

Using logarithmic spraying to visualise pesticide efficiency

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Logarithmic spraying allows farmers and advisers to visualise the effects of pesticides in the field, making it easier to optimise their use and reduce environmental impact. © Hanne Justesen Bach, AgroTech, Denmark.

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Introduction

Training and educating farmers to use less pesticide is a complicated task. Not only is it a challenge to create interesting and effective courses, it is also difficult to document if a new and somewhat innovative strategy is beneficial to the farmer or not. During a training session, it is important to make the teaching active and inspiring for the participants. One way to do this is to use visualisation.

People in general, and farmers in particular, have a tendency to better remember and believe what they see rather than what they hear. The reason why farmers use pesticides is that they want to avoid losses due to unwanted organisms such as weeds, pests and diseases. In other words they want to see an effect. A way to visualise the effect of a pesticide application is to use logarithmic spraying. The technique is described below, with suggestions for setting up training events with farmers and advisers.

What is logarithmic spraying?

In contrast to conventional sprayers, a logarithmic sprayer makes it possible to test pesticides in a very confined area, such as an experimental plot etc. It is especially useful for testing herbicides in areas where weeds occur in patches in the field, as it is possible to apply a wide range of doses in a small amount of space. The construction of the logarithmic sprayer may vary, but in its simplest version, the technique is rather simple (see Figure 1 below).

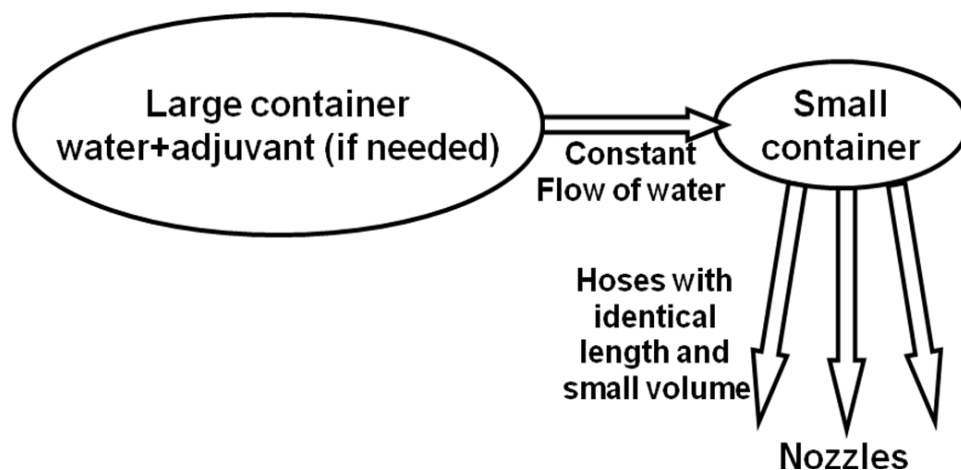
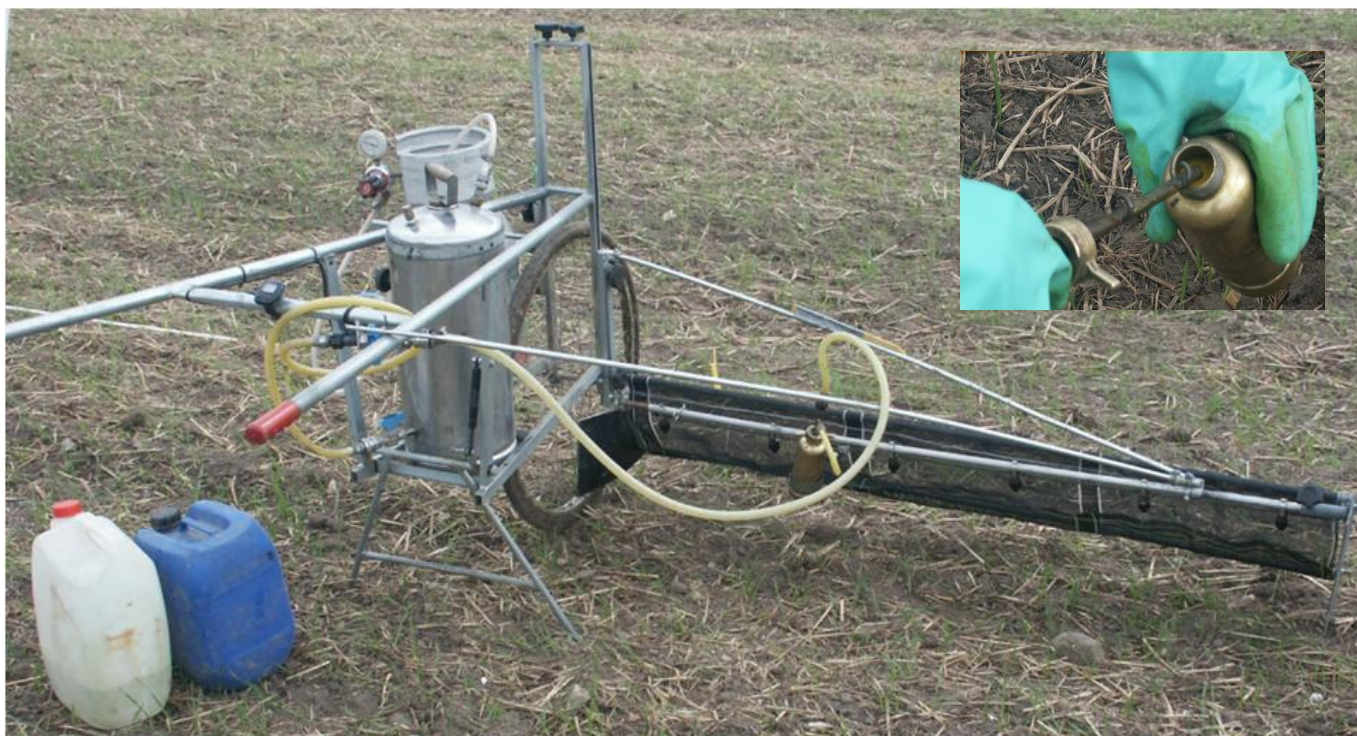


