATION

These contain details as to the application of a product to seeds. Furthermore, authorization is always connected with certain conditions which have to be shown on the label and product information: particulary special warnings and safety precautions in order to avoid damage to man, cereals and non-target organisms such as seed eating birds and fish (in case of accidental water pollution). In addition to this companies supply so-called positive lists in their instructions for use and product information to permit an effective seed treatment under practical conditions. Thus the positive lists for the equipment indicate the treatments for which it can be used. Conversely, the positive lists for the products contain information on suitable equipment with advice on adjustment, maintenance, cleaning etc. These lists are updated regularly to take account of the current situation as to seed treatment machinery and authorized products.

POST-AUTHORIZATION MONITORING OF SEED TREATMENT PRODUCTS

Because of the great diversity of factors which affect fungicidal cereal seed treatment, problems may develop in commercial use of these products. For this reason new products are monitored by the companies themselves and the official plant protection stations throughout Germany after their authorization as to factors such as disease control, phytotoxicity, yield response, resistance to pathogens and compatibility with other plant protection products (e. g. insecticidal seed treatments); application technique, quality of seed treatment and side-effects.

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THE NUMBER OF EXPOSED DRESSED SEEDS IN THE FIELD; AN OUTLINE FOR FIELD RESEARCH.

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ABSTRACT

To evaluate hazards of treated seeds for mammals and birds, decision schemes are being developed, in which information about the number of exposed seeds is an important aspect. An overview has been made of factors influencing the number of exposed seeds. The most important is the soil condition, followed by the place on the field, seeding technique and weather and time after seeding. Also small accidents, like spills, may offer a major exposure source of treated seeds. Information about the effect of seed size, seeding density and depth is almost lacking. A research project into the number of exposed seeds is outlined, focusing on seed size, seeding technique and soil type. Preliminary research in winter wheat resulted in 18.5 exposed seeds m^{-2} in the centre and 40 m^{-2} on the headland of the field.

INTRODUCTION

During evaluation of pesticides it is important that adverse side effects are taken into account. In The Netherlands a step wise assessment method has been developed, to assess the hazards of treated seeds for birds and mammals in the field (see Luttik & De Snoo, 1994 these proceedings). This hazard assessment method takes into account body weight, daily food intake and diet of the species of concern, repellency of the pesticide and the percentage of seeds incorporated in the soil. Luttik and De Snoo conclude that major uncertainties exist on the extent in which pelleted seeds are taken up by birds mistaking them as grit and about the number of exposed seeds after sowing. This article deals with the outline of a research project into the number of exposed seeds. The different factors that influence the number of exposed seeds are evaluated from literature and some preliminary results are presented.

FACTORS INFLUENCING THE NUMBER OF EXPOSED SEEDS IN THE FIELD

The following factors influence the number of exposed seeds: i) seed size, seeding density and depth ii) seeding technique and improper agricultural practice, iii) soil type and condition (incl. weather before seeding), iv) place in the field (centre vs headland), v) time and weather after seeding. Data are available on wheat and rapeseed: median mean resp. 4.3 and 10.4 m^{-2} (Table 1). For only a few sources seeding densities are given and the percentage exposed seeds ranges from c. 1.2 to 4.2% for wheat to 12% for rapeseed.

Seed size, seeding density and depth

These factors are correlated: larger seeds are mostly seeded deeper in lower densities and a lower number of exposed seeds can be expected under these conditions. The influence of seed size, seeding density and depth on the number and percentage of exposed seeds can not be derived from literature, since most research has been done with wheat (Table 1), in most cases without referring to seeding density. Only Davies (1974) mentioned a higher number of exposed wheat seeds, due to shallow drilling in order to reduce damage by insects.

