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Site-specific precision spraying

Precision spraying of plant protection substances raises new challenges for sprayer technology in application. In conventional systems the regulating system has only to apply an area-associated uniform dose of spray. Site-specific precision spraying requires a variable application of spray for different doses to suit mainly small areas of heterogeneity regarding weed density, disease or the crop itself.

Practical trials of precision site-specific herbicide spraying, e.g., on cereals and maize, indicate that in more than 2/3 of trial areas the resultant reduction of herbicide is justifiable from a crop production point of view. An off line check over several years featuring:

- manual assessment
- establishment of weed maps, and
- electronically controlled application

gave average savings of around 30% on recommended herbicide amount, or 20 to 30 DM/ha in material costs [1]. Comparative tests featuring fungicide and plant growth regulator spraying gave similar results [2]. But such advantages are only available where there are cost-efficient systems for precision spraying.

Realistic future advances in the development of alternative identification strategies and faster detection techniques for site-specific spraying in real time [4, 5, 6] will, in the near future, require new solutions, especially for hydraulic control of the sprayer.

Investigations into site-specific application and control via sensors of a commercially-available sprayer, e.g. for the sensing of weed density, led to first experiences of the new demands on future spraying technology.

Targets for sprayer control

The control of sprayers in site-specific applications is based on target values according to the heterogeneity and divisional structure of the areas to be treated. For herbicide application the target in the current systems is taken from weed density or the calculated yield loss caused by the weed growth. Target values upon which variations in the application rates of plant growth regulator or fungicide are also crop development (plant mass) or the surface area of the crop in question [6].

The adjustment frequency, which should transpose the regulating system, is a function of the heterogeneity division of field specific parameters. Thus the target of site-specific spraying economic viability is also determined by the precision with which application is varied according to requirement.

Heterogeneity of weed distribution

Weed population variation range and effect (density, yield loss) is large and often characterised by high frequency alteration patterns. Extreme differences of from 500% have been determined within a few decimetres [7]. Often, these can be traced to husbandry errors. Generally, the distribution of weeds is due to the local distribution of the given heterogeneity parameter following the principle of superimposed oscillations. The 'long wave' transition of sectors with low or high densities is continuously overlaid by 'short wave' changes of smaller area. These characteristics create the seed distribution potential in the soil and the site-specific differences under emergence conditions.

Investigations within a 1 m^2 grid emphasised the extent of weed population variability per site. Where the area used in calculations is 0.5 m^2 it must be remembered that this tends to further even-out original variability (*fig. 1*).

Not much further than 10 m laterally to the main cultivation direction of the field stretch

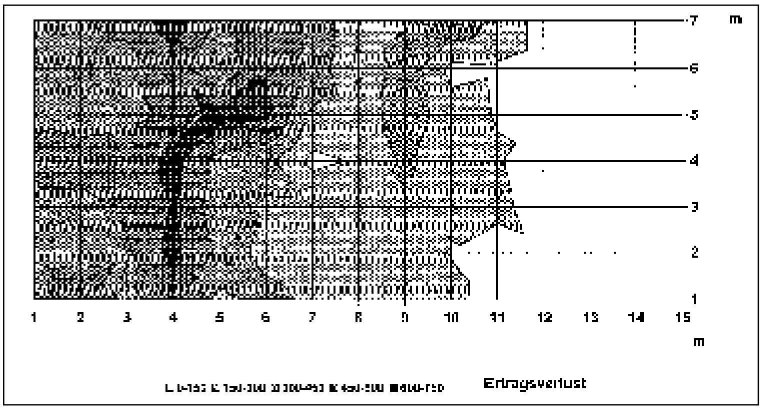

Fig. 1: Example for the heterogeneity of yield loss of the weeds population into winter wheat by highly resolution grid sampling.

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Precision agriculture, fieldsprayer, hydraulic control

small areas that require the same sort of spray treatment. Further investigation results show that in the longways direction, due to the cultivation and crop care operations in the field, larger areas of a comparable standard are to be expected. If this weed population reaction is applied to the conventional working widths of sprayers it shows the necessity for the creation in the future of technology for sectional control of spray application.

