Gerhard Wartenberg, Potsdam-Bornim

Spatially-specific weed control in online-application

Distribution and density of weed populations vary greatly. Certain types show a well-developed location dependency. The application decisions for weed control methods annually require considerable effort in investigating weed distribution. Spatially-specific herbicide application indicates financial savings of from 30 to 50 DM/ha are possible despite the already rational use of plant protection materials normal on farms. The system, however, is only economically viable with weed identification and herbicide application methods with online capability.

Dr.-Ing. Gerhard Wartenberg is on the staff of the Department of Cropping Technology, special area Plant Protection Application Technology, Technology and Procedural Technology of Spatially-Specific Herbicide Application at the Institute for Agricultural Engineering Bornim e.V. (ATB), Max-Eyth-Allee 100, 14469 Potsdam-Bornim (scientific director: Prof. Dr.-Ing. J. Zaske); e-mail: *gwartenberg@atb-potsdam.de*

Key words

Precision agriculture, optoelectronic sensor, online-application

Literature

Literature details are available from the publishers under LT 01512e or via Internet at http://www.landwirtschaftsverlag.com/landtech/local/fliteratur.htm

Aim of the work was development of an online-capable detection method for the relaying of tendentious application decisions for spatially-specific herbicide application in narrow row crops (cereals, oilseeds and protein plants). Investigated was whether a sufficient evaluation of the competitive effect could be achieved using minimal information on the spatial distribution of weeds.

For this, an optoelectronic dualband sensor (<670/>850 nm) was constructed. This used diode light sources to give constant reflection conditions [1]. Requirement for determining weed numbers at the seedling stage is a sufficiently precise representation of the detection area in individual measurement spaces. Photo diode arrays with blocking filters for measurement of spectral area red and near infrared are currently used for weed detection. The reflection beams pass through a beam separator (half-transparent reflector) site-proportional to, in each case, a sensor line. Per colour channel, the individual sensor lines evaluate eight picture spots. For complete representation of the detection track the measurement signal is currently received with an inquiry rate of 5000 samplings per second, i.e. read at every 0.7 mm at 12 km/h. Signal processing and evaluation is conducted with universal measuring equipment (*fig. 1*).

The developed sensor was applied thus in practical trials:

- for weed recording in crop-free areas (tramlines)
- for signal evaluation according to a model concept: yield loss = f (weed density) [1]
- for linear reduction of herbicide to a max. 50% of population-specific recommended amount to reduce the effects of spatial detection errors
- for field-specific checking of sensor signals according to weed growth stage, and
- for assumption of consistent weed distribution (yield loss effect) within the sprayer working width.

For every 5 m of detection length, an analogue signal regarding weed population is sent to the task computer of the sprayer and translated into spaying actions to give spatially-specific differentiating of spray amounts.

Practical investigations

A series of error influences is to be reckoned-with when applying the detection method in-field. These are caused by the measuring method but also by surrounding conditions and the interactions of sensor ad application system.

Methodological errors mostly occur in calculation of competitive potential based on weed numbers. For calculation of field-specific variability in functional relationships between weed population and yield penalty, the results of trials conducted over several years in various regions and on different cereal areas were applied [1]. The distribution of the calculated yield loss tended to be positively skewed indicating changing weed community composition for a part of the spot samples. The evaluation of the variabi-

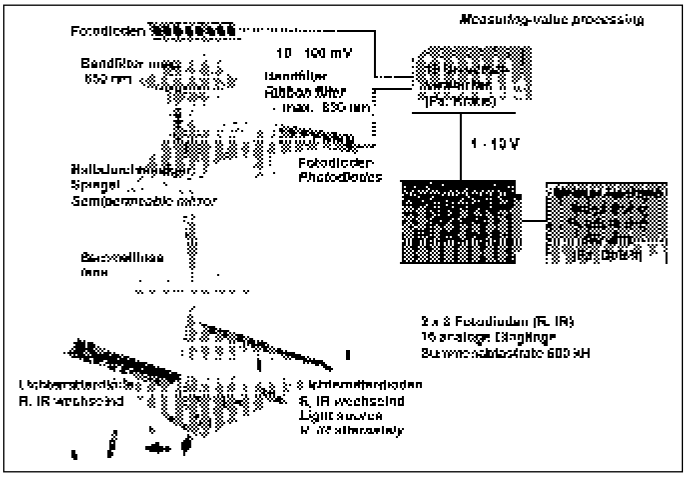

Fig. 1: Detection method applied by the optoelectronic sensor and signal processing

lity of the total information showed, however, that 76% of the results deviated only regarding a yield loss of ± 0.87 kg/ha • weed plant from the average value (3.43 kg/ha • weed plant), a further 12.4% deviated by up to ± 1.74 kg/ha • weed plant scattering, and that 1.7% could also reach extreme values (*fig. 2*).

These relatively small variations in yield loss effect are due to the rather consistent composition of the weed community. On average, these consisted only of three to five main weed sorts [2]. For this reason a visual check of the weed community components should be made before sensor application on fields with management that basically could cause deviations.

