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EPIDEMICS AND DAMAGE EFFECTS OF CEREAL APHIDS IN THE NETHERLANDS

R.Rabbinge, G.W.Ankersmit, N.Carter and W.P.Mantel

Department of Theoretical Production Ecology and Department of Entomology, Agricultural University, Wageningen, The Netherlands, and Research Institute for Plant Protection, Wageningen, The Netherlands.

Abstract

During the last decade considerable efforts have been undertaken to study the population dynamics of cereal aphids and their damage effects. Explanatory simulation models of the population upsurge were developed which are used in simplified form in management schemes. Advice is supplied on a field by field basis making use of real time forecasts.
Damage thresholds are nowadays based on the direct relations between peak density of the aphids and yield loss. The reliability of these relations for damage assessments is low and this may be due to the nature of the damage. Investigations of this damage show the relative importance of secondary aphid effects due to honeydew which promotes leaf senescence. Monitoring of the aphids is done by making use of simplified sampling and observation procedures, in which only the infestation of the tillers is determined. From this estimate average number of aphids per tiller around flowering is determined and introduced in the predictive simulation models.

Introduction

The increasing importance of pests and diseases as limiting factors for reaching the potential yield levels of wheat has given rise to an increased spraying activity in many commercial fields. Reasons for the increased importance of maturation diseases and aphids during the last decade may be the lengthened kernel filling period and the increased nitrogen level in the plant during this period, due to a top dressing of nitrogen around flowering. The EPIPRE project, discussed shortly in this presentation was started to prevent the increasing tendency of preventive spraying. Briefly, EPIPRE aims at flexible crop protection, based on detailed knowledge of crop growth and prevailing pests and diseases. By integration of this knowledge in large computers, dynamic decision rules have been developed which are used in the field to spray only when it is really necessary, i.e. when the yield gains will at least cancel out the costs of biocide application. This flexible response limits biocide use but requires highly developed knowledge of intensive plant protection systems. These might limit the rigid, low knowledge systems in which biocides are applied according to fixed schedules. At present, field experiments and dynamic crop pest and disease simulation models are being used to develop dynamic threshold levels. These levels will, in the course of time, be combined with a system of monitoring and forecasting of aphid populations to develop a reliable warning and pest control system. Within the system, advice is given on a field basis and concerns stripe rust, Puccinia striiformis, powdery mildew, Erysiphe graminis and cereal aphids, especially the English grain aphid Sitobion avenae. The core of the system is a computer bank and an associated administrative office. The data bank contains specific data on each field including location, sowing time, cultivar, some soil characteristics and herbicide application, and nitrogen fertilization. Also included are reports from the farmers themselves on the occurrence of pests and diseases. The information is stored in the computer and updated whenever additional information on the field is supplied by the farmer or the research team. This information is sent to the administrative office on preprinted postcards. Decision rules for each disease or pest based on simplified pest control algorithms using current weather data as an input generate recommendations which are sent to the farmer. A copy of the field observations and the recommendations is also sent to the extension service so that they can update their written general warnings. The weather data are updated daily. When necessary the decision rules are adjusted. The farmers perform the field observations themselves, since EPIPRE aims at a user oriented approach that supplies recommendations when farmers send new information. Farmers receive training to recognise symptoms and get clear instructions for sampling their fields. In addition, farmers receive a set of slides with disease and pest symptoms, together with a viewer which can be used in the field. Furthermore the farmers are asked to send plant leaves with early symptoms of diseases or pests to the central office in preprinted envelopes. The way of sampling and monitoring aphids will now be described in some detail.

