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Hohenheimer Measuring Methods on Stubble Cultivation

Evaluation Methods for Assessing the Quality of Straw Incorporation

In stubble cultivation, straw incorporation is especially important in the evaluation of implement tool mixing effects. Until now experimental evaluation uses visual classification of an exposed soil horizon [1]. In the following a method is presented, which is based on using specially designed ferromagnetic measuring bodies, which are incorporated into the straw. Their final position is determined contact-free with a metal detector.

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Keywords

Tillage, artificial straw, signal transmitter

For functional assessment of agricultural machinery signal transmitters were used successfully for examining conveying and processing tasks. Fechner [2] designed an artificial sugar beet with incorporated sensors to determine the impact load during harvest and transport. Kutzbach [3] fitted signal transmitters made from magnetic material into bundles of straw to examine transport inside a combine harvester by a system of electrical coils. In a new approach signal transmitters are used to describe the tillage effects during stubble breaking. Ferromagnetic tubes were designed to be used as 'artificial straw' and are spread on the fields' surface. The depth of their position after tillage is measured contact-free with a metal detector.

Introduction

When developing a new methodology, special effort is necessary to get an easy to handle and accurate system. The use of metallic elements which can be detected by customary metal detectors working on the principle of influencing an oscillating circuit seems to be a promising way. A standard detector type 3900 D fabricated by Whites Company was used, which was equipped with an analogue read-out and could be calibrated by the user to display the depth of detected objects. Beside ferromagnetic materials, a modern metal detector is able to distinguish nonferrous parts too, which could be an advantage, because of the basic content of iron incorporated in any kind of soil. In pre-trials, several kinds of metal and in addition different soils were examined and the detectors adjustable parameters were optimised to improve accuracy. Splits and balls of different size and material (aluminium, steel) were tested for their aptitude as a signal transmitter. It was found that splits of aluminium could be well detected by using the instruments discriminator option even under soil conditions characterised by a high iron content. However, the necessary size of the splits would be too large to create signal transmitters of similar size as straw. Splits of steel (30 • 10 • 2 mm) have been identified to give good results regarding a possible depth of detection of up to 20 cm, but since they gave different signals depending on their orientation they were replaced by balls made from steel (diameter 14 mm, weight 14 g), which enabled detection up to a depth of 15 cm without problems. The transmitters were designed following the geometric properties of stalks ('artificial straw') by fixing a ball into the middle of a 15 cm piece of shrinkable tube (*Fig. 1*). Further trials confirmed that the transmitters have a similar behaviour like straw and after tillage are placed in the same depth as stalks of the same length. Finally all transmitters were

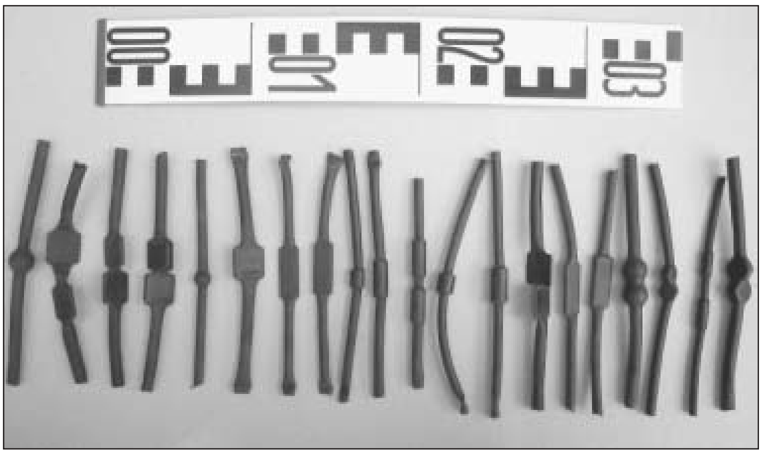

Fig. 1: Overview of the prepared objects of measurement, outside left the afterwards used type

Fig. 2: Determination of the placement depth of the objects of measurement with the metel detector

painted flashy to make recapture more easy and were numbered to enable an unambiguous identification.

