21 EPIPRE: A Systems Approach to Supervised Control of Pests and Diseases of Wheat in the Netherlands

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21.1. INTRODUCTION

For 20 years we have been developing models of epidemics of yellow stripe rust (*Puccinia striiformis*), a fungus disease of wheat that causes great damage in the Netherlands and elsewhere, but these studies were of an esoteric nature as long as effective chemical control of the disease was impossible. When such control came within reach, a project was begun in 1977 to utilize the models that had been developed in a disease management system. Implicit in the project is a change from explanatory strategic models to tactical ones.

Scientists are mainly interested in the content matter of a management system—"what", but in this chapter we focus on the introduction and practical execution of a system—"how". Emphasis on "what" at the neglect of "how" ensures the failure of a management system (Kampfrath, personal communication), but shifting emphasis from "what" to "how" is psychologically difficult for the research scientist.

21.2. THE EPIPRE PROJECT

EPIPRE (EPIdemics PREvention) is a cooperative project of some 300 farmers, the Extension Service, the Institute for Plant Protection Research (IPO), the Agricultural University, and various other institutions. EPIPRE is executed by the Laboratory of Phytopathology of the Agricultural University (Rijsdijk, 1982; Zadoks, 1981). The project is largely financed through the Netherlands Grain Centre, a nonprofit foundation funded by the Board for

Grains, Seeds and Pulses. The Board imposes a levy of 1 cent per 100 kg of wheat on farmers to create funds for wheat research.

It was soon realized that an attempt to manage only a single disease was bound to fail for at least two reasons:

(1) Diseases and pests influence each other, directly or indirectly (in our case the powerful chemical triadimefon, Bayleton ®, controlled not only yellow rust but also mildew).
(2) Farmers always have to deal with a variety of pests and diseases, and, accordingly, require a package of advice.

But, as manpower and knowledge were insufficient to work with more than one disease at a time, it was decided to begin in 1978 with yellow rust. In 1979, EPIPRE was extended with a negative forecast of mildew (*Erysiphe graminis*) for the whole country and with warnings against brown leaf rust (*Puccinia recondita*) and the English green aphid (*Sitobion avenae*) in a limited part of the Netherlands.

The objective of EPIPRE is to provide a system of supervised control of diseases and pests in wheat, aimed at minimization of biocide usage and subsequent environmental pollution, and maximization of the value added to the crop by biocide application (within the limits imposed by law). This optimization is not superfluous as EEC wheat prices are such that wheat farmers aim for top yields. Yields up to 10 tonnes per ha have been obtained and the average winter wheat yield of the Netherlands in 1978 was 6.8 tonnes/ha. The average number of biocide treatments per field in the Netherlands was about 1.4 in 1978, seed dressing excepted.

21.3. OUTLINE OF EPIPRE

In advanced agriculture, small causes may lead to large financial effects, and thus even relatively small differences between fields have to be taken into consideration. EPIPRE therefore operates on a field-by-field basis and gives specific recommendations for each of some 400 fields registered. A general outline of EPIPRE is given in Figure 21.1.

Basic data per field are entered into a databank once per year. Initialization is done in late winter and farmers supply basic data as in Table 21.1. Field observations are then solicited from farmers in April/May by means of computer printed postcards. The data comprise: field code number, date of observation, growth stage of wheat, disease and pest assessments, and fertilizer and biocide treatments with types and dosages used. Farmers send their data to the EPIPRE team in Wageningen, and the data are entered immediately into the databank.

The various simulation models and decision systems are stored in the computer and the EPIPRE operator goes through the files daily for updating

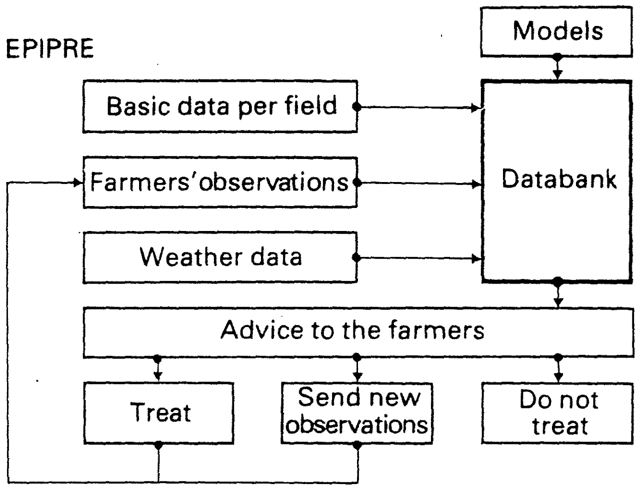

FIGURE 21.1 General outline of EPIPRE.

