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Sensor supported application of plant protection sprays

Plant protection according to crop requirements avoids blanket applications administering the appropriate substances only where economic damage is threatened. At the ATB weed and biomass recording sensors have been developed for spatially specific plant protection. Mounted on a sprayer these were used in real-time application of herbicides and fungicides. In addition to saving of spray substances, two years of trials resulted in no yield losses and no serious disease incidence or weed infestation.

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Keywords

Site-specific plant protection, sensors, fungicides, herbicides

A prerequisite for spatially-specific pest and disease control is the recording of their dispersion and population. The exact knowledge of these two characteristics as structural elements of a damage causing population is indispensable for estimation of expected economic damage as well as for planning location and time for spatially-specific chemical control. For the efficiency of plant protection operations the identification of damage factors along a relatively intense spot check grid is required because of the mainly scattered distribution of the damage-causing organisms. Manual counting cannot achieve a rapid determination of dispersion and abundance. Applying mobile sensors capable of real time reaction brings spatial determination of damaging organisms, in particular for weed control, into the realms of the possible. A rapid processing of the recorded results in a job computer and mounted computer for controlling a sprayer enables also the real time matching of the application amounts to the damage-causing organism populations.

Spatially-specific herbicide application

The real time application of herbicides using optoelectronic sensors for identifying weed populations is already successfully being used for weeds or unwanted vegetation on railway embankments [1], on fallow land or in fruit plantations [2] as well as on pasture [3] or in rowcrops such as maize or sugar beet [4]. Photo analysis methods enable species recognition in weeds as well as the differentiation between weeds and crop plants and are a very promising step towards real time application in cereals, sugar beet and maize [5]. At the Institute of Agricultural Engineering Bornim (ATB) an optoelectronic „green sensor" was developed which could determine the appearance of weeds in a tramline – without differentiating between varieties and thus allow real time weedkiller application at commercial speeds. System and method were reported in LANDTECHNIK 5/2001 [6]. The basis is the quasi-linear relationship discovered during field recordings from 1992 to 1998 between the total of weed-specific yield losses and the total weeds at each spot check point [7]. In the last two years the working mode of the weed sensors on the respective weed populations has been so adjusted that the principle of economic damage thresholds for spatially-specific application optimisation can be applied. Where, e.g., the costs for the required herbicide application have been put at 50 €/ha this means, at an assumed sales income from wheat of around 11.75 €/dt, a required increase in yield of around 4.25 dt/ha. According to the mentioned yield loss function [7] there is with 4.25 dt/ha an economic damage threshold of nearly 165 weed plants/m^2. The sensor signals in autumn during the cotyledon stage of the emerging weeds are correlated with the number of plants [7]. Based on the sensor detection area of 0.36 m^2 (0.07 m • 5.18 m) this economic damage threshold is represented by a sensor

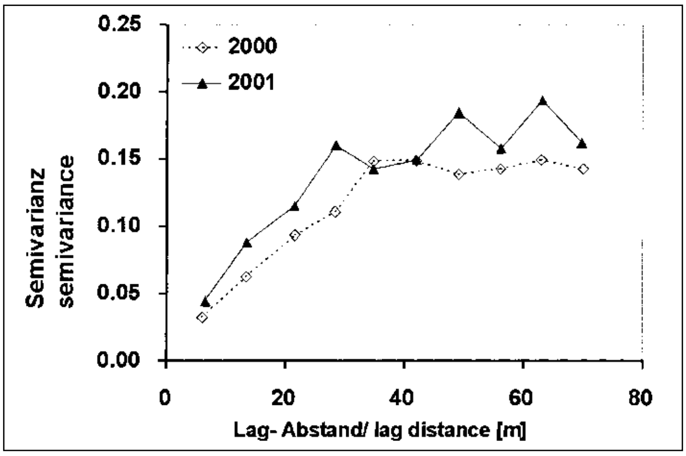

Fig.1: Variogrammes of the voltage signal within the tramlines in 2000 and 2001

value of around 60. Where this value is exceed in the respective detection sector the full herbicide amount is applied. Where the sensor value of 60 is not achieved the amount is cut by 50%.

Spatially-specific fungicide application

It is desirable, in the sense of spatially-specific plant protection, to apply fungicide only in the area of the field where fungus infection has appeared. Precise damage-causing organism distribution maps as basis for application of fungicides according to requirement – desirable because of the labour-input required where manual mapping is undertaken – are not being made available rapidly enough. Mobile, commercially-applicable sensors for direct determination of plant diseases at early stages of development are not expected on the market in the foreseeable future. A rapid spread of disease in a crop makes it additionally necessary to take action immediately after the identification by fungicide application where required Fungicide application as a separate operation thus involves timing problems.

