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CROP-Meter with Technical Improvements

A new Crop-Meter incorporates the experiences made since 2004 and stands out through numerous technical improvements. The height control was newly designed for direct soil surface sensing. A parallelogram guidance, combined with a relief spring, meets the height of the pendulum pivot point more precisely and is more robust against mechanical stress as well. By using an electric transmission motor, combined with beam tie, the CROP-Meter can now be switched alternately from transport into working position (and vice versa) from the tractor cabin.

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Keywords

Precision agriculture, crop biomass measurement, sensor, CROP-Meter

To perform site specific crop management in fertilisation and pest control in real time, sensors for measuring crop properties are used. Currently, in Germany three sensor systems are produced and exploited commercially. These are the Yara N-Sensor [1], the MiniVeg N Laser-System [2], and the CROP-Meter [3].

After the CROP-Meter was presented to the public first time at the exhibition AGRITECHNICA 2003, AGROCOM in Bielefeld (Germany) combined the sensor with the adequate farm management software and started to market the package. The sensor, developed at ATB (Leibniz-Institute for Agricultural Engineering Potsdam-Bornim) is based on a physical pendulum which is deflected while passing through a cereal crop stand. The deflection angle is measured by a potentiometer and it was found that the values measured are highly correlated with the crop biomass density [3]. In the past years numerous experimental data were gathered from using this mechanical sensor which resulted in a substantial redesign of the CROP-Meter.

Experiences made

The practical use of the CROP-Meter demonstrated that the pendulum measuring principle is basically suitable for reliable surveying biomass in standing cereal crops and also in oilseed rape. With regard to robustness it was observed that the feeler rod (1) for sensing the soil surface level (*Fig. 1*) was sensitive for mechanical damages under extreme conditions. Furthermore, the electro-mechanic actuator (2) and the for its controlling installed two contact-less switches (3) resulted in high costs and disturbance source. Additionally, from users (farmers and contractors) it was demanded that it should be not necessary to leave the drivers cabin for changing between transport and working position.

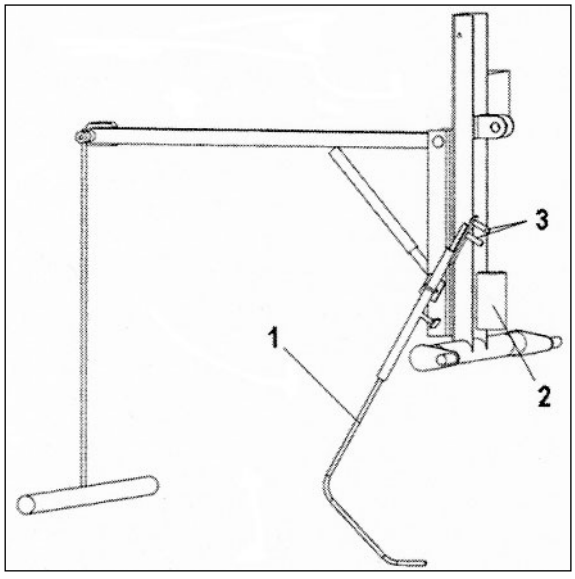

Fig. 1: Previous configuration of the CROP-Meter

The new CROP-Meter

Operational reliability of the sensor being basically confirmed, the investigations were focussed on the improvement of the height control, remote control of changing between working and transport position, and improved handling of the sensor.

For the new CROP-Meter (*Fig. 2*) the electro-mechanical actuator for compensation of tram line depth and the non-contact switches including wiring for the three point closed loop for height control were replaced by a direct height control system, consisting of a robust feeler rod (1) and a parallelogram guidance (2). To reduce the vertical forces, which consequently reduces the wear of the feeler rod, and to minimise crop damaging, a rubber cable as tension spring was installed (3). In contrast to a steel tension spring the rubber cable has damping features reducing vibrations. Furthermore, by installing a deflection pulley (4) the rubber cable can be designed very long for a smooth load deflection curve. With the new designed parallelogram guidance, height control is substantial-

