

ADAPTATION OF A GERMAN HERBICIDE ADVISORY (HERBASYS) TO NEW ZEALAND CONDITIONS

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SUMMARY

A knowledge based computerised herbicide advisory system, HERBASYS, has been developed in Germany. It consists of three modules, for (a) selecting herbicides for site-specific weed problems, (b) assessing potential danger of groundwater contamination, and (c) predicting potential effects of herbicide residues on succeeding crops by simulation of degradation. The system has simple hardware requirements and provides a user-friendly interface. To adapt HERBASYS to New Zealand conditions, initially various laboratory and bioassay data were collected on simazine and bromacil. A comparison of simulated results with those obtained from 13 field trials on simazine, bromacil, atrazine and ethofumesate showed that the model in general overestimated herbicide persistence in the soil. More information needs to be collected in New Zealand to enable this expert system to be used to its full potential.

Keywords: computer model, expert system, advisory system, HERBASYS, herbicide persistence

INTRODUCTION

A computerised advisory model for herbicide use would enable consultants and farmers to use a large information base obtained from various sources. Its applications could include weed control recommendations, economics of various options, and assessment of possible side effects of pesticides, e.g. crop damage due to soil residues or groundwater contamination.

The knowledge based computer system HERBASYS (Gottesbüren *et al* 1990) has been developed in Germany to solve problems concerning some economic and ecological aspects of herbicide use in agricultural practice viz, the selection of herbicides, the site-specific assessment of potential groundwater contamination and forecast of herbicide dissipation for estimating damage to succeeding crops. In this paper, the first results of collaborative research to adapt this model to New Zealand conditions are discussed.

STRUCTURE OF HERBASYS

As a knowledge-based expert system, HERBASYS uses information from scientific research, experience of consultants and growers, and theoretical descriptions of processes such as leaching of herbicides as basis of decisions. This wide range of knowledge is difficult to survey by a single person for a specific question, thus an easier access would be provided by a programme like HERBASYS. Models for research often depend on various input data which are usually not available to the consultant or grower. As HERBASYS has been designed especially for advisory purposes, it requires relatively simple input data and provides a structure and extent of results and conclusions that will be easily understood by the non-scientific user. This may lead to less precise results, but will make it beneficial for a wider group of users.

Because of the multitude of soil and climatic conditions, an adaptation to site-specific conditions and the capability for updating the information held in the system (e.g. registered herbicides, weather data, soil properties) is implemented. Simple hardware requirements (low-cost DOS computers with 640 Kbytes base memory and a small hard disk), the design of the computer/user interfaces to provide minimal typing,

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control of the logic of input data and explanations of the results should allow its wide acceptance in agricultural practice.

HERBASYS includes three different modules (HERBASEL, CHEMPROG and ANPROG) which are described in detail by Gottesbüren *et al* (1990). Fig. 1 shows the modular structure of HERBASYS, connections between the different modules and the general data base.

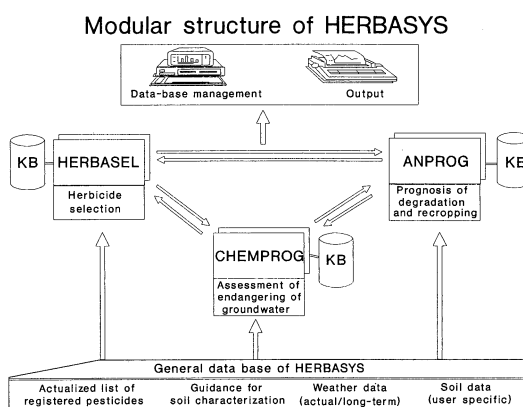


Fig. 1. Modular structure of HERBASYS (KB = Knowledge base)

HERBASEL is mainly a data-base programme and is designed to give an appropriate selection of registered herbicides for site-specific weed problems. Herbicide efficacy and economic thresholds for specific weeds (where available) are taken into account to provide the most economic herbicide treatment and to minimise application rates.