Figure 1:
Schematic
representation
of the principle
of a logarithmic
sprayer.

A small container contains a dose of a pesticide equal to the maximal dose required in the experiment or demonstration. The liquid in the small container is continuously diluted with water from the large container, which is under pressure. The content of the large container may be pure water, water with a known concentration of adjuvant or a known concentration of a relevant partner pesticide. If it is assumed that the liquids in the small container are mixed well, and that the hoses connecting the small container to the nozzles have the same length, it is simple to show that the logarithmic sprayer will provide an exponentially decreasing dose of pesticide (see Box 1 on page four).

The equipment

In order to conduct a demonstration using a logarithmic sprayer, it may be enough to modify an already available experimental sprayer. Below you can see the standard sprayer used for experiments in the Danish National Field Trials. The sprayer is operated with pressure from a gas tank, mounted opposite the spraying boom for balance. In order to monitor the moving speed, a small cycle computer is mounted on the sprayer. As mentioned, it is important that the small container is connected to the nozzles via hoses with similar lengths.



Above: a logarithmic sprayer used in the Danish National Trials. Inset: the small container used to hold the pesticide. © DAAS, Denmark.

Advanced equipment

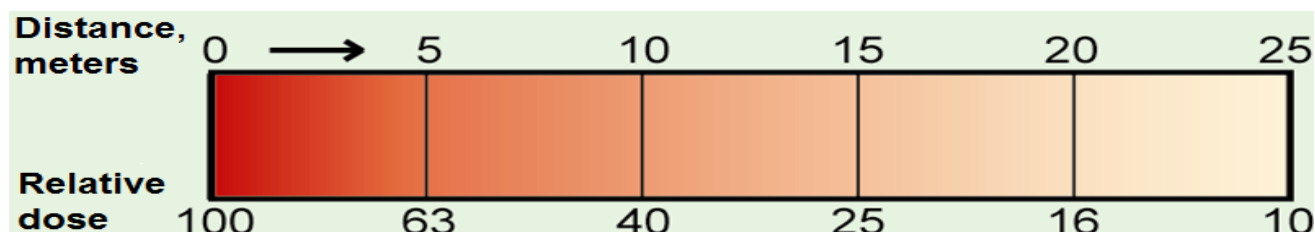
There are also more advanced tractor-mounted sprayers available on the market. The sprayer shown right is not only able to perform logarithmic spraying, but also has a higher degree of precision than the simple sprayer shown above. Besides electronic registration of the amount of water used, it is also possible to clean the entire system of hoses etc. from the tractor, as it includes a mounted compressor capable of emptying the hoses following each application. This type of sprayer is, of course, more expensive than the one shown above. For demonstration purposes, however, it is not necessary to employ such an advanced system.

Right: An advanced tractor-mounted sprayer which is capable of both logarithmic and standard spraying. © Jesper Svensgaard, University of Copenhagen, Denmark.



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Figure 2: Schematic representation of the development of the dose in an experimental plot treated with a logarithmic sprayer. It is assumed that the operator walks with a speed of $1 \text{ m} \cdot \text{s}^{-1}$. (Danish National Field Trials™, 2003 pp. 318)



In the field

When placing the experiment in the field, always have an untreated plot next to the treated one. In this way, the effect of the treatment becomes more visual.

For demonstration purposes, it may be necessary to establish an artificial population of ‘weeds’ by sowing these together with the crop. Following the treatment, invite farmers or other stakeholders into the field and show them the result.

On the following page you can see an example of control of Rough Meadow-grass (*Poa trivialis*) in winter wheat. In order to create an even population of Rough Meadow-grass in the field, the weed was sown into the plots. In the experiment, the pesticide Monitor (active ingredient (a.i.): sulfosulfuron) is used at an initial dose of 50 g a.i./ha (twice the maximum dose). The final dose at the end of the plot is 5 g a.i./ha. Ask the farmers to find the

Box 1: The maths behind the logarithmic sprayer

To calculate the dose at any distance in the plot, it is important to know the initial dose of pesticide and the half-life of the application (the time it takes to reduce the dose to half of the initial dose). The half-life ($L_{1/2}$) is calculated as:

$$L_{1/2} = 0.693/k_s$$

Where k_s is a speed constant given by:

$$k_s = \text{flowrate (ml} \cdot \text{s}^{-1}) / \text{volume of container (ml)}$$

For a sprayer where the small container has a volume of 0.320 L and a flowrate of $30 \text{ ml} \cdot \text{s}^{-1}$, the $L_{1/2}$ is:

$$L_{1/2} = 0.693 / (30 \text{ ml} \cdot \text{s}^{-1} / 320 \text{ ml}) \approx \underline{7.5 \text{ s}}$$

The distance at which the half dose is reached in the plot ($D_{1/2}$):

$$D_{1/2} = L_{1/2} \cdot \text{Speed (m} \cdot \text{s}^{-1})$$

With a speed of $1 \text{ m} \cdot \text{s}^{-1}$ the distance of half dose is therefore app. 7.5 meters.

In order to calculate the dose y at distance x and initial dose of c , the following function is used:

$$y = c \cdot \exp(-k \cdot x)$$

k is calculated from $D_{1/2}$. If $D_{1/2}$ is 7.5 metres, k is:

$$k = 0.693 / 7.5 = 0.0924$$

If it is assumed that the experimental plot is 25m long and the initial dose of the herbicide is 1 l/ha, the final dose will be:

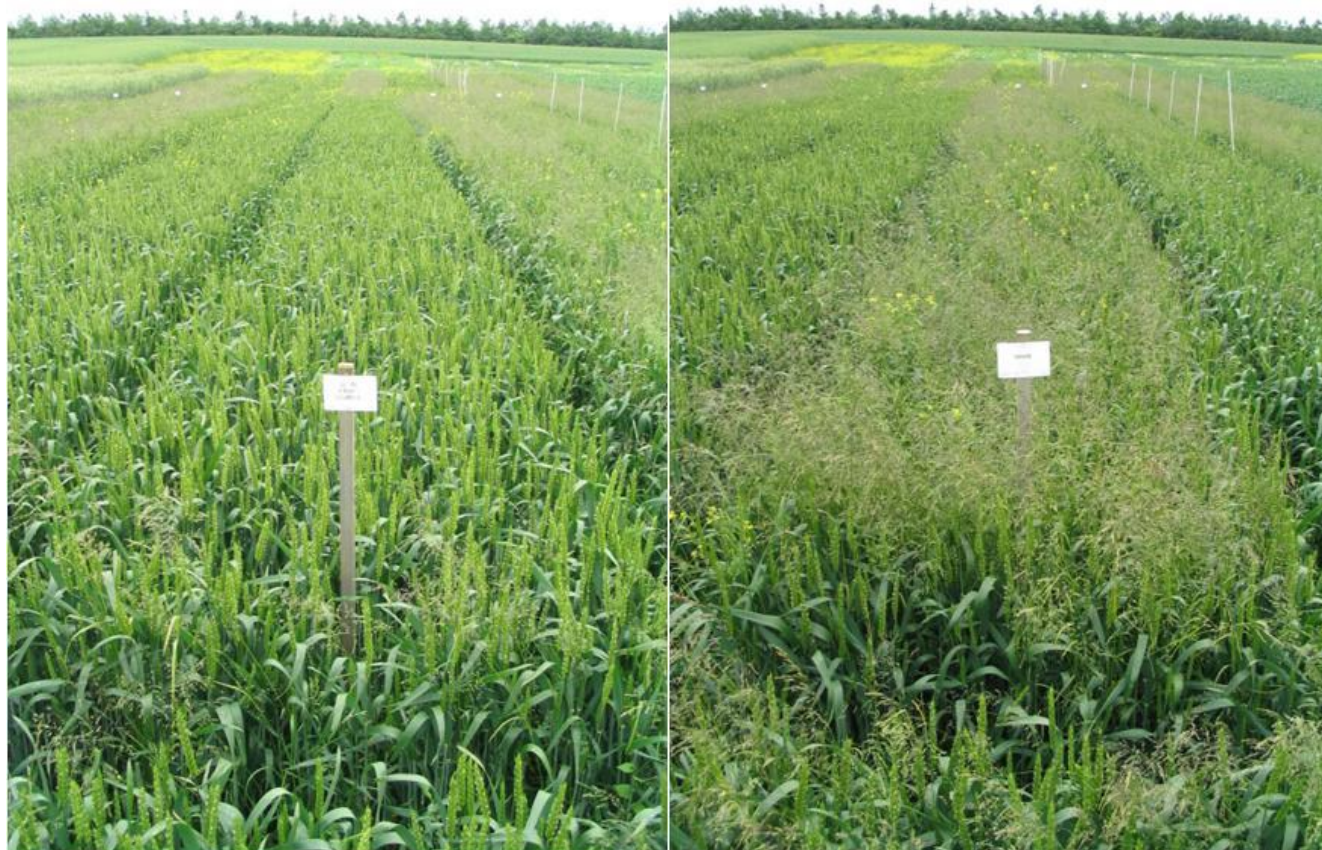
$$y_{25} = 1 \text{ l/ha} \cdot \exp(-0.0924 \cdot 25\text{m}) = \underline{0.1 \text{ l/ha}}$$

The dose may also be calculated for other distances.

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location in the plot, where they think satisfactory control of the weed is obtained.

Based on the calculations shown in Box 1, inform the farmers about the dose at this distance, and use it to initiate a discussion about the difference between complete control of a weed and economically optimal control. In many cases, it may not be necessary to apply the label dose of a product to receive satisfactory control.



A demonstration of the effect of the herbicide Monitor (sulfosulfuron) against Rough Meadow-grass (*Poa trivialis*). On the left is a treated plot, and on the right an untreated one. © DAAS, Denmark.