In field operation the measurement signal of the sensor is disturbed by diverse surrounding influences, in the main through:

- non-sharp optical presentation through focal distance changes caused by machine movements through ground unevenness
- varying light values and changing light spectral composition
- vibrating of the optic system
- steering mistakes in narrow tramlines

The non-sharp presentation of weeds and the exposure errors lead to changes in the intensity distribution of the measured spectral proportion. Where signal strength is reduced the smaller weeds in particular are not identified because the reflection echoes are below the threshold value. The threshold value is required for the separation of signals from ground and plants. In the opposite case, higher reflection signals from stones or dead plant material are identified as weeds. The sensor has been attached in a way that reduces vibrations so that these problems can be minimized. The use of a guide wheel also helped to keep the correct image level distance and eliminate to a large extent tractor-induced nodding and swaying. Constant lighting effect was also achieved through the arrangement of light-emitting diodes and evaluation of the detection field.

Sensor vibrations could also cause multiple counting of objects. Recordings show that such disturbances occur in practice mainly in the crop and where there is not enough vibration damping at the sensor attachment.

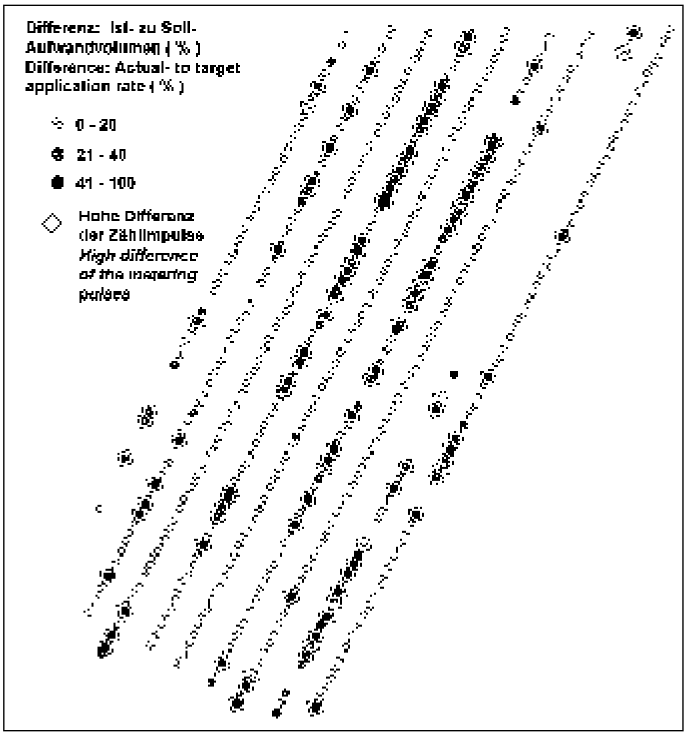

Fig. 3: Distribution of the differences between target- and actual application rate and identification of the counting sections with great deviations of the metering pulses of counting section to counting section. Winter rye, 6.5 hectares

Herbicide application represents higher demands on the control precision of the sprayer. This means that with increasing weed presence variability, the adjustment frequency and desired value difference of the volume flow to be controlled are also increased. Through the DGPS-supported recording of desired and realised actual application amount calculated from the sensor signal, the operational specific dynamic of the volume flow control can be followed. A comparison of the differences between desired and actual values shows that the application amount precision required for spatially-specific spraying is not possible with currently commercially-available sprayers where there are extreme variations in the weed density (*fig. 3*).

High deviations between desired and actual values can be found in the tramline sectors where the weed density shows great variation from one number-section to another. Because of the insufficient control adjustment-speed there occurred in the investigated winter rye field application rate deviations of >20% on 27% of the spatial areas. Here it has also to be observed that the requirements of plant protection law on spraying and misting equipment stipulate that deviations of more than ± 10% are only permitted for a maximum 5 s, e.g. during speed changes.

Summary

Field investigations in different crops showed that where the sensor equipment is adjusted to the spatially-specific development stage of the weeds, this solution concept allows a sufficient level of treatment success [4]. For further reduction of application errors hard and software solutions for the site-proportional adjustment of variable volume flow rates have to be developed.

Post-trial counts indicate that in none of the application cases could be determined crop production relevant errors in treatment. Remaining as problems are wrong decisions which occur through the larger differences between the detected weed distribution in the tramlines and deviating weed frequency within the working width of the sprayer [5]. These can be solved through the attachment of further sensors in additional detection tracks. This, however, requires a further sensor boom on the front of the draught vehicle and a control system which allows application regulation of parts of the sprayer working width.

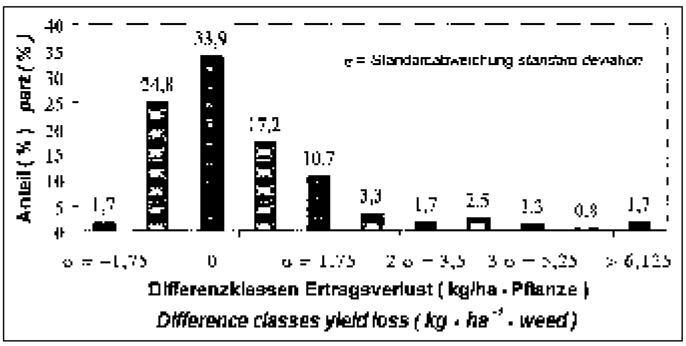

Fig. 2: Distribution of calculated yield loss differences to the mean average value from weed counts