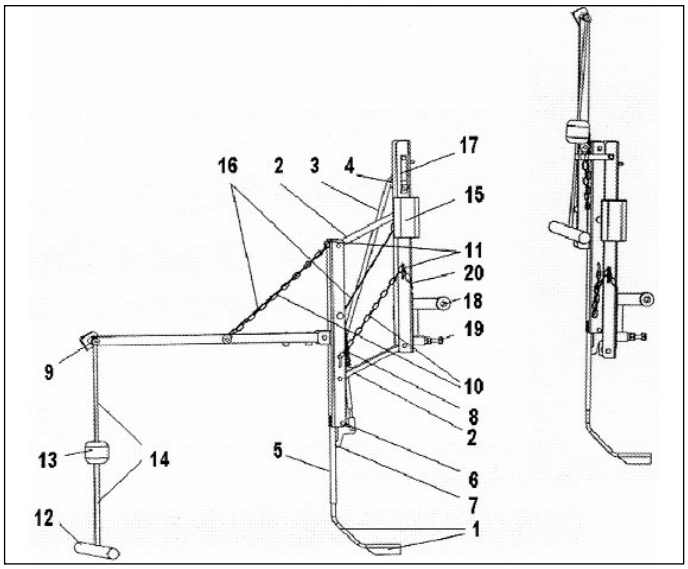

Fig. 2: New CROP-Meter in working and in transport position

ly enhanced. To minimise the effort for care and maintenance all eight bearing points of the upper and lower guide arms are made from female bronze.

Based on the combination of rubber cable and parallelogram guidance and chosen kinematics the vertical forces can be kept constant independent of the tram line depths. To keep the feeler rod on track it is pivot mounted in a tube (5) with a vertical axle. Additionally, the feeler rod can turn around a horizontal axle (6) to prevent damages caused by suddenly occurring high forces from compact stones, soil furrows and walls. To compensate the resisting power resulting from forward movement, the feeler rod is blocked by a dead stop (7) with pressure spring (8) whose preload force is adjustable. In the case of backward movement the feeler rod lifts off from the dead stop and straightens itself backwards without penetrating into the ground.

A further improvement of the new CROP-Meter is the simple and quick adjustment of the lower position of the feeler rod and also of the height of the pivot point (9). This will be performed by round steel chains (10), whose elements are fixed in corresponding slots (11).

Furthermore the pendulum ballast masses for adjusting the pendulum resistance moment are no longer installed inside the pendulum tube (12) but as one compact mass (13) at different positions on the pendulum rod (14). Two distance tubes allow for adjusting the pendulum mass and thus its sensitivity. For improved sensor handling (transport, mounting, removing) the pendulum tube and the pendulum rod were reduced from 1000 mm width to 800 mm width.

Changing between transport and working position from driver's seat will be performed by a small electro-mechanical drive (15), which is a mass product from the car industry. Its driving shaft is combined with a roll for winding up the tape (16). Two reflection pulleys and the tape connected with the arm of the pendulum allow swapping between working and transport position and vice versa. For permanent transport position and demounting ,the CROP-Meter can be secured additionally by a mechanical catch (17).

The CROP-Meter is conceptual designed for the tractor front arrangement. Due to increased ground clearance of 450 mm minimum in the transport position, the lifting movement of a tractor three point linkage is not required anymore. For mounting the CROP-Meter on tractors equipped with a three point linkage a specifically designed adapter can be used. This adapter is reinforced only via the bolt of the upper link (18) and a pressure adjusting screw (19) for sensor inclination.

With this simple mounting solution, the former adjustment of the lower links on the recommended height of 600 mm is not required anymore. A further advantage is the reduced distance to the tractor front, which results in reduced compensation movements of the height control device under rough ground conditions. This also beneficial when driving on public roads. On tractors without three point linkage the CROP-Meter can be installed using the rear U-profile for mounting (20).

Discussion and Conclusions

The new CROP-Meter is an improved mechanical low cost sensor for measuring crop biomass density is for site specific crop production. In contrast to the former model it features by increased robustness, improved accuracy and extended functionality. The robustness was increased by replacing sensitive mechanical and electrical components by new technical solutions with more flexibility and overload protection. The durability and the maintenance behaviour were improved by attaching a gliding skid from wear resistant steel at the feeler rod. The implementation of a parallelogram guidance increased the potential of height compensation for tramlines up to 450 mm.

The distance of non-contact switches, the programmed dead time (0.5 sec.) to avoid shattering, and the limited adjusting speed of the electro-mechanical drive (34 mm s^{-1}) of the former height control caused inaccuracy in the closed three point loop. The direct scanning of the ground surface reduces these inaccuracies widely in the future. Due to this improvement the range of crops to be scanned by the CROP-Meter can be extended and may include younger crop stands and earlier application dates.

The remote control via the ISOBUS-terminal for changing from transport to working position and vice versa from the driver's seat improves both the ergonomics and the potential operation time. Both, contractors and farmers will benefit from this improvement.

Literature

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