CHEMPROG enables a site-specific assessment of the potential danger of groundwater contamination by pesticides through estimation of the relative hazards. It combines parameters of the herbicide and site-specific data about the soil (texture, pH, organic C) climate (mean temperature, precipitation, climatic water balance), depth of the groundwater table and the farming system to describe the relative sorption and dissipation in soil according to the concept of Blume and Brümmer (1987). Because the lack of detailed information still limits precise simulations by leaching models, instead of a quantification of herbicide concentration, hazard levels for the risk of groundwater contamination are given by this module.

ANPROG combines models to simulate degradation of herbicides in soils (Walker and Barnes 1981) and to predict the potential effects of their available residues on succeeding crops (Pestemer *et al* 1980), according to the time and rate of application and site-specific soil and weather data. Appropriate degradation parameters, which quantify the effect of soil temperature and moisture content on the degradation of the herbicide in question are selected from the knowledge base. Since the soil characteristic which most closely related to the half life of most herbicides was the clay content (Allen and Walker 1987), the main emphasis lies on matching the clay content of the site with a soil where degradation parameters are available, followed by the organic matter content and pH. The amount of total residues in the soil is simulated using the above parameters and weather data, which may be provided by weather stations or by the grower himself (minimum and maximum air temperature, rainfall). From these data, the temperature and moisture content of the soil are calculated.

In order to provide information on the possible crop damage by the estimated residues, their potential availability to plants is calculated by using the distribution

coefficients in soil (K_d) which are also held in the database for a wide range of soils and herbicides. The appropriate value is selected mainly by matching the organic matter content of the soils. The amount of available residues in soil is then compared with the dose-response relationship for the herbicide and the crop in question to predict the potential damage caused by the remaining residues. By varying the input data then different recommendations such as, earliest safe recropping dates, less sensitive crops, reduced rates of the herbicide that will allow recropping at a fixed date, or appropriate alternative herbicides are given. The procedures, results and possible uncertainties of the forecast are explained to the user by the expert system.

ADAPTATION TO NEW ZEALAND CONDITIONS

To adapt HERBASYS to New Zealand conditions, the following information will be necessary for the three modules: For HERBASEL available information on the efficacy of herbicide applications in different situations for various crops and weeds needs to be summarized in the database. More work is necessary to establish thresholds for weed densities under New Zealand conditions. The basic data on herbicide behaviour in soil depending on soil properties also needs validation locally. For ANPROG, degradation parameters and K_d values for simazine and bromacil have already been determined in laboratory assays according to Stalder and Pestemer (1980). For these herbicides, dose-response curves were established with annual ryegrass (*Lolium multiflorum*), subterranean clover (*Trifolium subterraneum*), mustard (*Sinapis alba*), oats (*Avena sativa*) and tomatoes (*Lycopersicon esculentum*) in a nonsorptive substrate to make these results applicable to different soils (Pestemer *et al* 1980).

To achieve an accurate basis for the simulation of herbicide degradation, actual measurements of soil temperature were compared with data calculated by the model to evaluate possible differences between central European and New Zealand conditions. In order to check the validity of the persistence simulated by ANPROG, 13 field trials which included up to five herbicide application rates of simazine, bromacil, atrazine and ethofumesate at various sites in the North Island were simulated in ANPROG using the actual weather data. The results of the bioassays, which were carried out to investigate persistence, were compared with the simulated results provided by ANPROG. The soils used in these experiments included soil types of volcanic as well as alluvial origin. For simazine and bromacil the already determined degradation parameters from New Zealand soils were used while for atrazine and ethofumesate, parameters established in German soils were used for the simulation. Thus information is given on the validity of the parameters established in New Zealand, as well as on the applicability of the German data to different conditions.

RESULTS OF THE VALIDATION EXPERIMENTS

Calculation of soil temperature

A comparison between calculated and measured soil temperatures revealed that the average between minimum and maximum air temperature, which gave good results as a basis for the simulation in Europe, resulted in soil temperatures usually 2 to 5°C below the measured values in New Zealand. This may be due to the fact that the amount of energy given by radiation is higher in New Zealand and thus the soil is warmed up more quickly. The solar radiation per day (20-year average) varies between 1.4 and 18 MegaJoule/m² in Braunschweig and between 6.3 and 23.1 MJ/m² in Hamilton. Using the maximum air temperature, the simulation was more comparable, but on average showed values slightly higher than the measured ones. A weighted average (2/3 maximum + 1/3 minimum temperature) gave the most reliable results.

