Georg Fröhlich, Karl-Heinz Bröker, Heiner Link, Gerhard Rödel, Franz Wendling and Georg Wendl, Freising

Computer-Controlled Plot Fertilizer Spreaders for Precision Experiments

For fertilizing trials with solid mineral fertilzers on experimental plots, fertilizer is primarily spread manually. An acceptable mechanized solution which takes both required exactness and the ambient conditions during treatment into account does not exist. Therefore, a row fertilizer spreader with a working width of 1.5 m was developed, which applies the fertilizer extremely precisely thanks to its microprocessor-controlled metering system. It has a modular design and can be mounted to different carrier units. In addition, it can be controlled by different systems.

Dr.-Ing. Georg Fröhlich is a scientist working at the Institute of Agricultural Engineering and Animal Husbandry (ILT) of the Bavarian State Institute of Agriculture (LfL), D-85354 Freising; e-mail: *Georg.Froehlich(@)LfL.bayern.de*.
Dipl.-Ing.(FH) Heiner Link, S.g. ET Karl-Heinz Bröker, Dipl.-Ing.(FH) Gerhard Rödel, and Dipl.-Ing.(FH) Franz Wendling are technicians working at the Institute of Agricultural Engineering and Animal Husbandry. Dr. Georg Wendl is the director of the same institute.

Keywords

Solid fertilizer line-distributors, experimental plots, process controller

Precision experiments in arable farming are primarily carried out on small plots with a width of 1.2 to 1.5 m and a length of 5 to 10 m. Especially for experiments on these plots with increasing fertilizer application rates, an automated solution for precise fertilizer application was sought. So far, fertilizer has generally been applied manually based on the application rates determined for the individual plots, often under weather conditions which do not allow the experimental plots to be driven over by a tractor. High personnel- and time expenditures as well as the subjective errors caused by inhomogeneities in the application rate on the individual plot are a disadvantage. Available mechanized spreaders were either not able to realize the quick change in the application rates on randomized plots, or they were not sufficiently precise or not robust enough for the conditions of use.

Due to these experiences, a fertilizer spreader for precise application was intended to be developed which is characterized in particular by the following features:

- Use for broadcast fertilizer spreading and row fertilizing
- Freely adjustable application rate on the individual plots
- Use under extreme soil conditions possible
- Able to be coupled with electronic experimental plans.

Material and Method

For realization, two different approaches were available:

- a hand-operated, self-propelled implement
- a mounted implement for use with a tractor.

Since both approaches have advantages and disadvantages which exert different effects depending on the conditions of use, both are intended to be pursued. For this purpose, a design was chosen which enables the actual metering system to be adapted to both a strong, electrically-driven chassis and to a frame for a three-point hitch.

The core of the system is an electrically-driven metering shaft which drives one spreading unit with a bucket wheel per row (*Fig. 1*). The individual spreading units can be blocked so that different row numbers and sections can be realized. The spreading units can be equipped with height- and side-adjustable drop tubes, which enable fertilizer to be spread in rows. If they are not used, this results in broadcast application. The flow rate is controlled by the rotational speed of the metering shaft, which depends on the speed of travel. If working width is known, the rotational speed of the metering shaft can be described as a function of the flow rate:

$$U = F1 \cdot m + F2 \cdot m^2$$

In this equation, U is the rotational speed in l/min, while m stands for the flow rate in g/s. F1 and F2 are constants which must be determined experimentally for each fertilizer used by means of two calibration tests at different rotational speeds. For granular or grainy fertilizer, working speeds of up to 5 km/h, and required application rates of approximately 0 to 550 kg/ha (corresponding to ~ 150 kgN/ha given the common nitrogen content of 27%), the system error due to approximation is less than 3%.

The set flow rates are established based on the desired application rate, determined working width, as well as the current travel speed using a microprocessor-based control unit and converted into the rotational speed at which the step motor drives the metering shaft. As a compact unit, the metering sys-

