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On the adjustment of implements used in complete-area mechanical weeding

The structural change within agriculture is identified by the increasing size of farm and field, and this also applies to organic farms. In line with greater field size comes an increase in the different types of soil and weed distribution within the area. A weeding harrow adjusted according to type of soil and weeds can react to this sort of variation. The target must be to achieve a high degree of efficiency with the mechanical weeding while at the same time keeping damage to crop plants as low as possible.

The distribution of numbers and species of weeds within a field area is not homogenous and is principally dependent on the nature of the soil and the site-specific weed seed bank [1]. In many cases the appearance of weeds in “nests” or in lines across the field can be observed. As with spatially-variable application of herbicide [2] it would appear as practical with complete-area mechanical weeding systems, preferably using a weeding harrow, only to apply the implement in areas where weed populations exceed the damage threshold. In this way, damage to the crop plants through mechanical weeding operations, which can represent up to 9% [3], can be avoided.

Additionally, changing soil conditions within a single field length when weeding with a harrow leads to the situation where one particular setting can give an action that is too deep and too aggressive, when going through a sandy area, for example. The harrow then pulls out crop plants. But where soil in other areas features clay, the harrow setting does not work intensively enough to weed properly. As in other spatially-variable treatments, it makes sense here to use sensor technology. Thus harrowing intensity could be adjusted on-the-move to match changing soil conditions and achieve an as high as possible efficiency in weeding whilst keeping damage to crop plants as low as possible.

At the moment at Kiel Institute a harrow with MSR (Measure, Steer and Regulate) system is being developed which can adjust the intensity of its action to match different soil consolidation and types as well as the status of the weed population. The following concepts have been developed:

MSR system:

Soil consolidation – harrowing intensity

A ground sensor measures the soil consolidation in the upper 5 cm and conveys the information to a tractor-mounted computer. This processes the information on soil consolidation and forward speed and produces the necessary tine pressure required. The system has been calibrated through field trials this spring. A control device linked to the computer acts on the tines to give the pressure required (*fig. 1*).

MSR system:

weeding with an on-line system

With optoelectronic sensors the actual weed density in front of the harrow is measured. If the density lies above the damage threshold, the harrow is activated and a further sensor behind the implement records the success of the mechanical weeding operation (*fig. 2*).

MSR system:

crop plant damage – tine pressure

The reflection from the crop stand is measured with optoelectronic sensors before and after harrowing. Any damage caused by the operation is discernible from the alteration in the reflection values. This measurement is processed and allows tine pressure to be regulated in such a way that harrowing can continue at an intensity where any crop damage caused does not exceed the point where a drop in yield would result.

After continued trials, these three approaches will be merged into a total single system.

Measuring soil consolidation

To measure the consolidation of the upper soil layer, two different sensors were developed and these are being currently tested for their functionality.

The first principle is based on the penetration depth of a coulter into the ground. The basic thinking behind this measurement unit is that a disc coulter will penetrate further into lighter, sandy soil than into heavier clay-content medium. To measure the penetration depth of the disc coulter, a running wheel on the ground surface is used as reference. The sensor comprises a disc coulter (40 cm diameter) and a rubber-tyred running wheel (54 cm diameter) being individually mounted on bearings, side-by-side at the same height in their supports and fixed to a frame. On the supports at the height of the bearings is mounted a distance sensor on both the disc coulter and the running wheel (*fig. 3*).

The other measuring unit measures the soil consolidation through the force which acts upon a spring tine at a defined depth. Serving as sensor is a bending strength sensor integrated in a 8 mm spring tine. This

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Keywords

Weed distribution, mechanical weed control, soil solidity, sensor

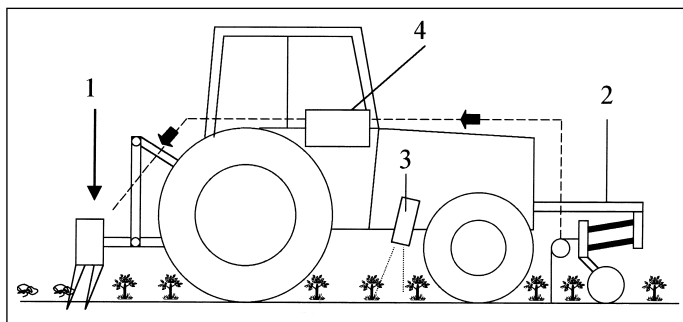


Fig. 1: Measure-control system: soil consolidation-weeder intensity; 1 adjustable tine pressure; 2 soil solidity sensor; 3 radar sensor; 4 control unit; 5 optoelectronic sensor; 6 weed harrow: in working position or neutral position

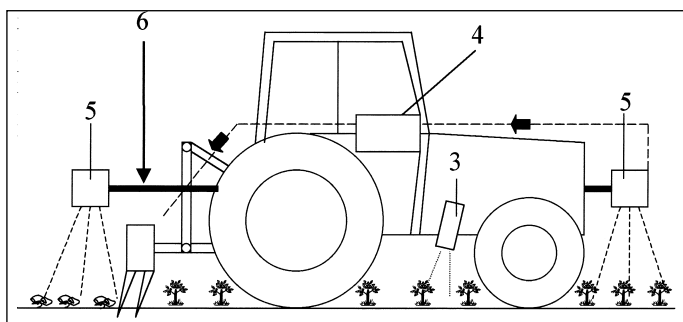


Fig. 2: Measure-control system: online weed control

spring tine is mounted on a parallelogram frame (fig. 4).