Seeding technique and improper agricultural practice

The number of exposed seeds also depends on seed bed preparation, seeding implements and soil finishing. Seed bed preparation influences the soil condition and this will be dealt with later. Broadcast sowing probably causes the highest number of exposed seeds. Standard drilling probably will leave more seeds on the surface than precise drilling, because the machines for precise drilling can place the seeds more precisely at the desired place and depth, but insufficient information exists on this subject. Maze *et al.* (1991) found a higher number of exposed seeds when a press drill was used (5.5 m^{-2}) than when a hoe drill or an air seeder (with or without harrowing afterwards) was used (1.3m^2). Davies (1974) describes a decline of 60% in number of exposed seeds if harrowing took place after seeding. Also small accidents or improper management increase the number of exposed seeds. Davies (1974) and Maze *et al.* (1991) pointed out that seed spilling may be a major source of exposure of treated seeds. Davies (1974) ascribes the

Table 1. Mean number of exposed seeds m^{-2} directly after sowing (days 0 or 1) under normal conditions (fallow soil, centre or whole field numbers, soil types and machine implements combined, single seeding, soil finishing); - = data not mentioned or not relevant; * = mean of the highest reading of grains for those fields examined.

exposed seeds m^{-2} mean	min	max	nr fields x samples	remarks	source
wheat					
4.3*	1.1	9.7	14 x 20	spring 1961	Murton & Vizoso, 1963
4.3*	1.1	14.0	12 x 20	autumn 1961	
4.0*	0.3	18.3	- x 20	spring 1962	
0.9	0.8	0.9	2 x 10		Jefferies *et al.*, 1973
3.0	1.0	8.0	4 x 1-2	autumn 1966	Davis, 1974
5.8	0.5	20.7	12 x 20	autumn 1972	
9.4	-	-	1 x 60		Wildlife Survey, 1975
4.0	-	-	1 x 60		Westlake *et al.*, 1980
2.3	-	-	12 x 10	experiment	Maze *et al.*, 1991
18.5	0.0	72.0	6 x 10	autumn 1991	own research, see Table 4
rapeseed					
13.9	0.0	52.0	4 x 10		Riedel *et al.*, 1992
6.9	2.0	14.4	3 x 10		Hänisch & Gemmeke, 1992

Table 2. Mean number of exposed seeds m^{-2} on the centre and headland of the field directly after sowing (days 0 or 1), see also Table 1; ratio calculated as geometric mean; * = recalculated assuming headland 5% of field area; ** = comparison single ("centre") vs double ("headland") seeding; soil type, seeding implements etc. combined.

centre field	head field	ratio H/C	number fields	source
3.6*	11.6	3.2	1	Davis, 1974
6.8	20.8	3.1	1	Wildlife Service, 1975
4.0	23.1	5.8	1	Westlake *et al.*, 1980
2.3**	3.0	1.7	12	Maze *et al.*, 1991
5.4	9.1	3.4	3	Hänisch & Gemmeke, 1992
18.5	40.0	2.7	6	own research, see Table 4

high number of exposed wheat seeds (4 m^{-2}) on the 8th day after sowing, as a consequence of the harrowing, rolling and reharrowing of a field to bring buried potatoes to the surface. In Table 4 the effect of an accidentally open seedpipe in field 6B is evident, in comparison with field 6A.

Place in the field (headland vs centre).

More seed often remains exposed on the headland than in the centre of the field, because the soil condition of the headland is worse, due to the turning of the machines, because seeds are spilled when the sowing equipment is taken out of the soil, and because part of the headland is double seeded when the headland is seeded crosswise. The number of exposed seeds on headlands is in general 3-4 times higher as in the centre of the fields (Table 2). In a heavy loam soil the number of exposed seeds is also high in the centre of the field, because of the overall bad field conditions (Hänisch & Gemmeke, 1992). The number of seeds after double seeding ("headland") is higher than after single seeding ("centre"), but the percentage exposed is lower if the double amount of seeds is taken into account (Maze *et al.*, 1991).

