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New technology for variable rate pesticide application

At the Institute of Agricultural Engineering a sensor for detecting the biomass of crops was developed, a weed sensor for weed identification is under development. Both sensors detect locally heterogeneity's on the go and enable the adaptation of the application amount of fungicides and herbicides in real time by on the go signal processing. With new nozzle technology it is possible to deliver broad range of spray output. The paper deals with the BUS-system for information transfer and with the rate of flow reference lines of the VarioSelect® nozzle systems.

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Keywords

Site-specific plant protection, application technology, field sprayers, multiple nozzle technique

The portion of site-specific application of herbicides and manure in relation to homogeneous application will increase in the future because of the economical and ecological advantages, but only on the condition that the necessary technology is available. The land machine and electronic industry have reacted to this knowledge with further developments of some of their products and with new developments. In the research area the fundamentals have been created and the technological possibilities of realization, crop efficiency, and the economical usefulness of sensor-based processes have been shown.

There are two methods to measure the variability of plants and to apply site-specifically:

- Measurement of variability is distinct in time from application (offline technology). The offline technology uses application maps based on yield maps, soil maps or aerial views. The application map includes the crop variability in conjunction with geographical data. The creation of application maps is a time and resource consuming process. That is why the application is time-shifted. Offline technology means that the application map works together with the differential global positioning system (DGPS).
- Measurement of variability and application are in time (real time or online technology). Information is measured with sensors on the move and application amounts are calculated in real time.

Figure 1 shows the technical requirements and explains the function of the parts for a machine complex for site-specific herbicide application in real time:

The sensor for weed detection works in front of the tractor. The application is realized via the boom at the back of the field sprayer. The signals are transmitted from the sensor to the sprayer along the electrical data link, the data bus. The transmission of data occurs in digital form and complies with a special standard. The goal of that standard is to achieve compatibility between tractors and land machines. The compatibility between land machines of different producers or from different countries was a problematic issue, but now the standard ISOBUS will solve the compatibility issue worldwide. All aggregates and elements of land machines use job computers. Each job computer has its own identifier, can change internal data to ISOBUS data, can read ISOBUS data and translate data to control signals for actuators. The job computer „field sprayer" communicates directly with the job computer „weed detector", from which it receives sensor values about the weed amount, and with the job computer „tractor", from which it receives the number of revolutions.

The user terminal inside the driver's cab of the tractor is a very important part for the entire system. The driver can change values in the job computers; he can check the adjustments of the application and interrupt the system. The job computers of the system send information to the terminal and the terminal display shows graphics for each device and their values of significance. In this case it is the field sprayer with its significance values (momentary application amount, pressure inside the pipe, tank volume and area potential). Additionally the user terminal is capable of calculating GPS coordinates and to store the coordinates together with application data on chip cards.

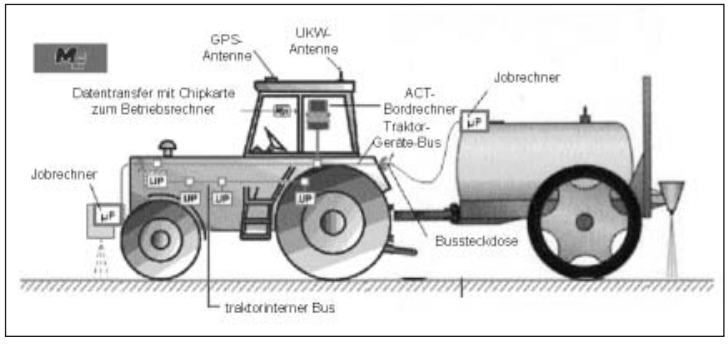

Fig.1: Machine combination of sensor, tractor and field sprayer with connection via the BUS-system

Fig. 2: Prototype of the pulled field sprayer with unfolded 24 m boom and the VarioSelect® nozzle system

New dose applications for field sprayers

Usually, field sprayers have been equipped with single nozzles; the pressure change could only be varied over a narrow range, approximately 1:2. Clearly different application quantities could be obtained only by different driving speeds. For a site-specific application a larger range of control is necessary, using the latest technology, different position-dependant yield quantities should be realisable with as high a driving speed as is possible.

