

# BIOLOGICAL EVALUATION OF HERBICIDES IN THE NETHERLANDS

W. VAN DER ZWEEP (I.B.S.) and  
P. ZONDERWIJK (P.D.) Wageningen, Netherlands

## 1. Introduction.

The biological evaluation of herbicides comprises studies on the action of these products on crops and weeds. These investigations are mainly but not exclusively carried out in the field, their final practical aim being, of course, the establishment of accurate, reliable recommendations as to the application of the products. No, or a minimal, undesirable effect on the treated crop and satisfactory weed-control should be guaranteed.

In reviewing for this conference some Dutch experiences and thoughts as to this biological evaluation of herbicides we would like to restrict ourselves to the biological evaluation of commercial herbicidal formulations and not discuss special techniques followed in the screening or primary evaluation of herbicides in their early stages of development.

The elaborate and costly evaluation programmes of many pesticide firms demonstrate the willingness of, or more the commercial necessity for industry to establish good recommendations as to the use of its products. In many countries, however, the Governments do not accept this industrial research endeavour as the only basis of recommendation. Neither is this the case in the introduction of pharmaceuticals. The State wants to protect the buyer and the user of pesticides against unjustified recommendations put forward by the marketing firms. Moreover, the State wants to protect the general public against possible ill effects of the active substances upon public health. In several European countries we see that special bodies in the Ministry of Agriculture are charged with verifying claims on the agricultural use of these products and with giving or refusing official sales approval of pesticidal formulations. The creation of these government approval schemes has first of all had a preventive influence on the commercialisation of not yet sufficiently evaluated pesticides or on new uses of these products. In addition the approval schemes have given the user of the pesticides the assurance that the use of the product and the technique recommended on the label has been studied and verified by independent, qualified, government-employed research workers and that the recommendation of this use or technique has been found to be justified. This official agricultural and usually simultaneously occurring toxicological evaluation of the products should contribute to a feeling of security in the farming community. In our opinion the development in Ireland, towards such a sales approval scheme should be greatly welcomed by the users of pesticides. It requires, of course, the presence of a qualified and well equipped staff of personnel in the Ministry of Agriculture. This staff should always bear in mind, however, what was recently expressed in an editorial in *Science* discussing the thalidomide problem "the effect of delays in making new drugs available could be as detrimental as the effect of putting them into use too hastily."

## 2. Principles applied in the verification of manufacturers claims concerning the use of herbicides.



In the Netherlands the Plant Protection Service, working under the Ministry of Agriculture, issues the official sales approval for agricultural pesticides. In the study and consideration of claims made by industry as to the agricultural use of their herbicidal formulations some principles can be recognized which can be briefly outlined as follows :

1. All data concerning the composition of the herbicidal formulation have to be supplied on request by the manufacturer to the Plant Protection Service, but they are confidential. Also toxicity data should be made known, if available.
2. In the biological evaluation not the active substances but formulations of herbicidal chemicals are evaluated. A specified active substance as a specified salt, ester or other derivative and present in a specified percentage is being studied. Other constituents of the commercial product, like wetting agents, co-solvents, etc., do not have to be disclosed, but if after issuing the approval, changes take place in the formulation that effect its phytotoxicity or selectivity, these changes have to be announced. Otherwise it will be considered that samples of the product will have the composition and biological effectiveness of the sample originally studied. In practice this means, that if unexpected experiences with a product occur, if possible a sample of the material used in the particular case will be carefully studied and compared in the greenhouse and laboratory with the original or comparable sample on its phytotoxicological properties.
3. Although advantage is taken of foreign experiences and research data, these data are not considered to give sufficient experimental support to claims made by industry. It is even desired that field experience obtained in the Netherlands shall be presented by the firm asking for approval. The frequently observed divergences in research data obtained in regions of different soil type, climate, weed flora, crop growing techniques and varieties grown, justifies this requirement of submitting "home-produced" experimental data. In particular American experiences should be verified, as they are generally made under ecological conditions diverging widely from those encountered in Western-Europe and by growers working with different techniques and interpreting possible influences on the crop not in the same way as is being done in this part of the world.
4. In the evaluation procedure the herbicidal formulations are being studied at dosage rates, stages of development of the crop and of the weeds and under environmental conditions agreed on between the Plant Protection Service and the firm. Consequently, the system is a "label-checking," it is a consideration of recommended usages.
5. In the decision on the approval of the product the opinions of independent crop specialists concerned are generally incorporated. As a rule weed control recommendations should emerge from considerations in which weed research workers as well as crop specialists take an active part.
6. Final evaluation of herbicidal formations is carried out under actual growers conditions. Practical weed control is an aspect of applied ecology and the variation in the complex ecological conditions of a crop environment can never be duplicated in greenhouses or climate controlled rooms, not even



in experimental gardens of Institutes and experimental stations.

