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Erosion Protection using Harmonised Cultivation and Software Technology

Till now precision farming has been associated with saving production means and increasing work efficiency. The possibilities for environmental and resource protection have been unnoticed and unexploited for the most part. Local site-specific cultivation offers promising solutions for minimising erosion risks to agricultural land. In addition to the requirements placed on soil cultivation technology, control software and electronic regulation, this article also presents two approaches to map straw coverage.

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The project is sponsored by Amazone company.

Keywords

Site-specific tillage, soil coverage, camera system

Literature

[1] *Knappenberger, T., und M. Ströbel*: Hohenheimer Programm zum Anlegen von Feldversuchen. Landtechnik 62 (2007), H. 3, S.152-153.
[2] *Pforte, F., and O. Hensel*: Online-measurement of percent residue cover for implement control in conservation tillage. VDI Berichte Nr. 1958, World Congress Agricultural Engineering for a better world. VDI-Verlag, Düsseldorf, 2006

In soil tillage there is a rule: the shallower the tillage the stronger is the mulch cover and hence the protection against erosion. And: the deeper the tilling, the better the straw rot and for the field emergence of the following crop.. The farmer must therefore ask himself, what depth of tillage is most advantageous in each case. This decision is often a tricky one, when also considering erosion protection, because many agricultural areas exhibit crop yield and relief heterogeneity. If one wishes to account for the straw yield and the slope, it is necessary to implement diverse tilling depths across the area. However, when calculating manual depth variations the farmer will very quickly face limitations. It is therefore advantageous to utilise precision agriculture technology.

In addition to satellite navigation, the soil cultivation equipment should also be equipped with appropriate decision models and control systems.

The following article looks at two examples of cultivation in order to provide an overview on Hohenheim strategies applied for avoiding erosion.

Requirements

Site-specific tilling places certain requirements on cultivation technology. In order to avoid erosion, the depth of tillage must be adjusted to the straw quantity and to the incline parameters, meaning that it must be possible to electronically control the depth of processing. In many series production soil cultivation implements, the tillage depth is adjusted via the depth regulation bolts. However, a number of manufacturers also offer hydraulic depth adjustment. This option is used together with an appropriate regulation system, to enable the electronic variation of tillage depths. The straw yield is calculated during the harvest and presented on a grid map, which is created using GIS software. In contrast, the incline is logged online, i.e. during cultivation, via a twin-axle machine-mounted inclination sensor.

These two values are recorded in the Hohenheim control software, which enables a direct computation [1]. A tillage depth target value is predefined. A RTK-GPS receiver fitted to the cultivator ensures the correct spatial orientation around the field and on the straw yield grid map. In the event of changing input values, such as straw quantities and/or inclination angles, the cultivation depth is adjusted in accordance with a predefined decision process (*Fig. 1*). In order to equalise differences between target and actual tillage depths, a potentiometric displacement gauge determines the actual cultivation depths and takes this into account within the regulation process.

Calculating the straw cover

The calculation of the straw cover, which depends on the preceding crop, is based on two different approaches. If the preceding was a reaped crop, then a yield mapping system is used. Taking into account the grain-variety parameters and the accepted grain-straw relationships, the previous grain harvest yield enables a sufficiently accurate estimation of the straw yield. The data is subsequently imported to a GIS program and interpolated using the Kriging process to provide a grid map.

This process has the advantage that neither additional technology nor a second crossing of the field is required. A further advantage is the three-dimensional image of the soil coverage by straw.

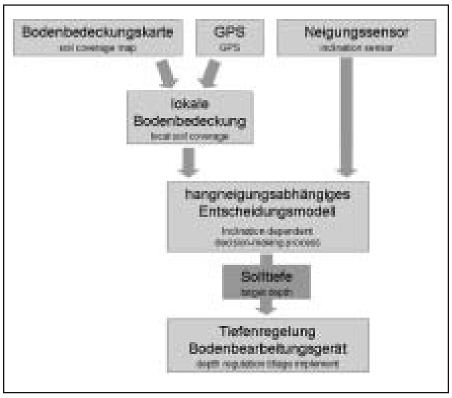

Fig. 1: Decision making and control of tillage depth

Fig. 2: ATV with RTK-GPS and camera chassis for the determination of the collection of soil straw coverage

Fig. 3: Raw picture (mustard straw)

The second approach is utilised if no yield map data is available. This is often the case in spring, during which tillage takes place for maize and sugar beets on frost-damaged intercrops. The aim is to design a simple, functional system for logging the soil coverage. The decision made on these grounds is to opt for a camera system with a mapping facility. A particular challenge to the camera system is posed by the frost-damaged intercrops.