The company Amazone offers a new field sprayer equipped with'intelligent nozzle transmission', which incorporates these requirements [6]. Multiple nozzle carriers with the designation VarioSelect® are used, in which four nozzles of different size are arranged. Dependent on the necessary yield quantity the control of a certain nozzle and/or several nozzles takes place in combination. Switching the nozzles takes place by means of spring-tensioned pneumatic pistons, which are directly connected to the spraying liquid valve. The valves are then closed. Each partial width is individually controllable via electro-pneumatic valve blocks. The intelligent control takes place from the job computer field sprayer, which was developed in co-operation with Müller Elektronik.

The ATB has a field sprayer from Amazone/BBG, which was equipped with the intelligent nozzle transmission. *Figure 2* shows a section of the spray bar with the multiple nozzle carriers. These are equipped with large droplet injector nozzles of the type ID. According to the standard set-up this assembly occurs with the nozzles ID 015, 02, 03, 05. Based on requirements after minimum yield quantities of approximately 50 l/ha with an average driving speed of 8 km/h, a nozzle combination was selected. The smallest possible nozzle sizes include ID 01, 015, 02, and 04. The functional adjustment of the system parts and the software was carried out in co-operation with the manufacturers. In addition the material characteristics of the nozzles and nozzle combinations when inserted in the normal spraying mode of the field sprayer were determined (all partial widths switched on, simulated driving speed 8 km/h, medium water). Installed measuring instruments were used in series as primary detectors for pressure and flow for the regulation of the yield quantity in the sprayer pipeline. The characteristics for the parameters necessary for the regulation (nozzle combination, threshold) were specified and accordingly programmed by the job computer field sprayer.

In *figure 3*, the programmed nozzle combinations and the associated characteristics for a constant driving speed of 8 km/h are represented. The optimal work area of the nozzles is with a pressure between 3 and 8 bar. In this range, spraying quantities are realisable for between approximately 50 and 500 l/ha. Depending upon the desired default value by the job computer, specific nozzles are activated and thus the assigned characteristic is specified. The operating point is then started, depending on the pressure characteristics. In the job computer the thresholds are deposited, which regulate the transition from one characteristic to another. If the yield quantity is to be changed e.g. from the current operating point A with 185 l/ha to the point B with 275 l/ha, the program selects the characteristic section above the threshold 255 l/ha, switches the nozzles 01 and 015 off and nozzle 04 on at the same time. By switching with the existing pressure of 5.7 bar, a yield quantity of 300 l/ha adjusts itself. This is reduced by down regulation of the pressure to the given desired value.

The field sprayer with the intelligent nozzle transmission has been used over the past year in field tests for the sensor- guided herbicide and fungicide application successfully for both Winter wheat, Winter barley and fodder peas. Work was done on approximately 100 hectares that were comparatively uniform both site-specifically and overall surface. The herbicide application predominantly took place in a range from 100 to 200 l/ha, the fungicide application ranged from 50 to 200 l/ha.

Results

Site-specific plant protection makes increasing new demands on today's technology. Development needs insist on priority for suitable sensors. For signal transmission the ISO-BUS system has been proposed for the near future. The application technology for a new field sprayer with „intelligent nozzle transmission" involves much higher requirements. The range of control of the yield quantity was closely studied in this paper. It was shown that the nozzle combination used by the manufacturer could be adapted by using smaller nozzles and the software can be replaced. Thus the existing large range of control can be expanded as such small yield quantities are necessary for patch-specific fungicide applications.

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Fig. 3: Nozzle combination and reference lines for characterising the function of the VarioSelect® nozzle system (speed: 8 km/h)