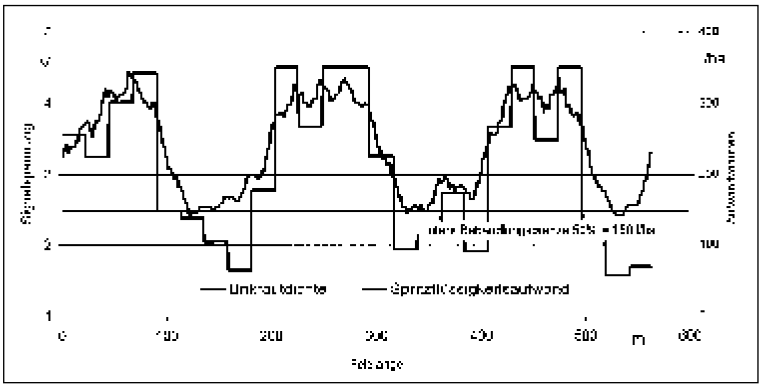

Fig. 2: Relationship beween desired value and actual value by the sensor controlled application into real time

Spray reaction to controls and practical investigations

Current generation sprayers feature a bypass system.The pto driven pump delivers against the resistance of all opened nozzle cross sections. When the spray boom is activated or closed a main valve reacts to the immediate pressure increase or decrease in the nozzle pipelines through opening or closing the bypass in the sprayer tank. A regulating stretch is seen as a way of maintaining consistent area coverage by the spray. This consists of an engine-powered throttle valve and the sensor arms for the determination of driving speed and volume flow. Both parameters along with the predetermined desired value (l/ha) of the resultant pumped volume is then calculated by the job computer. The reading of the sensor arm and the transmission of the signal to the throttle valve takes place after a constant interval of time. From the adjusting speed and the and the reading time interval there results the following speed of the actual value. The control loop's dynamics depends upon the proportionality of both parameters. Used because of cost grounds control loops with longer reading time intervals and slow adjusting speeds. These cushioned the over-oscillations of the control process but also led to slower following speeds for the matching of the actual value and desired value.

For field tests a standard sprayer was fitted for regulating according to target values. For this special software was developed which expanded the control algorithm specific to the sprayer. No change was made in the hardware. In practical operation it was shown that a satisfactory quality regarding the following of the actual value was able to be reached only through with low frequency alterations (*fig. 2*)

The limited velocity of the following of the adjusting parameters – effort volumes – led, where there were sudden increases or decreases in weed density, to deviations representing over 5% of the desired value. Generally, the investigations showed on average that deviations appeared with about 60 % of the individual values lying over this threshold.

This problem was able to be solved with the alternatives:

- sensor arm readings taking place over shorter time intervals (software),
- equipping throttle vale with faster motor (hardware), or
- using a proportional regulator.

Summary

Practical solutions for site-specific precision plant protection in real time can bring economic and environmentally-relevant advantages for the farmer. The sensoric identification of weed populations will be practical in a few years. With regard to the present development targets of sensor development for weed identification, there are differing challenges, especially for the hydraulic control of the sprayer. These challenges are in the main dependant on detection principles and the arrangement of appropriate sensors on the sprayer (*table 1*).

Further challenges result from practices used nowadays by farmers in conventional spraying operations. Among the main components here are:

- the successive application of different active ingredients, on different field areas however,
- the combined use of site specific and conventional methods (plant protection, fertilising) and
- the parallel application of different methods with different distribution patterns of the target values (same-time application of different sensors, herbicides, plant growth regulators, fungicides).

Table 1: Influence of weed detection technique on the control the plant protection machinery

	System solution	Requirements for sprayer control
1	Sensor attached to sprayer tractor front and averaging over an as long as possible length of the distance between sensor and spray pipeline	• short adjustment times • high adjusting dynamic • no over-oscillation
2	Several sensors fitted on sprayer tractor front on the support struts (partial working width) and averaging over an as long as possible length of the distance between sensor and sprayer pipeline	• see point under 1 • sectional control
3	Sensors on the spray pipeline (sectional detection, individual nozzle control), highest development, individual plot control almost without prior application, no averaging	• minimum adjustment time (ms) • nozzle-associated control, • retention of fogging quality

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