Smart plant protection

An important prerequisite for low pesticide use in Denmark is the free access to results from a large number of field trials with plant protection products. These results are the backbone of the decision support system Crop Protection Online that has proved its potential in practice and is an important tool for advisers.

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Why is pesticide use low in Denmark?

■ Despite an increase in pesticide use in Denmark during the past four years, Danish agriculture is characterized by a relatively low use of chemical inputs while maintaining high crop yield. This paper will focus on the Danish way of practising 'smart plant protection'. Several driving forces have interacted to achieve a relatively low level of pesticide consumption:

- A tradition for strong collaboration between agricultural scientists at the The Faculty of Agricultural Sciences (FAS) and the Danish Agricultural Advisory Service (DAAS), enabling swift communication of recent research results to end users, and communication of research needs from end users to scientists.
- A comprehensive and independent agricultural advisory service targeting approximately 85% of Danish farmers and focusing on optimisation of economic output at farm level.
- A strong system of National Field Trials, conducted by DAAS. The objective of many of the trials is to test plant protection strategies in farmers' fields.
- Farmers are generally willing to use new knowledge, change crop varieties etc.
- Pesticide taxes (currently 33% for herbicides, fungicides and plant growth regulators, and 54% for insecticides)
- National action plans for reduced pesticide usage since 1986. Currently, the third action plan known as 'Pesticide Plan 2004-2009' is in its implementation phase. The action plan aims to reduce the so-called treatment frequency index (TFI) to 1.7 by the end of 2009. The TFI is defined as the number of times the agricultural area may be treated with pesticides at labelled dosages.

Results from pesticide efficacy experiments carried out at FAS and the National Field Trials at DAAS are published within three months from harvest. Furthermore, results are freely available to advisers and farmers and all results are published. This forms the basis for a detailed knowledge of strengths and weaknesses, the performance of reduced dosages etc. of the pesticides that are currently marketed in Denmark, and thus for the further development and maintenance of decision support systems.

Figure 1 shows a summary of 130 National Field Trials on weed control in spring barley. Various herbicide mixtures were used in the trials, but all were considered to control a broad spectrum of weed species. Hence, they have been pooled in this summary. It follows from Figure 1 that a fair trade-off between level of weed control and maximisation of net yield (i.e. yield after subtraction of expenses to herbicides and application) was obtained with a TFI of 0.5, corresponding to a mixture of a sulfonylurea herbicide with a suitable partner, each at a quarter of the recommended dose. If the choice of herbicide is adjusted to the weed flora present, it will be pos-

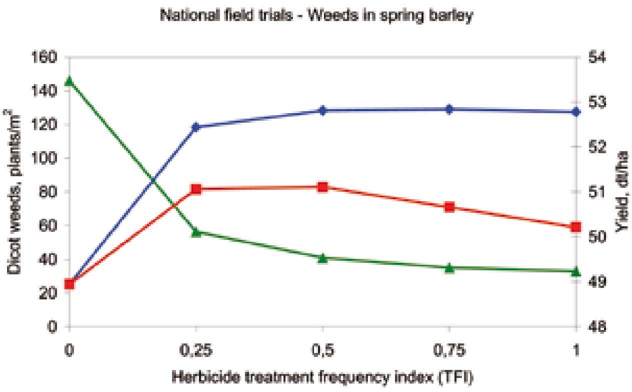

Figure 1. Summary of 130 Danish National Field Trials on weed control in spring barley 1999-2006. The figure shows the response of dicot weeds counted 3-4 weeks after spraying (green), gross yield (blue) and net yield (red) to herbicide dose. The treatment frequency index denotes (TFI) relative herbicide dose. If e.g. two herbicides are mixed each at quarter labelled dose level, then the TFI of the mixture is 0.5.

sible to obtain an even better weed control effect with a low herbicide dose.

