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Site specific application of nitrogen fertiliser in real time

Sensors can play a decisive role in the successful introduction of site specific management. With a mechanical sensor in the form of a physical pendulum, it is possible to indirectly determine the plant mass in a standing crop. Through the application of this sensor in combination with a tractor and centrifugal fertiliser spreader for measuring late applications of nitrogen, the efficiency of the fertilising could be improved and the environment protected. To show the resultant effects, a large plot trial laid out in strip form was recorded and the results presented in terms of fertiliser use and grain yield.

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Keywords

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The development of site specific fertilising including the required technical components as a main part of computer-supported farm management is the aim of a wide selection of research and development work. Currently, various fertilising strategies are followed, their advantages and disadvantages intensively investigated and discussed.

Of especial interest is nitrogen fertilising in that this determines to a great extent yield and quality in cereal production. The site specific fertilising methods required in agricultural practice must be operator-friendly with limited technology and labour input costs. Sensor supported solutions for Nr. fertilising in real time offer very good conditions for the realisation of these basic requirements. The Hydro-N Sensor [1] can be mentioned as a solution already available on the agricultural machinery market, and this will not be detailed here. In this report a method for sensor-supported site specific N-fertilising developed at the Institute for Agricultural Engineering Bornim (ATB) is introduced which should be applicable for late applications.

Trial method

For the first time on a commercial farm (Nuthequelle Niedergörsdorf) the third site specific application of Nr. during vegetation period 2000 was investigated May 22 on a total area of 50 ha winter wheat (variety Batis). Field quality points on the trial area varied from 29 to 58.

The previous crop was winter wheat. In the trial crops two uniform fertiliser applications totalling 125 kgN/ha were made. The aim of this technological large trial lay in spatially varying the 3rd Nr. application according to crop bulk at growth stage BBCH 55 to 59. The measurement of the site specific amount of fertiliser took place thus: with maximum crop development 250 kg/ha calcium-ammonium-nitrate (CAN) (27 % N) was applied. Where the stand was less developed, the amount of fertiliser was proportionately reduced. This form of fertiliser measurement took account of site conditions, often characterised by lack of soil moisture. In that plant nutrients can only be absorbed in soluble form by roots, the fertiliser for cereals under drought stress at this growth stage could no longer achieve any plant development effect, leading only to unnecessary economic expenditure and ecological damage.

To measure the effect of the 3rd application of Nr. under site specific methods, comparative strips were laid out featuring alternative strips with uniform application of fertiliser and with site-specific application. These were part of a large plot trial with four repetitions. The fertiliser applied uniformly according to Hydro-N sampling equalled 197 kg CAN/ha. In order to clarify whether the different fertilising methods still had an effect on vegetative development, the trial plots were driven through on June 22, 2000 at growth stage BBCH 69....75 with the pendulum sensors [2] described in the literature and which featured different construction parameters. Grain yield was determined via weighbridge after threshing about 40% of the crop area in the middle of the plots so that headland effects could be avoided. Additionally, data from the yield recording equipment on the combine harvester was used to compare results.

Table 1: Influence of site specific nitrogen fertilising (3rd N-application) with pendulum sensor on nitrogen amount and yield

	Unit	3rd N-application site-specific	uniform
Trial area	ha	13,2	13,2
Plot size	ha	3,3	3,3
Repetitions	-	4	4
Ca-ammonium-nitrate	kg/ha	178 (25...225)	197
Nitrogen	kg/ha	48 (7...62)	53
Grain yield	dt/ha 1)	27,6 (23,9 ...31,6)	26,5 (24,6...28,4)
In-field threshing area	ha/plot	1,3	1,3

(Strip trial: winter wheat, variety Batis, Niedergörsdorf/Fläming, May 22, 2000)
1) 14 % moisture

Table 2: Comparison of measured pendulum angles

	Average pendulum angle (°) site specific	uniform
Pendulum 1	44,18	44,13
Pendulum 2	32,80	32,45
Pendulum 1+2	38,49	38,29

(Strip trial: winter wheat, variety Batis, Niedergörsdorf, Fläming, June 22, 2000)

To investigate the influences of the different fertiliser rates on grain quality, manual grain samples were taken at 28 points and subsequently tested in laboratory for crude protein content, sedimentation value, falling number and the thousand grain weight.

Methods

The sensor design used featured a physical pendulum which, on driving through a crop stand, is deviated by the overcoming of the resultant resistance [2]. In previous trials a large amount of data about the functional association of cereal plant mass and the resultant pendulum angle for different pendulum parameters was collected. In the case of favourable pendulum parameters decisive measurements in the area of $R^2 = 0.9$ could be achieved for these functional relationships. The pendulum used in the fertiliser trails carried out had the parameters: fulcrum height 1.30 m, pendulum length 1.05 m, mass 1.279 kg, width 0.96 m.