In the photographs on the following page, you can see an example of the effect of two herbicides on lupin. In the experiment, the herbicides DFF (a.i. diflufenican) and Fenix (a.i. aclonifen) were applied at an initial dose of 0.3 l/ha and 5.0 l/ha respectively. These doses correspond to approximately twice the approved dose of both herbicides.

Whereas no damage is visible in the plot treated with DFF, the plot treated with Fenix has been much more affected. Not only is this experiment very visual, it also provides valuable data on the sensitivity of lupin towards different herbicides and the selectivity of DFF and Fenix. Although it may be slightly more difficult, the same method can also be applied for fungicides. Note that these plots cannot be used to reveal details about the economical yield

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of a plot, but only give an idea about the efficacy and selectivity of different pesticides. In order to reveal details about economical yields, normal plot experiments have to be made.



Screening for herbicide sensitivity in lupins using logarithmic spraying. In the photograph on the left, the herbicide DFF (diflufenican) has been applied. On the right, the herbicide Fenix (aclonifen) has been applied. © DAAS, Denmark.

What dose is necessary?

The data obtained from the assessment of the effect is used to determine the optimal dose of the tested herbicides. In many cases, the dose recommended on the label of a pesticide is higher than needed, as the chemical companies have to guarantee the effect of the label dose under varying circumstances. The data obtained from the logarithmic sprayed plots can therefore be used to check whether or not it is possible to use a reduced dose of the herbicides.

In order to find the optimal dose of an herbicide, the plots are assessed visually. This is, for example, done by assessing the relative biomass of the weed in the plot, at various distances. By doing this, a so-called dose-response curve can be formed. This curve presents what dose of a compound is needed to give a certain level of control of a weed. In Figure 3 an example of a dose-response curve is presented. Here, four herbicides have been tested against Rat's-tail Fescue (*Vulpia myuros*) in winter wheat. On the curve, the visual assessments of biomass are presented as a function of the calculated dose at the particular distance in the plot (the points

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on the curves). A so-called logistic curve is then fitted to the points (Seefeldt, S. S., Jensen, J. E., & Fuerst, E. P. (1995). *Log-logistic analysis of herbicide dose-response relationships*. Weed Technology, 9(2), 218-227).