Soil type and condition

Soil condition is the result of soil type, weather before and during seeding, seed bed preparation and the presence of previous crop debris (stubble) and influences the number of exposed seeds considerably. Hänisch & Gemmeke (1992) report a higher number of exposed rapeseeds in heavy (14.4 m^{-2}), more cloddy soils, than in light soils (2.0 m^{-2}). The highest number of exposed wheat seeds were found (Table 1) in a heavy clay soil in combination with heavy rains before seeding (Table 4). According to Davis (1974) soil condition had a greater effect than soil type. The number of exposed seeds was highest on clay after heavy rain. On a sandy loam with a better tilth the number was less, however the number of exposed seeds was even less on clay with a good tilth. The lowest number of exposed seeds occurred on a peaty soil under good weather conditions. In the Wildlife Survey (1975) 4 to 5 times more seeds remained on the cloddy part of a field compared to the good tilled part of the same field. Davis (1974) describes a negative influence of the presence of sugar beet debris on the number of exposed wheat seeds, whilst Maze *et*

Table 3. Percentage decrease of exposed seeds per day and number of weeks needed to reach 90% loss of exposed seeds; see also Table 1; calculations carried out with simple exponential equation; - = data not mentioned; * = recalculated assuming 10% of seeds left after stopping of the counts; ** = decrease retarded by heavy rain in first week.

Decrease % d^{-1}	nr fields	nr dates	$t_{90\%}$ (wks)	remarks	source
14.3	24	16	2.3	spring 1961	Murton & Vizoso, 1963*
16.4	27	14	2.0	autumn 1961	
38.3	-	6	0.9	spring 1962	
15.1	1	10	2.2		Jefferies *et al.*, 1973
30.8	3	3	1.0		Davis, 1974
32.2	1	5	1.0		Wildlife Survey, 1975
8.1	1	10	4.1		Westlake *et al.*, 1980**
15.8	1	5	2.1		Hänisch & Gemmeke, 1992

al. (1992) reported the contrary effect: 2.7 wheat seeds m^{-2} on summer fallow and 1.1 seeds on stubbled field.

Time and weather after seeding

Not only the weather before and during seeding is an important factor but also the weather *after* sowing. From the results of Westlake *et al.* (1980) an increase in seed exposure of 10-30% after a heavy rain (10 mm) can be calculated, but from 2 weeks after sowing heavy rains no longer had an effect, because the sprouted seeds were firmly anchored in the soil. Jefferies *et al.* (1973) describes a strong effect of snow and thaw, which resulted in a crumbled soil: from 0.9 exposed seeds m^{-2} also on the first day till 6.5 m^{-2} on the 15th day. Exposed seeds disappear in the course of time, by moving into the soil or by predation by mammals and birds. The median percentage decrease per day is ca. 16%, which means that within two weeks ca. 90% of the exposed seeds have disappeared (Table 3).

OUTLINE FOR FIELD RESEARCH FOCUSED ON THE NUMBER OF EXPOSED SEEDS IN THE FIELD

The most important factor influencing the number of exposed seeds is soil condition (especially soil type in combination with weather before and during seeding), followed by the place in the field and the seeding implements. From the overview it further becomes clear that little information is present about the relation between the number of exposed seeds and seed size (crops), seeding density and depth. In order to get a systematic and representative picture of the range of the number of exposed (and dressed) seeds in the field for the different crops (seed sizes) under different conditions and techniques used a research project has been started. Results of preliminary measurements are presented in Table 4; the results are already discussed in the preceding paragraph.

Table 4. Number of exposed seeds of winter wheat m^{-2} on centre and headland of field, fraction (%) of seeding density; results of preliminary field research in 1991 in the Haarlemmermeerpolder, The Netherlands; (200 kg winter wheat/ha, presumed 22 seeds/g; n = 10 squares (1 m^2) for centre field and 2 for head field; counts direct after sowing; clayey soil and rainy weather during sowing; * = accidental spilling; mean without 6B).

