

Application according to Plant Biomass

The pendulum-meter for measuring the crop biomass density has left the research stage and is now available on the market under the name "CROP-Meter." To investigate the agronomic potential, the sensor was combined with a centrifugal spreader and a field sprayer and used for site-specific variable rate application of nitrogen fertiliser, growth regulators and fungicides in real time.

Information about the distribution of the density of crop biomass growing in a field is an important prerequisite for precision agriculture operations. Therefore sensors are needed which can measure - preferably on-line - the crop biomass. Determination of spatially variable crop biomass can be used for optimising inputs of agro-chemicals, improving crop management and reducing ecological damage.

The objective of this study was the technological realisation of CROP-Meter based variable rate application of nitrogen fertiliser, of growth regulators and of fungicides including the assessment of yield effects.

Materials and methods

The sensor (Fig. 1) was modified to work with on-board computer (agrocom. ACT) and job calculators (Müller-Electronic) using the agricultural bus system (LBS), based on the international standard ISO 11783.

To indicate the agronomic effects of site-specific applications of nitrogen fertiliser, growth regulators and fungicides, farm scale strip trials were set up with 1 to 4 replications [1].

To perform the site-specific fertilisation trials in real time, the CROP-Meter was combined with a tractor and a fertiliser spreader (Amazone ZAM MAX-tronic). The tests were performed in four years 2000 - 2003 for the 2nd and the 3rd application of nitrogen to winter wheat under practical conditions. The total area was 328 ha on 9 fields in different regions of east Germany. The application rate for nitrogen fertiliser was based on the rule that, in the parts of field with dry stress (small plant growth) the fertiliser can not be absorbed by the roots of the plants. Therefore the application rate in these parts was reduced without danger of

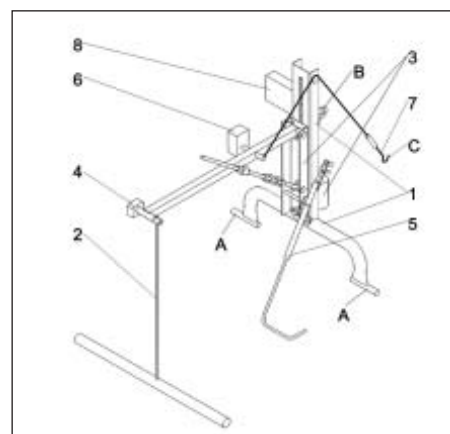


Fig. 1: Diagram of sensor pendulum-meter; 1 - Frame, 2 - Pendulum body, 3 - Depth compensation, 4 - Potentiometer, 5 - Surface sensor rod, 6 - Inclination sensor, 7 - Drawing cable, 8 - Electronic box; A,A,B,(C) - Linkage points
Main parameters: Complete mass - 40 kg; Working width - 1.0 m; Voltage - 12 V; Energy consumption - max. 50 W

yield reduction. Each strip was the width of two working widths of a centrifugal spreader.

The variable-rate application of growth regulator and fungicides was performed using a commercial 4000 l sprayer (Fig. 2) in two versions (trials in 2000 and 2001: Air Matic® system, 18 m boom width; trails in 2002 and 2003: VarioSelect® system, 24 m boom width). The rule was also to reduce the application rate for growth regulator in parts of fields with sparse vegetation resulting in a lower risk of lodging. Because of reduced surface of leafs and stalks has to be covered by the fungicide droplets in sparse crop stands, the application rate was decreased too.

The yield measurements were performed by a weigh-bridge as well as with the yield

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Keywords

CROP-Meter, crop biomass, variable application rate

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Table 1: Savings in sensor based nitrogen fertilising in winter wheat

Year	No. of trials	Area ha	Growth stage	Savings (nitrogen) %
2000 ¹⁾	1	50	ear emergence	9,4 (CAN)
2001 ¹⁾	2	75	ear emergence	12 (CAN)
2002 ²⁾	4	92	flag leaf - ear emergence	16 (CAN/ Alzon 47)
2003 ³⁾	2	111	flag leaf	16,9 (Alzon 47; Pisan 28)
total	9	328		14,6

¹⁾3rd application only ²⁾2nd and 3rd applications ³⁾2nd application only



Fig. 2: Sensor in combination with a field sprayer for fungicide application

monitors in combine harvesters (Claas; New Holland). The references were two to tree passes of full working width of a combine harvester in the centre of each strip. This was done to minimise the problem of imprecisely distributed fertiliser and considering the triangular distribution pattern of a centrifugal spreader.

Results

Nitrogen fertilisation

In the years from 2000 to 2002 the solid fertiliser spread was calcium-ammonium-nitrate (CAN) with 27 % nitrogen. In 2003 solid Alzon 47 with 47 % nitrogen and liquid Piasan 28 with 28 % nitrogen was applied. The Piasan 28 was applied by the field sprayer. Based on the above described application algorithm and the specific conditions in each field, the savings in nitrogen fertiliser were achieved in winter wheat (Table 1).

The field specific savings were very different in the range from 4.9 to 28.0 %. In the average for all nine fields the savings were 14.6 % nitrogen fertiliser.

To assess the effects of reduced fertilising on the yields the harvested grain for each

strip was measured by a scale platform (Table 2). The yield differences were in the range from - 0.2 up to 9.2 % and show an advantage for the variable rate fertilisation in total 1.5 dt/ha⁻¹ and 3.1 % relatively.

Growth regulators and fungicides

Table 3 demonstrates the four-year results of 10 trials for variable rate application of fungicides and growth regulators. The single values of savings varied from 7.0 to 48 % and had the mean value 23.1 %. A visual assessment of diseases was performed in adjacent areas of uniform and variable rate fungicide treatment mainly at milk ripeness of cereals. There was a negligibly low disease incidence in the samples and no tendency in yield differences between the variable rate and the uniform strips [2]. Despite of the application rate reduction for the growth regulator Moddus® in the range of 48 % no lodging of winter barley was registered.

Conclusions

The CROP-Meter is a robust low-cost sensor (5 000 €) for the continuous determination of crop biomass distribution in cereal crops be-

ginning from the growth stage BBCH 35. It can be used preferably for site-specific differentiated treatment with agro-chemicals in real time when dryness is the main growth-influencing factor. Because of market availability of the sensor in 2004, farmers can start on a low cost level with site specific management.

Year	No. of trials	Area ha	Yield dt/ha		Difference dt/ha	Difference %
			uniform	variable		
2000	1	50	26,5	27,6	+ 1,1	+ 4,2
2001	2	75	80,5	81,1	+ 0,6	+ 0,7
2002	4	92	58,7	59,7	+ 1,0	+ 1,6
2003	2	111	45,1	48,7	+ 3,6	+ 7,8
total	9	328	56,9	58,4	+ 1,5	+ 3,1

Table 2: Yields in winter wheat for uniform and variable nitrogen fertilising

Year	Crop	No. of fields	Area (ha)	Agrochemicals	Savings (%)
2000	WW	4	60	Juwel Top®; Opus Top®	15,8
2001	WW	1	21	Caramba®	25,0
2002	WW; SG	3	68	Juwel Top®; Caramba®	20,3
2003	WW; WG	2	57	Opus Top®; Moddus®	40,6
total		10	206		23,1

Table 3: Savings in sensor based application of fungicides and growth regulators in cereals

Literature

- [1] Ehlert, D., J. Schmerler and U. Völker: Variable Rate Nitrogen Fertilisation of Winter Wheat Based on a Crop Density Sensor. Accepted paper for journal "Precision Agriculture", © Kluwer Academic Publishers, 2004
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