The pendulum sensor, front-mounted on a tractor, recorded pendulum angle during the drive through the crop. This represented the basis for calculating the fertiliser amounts to be applied.

A mounted centrifugal broadcaster from Amazone (ZAM MAX-tronic) with 18 m working width applied the mineral fertiliser. On-board computer was an ACT from agrocom on the basis of the agricultural BUS system (LBS) and compatible with the applied DGPS navigation technology. In order to translate the pendulum sensor readings into instructions for fertiliser application, a job computer from Müller Elektronik was configured.

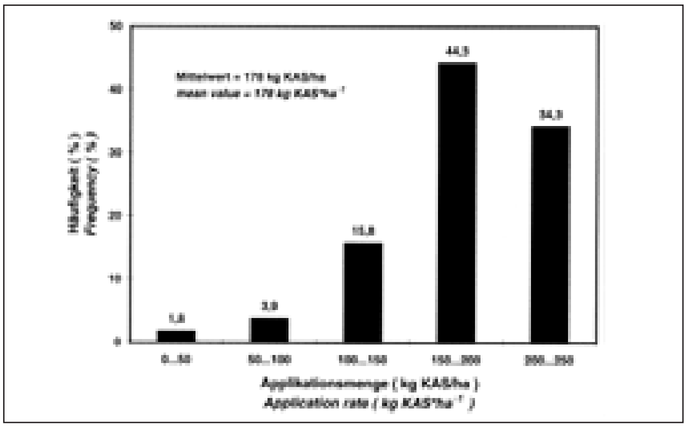

Fig. 1: Frequency distribution of site specific fertiliser rate

Trial results

Through the use of the pendulum sensor for the third Nr. application it was possible to save 19 kg/ha of CAN on the site specific strips (*table 1*), a saving of around 10% resulting from varying fertiliser application spatially (*fig. 1*). Although the maximum fertiliser dressing of 250 kgN/ha applied in the well-developed crop areas was well over the uniform application of 197 kg/ha, considerable amounts of fertiliser were able to be saved in less well developed crop areas.

The late fertilising seems to have no further effect on vegetative plant growth. The drive through with both pendulum sensors resulted in an average value for the measured pendulum angle of 38.49° for the four site-specific fertilised plots, and for the uniformly fertilised areas an average reading of 38.29° (*table 2*). Because the difference of average values was not statistically significant at only 0.5%, it can be assumed that the differences in vegetative growth did not occur through the fertilising methods used. Further, this small difference can be taken as a confirmation of the representability of the trial facility.

That the 10% reduction in fertiliser applied had no negative effect on the grain yield can be supported by the weighed harvest results which indicated an average increase of 1.1 dt/ha of grain on the plots fertilised spatially (table 1). The yield recorder on the combine verified this result with a difference which was a little higher at 1.8 dt/ha.

On quality (*table 3*), despite the different fertiliser applications of from 7 to 62 kg N/ha no significant difference was found on the grain from the 28 sampling points. In fact a slight improvement in grain quality regarding crude protein content, sedimentation value and falling number was apparent where Nr. application rates were low. This unexpected effect can be seen in a positive light in that a reduction in quality as a result of the reduced fertiliser application would put in question the justification for site specific Nr. application. Only the TGW was reduced with reductions in Nr. application.

The trial results thus collected during the year 2000 were assimilated under specific location and weather conditions (no precipitation in months May and June). To ensure results that can be applied generally, further trials in following years are required.

Literature

[1] *Marquering, J. und S. Reusch*: Online- Düngung: Sensor und Ausbringtechnik für eine teilflächenspezifische Stickstoff-Düngung. VDI Verlag, Düsseldorf, 1997 , VDI Berichte 1356, S. 93-96

[2] *Ehlert, D.*: Pflanzenmasseerfassung mit mechanischen Sensoren. VDI Verlag, Düsseldorf, 2000, Tagungsband der Tagung Landtechnik 2000, S. 289-294

Table 3: Influence of site specific nitrogen fertilising (3rd N-application) on grain quality

Nitrogen application kg N/ha	Sampling points -	Grain quality crude protein %	sedimentation value ml	falling time s	TGW [1] g
62	10	12,9	37,4	237	41,9
48	7	13,2	38,5	241	41,2
34	2	13,4	39,8	290	36,3
20	4	13,0	36,9	245	37,2
7	5	13,4	40,0	280	36,9

(Strip trial: winter wheat, variety Batis, Niedergörsdorf, Fläming, June 22, 2000)
1) Thousand grain weight