Field	Head field		Centre field	
	m^{-2}	%	m^{-2}	%
1	89	20.2	18	4.1
2	67	15.2	18	4.1
3	18	4.1	1	0.2
4	3	0.7	2	0.5
5	62	14.1	72	16.4
6A	0	0.0	0	0.0
6B*	95	21.6	5	1.1
mean	40	9.1	18.5	4.2

The outline of the project is as follows. In the spring of 1994 the effect of seed size (crops) and seeding technique will be investigated in a.o. the Haarlemmermeerpolder and in Flevoland in The Netherlands. Three seed size classes (small, medium, large) are combined with three groups of seeding techniques (broadcast sowing, standard drilling and precise drilling), which results in seven relevant combinations (Table 5). Within the seed size classes some major crops (area > 10000 ha) are selected. In one combination two crops are selected (bean and maize), which are seeded in a high respectively low density to investigate the relation between seeding density and fraction of exposed seeds. In the autumn of 1993 and 1994 the influence of soil type (sand, light clay, heavy clay) and soil condition, the influence of the weather after seeding, the disappearance rate (permanent quadrats on days 0, 1, 2, 5, 8 and 14) will be investigated in winter wheat. Ten counts (quadrat of 1 m^2, which lie at a regular distance from each other) will be made separately in the headland and the centre of at least 10 fields per treatment. First results of the 1993 counts will be presented during the symposium.

DISCUSSION

A lot of attention is paid to the number of exposed seeds, but also the buried seeds, sprouted seeds and seedlings (e.g. Beri *et al.*, 1969; Porter, 1977; Green, 1980) are subject to predation by a large variety of mammals and birds. The percentage decrease per day (Table 3) has been based on averaged field values and therefore are too low, because also quadrats with no or a low number of seeds are included. If only the quadrats were taken into account, in which exposed seeds are really present (e.g. Hänisch & Gemmeke, 1992), the percentage decrease per day for those quadrats would be 2-4 times as large.

Table 5. Selected crops as a result of seed sizes and seeding techniques in which the number of exposed seeds will be investigated; seed size: small < 0.015 g; 0.015 g < medium < 0.1 g, large > 0.1 g.

seed-size	broadcast sowing	standard drilling	precise drilling
small	-	spinach	sugarbeet
medium	wheat	wheat	sugarbeet (pelleted)
large	-	pea	bean & maize

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ENVIRONMENTAL HAZARD ASSESSMENT OF THE USE OF PESTICIDES FOR SEED TREATMENT: THE DUTCH CONCEPT

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ABSTRACT

In this article a method is presented to assess the hazard/risk for birds and mammals of the use of pesticides for seed treatment. The method takes into account: body weight, daily food intake and diet of the species of concern, percentage of incorporation of the seeds into the soil and when applicable (not in this paper) repellency of the pesticide. The application rate of the active ingredient, sowing density and mean weight of 1 seed are according to the Dutch situation. The scheme has been applied for all pesticides (35 active ingredients in 1992) used for seed treatment in the Netherlands. High risk had to be assumed for 11 compounds and 2 additional combinations of two compounds for mammals and/or birds for 1 or several crops. For 5 of the compounds with high risk incidents have been reported in Great Britain or the Netherlands.

INTRODUCTION

"In about 1650 a shipload of wheat was beached by a high tide on the Somerset coast. Its cargo was salvaged, dried out with lime, and used as seed by local farmers. To their delight those crops suffered far less from stinking smut than their neighbours'. The practice of steeping seed in brine and drying it with lime, as a precaution against the disease, evolved as a result" (Anonymous, 1992).

The treatment of seeds for protection against fungi or invertebrates is a long existing phenomenon and meanwhile all kind of ingredients are used. At the end of the sixties the use of seed treatment became suspicious as a result of large bird kills, due to the use of organochlorines such as dieldrin and heptachloro-epoxide against insects and organomercurials against fungi (for instance Fuchs, 1967; Blus et al., 1984). The use of organochlorines and organomercurials was banned and the introduction of organophosphates in the beginning of the seventies resulted in a lot of new incidents but mostly with less victims. In 1992 35 active ingredients of different chemical groups were used for seed treatment in the Netherlands (Anonymous, 1991). To evaluated the hazard of these components for birds and mammals a step wise assessment method has been developed. For all active ingredients (and/or combinations) used in the Netherlands the hazard has been calculated for every crop in which the pesticide is allowed. This research is part of a larger project in which the hazards of the different application methods of pesticides for birds and mammals will be evaluated (Luttik, 1992).