Monitoring and sampling aphids

Continuous monitoring of aphids is a very time consuming procedure and methods which may reduce sampling and monitoring acitivities were urgently needed. Population models which simulate the population curve of the aphids from immigration until the flattening of the curve may help in this. Detailed population models (Rabbinge et. al., 1979, Carter et. al., in prep.) explain the upsurge of the population and the period of flattening, but are still inadequate in explaining the collapse of the population. Based on a sensitivity analysis of these explanatory models decision models were developed which are used to produce short term predictions. Proper validation techniques have shown the reliability of the models for this job. Thus knowledge of the population densities around flowering suffice to start the simulation model and to predict the population upsurge when additional information on immigration is supplied. To assess the initial population densities and the size of immigration, Carter and Dewar, (in press), describe how suction trap catches may be used to determine the size and timing of immigration. These findings are at present being compared with the number of aphids collected in the field using an insect suction sampler. When this immigration has begun, farmers are advised to inspect their fields for aphids. The aphid assessments may be used to update the decision models of EPIPRE and enable prediction of the course of the aphid population in time. Advice whether spraying is needed is based on the expected population peak and the still unreliable corresponding damage predictions (see later). Estimates of population densities should be made using simple but reliable methods that are not labour intensive. To derive such methods, the distribution of the aphids in the field was considered. In 200 out of 225 cases the distribution of the aphids fits a negative binomial distribution, with k-values ranging from 0.5 to 2. When average numbers are lower than 0.3 per tiller determination of the distribution in the field requires more than 1,000 tillers to be searched, as the colonies are then scattered. Very rarely a Poisson distribution gives a better fit (20 out of 225 cases). Tests were made of the relation of the probit value of the infestation level and the logarithm of the average number of aphids per tiller for S. avenae, Metopolophium dirhodum and Rhopalosiphum padi and combinations of these species. Figure 1.a. shows the relation between the average number of M. dirhodum per tiller and the percentage infected tillers, Figure 1.b. shows the relation between the average number of M.dirhodum, S.avenae and R.padi per tiller and the percentage infected tillers and Figure 1.c. shows the average number of S.avenae and R.padi per ear and the percentage infected ears.

In all cases the mentioned linear relationship exists (correlation coefficients in all cases > 0.92 number of cases > 225). The regression coefficient is scarcely different for all three cases (1.4, 1.51 and 1.54 respectively), so that it seems possible to use the same regression line for all cases. The presence of these linear relationships allow the use of a simple sampling method. The infestation level is determined and this gives the average number of aphids per tiller which is used to initialise the decision models. The procedure used in EPIPRE is now as follows. At flowering farmers are asked to determine the infestation level of aphids by inspecting 100 tillers taken at random over a diagonal of a field. When infestation levels are lower than 70% farmers may delay any action against aphids for two to three weeks. At infestation levels higher than 70% the damage threshold will definitely be exceeded (350 kg of wheat/ha), and farmers are advised to spray. However it should be realised that one determination of the percentage may give an under or overestimation of the population density. Therefore repetition of the monitoring is necessary. The timing of the second observation by the farmers depends on computer calculations with simplified simulation models. This period may vary from 10 days to 20 days after flowering. For the second observation, farmers are asked to determine the proportion of tillers with over ten aphids. These proportions, again after transformation, are linearly related to the average density per tiller. They provide supplementary information on the number of colonies and the potential for emigration, since population density is, as indicated by the models, one of the most decisive factors inducing wing formation. All field observations are entered on the preprinted cards and are sent to the forecasting team who recom mends whether to spray or not. The weakest point in the scheme is the determination of the damage threshold and at present is more or less guesswork. Additional research of the type discussed below is needed to improve this situation.

<u>Damage effects of cereal aphids and damage thresholds</u>

Yield losses of wheat due to aphids have varied considerably during the last decade, but have often exceeded 1000 kg of wheat per ha. These considerable yield losses explain the increasing research effort in understanding aphid population dynamics and their effect on the host plant. Although considerable yield losses due to aphids have been measured, a consistent relation between actual aphid density and yield loss seems absent. The relation between the peak density of the aphids, either <u>S. avenae</u> or <u>M. dirhodum</u> or a combination of both, and yield loss has a correlation coefficient of 0,69, figure 2, whereas the correlation coefficient of the relation between integrated aphid numbers (Rautapää index) and yield loss is even lower. This may be due to the nature of aphid damage. Direct aphid suction damage only explains part of the yield losses. Indirect effects due to honeydew seem at least of equal importance. Data gathered by Vereijken (1979) showed that when secondary effects were prevented by spraying activities this did result in a damage reduction of about 50%. This may be due the secondary effects caused by the honeydew and the stimulation of secondary perthotrophic fungi. Detailed laboratory studies of the light response of flag leaves covered with honeydew and flag leaves without honeydew show a decrease of total photosyntheticactivity per day of about 20% (Rabbinge et. al. in prep.). This result of decreased photosynthetic activity will only show up in the field when very high aphid densities are reached. Direct measurements under field circumstances with a mobile laboratory confirm this statement. Another effect induced by honeydew, which shows up at rather low honeydew quantities, is the promotion of blackmolds and other perthotrophic fungi (<u>Cladosporium spp.</u>, <u>Aureobasideum</u> pullulans)and white and red yeasts (Cryptococcus spp. and Sporobolomyces roseus). The direct effect of these black molds on photosynthetic productivity seems neglectable. (Rabbinge et. al. in prep.). Honeydew also affects the senescence of cereal leaves (Wratten, 1975). Detailed laboratory experiments demonstrate that the presence of honeydew on the flag-leaves may shorten the flagleaf duration by 3-4 days. This phenomenon is already present at relatively low honeydew quantities (coverage percentages of 30%). These effects were confirmed by field experiments. Detailed analysis under field conditions demonstrated that the direct effects of aphids and their excretion products on photosynthesis seems neglectable. Both, light efficiency and maximum photosynthesis, are not significantly affected and the indirect yield losses due to aphids which show up, clearly cannot be attributed to these effects of honeydew on the assimilation activity of the plant. Apparently the decrease in leaf area duration which is clearly demonstrated is the most important factor, besides the direct suction damage, which affect yield loss (Table 1). Within 12 days these differences between treated and untreated plots show up. (Drees et. al. in prep.). These results are confirmed by detailed analysis of ear diseases in winter wheat (Spiertz, 1978). The experiments in which these effects were measured were at a production level of 7500 kg wheat/ha. The yield losses due to aphids (maximum density 25 aphids, a combination of S. avenae, M. dirhodum and R. padi) were 800 kg of wheat per ha. Thus we may conclude that the causes of damage are of a complex nature direct effects and indirect effects both playing a role. Therefore the damage thresholds are difficult to define and additional research of the type discussed above is needed to improve these damage thresholds.