Figure 2 is based on the results of 73 National Field Trials focussing on ear treatment against Septoria in winter wheat. In these experiments various fungicides and fungicide mixtures were used. Due to the relative higher price of fungi-

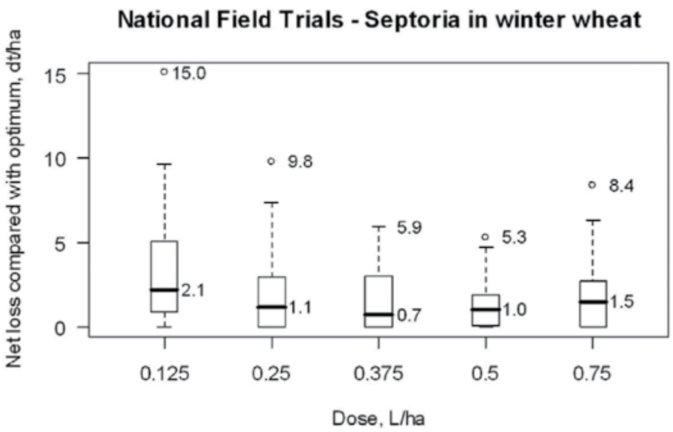

Figure 2. Summary of 73 Danish National Field Trials on ear treatment (primarily against Septoria) in winter wheat 1999-2006. For each experiment the optimum fungicide dose and the corresponding net yield was calculated. The box plots at each dose show the distribution of the net yield loss when consequently choosing a certain dose rather than the optimum dose in each experiment. The numbers indicate median and maximum yield loss at each dose.

cides, it is more expensive to apply higher than the optimal dose It can be seen from the figure that the variability in the final net yield is lower applying doses in the range of 0.375 to 0.5 L/ha than applying lower or higher dosages. In other words: applying optimum dose ensures optimum yield and minimum uncertainty. This may in part explain why the current fungicide use in Danish cereals is close to the optimum derived from the results of field trials.

Figure 2 covers a range of winter wheat varieties with different resistance to Septoria. Dividing the data into two groups consisting of relatively resistant varieties (officially grouped 0 or 1 regarding Septoria susceptibility) and susceptible varieties (grouped 2 or 3), a similar analysis revealed an average optimum dose of 0.375 L/ha for the resistant varieties and 0.5 L/ha for the susceptible varieties, indicating that there is some potential in adjusting the fungicide dose to the resistance level of the variety.

Tools for farmers and advisers

Danish farmers and advisers have access to several tools to assist farmers in selecting their strategy against weeds, pests or diseases in the field. Data from field trials are used to update the different tools continuously. The flagship is ‘Crop Protection Online’ (CPO), an internet-based decision support system developed and marketed in collaboration between FAS and DAAS. The architecture of CPO has been described elsewhere (Rydahl *et al.*, 2003). From the user viewpoint, CPO demands input of current weed, pest or disease incidence at the field level and provides an evaluation of the need for pesticide treatment. Furthermore, it ranks potential solutions according to either costs or TFI. The potential of CPO for reducing herbicide use in cereals has recently been estimated to be between 44 and 48% as compared to the current practice (Table 1), while the potential for reducing fungicide use has to a large extent already been realised. CPO is being used extensively by agricultural advisers and by a small group of farmers and is an important tool to optimise pesticide use.

The Danish Monitoring Network is another important tool, where advisers report weekly about pest and disease incidence in local fields. These data are summarized as a map of Denmark showing which locations currently need treatment and which locations do not exceed thresholds for treatment. Experience has shown that early fungicide treatments are often not economical, and

Table 1. Comparison between TFI from official sales statistics, TFI calculation on farm level and TFI from testing of Crop Protection Online (CPO) (unpublished data).

	TFI herbicides		TFI fungicides	
	Winter wheat	Spring barley	Winter wheat	Spring barley
Official statistics*	1.18	0.86	0.69	0.33
Farm TFI**	0.97	0.80	0.76	0.40
CPO testing***	0.75	0.51	0.70	0.40

*Average of 4 years (2000-2003) sales data. ** Average of TFI budget calculated at farm level during 2000-2003.
*** Average TFI over several years' testing of CPO from field trials.

this tool helps farmers and advisers in making decisions about such treatments.

Why is pesticide use increasing?

There are many plausible reasons why pesticide use in Denmark has increased in recent years. We will not go into details here, but Figure 1 may serve as an example. According to the official Danish statistics, the average herbicide use in spring barley corresponds to TFI=0.86 (see Table 1). Figure 1 illustrates that the herbicide dose-response curve for net yield is quite flat around its optimum. By applying herbicide dosages slightly higher than optimum, the farmer insures high efficacy at a relatively low cost, while saving time to carry out a more detailed inspection of his fields to assess the optimum dose. With current price relations of crops and herbicides, many farmers argue that it often pays to take such an insurance considering the overall economy of farming. This approach is often practised on larger farms to overcome labour bottlenecks during the growing season. As mentioned previously, there are several other possible reasons for the increasing use and currently, possible tools to enforce the target of 'Pesticide Plan 2004-2009' are being evaluated by the authorities.

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