In this article the stepwise hazard assessment method is presented. First the basic principles underlying the hazard assessment method are given. Afterwards the hazard assessment method itself will be explained and illustrated by an example. In the end the results of the calculations are presented and discussed.

METHOD

Basic principles

In order to carry out the hazard assessment properly, it is necessary to have information about the following subjects: acute oral toxicity, body weight (BW) and daily food intake (DFI) of bird and mammalian species, application rate of active ingredient (kg a.i./kg seeds), amount of seed (kg seed/ha), mean weight of 1 seed, efficiency of incorporation of seeds into the soil, repellency, and last but not least ecological knowledge about the bird and mammalian species used in the hazard assessment.

For the hazard assessment the lowest available LD50 has to be used. The data submitted by industry were supplemented by on-line research. Because LD50 values are conventionally expressed as mg/kg BW, it is necessary for this scheme to adjust these units to take account of the body weight of the species of concern.

The concentration of the active ingredient or a combination of several active ingredients per 1 particle (A in scheme) can be calculated when the application rate of an active ingredient and the mean weight of 1 seed is known. The number of particles per m^2 available at the surface (K in scheme) can be calculated when the amount of seeds used per hectare and the mean weight of 1 seed is known. This number can be corrected for the percentage of incorporation. The hazard assessment is carried out by using data applicable to the Dutch situation (good agricultural practice). Not much information about the percentages of incorporation of seed is available, for the time being the following percentages are used in the Netherlands (see also Tamis *et al.*, these proceedings): 99% in case of favourable sowingconditions, 95% in case of less favourable sowing conditions and 90% for the edge (turning point of sowing machines) of the field.

The PEC(seed) is the predicted environmental concentration of a compound in seed (mg a.i./kg seed) which is adjusted by the DFI for the species of concern. Preferably information about the DFI of wild species has to be used for the calculations. As a broad generalisation, it is sometimes assumed that small species (less than 100 g) eat about 30% of their body weight daily (dry weight basis), whereas larger species eat about 10% (Kenaga, 1973). More accurate predictions (used for the results in this paper) of the DFI are available from Nagy (1987), using regression equations to predict dry weight intake for an animal of a particular body weight:

Birds $\quad \text{Log DFI} = -0.188 + 0.651 \log \text{BW}$ ($n=50$, $r^2 = 0.92$) and

Mammals $\quad \text{Log DFI} = -0.629 + 0.822 \log \text{BW}$ ($n=46$, $r^2 = 0.96$).

Method for hazard assessment

The decision scheme for environmental hazard assessment of the use of pesticides for seed treatment is presented in Figure 1. In the first step of this scheme the amount of active ingredient in/on 1 coated or pillorized seed is compared with the LD50 of the species of concern. When the quotient is ≥ 1, high risk is assumed for the species of concern, which means that for the species 50% or more of the animals will die after consumption of 1 particle. This cut-off criterion is also adopted by the Subgroup on Terrestrial Vertebrates of the EPPO.

In step 2 it is assumed that the complete daily food intake (DFI) of the species of concern consists of the particles under consideration. When the quotient is ≤ 0.001, low risk for birds and mammals is assumed.

In step 3 one has to decide if the particles do resemble natural food or grit. Differentiation is necessary because it is assumed that natural food will be eaten until the bird or mammal is saturated, in contrary to grit consumption (not *ad libitum*).

In step 4 a trigger-value of 20 particles has been chosen for grit consumption. This trigger-value is based on research carried out by Best and Gionfriddo (1991a and 1991b). They found that the mean number of particles in the stomach of birds ranged between 0 and 70 (*Phasianus colchicus* 38 and *Passer domesticus* 69). Only for one species (*Passer domesticus*) the half-life of the grit particles is approximately known: $T^{1/2} = 3$ days. When the quotient is ≤ 20 risk is assumed to be present. The "real" risk has to be assessed by comparing the characteristics of the particles and of natural grit.

In step 5 it is supposed that the risk for birds and mammals is related to the amount of available active ingredient per unit area. High risk is assumed when the quotient is ≥ 10 (this criterion is the same as the one used by the EPA, 1992), and low risk when the quotient is ≤ 0.1.