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Fig. 1a.

Average number of M.dirhodum per tiller versus percentage infested tillers

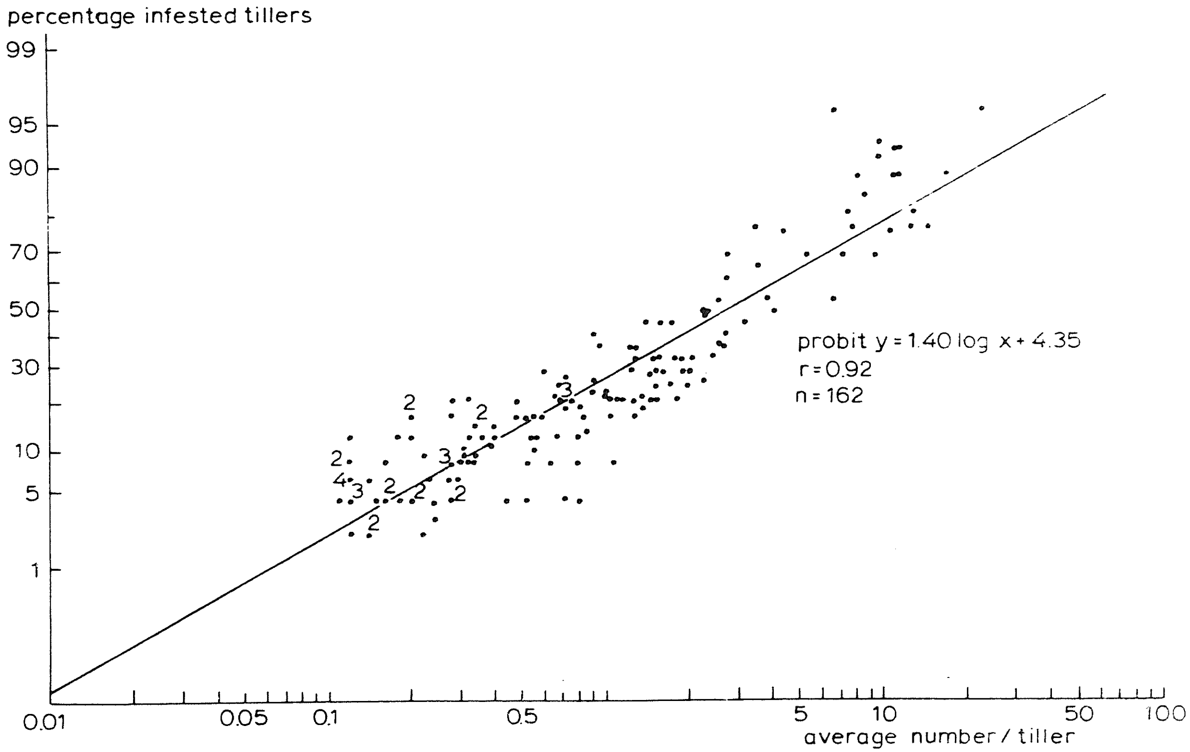


Fig. 1b

Average number M dirhodum, R padi and S avenae per tiller versus percentage infeste