TABLE 21.1 Initial data asked of the farmers (Anon., 1979).

Cropping plan
Spray equipment (own or hired, beam length)
Size of field
Soil type
Clay fraction (lutum content)
Sowing date
Preceding crop
Yield expectation
Herbicides (dates, chemicals)
Fertiziler (dates, kg N_2/ha)
Cultivar

and advice. The advice falls essentially into one of three classes: "treat", "no treat", or "send new observation", and this information is sent to the farmers. The Extension Service and other interested individuals or institutions receive printouts according to their needs: regional data ranked per cultivar, or cultivar data grouped per region.

The computer used is a DEC 10 with 48 K per job, and the databank is handled through databank management system (DBMS) software. The models used in the operations are not detailed simulation models, but simplified versions in which the growth curves are adjusted to the particular cultivar–race combination present and to the disease fractions x calculated from the observations.

For yellow rust the model is a *mixtum compositum* of epidemic growth functions and damage functions:

$$A = [\exp(BCD) - 1]E, \qquad (21.1)$$

where A is the expected yield loss (kg/ha); B is a function of cultivar resistance; C is a function of N fertilizer applied; D is the field assessment of yellow rust (in number of diseased leaves per 10 m drill length $\simeq$ 25 m^2 of crop); and E is the expected yield (kg/ha) as specified by the farmer. Similar procedures have been developed for aphids and brown leaf rust (Rabbinge and Carter, Chapter 15).

21.3.1. Disease Assessment

The participating farmers carry out their own disease and pest assessment. Since the advice given is based on the farmers' own observations, the procedure places the primary responsibility where it should be. Farmers also find this valuable and instructive. We have endeavored to develop a uniform observation procedure for all diseases and pests. The farmer is required to walk through the field along a diagonal and to look out for the disease(s) or pest(s) to be assessed. At the first finding of yellow rust he is requested to take a sample of rusted leaves and to send it to the EPIPRE team, which then confirms the identification. Yellow rust samples are handed in to IPO for race identification and if a new race is found EPIPRE can be adjusted. The farmer returns along the other diagonal, selects 50 cm of drill length (in different drills) 20 times, and counts the number of leaves with yellow rust. Counts and total are marked on a form. The farmer also takes two stems from each of the 50 cm drill lengths with him. When he has left the field he counts the total number of leaves free from mildew and enters this number on the form. He also enters other relevant information, such as the date of observation, growth stage of wheat, time needed for disease/pest assessment, and biocide and fertilizer treatments.

In essence, disease assessment is a matter of incidence determination. We have found that at low disease severities the log incidence is proportional to severity. Consequently, we can estimate the diseased fraction (van der Plank's x) with sufficient precision for present purposes combining the counts and the growth stage.

21.3.2. Communication with Farmers

Interested farmers all over the country have been invited to participate through the Extension Service. Regional instruction meetings are held in late winter and though the weather in early 1979 was extremely bad and the roads were hardly passable, attendance was over 60%. Early in the season the participants receive instructions for easy symptom recognition in the field. During the season communication is normally by mail, except in the case of aphids where speed is required in communicating data and advice, and information is provided by telephone. Members of the EPIPRE team visit fields to check observations, but are unable to visit all participants and have insufficient time to talk at length with all of them. After harvest, participants receive a printout of their observations and treatments for each field, with the request to check, correct, or complete the data, and to send their yield figures. Amendments and yields are then entered into the databank. The Research Station for Arable Farming and Field Production of Vegetables (PAGV) provides economic analyses, differentiated according to region, soil type, and agricultural activities. These data are used for a standardized calculation of costs and benefits per field due to EPIPRE, or due to deviations from EPIPRE. The cost–benefit analyses are sent to the participants with a request for comments. In general, the farmers agree with our calculations, and believe them to be instructive. Finally, participants and sponsors receive an annual report on the practical aspects of EPIPRE (Rijsdijk and Hoekstra, 1979).

The philosophy of EPIPRE is that the farmer is the master of his own field. EPIPRE gives advice, but advice that is field specific compared to the advice of the Extension Service, which by necessity is more general. The farmer then uses or disregards the advice at his own discretion. EPIPRE only requires that the farmer reports what he has done. As yet, there have been no problems of legal liability.

21.3.3. Cost of Treatment

The cost of treatment consist of four elements: (1) chemical, (2) equipment, (3) labor, and (4) wheel damage. The costs of the chemical are known; use of the farmer's own equipment cost about Dfl 7.50 per ha in 1978; and labor costs depend on the cropping pattern. When cereals are less than 60% of the farmer's acreage and when the farmer grows labor-intensive root crops, he can spend his time more profitably on his root crops. For treatment in cereals he will then hire labor. Tables 21.2 and 21.3 provide data for own and hired labor.