For testing, the sensors were applied over a suitable field area with differing soil properties and the results compared with the type of soil and the soil consolidation in the upper 5 cm. Soil type and consolidation degree were determined via finger probe, share resistance and vertical penetrometer.

Harrowing intensity

The harrow effect results from the pressure and the application angle of the tines and the working speed. With increased tine pressure and reduced speed, the intensity of action is increased. In order to classify optimum harrowing intensities in different types of soil and soil consolidation in cereal stands at different growth stages, i.e. an as high as possible efficiency with minimum crop plant damage, field tests this spring were carried out with variations of tine settings. These trials were to clarify the influence of the different harrowing intensities on the effects of the weeds and the crop plant stand at different growth stages and on different soils. The aim was to achieve a calibration of tine pressure with consideration of the following components: soil consolidation, weed density, growth stage of the weeds, growth stage of the cereal plants, damage to the cereal crop.

On-line system for weed control

With the aim of special weed control, a sensor system was tested which utilises an on-line system to determine weed density or population before and after the harrow. The results are then processed for immediate

activation of the harrow when the damage threshold is exceeded.

The weed population in the tramlines of a cereal crop correlated with that within the crop stand up to ear-shooting stage [4]. With optoelectronic sensors, the weed presence in the tramlines, and the ratio of ground cover with weeds (green) to open ground (brown) has to be quantitatively determined. Should the weed density lie above the damage thresh-

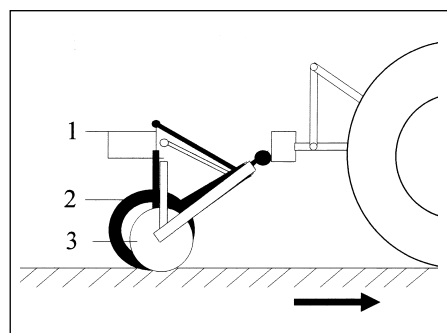


Fig. 3: Soil consolidation sensor: disc coulter-wheel; 1 distance sensor; 2 wheel; 3 disc coulter; 4 spring steel tine; 5 bending strength sensor

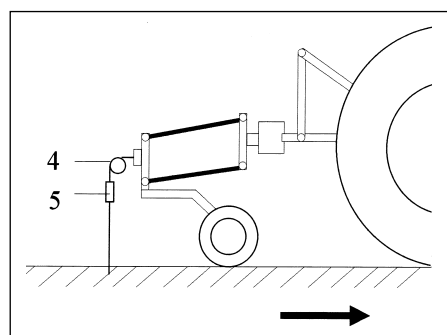


Fig. 4: Soil consolidation sensor: spring steel tine with a bending strength sensor

hold, then the harrow is activated through hydraulic lowering of its frame. A further optoelectronic sensor behind the harrow measures the numbers of weeds remaining after the passage of the harrow in the tramlines in order to assess efficacy of the operation.

The tines on the harrow model used in the trials were arranged on frames hung on parallelograms with the downward pressure on the tines exerted from the tractor hydraulics. This was modified so that the pressure on the tines could be varied during harrowing. Activating and deactivating the harrow, as well as varying the tine pressure, takes place via the harrow frame height adjustment.

Conclusion

On the basis of varying soil types and weed distribution within a field area, a weeding harrow with an MSR system was developed and tested. Sensors recorded the different soil conditions, the weed population density in the tramlines and possible damage to the crop plants. From the results thus obtained, and the effects on crop plants and weeds determined by previous tests and therefore not unexpected, it was clear that an efficient harrowing should be possible which, despite high weeding efficiency, caused no subsequent yield penalties in the crop.

Literature

Books are signified with •

- [1] Pluschke, U. und B. Pallutt: Zur Verteilung von Unkräutern auf Getreidefeldern und deren Auswirkung auf die Nutzung von Schadensschwelen. Z. PflKrankh. Pflschutz (1996), Sonderheft XV, S. 141 – 147
- [2] Schwarz, J. und G. Wartenberg: Wirtschaftlichkeit der teilflächenspezifischen Herbizidanwendung. Landtechnik 54 (1999), H. 6, S. 334 – 335
- [3] Böhrsen, A. und V. Bräutigam: Mechanische Unkrautbekämpfung mit Striegel und Netzege in Winterweizen. Z. PflKrankh. Pflschutz. (1990), Sonderheft XII, S. 463 – 469
- [4] Petry, W.: Unkrautkontrolle im landwirtschaftlichen Pflanzenbau mit Hilfe der quantitativen Bildanalyse. Universität Bonn, Dissertation, 1989