Heterogeneous cereal crops are characterised by a differentiated development of above surface biomass and thus differ in the amount of plant surface to be covered by the spray. Because of this, work at the ATB has been looking at basing the amount of active spray ingredient applied on the surface area of the plant foliage (target area for the spray). For spatially-specific real time applications of fungicide the pendulum sensor developed at the ATB was used. The construction and principle of which was reported on in LANDTECHNIK 2/1996 [8]. As a result of the identified correlation of the pendulum angle with the value of the leaf area index (m^2 plant foliage surface per m^2 soil surface) target area quantification is possible. Where the leaf area index is low, application amount is reduced.

Sprayer operation

For the field trials carried out in 2000 and 2001 aimed at spatially-specific matching of application amount an air-boosted sprayer was used (Air Matic System ®, container capacity 4000 l, working width 18 m) from BBG Leipzig. Starting from the maximum application amount decided on by the farmer, there then took place according to the commencement signal a matching of the throughflow amount to weed frequency or plant foliage surface (that which is to be covered by fungicide). During use of the respective sensor an analogue signal (current: 1 V to 4 V) was sent at intervals of around 5 m (detection route represents a revolution of the tractor rear wheel) to the sprayer job computer. With an average driving sped of 12 km/h this meant that the regulator on the sprayer had to react around every 1.5 seconds to a new desired value. The dynamic of the volume flow regulation was subject to a certain inertia. As already presented in [6] high deviations took place in the herbicide application between desired and actual values of throughflow with extremely high alterations in the weed frequency in detection sections. With the fungicide treatments an average per wheel revolution was created from the values of signal current produced through the oscillation of the pendulum on the potentiometer which reflects crop growth and therefore the leaf area index. Extreme changes in the crop stand within a few metres due, e.g., to wet or sandy spots are, admittedly, to be repeatedly found in fields. However, changes in crop density are mostly „longwave“ (gradual). *Figure 1* shows the variogramme of the signal current from a field where, during 2000 and 2001, spatially-specific fungicide application in winter wheat took place. Through the parameter selection in the calculation of individual semivariance values only values within the wheeltracks applied. The variability of the signal current recorded averages increased in both years up to a distance from the recording location of around 30 m. Up to this distance the values and the resultant crop stand were similar i.e. spatially dependent. From this distance the measurement values varied the semivariance by a constant value (2000: around 0.15, 2001: around 0.17) which indicated that the signal current could not be correlated. In the case of these mainly longwave crop differences there was, contrary to the herbicide application [6] no extreme changes in desired values of application amount required by the regulating system. In [6] the dosage regulating reaction of the sprayer with herbicide application was assessed through comparison of desired and actual values on the same location. The geostatistical results through co-variogramme additionally enabled inclusion of spatial information for determining the average inertia of the regulating system. In 2000 the cosemivariance from signal current and throughflow on neighbouring recording locations was nearly zero (*fig. 2*). In 2001 the around 10 m between measurement points still returned a co-semivariance of almost zero. The sprayer reacted accordingly over driving section from 5 to 10 m with adjustment to match desired value. With increasing distance from the measurement points the spatial dependency of the throughflow on the signal current, as expected, decreased. With the cooperation of industry partners, practical trials on regulation performance of the system and of technical improvements are to be continued in the coming years.

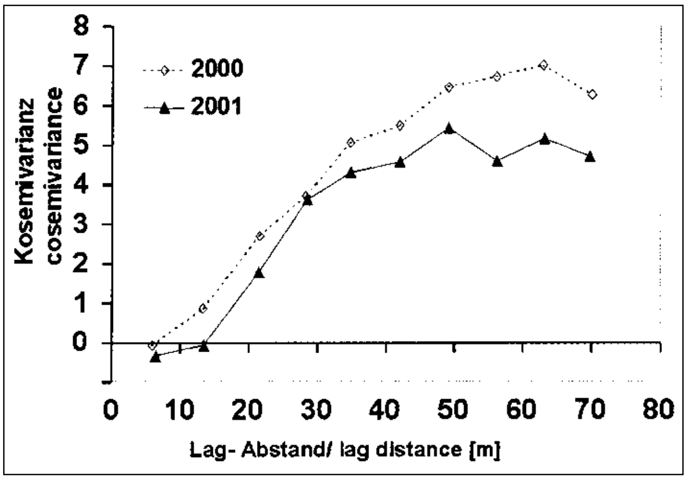

Fig. 2: Co-variogrammes of the voltage signal within the tramlines in 2000 and 2001

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