Corrections can be made for the repellency (when applicable). In step 1 one must not take repellency into consideration, because repellency is often a learning process, which can not be applicable for 1 particle. In the results presented in table 1 no correction has been carried out for repellency, because repellency studies are often not available and are difficult to translate to the environment (see Luttik, 1993 in prep.).

As example of the calculations in the scheme the case of a harvest mouse (*Micromys minutus*) of 8 gram, eating oats treated with fonofos is presented.

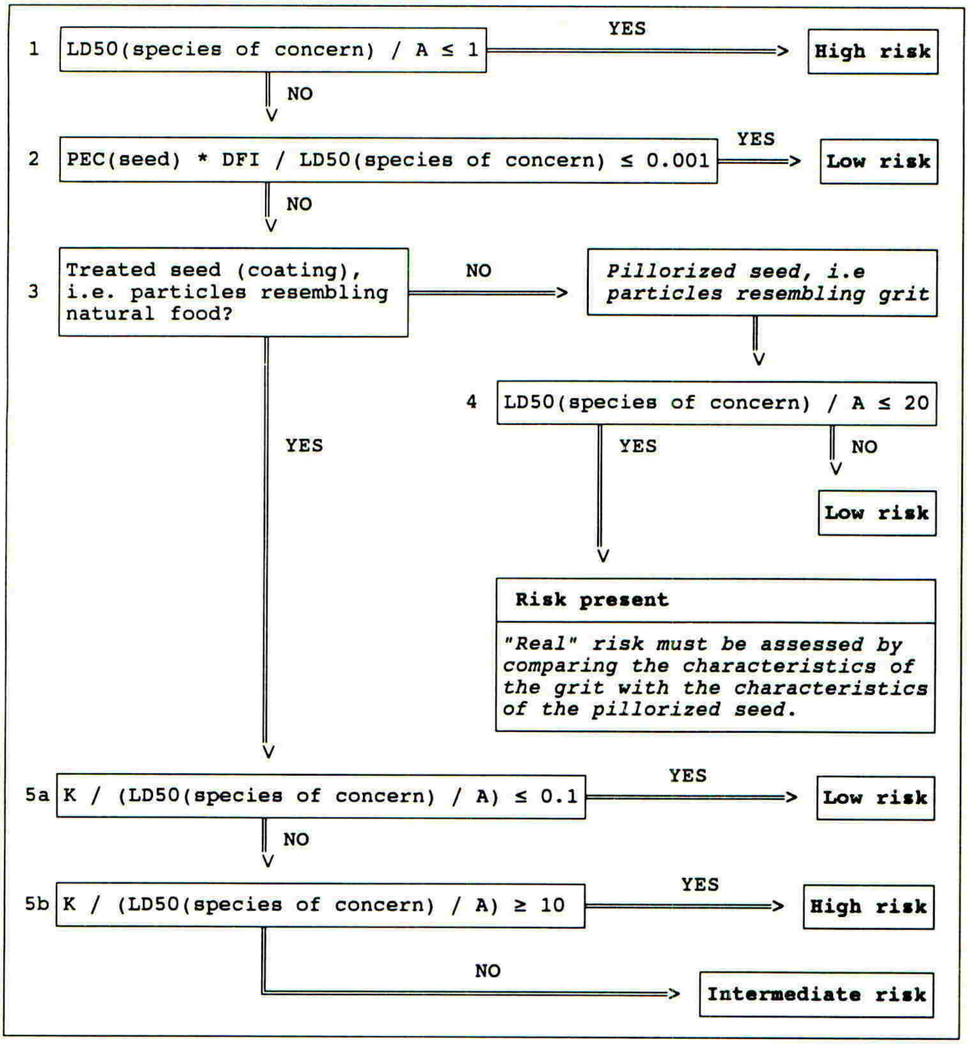
Basic data:

LD50(rat) = 3.16 - 24.5 mg/kg BW (n=7); application rate of formulation = 4 ml/kg oat (250 g a.i./l); 24-33 seeds/g and 330 seeds/m^2.