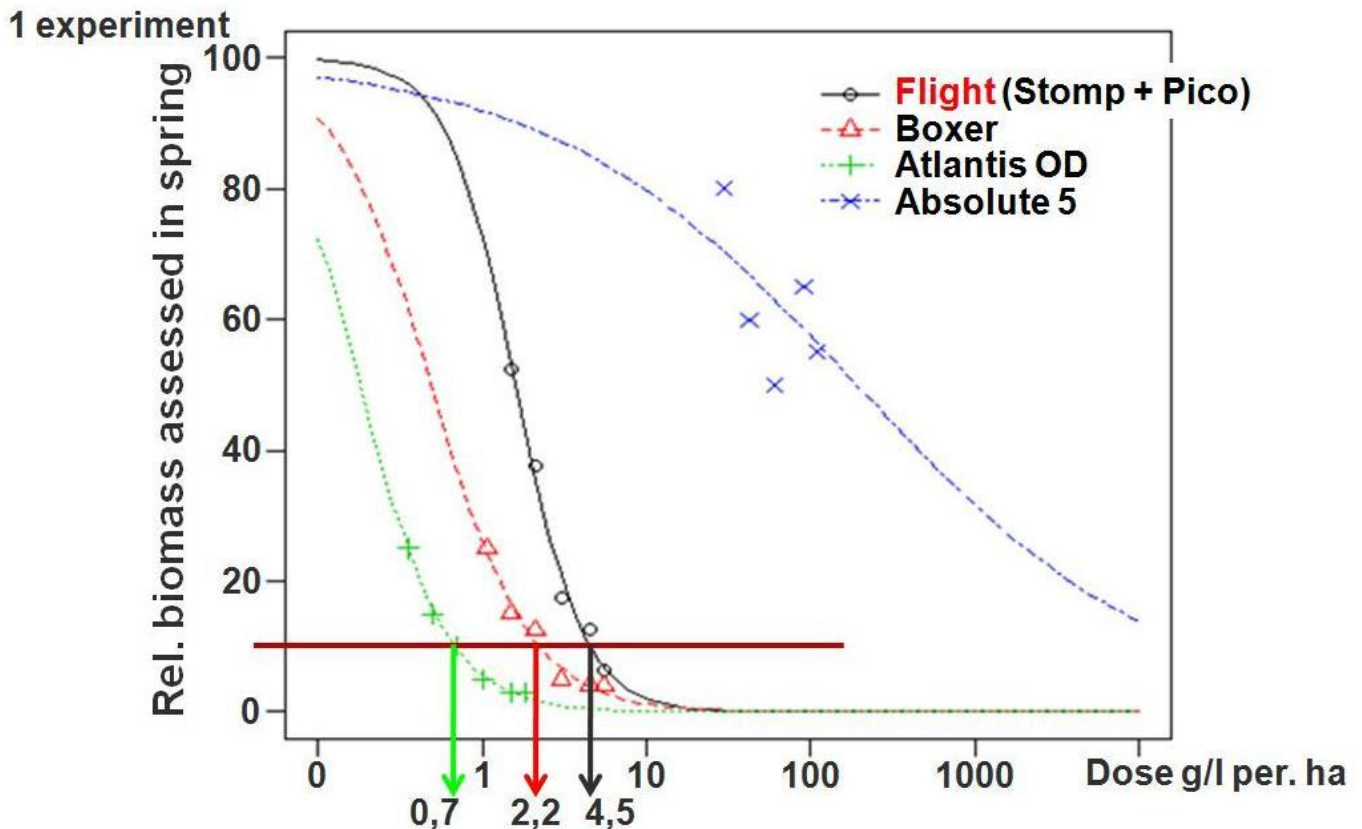


Figure 3: A dose-response curve is used to determine the dose of a pesticide needed to give a certain control of a particular pest problem. In this case, four herbicides have been tested against Rat's-tail Fescue (*Vulpia myuros*) in winter wheat. The herbicide Absolute 5 gives only very limited effect, whereas the other three compounds are more effective. (Danish National Field Trial Experiments TM, 2010 pp.75)

From the curve it can be seen that the three compounds Flight (picolinafen plus pendimethalin), Boxer (prosulfocarb) and Atlantis OD (mesosulfuron plus iodosulfuron) give a 90% effect with a dose of 4.5, 2.2 and 0.7 l/ha respectively. For Atlantis OD, the dose corresponds to approximately 75% of the label dose, whereas for Boxer, the dose is slightly more than 50% of the label dose (4 l/ha). Flight is not yet approved in Denmark, so no information is available about the approved dose. Depending on the level of control needed, the dose of Atlantis OD and Boxer may therefore be reduced when spraying against Rat's-tail Fescue in winter wheat, as compared to the label dose. This is a benefit both to the environment and the farmer's budget. The last product tested, Absolute 5 (diflufenican plus flupyrsulfuron) did not provide satisfactory control of the weed, not even at doses higher than the label dose.

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Summary

Logarithmic spraying is a spraying technique used to test various pesticides, most commonly herbicides. The technique is however also very valuable as a demonstration tool, as it is possible to show advisers, farmers and others, exactly what is the effect of a given dose of a given pesticide against a given pest.

This leaflet presents the technique behind logarithmic spraying and provides examples on how to use it in a training situation. Information on how to use the logarithmic sprayer to identify the dose necessary to control a given pest is also provided.

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About ENDURE

ENDURE is the European Network for the Durable Exploitation of Crop Protection Strategies. ENDURE is a Network of Excellence (NoE) with two key objectives: restructuring European research and development on the use of plant protection products, and establishing ENDURE as a world leader in the development and implementation of sustainable pest control strategies through:

- > Building a lasting crop protection research community
- > Providing end-users with a broader range of short-term solutions
- > Developing a holistic approach to sustainable pest management
- > Taking stock of and informing plant protection policy changes.

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