7. The firm requesting approval has to pay about £50 per dosage rate of product investigated. If after approval of the label new usages of the product become known, they are placed on the label without extra cost.

### **3. Research on weed control problems.**

In addition to field experiments carried out by the Plant Protection Service under the approval scheme, the Plant Protection Service itself, the Weed Control Department of the I.B.S., several specialized field crop and horticultural experimental stations and some other Governmental research institutes carry out weed control experiments, not primarily focussed on a specific chemical, but more on urgent weed problems. Many crops are grown on too small an acreage to be of commercial interest to industry and therefore government or grower supported institutes have to carry out these weed control and other studies. This is especially true in horticulture, where not only the great number of crops, but in addition the great number of varieties make the research problem rather complex.

In other crops the variety of growing techniques, soil types, and crop varieties is so great, that many years of fundamental studies may be necessary before the recommendation of a specific herbicide or weed control technique can be considered sufficiently accurately established. This is, for instance, the case in strawberries, where the use of simazine after harvest could only be recommended after 5 years of experimentation.

Also the integration of the use of individual herbicides, mechanical weed control techniques and cultural measures aimed at control of the weed problem is mainly carried out by workers of the research institutes, in co-operation with the national advisory services.

Some of the field problems have been solved with field work only, in other cases greenhouse investigations were also included. A good timely example of integrated problem research are studies on the control of *Poa annua* in herbage seed crops, mainly in *Poa pratensis*. In this programme are included :

1. Greenhouse study of the phytotoxicity to *Poa annua* of new herbicides.
2. Phytotoxicity studies of many herbicides on 7 cultivated and 2 adventitious grasses at early stages of development.
3. Greenhouse study of selected chemicals on the selective control of germinating and seedling *Poa annua* under established *Poa pratensis*.
4. Field screening studies with chemicals selected from the greenhouse studies.
5. Large scale development work with selected products on several soil types, at some dosage rates, times of application and crop varieties.
6. Consideration of seed cleaning techniques.
7. Biological study of the development of *Poa annua* in herbage seed crops.

One could characterize this type of concentrated study, in which several workers are co-operating and industry takes an active part by supplying herbicide samples, as a "Task Force" approach, in which depending upon results and problems encountered other specialised research workers may become involved.

### **4. Some experiences and thoughts resulting from herbicide evaluation studies.**

For the following paragraphs we have made a choice from a greater series of



observations deserving special mention :

1. The question may be asked for how many years field evaluation has to take place before justified conclusions can be drawn as to the value of a product. The general answer to this question is: Until we have with absolute or almost absolute certainty, established the reproducibility of the good results of the practical recommendation. The required time necessary for "recommendation checking" may be favourably influenced by carrying out research on factors determining the activity of the product, for instance on the interaction with soil type, the importance of spraying techniques, etc. For practical purposes insight into the importance of these factors is of great value and can only be obtained in a carefully set up research programme, in which field and laboratory experiments have their place. Under such a programme, to which several specialized research workers and techniques can contribute, an "approval-study" time of about 2-3 years appears to be justified, though in some cases a decision may be taken more quickly, for instance, when reliable research data from other sources are available.

It is certainly true that we shall probably never be able to take all risks away from recommended usages of herbicides. It is not very easy giving an answer to the question "How far can we go in not knowing exactly what we are doing?", but practical experience indicates that it is possible to come to a justified system of recommendations.

2. How far can we go in accepting dangers to the environment related to the use of herbicides?

The possible effects of auxin herbicides on susceptible crops are well known. Applications of these products on cereals and grassland do not have to lead, however, to any damage to neighbouring crops when they are made under good weather conditions and spraying technique is correct. In the Netherlands greater problems arise, however, with the use of chloro-IPC. With this chemical fibre formation in flax may be severely influenced through vapour action even if the application of the product on neighbouring onions takes place under correct weather conditions. In other cases damage has been observed on seed-setting in cereals and in grass seed crops. The great importance of chloro-IPC for the onion-growers has not justified withdrawal of the sales approval yet, but the need for a chemical not having these unpleasant side-effects is great.

As is the case in auxins damage occurring through spray drift of diquat and paraquat droplets can be avoided by applying high volume low pressure spraying techniques.

The observations demonstrate that in the evaluation of new chemicals volatilisation and vapour drift studies on several crops have to be considered in the programme and in each individual case the importance of possible dangers has to be considered.

