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Hohenheimer Measuring Methods on Stubble Cultivation

Determining the Working Depth

Working depth is an important process parameter, when measurements are taken on tillage implements. In Hohenheimer investigations not only various methods for measuring working depth were compared. Additionally comparative measurements with sensors were undertaken, allowing working depth measuring during driving. The best results were attained with such sensors, where a touch sensing of the soil surface is done.

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Comparing tests of tillage implements demand the consideration of the working depth if working quality or tillage draught force are ascertained or compared. Furthermore knowing the actual working depth is interesting for tillage in practice with regard to an online variation of the working depth. Comparing measurement of tillage implements can be done in a subsequent way whereas simultaneous measurements are reasonable for other applications. Especially if working depth can be changed during work, online sensors for ascertain the working depth are gaining importance.

Subsequent Methods for measuring working depth

Especially for direct control during tillage laying bare the working ground after one tool of the starting tillage implement is useful. Taking place at the tools at the side, the untilled soil can be used as comparing height, whereas the tool incorporated into the soil helps to find the working ground. After tillage this method can be also carried out across the whole working width by eliminating the loose soil crossways to the driving direction (*Fig. 1*).

In the test method of the „German Agricultural Society (DLG)“ this measurement technique is enhanced by measuring the surface contour of the bare profile with an ultrasonic sensor, crossways to the driving direction [1]. Furthermore methods are possible with gauging that profile by touching sensors [2, 3]. In Hohenheim and Bonn a soil scanner is used for detecting fully automated the bare soil ground in the driving direction with a two-axel controlled laser scanner [4] in an additional spatial dimension. Thus the necessary number of repetitions for one measurement is significantly minimised and a reproducible view of the evenness of the working depth is produced. A cut-out of the with a laser scanner three dimensional detected working ground of a stubble cultivator can be seen in *Figure 2*, in which the measuring area is limited to a measurement window of 800•1200 mm.

Besides ascertaining the minimal and maximal working depth across the working width for these enhanced methods it is obvious to quantify the evenness of the working ground by one measurement value. The use of the „Rauheitsindices - roughness indices“, which is defined by the deviation from the mean working depth is imaginable [5].

Thereby the mean working depth is defined whose manual ascertainment is often difficult since it is not known at which point the measurement of the working depth has to take place. Those enhanced methods normally are justified only for tests of tillage machinery, since laying bare the working ground and the application of the measurement technique with an appropriate number of repetitions need a high amount of work.

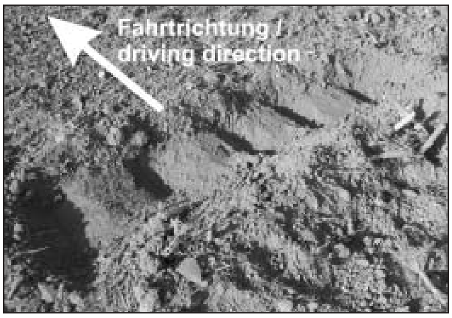

Fig. 1: Determining working depth by digging away the soil loosened

Table 1: Used sensors for measuring working depth

Sensor	Manufacturer	Starting signal
Tactile wheel (Drehwinkelsensor potentiometrisch)	Megatron MP 22	voltage 0 - 5 V resolution < 1°
Ultrasonic sensor	Honeywell Serie 942	voltage 0 - 2,56 V accuracy 1 mm
Infrared sensor	Sharp GP2Y0A02YK	voltage 0 - 3 V accuracy ~ 1 mm
Position sensors lower link arms	John Deere standard fitted	CANBUS (0 - 100%)

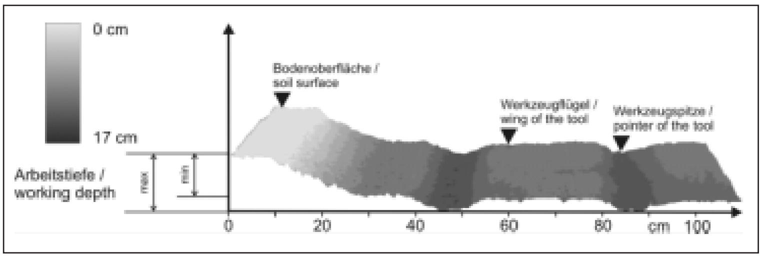

Fig. 2: Laser-scanned surface relief of working ground of two tine tools of a stubble cultivator

