
Robot spraying – vision or illusion

Use of herbicides can be reduced by at least 40 percent if weed control is carried out with spraying robots. The amount of reduction depends on the requirements for precision and capacity.



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■ The pesticide treatment index is increasing in Denmark despite the expected and desired goal of decreasing the number of treatments to 1.7 by the end of 2009. Optimisation of herbicide choice, dosage, mechanical methods and spraying technique have not counteracted the general increase in treatment index. Therefore, there is a need for new thinking and a technological leap if the goal is to be obtained. The paper presents three categories of spraying robots with different levels of resolution and precision.

Spraying robots

Robot technology has been used in the industrial sector for decades and has in the past 10 years also found its way into greenhouses and animal production systems. Robots can take over tasks in the field that require great manual input or operations with more precision than conventional machines can handle. For example, it is obvious to use a robot to gather stones or to let a robot control the use of herbicides with great precision. Technically speaking, robot technology is ripe for developing spraying robots to control weeds and, in the long run, other pests.

There is great potential in identifying weeds and limiting herbicide application to those areas where there is a need for weed control. It is necessary to differentiate between three different levels of precision and technology:

- **Spot sprayer**, where the boom is divided into sections that are controlled by a combined camera-computer system that identifies weed

occurrence and the control requirements. The camera-computer system can be mounted on the front of the tractor.

- **Cell sprayer**, where each individual nozzle is made to spray small units such as 50 cm². A camera system is mounted on the boom and identifies the occurrence of weeds in each cell.
- **Micro sprayer** is technically speaking, very different from the spot sprayer and the cell sprayer. A micro pump with a high level of precision is used to target the individual plants with a jet. Each plant in the picture is identified and the weed plants are localized with a camera system.

Spot and cell sprayers look like conventional manned sprayers. Micro spraying requires very high precision, both with regard to identifying weed plants and targeting the jet. Such precision cannot be attained at the speeds that are normal for conventional, manned sprayers. The required precision can only be attained with a low speed and are therefore only realistic with an unmanned sprayer.

Spot spraying

There is already spraying technology that can perform spot spraying of areas with weeds on the basis of a weed maps e.g. obtained from manual weed surveying. However, the technology is not used in practise because manual weed surveying is too expensive.

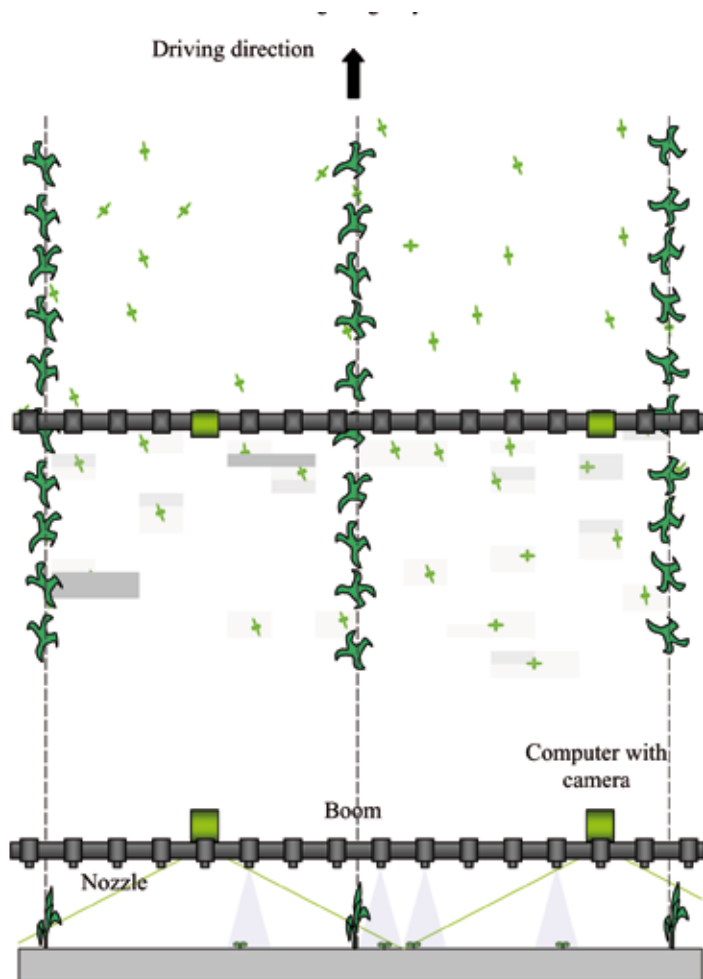


Figure 1. Illustration of a spot sprayer. The upper part of the figure illustrates a vertical view of the spot sprayer from above, the lower part a horizontal view.

In Germany, research has been carried out with automated weed identification system and a precision spraying with three different herbicides (Gerhard *et al.*, 2003). The automated weed identification was based on digital cameras and embedded algorithm for images analyses and a decision algorithm to control the spots with weed density beyond a target economic threshold.

The sprayer had a 21 metre boom divided into three metre sections. The sprayer had three tanks with different herbicides and a control system that operated each boom section due to the output from the decision algorithm.

A series of four years of whole field experiments was carried out in different crops and fields with the spot sprayer. The three tanks contained different herbicides to control annual grass weeds, annual broad leaved weeds and perennial weeds.

The results of the experiments showed an average of 60% herbicide savings when spraying annual broad leaved weeds and up to 90% when spraying annual grass weeds.

Cell spraying

The expression 'cell spraying' comes from the division of the field into area units or cells of approximately 50 cm² each. Figure 1 shows the principle of cell spraying. The sprayer has cameras that take the images and embedded software that divide the images digitally into cells and discriminate weeds from crop plants. The output from the image analyses is used in a decision algorithm to control the nozzle individually when weed density of a cell is beyond a target threshold. This means that cells with no weeds will not be sprayed.

Preliminary results with a prototype developed



Figure 2. The photo illustrates micro spraying principles. The image is divided into small 25 x 25 mm units. The units containing at least 50% weed tissue are marked (blue dots) for spraying.

at the Department of Agricultural Engineering, The Faculty of Agricultural Sciences, shows a potential herbicide saving of 50% compared to a blanket application of herbicide.

Micro spraying

The largest possible herbicide saving can be achieved by targeting each weed seedling with jet of herbicide applied with a micro sprayer. A proof-of-concept of a micro sprayer has been developed at UC Davis, California and at the Department of Agricultural Engineering, The Faculty of Agricultural Sciences. Preliminary results show that it is technologically possible to target a jet when weeds are located with a computer vision system. Furthermore, the results of analysing several hundred images from different crops and fields have shown that the theoretical savings when targeting each weed seedling could be up to 99%.

The technical development of a prototype of the micro sprayer comprises several challenges. Identification of the weed plants must be very precise, including those cases where the weeds are partially covered by other weeds or by the crop. In addition, the spraying technique must be precise enough so that the micro jet not only hits the plant but also hangs onto it.

More information

Spot spraying:

Gerhards R & Christensen S. 2003. Real-time weed detection, decision making and patch spraying in maize, sugarbeet, winter wheat and winter barley. *Weed Research* 43, 385-392.

Cell spraying:

Lund I. 2006. Micro patch spraying of weeds in maize. *DaNet newsletter*, October 2006. www.danet.dk

Micro spraying:

Søgaard HT. 2006. Technology for spraying single weed plants. *DaNet newsletter*, November 2006. www.danet.dk

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