These must be known to determine appropriate damage and action thresholds (Zadoks and Schein, 1979). For yellow rust the damage threshold is: (1) before booting—10% of leaf area covered by disease symptoms; and (2) after booting—5% of flag leaf area covered by disease symptoms (up to three weeks after flowering). For brown rust the damage threshold used is about $x = 0.0005$ at growth stage 10 (Feeke's scale = 45 in decimal code; Zadoks *et al.*, 1974). The actual value depends on the cultivar; information on races is not available. For mildew the damage threshold lies at about two mildew-free leaves per stem, but the actual value depends on cultivar, soil type, and region. This differentiation is essential because mildew is much affected by macrocli-

TABLE 21.2 Approximate costs of yellow rust control in 1978, in kg/ha (wheat price per kg is approximately Dfl 0.48).

Chemical	
Bayleton	95
Bavistin-M	150
Labour	
Hired	65
Own	20
Wheel damage	
1 treatment	150
2 treatments	225

TABLE 21.3 Approximate costs of yellow rust control in 1978, in kg/ha (wheat price per kg is approximately Dfl 0.48).

Chemical used	Number of treatments	Labour Hired	Labour Own
Bayleton	1	310	265
Bavistin-M	1	365	320
Bayleton	2	545	565
Bavistin-M	2	655	565

matic and microclimatic factors. In general the disease damage thresholds quoted are still somewhat tentative, since good experimental evidence is scarce in the Netherlands.

For the aphid *Sitobion avenae*, the 1978 threshold was 15 aphids per ear but this value is subject to change. Preventive schedule treatment against aphids is meaningless, but treatment when needed is highly remunerative, improvements of 1 tonne/ha being obtainable.

If "ear diseases" (mildew, *Septoria* spp., *Fusarium* spp.) and aphids occur together, the damage thresholds of both are lowered as postponement of treatments and mixing of chemicals economize on wheel damage and application costs.

21.4. RESULTS AND PERSPECTIVES

The results for 1978 have been evaluated. Crops were generally healthy but there were localized outbreaks of yellow rust and a late attack of cereal aphids in July surprised farmers and scientists. Yields were unusually high, with an EPIPRE mean of 7.3 tonnes/ha.

Out of a total of 397 fields, 80 fields with yellow rust were treated, of which 36 were treated unnecessarily because the farmers were afraid of yellow rust after bad experiences in 1977, when treatment was not allowed. Of the remaining 44 fields, 18 were treated according to EPIPRE advice. The other 26 fields were treated too early, but they would also have been treated according to EPIPRE. In two cases out of the 317 nontreated fields, the wrong advice was given: in one case due to an incorrect disease assessment by the farmer. In the other, with a late attack on a moderately resistant variety, the loss was still negligible. *Experiments showed that treatment according to the flexible EPIPRE criteria was cheaper than, and equally effective as, a schedule treatment at two predetermined dates.*

Farmers' observations carried out according to instructions were shown to be accurate and adequate. At low disease intensities, farmers had to spend about an hour per field on average, but it was possible to simplify the observation procedure so that in 1979 yellow rust observations took some 30 minutes per field only. In 1978, EPIPRE advised farmers to make three rounds of observations, although in 1979, EPIPRE advised four rounds for yellow rust, brown rust, and mildew together, and one more round for aphids. In the future, more aphid rounds will be needed.

The 1979 data have not yet been evaluated. The winter was long and severe, the summer cool and very long. Yellow rust was relatively unimportant, so that observations and advice appear to have been adequate. Dutch farmers tend to spray early (mid-May) against mildew, but EPIPRE was able to postpone the first treatment, so that a second treatment could be avoided. Warnings against brown rust and *Sitobion avenae* were generally adequate. However, other aphids such as *Metopolophium dirhodum* and *Rhopalosiphum padi* were found. The advisory season was closed around mid-July but this was a mistake in view of late aphid attacks and the possibility of a cool and prolonged summer; it is now clear that EPIPRE should continue until at least the end of July.

In June 1979, the EPIPRE project was reviewed by representatives of the sponsors and the advisory committee. A policy decision was made to extend EPIPRE to 800 participants in 1979 and 3000 in 1980, but these targets could not be achieved. With a long-term perspective we can distinguish the research phase from 1970–77, the present development phase from 1977–80, and an application phase from 1981 onwards. The Laboratory of Phytopathology will take care of the development phase, but will transfer information and equipment to another institution for general application.

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