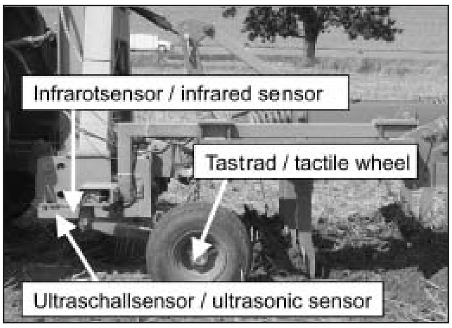

Fig. 3. Working depth sensors mounted on a stubble cultivator

Simultaneous methods for measuring working depth

Especially in sowing technology, principles for simultaneous measuring of the working depth with touching [6] and non-touching [7] sensors are already known. With in the scope of experiments with tillage implements different simultaneous principles for measuring the working depth of a cultivator have been applied at the same time (*Fig. 3*).

The output signal of non-touching sensors is a voltage value proportional to the distance to the soil surface. The position of the rotatable borne sensing wheel is recorded at the rotating point of the swing of the free wheel by a rotary potentiometer. To the side of the tractor standard sensors is a further information source at disposal for recording the position of the lower links that has been listed in the examination (*Table 1*). In *Figure 4* the measurement values of the working depth of the different simualtaneously applied sensors for a driving distance of 60 m are assigned. An elongated soil hollow that was caused by former underground engineering is characteristically for the chosen cut-out of the driving distance of the first stubble cultivation after wheat. The surface contour listed in the depiction was developed using height data of a highly sensitive RTK-GPS-receiver. The actual working depth shows a mean value of ~5 cm as has been detected with digging by hand. Conspicuous is the overestimation of the working depth by the ultrasonic sensor of about 10 cm, which is conform with the mean height of the stubbles of the pre-crop. Whereas good results are obtained with the ultrasonic sensor on blank soil surfaces with little constructional effort, a measurement of the working depth with organic residues on the soil does not always lead to adequate results.

On even soil surfaces a good conclusion from the converted values of the position of the lower link arms to the working depth can be made, if a determination of the working depth „0 cm" was done previously. In the shown case of driving over a soil hollow the relative angle between tractor and machinery device changes. Thus the calculation of working depth out of the linkage position results in negative values, even though the tillage implement is in the soil. The sensing wheel can be seen as the most reasonable method for measuring working depth simultaneously, since it follows the soil surface most accurately and is not influenced destructively by the surface contour (position of lower links) or by organic matter on the soil (ultrasonic sensor).

Summary

For comparing measurements of soil implements particularly subsequent methods, with which the working depth at the laid bare working ground is measured over the whole working width are appropriate for measuring working depth. Thereby an automatic laser scanner is applied besides manual measurement in Hohenheim. Tillage implements with hydraulic control possibilities of the working depth offer a potential for simultaneous measurement of the working depth. Therefore a sensor for the working depth as element in the feedback loop is necessary, if an online variation of the working depth should be carried out. A sensing wheel connected with a rotary potentiometer has proven to be the optimum principle in this experiment, whereas other tactile variations of scanning (e.g. skid glides) promise good results for an online measurement of working depth, too.

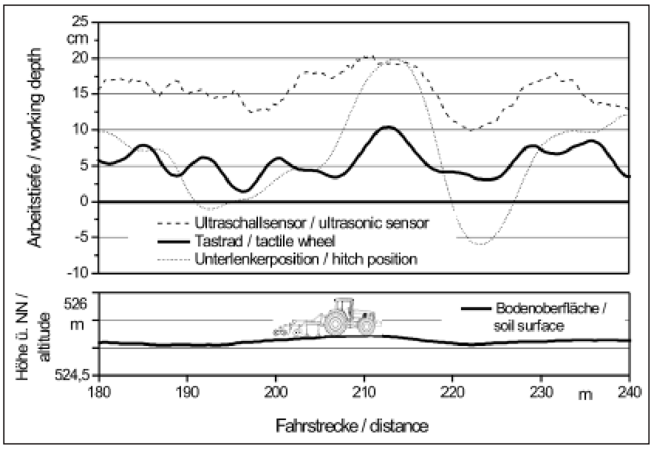

Fig. 4: Comparing sensors for working depth measuring above the relief of the field's soil surface

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