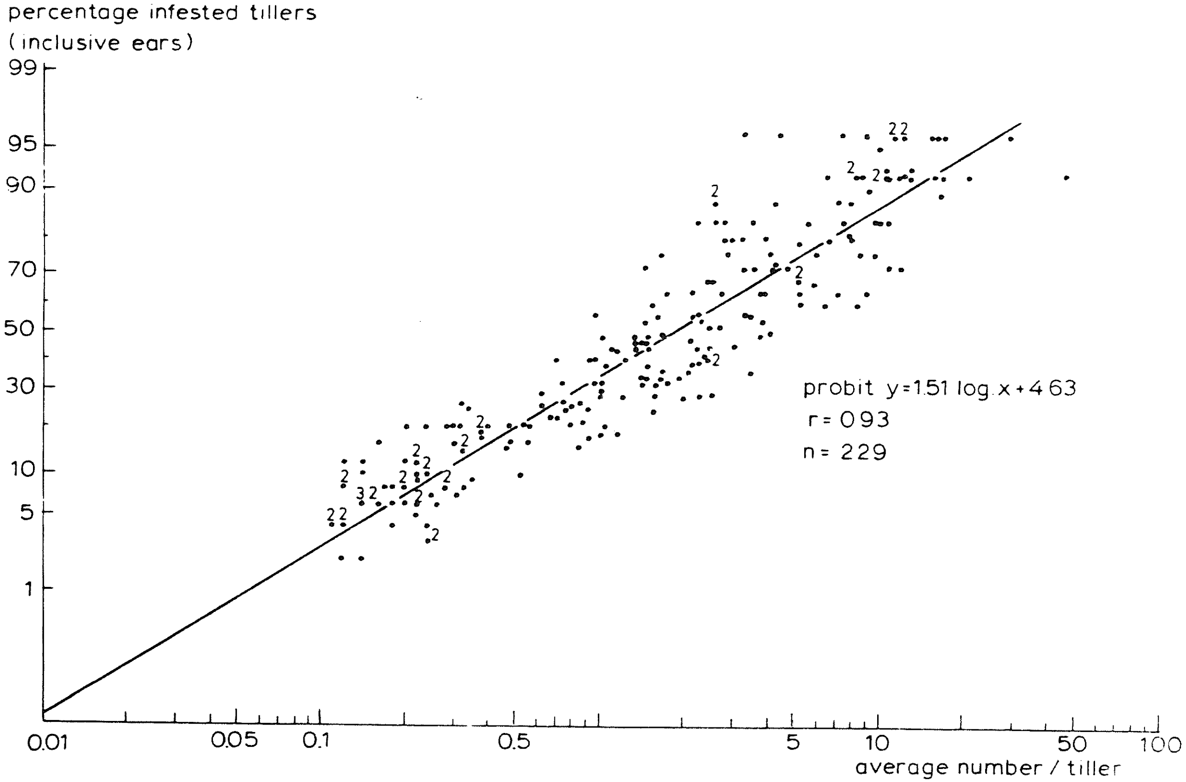


Fig. 10

Average number R padi and S avenae per ear versus percentage infested ears

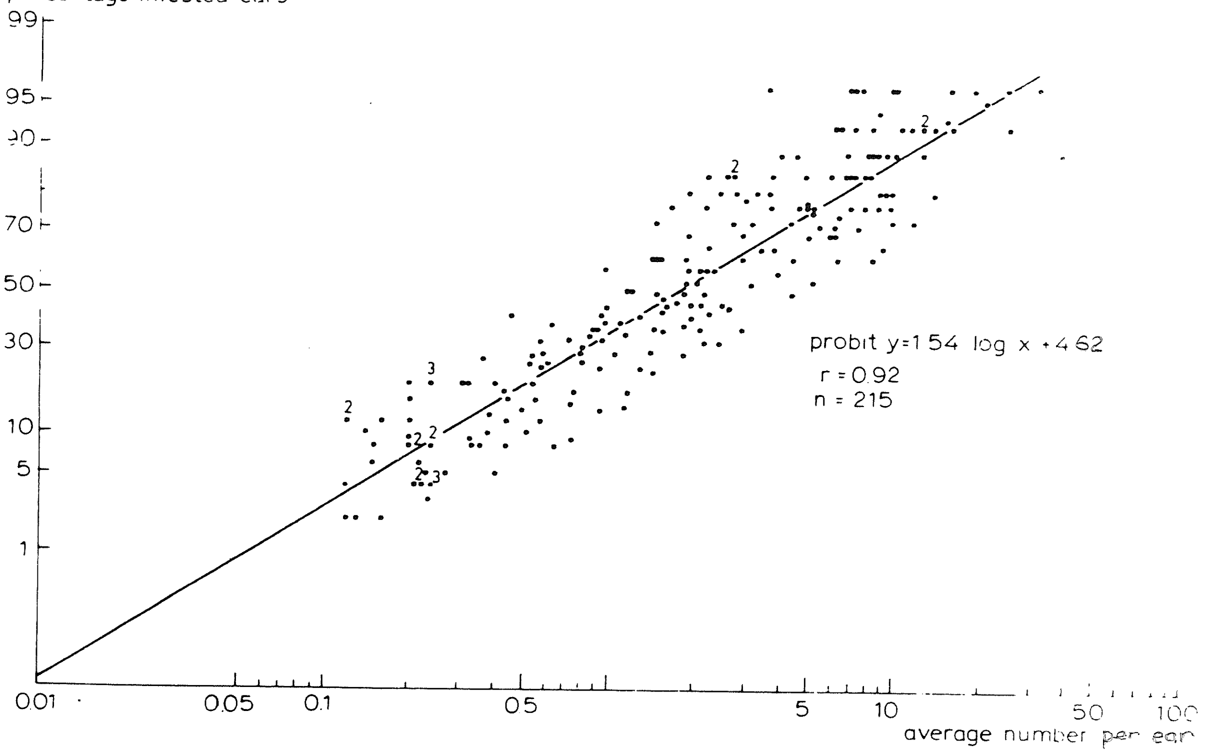
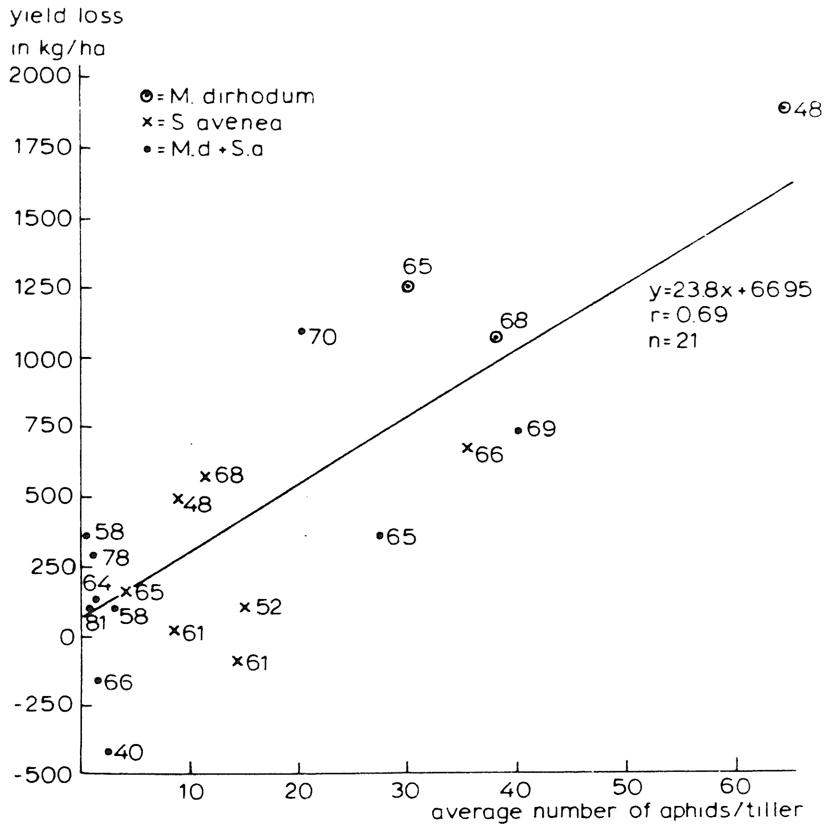


Fig. 2



yield loss
in kg/ha
2000
1750
1500
1250
1000
750
500
250
0
-250
-500
⊙ = M. dirhodum
× = S. avenea
• = M.d + S.a
y=23.8x+66.95
r=0.69
n=21
10
20
30
40
50
60
average number of aphids/tiller
48
65
68
70
69
66
68
48
58
78
64
65
58
81
61
52
61
65
66
40