Prediction of crop response

Results of the validation of ANPROG for the four herbicides using the data collected in 13 field trials at different sites are presented in Table 1. For atrazine, degradation parameters for German soils of similar characteristics resulted in good agreement with bioassay results in light soils, but in heavy soils the persistence was underestimated. A good accord between observed and predicted length of persistence was found for simazine where degradation parameters were available for New Zealand

soils (Horotiu sandy loam and Te Kauwhata clay loam). However for Hamilton clay loam soil, the persistence was largely overestimated using German parameters. For ethofumesate, predicted residual activity was up to 4 months longer than that observed in the field using German degradation parameters for the simulation. The prediction of bromacil persistence was not satisfactory, since the simulated degradation was far too slow, in spite of using parameters established in New Zealand soils. This may be due to the fact that rapid dissipation under field conditions in New Zealand soils often appears not to follow the first order degradation kinetics used in the model.

TABLE 1: Months after application when herbicide residues fell below phytotoxic levels: comparison between observed (O) and predicted (P) duration in several soils*

	Duration of persistence in months							
	O	P	O	P	O	P	O	P
Rate (kg ai/ha)								
atrazine								
	H sL (1)*		H sL (2)		H cL		M siL	
0.5	3	4	3	4				
1	5	5	4	5	4	4	7	3
1.5					5	4	10	4
2	7	7	6	7	8	5	>11	5
3					>11	5	>11	5
4					>11	7	>11	6
simazine								
	H sL†		H siL		T cL†			
2	4	5	4	6	>6	6		
3	5	6	5	7	>6	7		
4	6	6	5	8	>6	9		
ethofumesate								
	H sL		T siL		M siL		W siL	
2	4	8	5	8	7	9	7	9
4	7	9	7	9	9	11	9	11
bromacil								
	T siL†		H sL†					
1	7	24	7	21				
1.5	9	43	9	24				
2	15	44	13	25				
3	16	48	15	27				

* Soil types (sL = sandy loam; siL = silt loam; cL = clay loam):

Atrazine: H sL (1) = Horotiu sL, org. C 5.6%, pH 5.8; H sL (2) = Horotiu sL, org. C 11.8%, pH 6.1; H cL = Hamilton cL, org. C 4.1%, pH 5.9; M siL = Matawhero heavy siL, org. C 3.0%, pH 6.0.

Simazine: H sL = Horotiu sL, org. C 9.4%, pH 5.4; H siL = Hamilton siL, org. C 4.6%, pH 5.5; T cL = Te Kauwhata cL, org. C 2.5%, pH 6.8

Ethofumesate: H sL = Horotiu sL, org. C 9.1%, pH 5.8; T siL = Tokomaru siL, org. C 4.0%, pH 6.0; M siL = Matawhero heavy siL, org. C 3.0%, pH 6.0; W siL = Waipukurau siL, org. C 4.3%, pH 6.0.

Bromacil: T siL = Te Kowhai siL, org. C 8.4%, pH 6.2; H sL = Horotiu sL, org. C 9.4%, pH 5.4

† simulation with New Zealand parameters; for the other simulations, parameters of similar German soils were used.

Over all, for the four herbicides, a trend to overestimate the duration of persistence was observed. For only 22% of all assays analysed was the persistence estimated to be shorter than those in field trials and this happened where no degradation parameters had been determined in New Zealand soils. Normally an overestimation of existing residue levels by HERBASYS would result in a safety factor in the prediction of damage to succeeding crops. These results demonstrate that some of the degradation parameters established in German soils may be transferred successfully. However, with the limited data available, no relationship could be found between German soil properties and the applicability of the data determined in these soils under New Zealand conditions. Therefore it will be necessary to establish more New Zealand information to be able to use this expert system to its full potential as an aid to decision making.

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