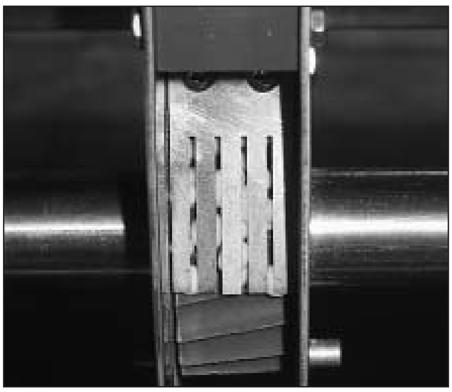

Fig. 1: Dosing unit (bucket wheel) with deflector

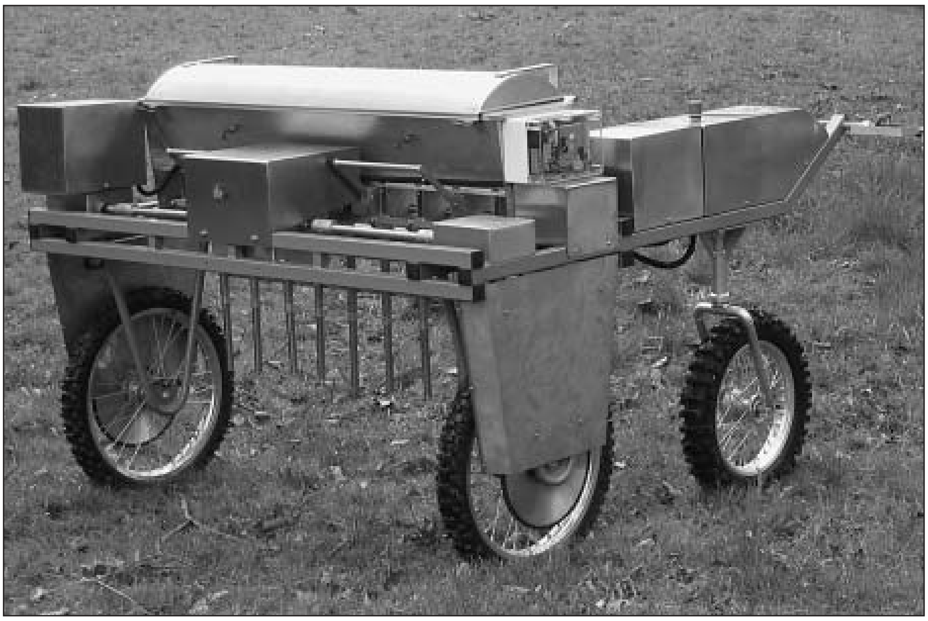

Fig. 2: Hand-operated automotive fertilizer for experimental plots

tem with ten spreading systems linked by a shaft was firmly connected to a hopper containing ~ 50 kg of fertilizer.

Results

So far, a self-propelled, hand-operated version of the precision fertilizer spreader with an electric drive has been developed and tested. For the operator to be able to drive over soft soils in the spring without expending too much strength and without significant slip, an asymmetric tool geometry featuring a driven front axle was used (*Fig. 2*). Track width is 1.5 m. Maximum ground clearance amounts to 70 cm, and distance between the front axle and the end wheel is 80 cm. The implement is driven by a common electronically-controlled 0.75 kW electric vehicle motor, which is fed by two maintenance-free, rechargeable lead-gel batteries. The service weight of the empty implement is approximately 260 kg. Even weight distribution and the powerful motor make maneuvering during fertilizing, turning, and loading easy. The vehicle is controlled like a motorbike using a throttle twist grip. Optimal working speed is 3 to 4 km/h. The application rate is controlled with the aid of six variably programmable keys so that six different previously set degrees of fertilizing intensity can be chosen. Before use, calibration tests must be carried out at two different rotational speeds of the metering shaft, and the samples must be weighed. Currently, setting is supported by a PC program.

So far, the metering accuracy of the system has been determined during the final check of the machine under conditions which corresponded to those required by DIN 13740 [1]. The reproducibility of the application rate has a variation coefficient of less than 3%. The variation coefficient of lateral distribution was determined at three different rotational speeds of the metering shaft using an implement placed horizontally on a frame and reached a maximum of 3.6%. The deviation of the application rate from the set value in longitudinal distribution was determined over measured distances and ranges between 2% and 3%. The systematic factor caused by the wheel during speed measurement, however, can be corrected under defined ground conditions on the field depending on the soil properties so that only the variation coefficient of ~ 2% causes errors [2].

According to practical measurements, the resulting total error is below 5%.

In order to avoid sensitive, complex operating elements on the machine, the terminal software used to set the parameters of the fertilizer spreader communicates with the fertilizer spreader via a wire interface. In the implements currently applied in practice, the terminal software is used on notebook PCs. A variant for PDA (handhelds) is being tested. For the semi-mounted implement, integration into the tractor terminal, which is ideally an ISOBUS terminal, suggests itself. The terminal software enables the work parameters (width, wheel dimensions, limit speeds) to be entered, the calibration process to be controlled, the calibration factors F1 and F2 to be determined based on the quantities of the calibration samples, and these quantities to be transmitted to the process computer of the fertilizer spreader. In the hand-operated implement, the software is used to calculate and set the metering rates depending on the degrees of fertilizing intensity which can be chosen with the aid of the keys.

Conclusions and Future Prospects

With the presented system, a very precise solution for experimental applications was created which is suitable for practice, facilitates work, and saves time. Currently, the Bavarian Agricultural Administration and research institutes use three implements under various conditions.

Based on the chassis, a carrier system for N-sensors was developed as well. A special feature of this implement was the stepless adjustment of working widths up to 3 m. Even given the large track widths in practice, the implement was able to be controlled. In the future, this could also apply to the working width of the fertilizer system because larger working widths on experimental plots are being discussed.

Based on the metering module, a three-point-mounted implement is currently being designed as the next stage of development. This implement is intended to be run with a tractor equipped with an autoguidance system (Trimble AgGPS RTK autopilot / field computer AgGPS 170 with special software for the division of plots into blocks and the starting of sowing processes according to a plan previously developed with the aid of the PIAF software). The speed signal of the GPS receiver is used as a control variable, and the application of fertilizer at the desired rate is started according to the set sowing rate.

Literature

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