Meaningful soil coverage acquisition requires that the straw be horizontally logged. Standing blades are only partially depicted and corrupt the actual values. The camera is required to travel at a defined distance above the ground, and as such it makes sense to integrate it into a support chassis. The selected carriage form enables it to push down standing crop blades and provides the perfect conditions from which to create an image from a bird's eye view (*Fig. 2*).

Changes in the light, which affect the image quality, must be eliminated. In order to achieve this, the images are taken using no outside light and with the application of defined artificial light.

Reflexion spectroscopic measurements document a maximum difference between the straw and the ground in the near-infrared range [2]. This provides the possibility for optimisation by applying appropriate infrared lighting.

The decision for the purpose of the Hohenheim university test rig is to use a high-quality camera with a shutter speed of less then 0.5 ms and a strong Gain also suitable for limited, defined light conditions. This provides identical conditions for the capturing of all images, because the straw cover presents the only variable. For the purpose of capturing the images, the support chassis (with an ATV to be fitted with an RTK-GPS system) is raised to a distance of 6 m above the mapping area. The results are geo-referenced images with an image frequency of 1.5 m (*Fig. 3*). Following the mapping process, a pixel count on the basis of grey-scale values enables the calculation of the ground coverage for each image. If this data is imported to a GIS program and interpolated using the Kriging process then a meaningful straw coverage map is obtained (Fig. 4).

There is a risk at higher speeds that the image will be blurred due to the motion, thus the travel speed during mapping should not exceed 6 km/h.

In addition to capturing the degree of coverage prior to crossing the field, the camera system also offers the option of calculating the quantity of straw remaining on the ground following cultivation without further time-intensive calculation processes.

Modified cultivation technology

As described before, the site-specific variation of tillage depths places certain demands on the technology in use. A basic requirement is the electronic regulation of the tillage depth. For testing purposes, one passively and one actively driven tillage implements were modified accordingly. Amazone company made available one cultivator disc harrow combination (Centaur 3002) and one rotary harrow (KG 3000 Super). Both machines are equipped with hydraulic tillage depth adjustment; the combi-cultivator implements this via the tine array and the rotary cultivator via the rear roller. In both machines the control electronics described were applied, following the appropriate adjustments of the characteristics of the respective machine.

Within the scope of the test application, the cultivator disc harrow combination was used in autumn following stubble cultivation and the rotary cultivator in spring on intercrops.

Results

Site-specific tillage enables differentiation according to relief and straw yields, which allows the farmer to act against soil erosion. The application of control software, electronic regulation and underlying decision processes opens up the possibility of utilising soil cultivation machines, which possess hydraulic depth adjustment.

Further to the field incline, the straw yield is the central value required in attaining a suitable erosion-limiting degree of soil coverage. The camera system described for the capturing of soil coverage also offers additional optimisation potential. Appropriate lighting enables a further reduction in the camera shutter speed, meaning that soil cultivation by straw cover with the camera would also be possible in a single-phase process.

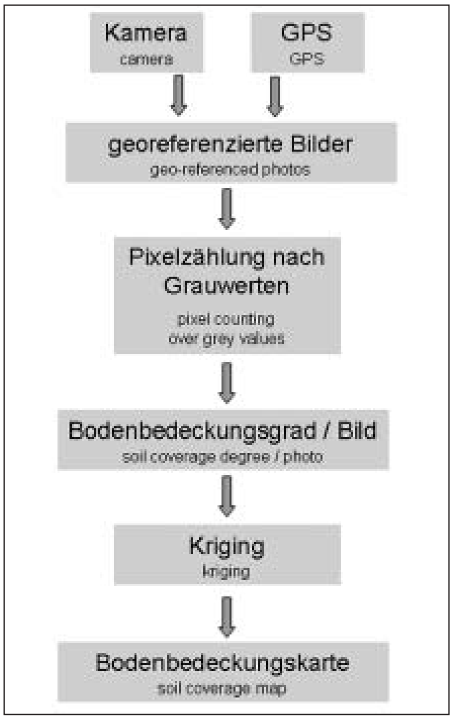

Fig. 4: Procedure for establishing a a soil coverage map