3. In the use of herbicides possible differences in susceptibility of different crop varieties needs careful consideration in any evaluation programme. The data on the reaction of various barley varieties to barban and of strawberry varieties to simazine are good examples supporting this point. Also, in weeds variations may occur and especially in perennial weeds



attention to the susceptibility of different varieties should be studied. In this case it is, however, frequently difficult to distinguish in the field influences due to varietal difference from different effectiveness of the herbicide due to ecological, growth-site factors.

4. Stages in the physiological development and in morphological characteristics should always be included in the studies. Results of research on the effect of auxin herbicides on cereals and in grass seed crops clearly illustrate this point. Factors like tillering, ear initiation and development and jointing had to be well understood in their relation to auxin herbicide application before safe application methods could be recommended. But in almost any crop and for any weed examples may be found. These data are actually a real contribution of weed research to physiological crop knowledge, of which in our personal opinion not sufficient advantage is taken by research workers in other fields.

It is true, of course, that in studies on the sensitivity of plants at various stages of development another factor, the herbicide, is included and that these studies give us also more insight on the properties of the product.

5. Extreme ecological conditions have to be included in the research programme, not only to cover the potential application region of the chemical but also to learn more about the properties of the product. As an example, very sandy soils poor in organic matter as available in the Netherlands along the coast, or soils recently reclaimed and poor in organic matter are, if possible, included in our programmes. Growth sites with high water tables are often of great importance and early insight in reaction of crops and behaviour of herbicides may also at these localities save us many unpleasant moments after handing over a recommendation to practice.
6. How shall we consider herbicidal applications with a long "residual?" Although mainly the selective usage of substituted ureas and triazines has brought this problem to us, it is also connected to the selective use of some other products. In these cases research data have to be available on the rate of disappearance of the chemicals from the soil, preferably by bio-assay test, this test having the advantage that also possible phytotoxic intermediate compounds are detected. In the Netherlands, according to the requirements of the Plant Protection Service, at the moment of planting the succeeding crop in the field no phytotoxic residues from a previous application may be present in the soil. For some chemicals, e.g., triazines and ureas, this requirement requires much research as the rate of disappearance is not only influenced by soil type but also by the application time, by the crop grown and the weed vegetation present.

Following this procedure up to now no important residue problems have occurred. In connection with some developments in crop-growing the matter requires the constant attention, however, of research workers and the advisory service. For instance, the use of rented land for the culture of simazine-resistant crops, e.g., roses, could lead to use of higher rates than officially recommended and to damage to crops grown by the next user of the land.

7. A characteristic of many recently developed herbicides is that they do not control one or more weeds because of inherent or other form of resistance.

In chloro-IPC the advantages obtained by the use of the chemical generally outweigh the fact that *Senecio vulgaris* is not controlled, but under conditions where this weed or *Solanum nigrum* are the main weeds present the use of the chemical becomes problematic. The sooner these resistance phenomena can be established and assessed on their practical importance the better. Therefore initial evaluation studies on a great number of weed species are recommended. To solve the resistance problem, crop rotations including smother crops, or mixtures of chemicals, or spraying schemes including different herbicides, frequently marketed by more than one firm, have to be developed. This type of research is rather typical of total weed control, where often very complex herbicidal mixtures have to be used or the type of weed remaining after a treatment determines what herbicide has to be used next.

8. A field of great practical importance in the Netherlands is the evaluation of herbicides for use in waterways. It is certainly the most complex problem, as a matter of fact, group of problems, that we have been dealing with during the past five years.

The sensitivity of emergent aquatic weeds to herbicides can be studied with techniques similar to, or modified from, those applied in other environments; time and rate of application and spraying technique being the most important factors. For emergent aquatics, like *Phragmites* and *Glyceria*, and many dicotyledonous weeds the use of dalapon and auxin type herbicides has been satisfactorily worked out and recommendations are beyond the research state. A difficult point remains, however: the establishment of "replacement flora's" of emergent weeds (e.g. of *Buromus* or *Sparganium*) or (much worse) of submerged weeds, e.g., of *Elodea canadensis* or *Potamogeton species*. This problem of going from bad to worse will perhaps be solved by the development of new herbicides, acceptable from the point of view of fish toxicity and public health, for the control of submerged plants. Although diquat and paraquat are promising in this respect it is too early yet to make practical recommendations.