Trials

Field trials were conducted under real tillage conditions on soil characterised as loamy loess for stubble breaking of Triticale on the extension farm 'Einsiedel' (Kirchentellinsfurt, Germany) of the Südzucker Company. Several types of chisel ploughs and disc harrows were used to attain different tillage depths. In overall six trials, signal transmitters were spread on the surface, their placement localised individually and tillage done as usual. Afterwards their vertical position was measured using the metal detector which was calibrated with respect to the soil's natural content of iron (*Fig. 2*). All detected signal transmitters were digged out to check the real depth in which they have been placed by the implement.

During the test sessions, there were a large number of other metallic objects detected by the instrument which didn't belong to the experiment and therefore were not taken into account. They could be identified as being rust-eaten scrap like bolts, screws or shackles [3]. Their quantity of 25 % related to the number of spread signal transmitters was remarkable.

For evaluating the signal transmitters' position, the incorporated ball at the centre of the artificial stalk was taken as the reference mark for the depth of placement. *Table 1* shows the comparison of the readings done with the metal detector and the real depth of placement, calculated as the arithmetic average per trial.

It was shown that the error of measurement was mostly below 1 cm of depth, which is a significant increase of accuracy compared to the traditional grid based assessment in steps of 5 cm. Since in all experiments the depth of placement was overestimated by the instrument, it can be assumed that by further calibration of the detector the accuracy can be enhanced.

Table 1: Comparison of the measured and the real placement depth

Trial	Qty. of spread transmitters	depth in cm measured	real depth
1	10	3	2
2	10	5	4.5
3	9	4.5	3.5
4	12	5	2.5
5	15	6	5
6	20	5.5	5

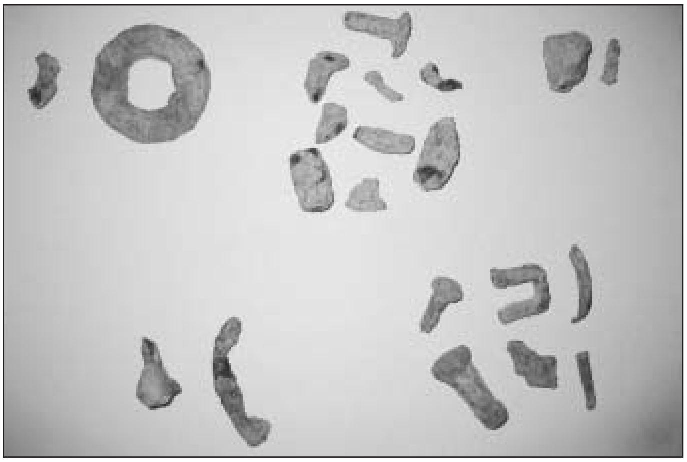

Fig. 3: Detected scrap metal in the series of experiments

Conclusions

It has been shown that in principle the new methodology is a promising way to determine the effects of tillage during stubble breaking by tracing marked stalks of straw. The accuracy is superior to the traditional grid method which is limited to 5 cm steps. The current disadvantage of the methodology is its sensitivity to foreign metal objects like scrap which results in a source of error. Therefore controlled experimental sides have to be used. Further research is recommended to overcome this by the use of radar reflectors commonly used in meteorology or in skiing (clothes marked for avalanche accident search).

Literature

[1] *Voßhenrich, H.-H., J. Brunotte und B. Ortmeier*: Methoden zur Bewertung der Strohverteilung und Einarbeitung. Landtechnik 58 (2003), H. 2, S. 92 - 93

[2] *Fechner, W. und W. Büscher*: Elektronische Messrübe mit sechs Beschleunigungssensoren. Landtechnik, (2000), H. 1, S. 42 - 43

[3] *Kutzbach, H.D. und P. Wacker*: Die Bestimmung der Gutbewegung in Axialdreschwerken. Grundlagen der Landtechnik, 30 (1980), H. 4, S. 101-104