Hazard assessment:

LD50(harvest mouse) = 0.025 mg/mouse. A = 0.03-0.042 mg a.i./seed. K for 90% incorporation = 33 seeds/m^2. Outcome of criterion 1 = 0.6-0.83 ==> high risk. Outcome of criterion 5b = 40-55 ==> high risk.

FIGURE 1 Decision scheme for pesticides used for seed treatment.



RESULTS

The scheme has been applied for all pesticides (35 active ingredients) used for seed treatment in the Netherlands. High risk had to be assumed for 11 compounds and 2 additional combinations of 2 compounds for mammals and/or birds for 1 or several crops (see Table 1). The results of all other calculations and the exact data used for the hazard assessment will be presented in Luttik & de Snoo (1993, in prep.). In Table 1 the body weight for birds and mammals at which the quotient of LD50 species of concern/A (criterion 1) is equal to 1 and at which the quotient K/(LD50 species of concern/A) is equal to 10 (criterion 5b) for 90% incorporation of the seeds into the soil. It is assumed that small birds (≤ 100 g) will not eat large seeds (maize, peas and beans) ad libitum and that the smallest seed eating mammal (6 g) will eat large seeds. For instance the outcome of criterion 1 for birds exposed to bendiocarb on maize is 430 gram. This means that for all the birds with a body weight ≤ 430 high risk must be assumed. For 5 of the compounds (bold in table) with "High risk" incidents have occurred in Great Britain: bendiocarb, chlorfenvinphos, fonofos and lindane (based on incident registration in the UK between 1983 and 1991) and in the Netherlands: methiocarb (written communication of the Dutch Central Veterinary Institute).

TABLE 1 Chemical/crop combinations in the Netherlands for which the outcome of the risk assessment scheme is "High risk".

Compound	Crop	Criterion 1		Criterion 5b	
		Birds	Mammals	Birds	Mammals
Antraquinone	Broad bean	11	--	--	--
Bendiocarb	Beet	34	--	--	--
	Maize	430	48	--	--
Benfuracarb	Beet	11	--	--	--
	Onion	--	--	98	28
Benomyl	Broad been	29	--	--	--
Dichlofenthion	Beans	36-107	9-12	--	--
Fonofos	Barley	--	16	14	44
	Oats	--	13	14	44
	Rye	--	9	--	27
	Wheat	--	14	15	47
Furathiocarb	Beet	375	11	--	--
	Onion	100	--	3050	92
Isofenphos	Onion	--	--	184	80
Lindane	Black radish	--	17	--	17
	Maize	--	8	--	--
	Rape-seed	--	8	--	11
	Turnip	--	6	--	6
	Mustard	--	8	--	10
Methiocarb	Beet	63	8	--	--
	Beetroot	84	11	35	8
	Green pea	376	50	338	45
	Maize	1253	167	125	17
	Pea	752	100	451	60
Thiram	Beans	10-15	7	--	--
	Pea	12	6	--	--
	Spinage	--	--	23	11
Chlorfenvinphos /thiram	Carrot	10	--	--	--
Benomyl/thiram	Green pea	10	--	--	--

DISCUSSION

In the presented hazard assessment method some gaps can be pointed out. First the exposure of birds and mammals to the amount of available seed after sowing is not clear for all crops and sowing methods from literature. Secondly the amount of grit in the stomach of several european birds species is not known. A field study to investigate both aspects is being carried out at the moment (see Tamis *et al.*, these proceedings). Further point of discussion is the use of the cut-off criteria in the scheme. As far as possible they are based on literature and conventions of international organizations. But for example the criterion of 0.001% in step 2 is maybe too strict.

From the results it is concluded that of the 35 a.i.s used for seed treatment in the Netherlands, 11 a.i.s and 2 combinations result in a high risk for wild living birds and mammals in certain crops. In some cases high risks were calculated for all bird species and for many mammals. 10 of the 11 a.i.s result in a high risk when a bird or mammal eats one seed only! Some of these pesticides are used in large scale crops such as beet and maize. The indications from the reported incidents in the UK and the Netherlands show that the outcome of the hazard assessment is realistic.

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