The evaluation of the use of herbicides in waterways is attended by the study of many additional problems, not immediately concerning the control of the vegetation. As was already mentioned fish toxicity has to be considered. Experiments have to be carried out on the toxicity of herbicides to fish eggs, young and mature fish and to fish food. The time and technique of application of the herbicide in the field has to be studied in relation to these toxicity data. In the decision on the official approval of herbicides for use in aquatic weed control, safety factors have to be set, in which the rate or concentration toxic to fish is compared with the concentration required to kill the vegetation. In the Netherlands a factor of 10 between the levels of these critical concentrations is considered to be sufficiently safe for practical applications. As is the case in the application of herbicides to the soil so also on the water—environment data have to be available on the residual life of the products. Residue-life should preferably be as short as possible. In most chemicals we know little of the factors



of importance in determining their rate of disappearance from the water. Recent studies indicate, that at practical application rates the persistence of diquat and paraquat in ditch water is relatively short and of auxin herbicides and amitrol much longer, several weeks.

In the Netherlands the use of herbicides in watercourses is controlled by the Dutch Health Service (Commissie Voor Fytofarmacie) and by the regulations of the drainage districts. There is a tendency to insert in these regulations a paragraph, indicating that any use of herbicides in the watercourses of the drainage district is prohibited. Through exceptive clauses the use of the products can then be kept in hand and, e.g., damage to horticultural holdings avoided.

9. I would like to conclude by stressing the importance of greenhouse studies in evaluation research, as many field workers do not realise sufficiently the meaning of these studies for practical field applications. In the greenhouse and laboratory environment we can usually study the chemical under extreme conditions better than in the field. Especially the importance of individual factors can be much better isolated and their importance much better understood. Moreover data are obtained at a cost often much less than is common in field experimentation. For instance, through simple experimentation with 3 or 4 soil types, important information can be obtained on the relations between herbicidal effectiveness and soil type, germination studies disclose the influence the herbicide may have on this important process and on young seedling growth. The choice of test plants is much greater than would be possible in field tests. Of course we may never isolate data obtained from greenhouse studies from our field programme but if available they contribute substantially to the field evaluation.

In the Netherlands in soil samples obtained from treated fields residues are determined by means of bio-assay tests carried out in the greenhouse, the Plant Protection Service is further comparing in the greenhouse the toxicity of samples of commercial products with the toxicity of the standard product to which the official approval has been given. This is consequently a check on the standardized nature of the herbicidal formulations. At the I.B.S., if possible, bio-assay tests are also applied for residue studies of herbicides in water and a very sensitive technique using *Lemna minor* and *Spirodela polyrhiza* is used for diquat and paraquat studies.

I have gone briefly through some points of importance in the evaluation of herbicides. Many other equally important topics were not discussed, for instance the importance of studies on weather-conditions and herbicidal action, soil cultivation in relation to the activity of the chemical, studies on spraying technique, influence of the herbicide on crop qualities, and evaluation of herbicides in total or industrial weed control. This just shows that biological evaluation of herbicides is not a simple process and that research workers in charge of studying the official approval of herbicides have to gather their basic information from many sources, from industrial research groups as well as from colleagues engaged in crop and weed

the  $\mathbb{R}^n$ -valued function  $\mathbf{f}$  is a solution of the system (1) if and only if  $\mathbf{f}$  is a solution of the system (2). The system (2) is called the adjoint system of (1). The adjoint system (2) is a linear system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients.

The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients.

The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients. The system (2) is a homogeneous system of ordinary differential equations with constant coefficients.

research. Much additional research often has to be carried out before a decision can be taken.

#### **5. International Contacts on Evaluation of Products.**

The growing co-operation on the European continent and the related liberalisation of export and import barriers will not remain unnoticed in the trade of pesticides. Consequently, especially between countries in which approval schemes are in operation or under consideration, frequent exchange of experiences on field evaluation is desirable and necessary. At the moment field evaluation techniques for approval scheme purposes and their possible standardisation are under discussion in a special "Committee on Methods" of the European Weed Research Council. This Committee, headed by Dr. Johannes, at Braunschweig, Germany, last month had its 3rd meeting at Copenhagen, Denmark, and will soon distribute for consideration by a wider group of research workers suggestions to standardize evaluation techniques.

It is the experience in several countries that a careful consideration of experimental techniques and of instruction of people carrying out the field work has considerably raised the level of experimentation. At least in the Netherlands and France the publication of instruction books on the procedures to be followed in field experimentation and instruction-courses on this subject have considerably improved the way in which experiments are carried out and also the reliability of the results obtained. A similar discussion on methodology in weed experimentation research is going on at the moment in the Weed Control Sub-Committee of the International Institute of Sugar Beet Research, in which Ireland is represented by Mr. Thomas.

Although discussions on the standardisation of techniques are time-consuming and, compared to the speed of introduction of new herbicides, progress is slow, the activities in this connection have to be considered of great importance for the weed research field.

*Reprint from Irish Crop Protection Conference  
Dublin, 1962*