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Comparison of stubble working with cultivator or compact disc harrow

In comparison to stubble cultivator the investigated compact disc harrows shows slightly lower drawbar forces. Higher vertical forces at the shares of the cultivator result in a better compaction of the roller. The soil surface is evaluated by means of a fully automated profile meter. When the disc harrow runs deeply, the profile ground becomes smoother compared to a cultivator, but on shallow working depth the profile of the cultivators performs better. At the same implement depth the disc harrow shows a better straw incorporation.

Keywords
Stubble processing, drawbar force, profile of soil, straw incorporation, compact disc harrow, cultivator

Abstract
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Compact disc harrows are regarded in farming as requiring less draught; thus giving a high area performance and mostly leaving an acceptable field surface. These implements have won a substantial market share in the last years. The target of stubble cultivations is, among other things, good incorporation of straw into soil so that straw rotting is encouraged. Grain landing on the ground during harvest and weed seeds should be encouraged to germinate and the capillary structure of ground and stubble be broken, helping retention of soil moisture. Comprehensive investigations are being carried out at the Nürtingen-Geislingen University (HfWU) [1] into the long-term effects of stubble cultivation methods. In this association, precise measurements were made on three locations, the results of which are presented here. These results include the relationship of the forces acting between tractor and implement and the results of subsequent soil profiling. Also included: the effect of the implement on soil reconsolidation, straw incorporation and subsequent volunteer grain and weed emergence.

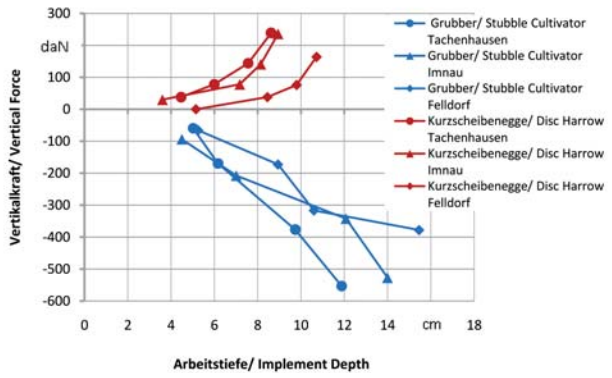
Methods

Compared were the Karat cultivator with three rows of tines and the compact disc harrow Rubin – both from Lemken. In order to accurately represent the targeted working depth and working speeds the mounted implements were pulled by a Fendt 820 with rated power of 140 kW. For recording the forces applied and moments, a 6-component power measurement frame with amplifier and datalogger was available. This also recorded nominal driving speed, engine rpm and fuel consumption. Through time required to cover a marked-out distance of 50 m, wheelslip and area performance could also be measured. Each implement was tested at four working depths with six repeat passes for each depth at three different locations. Pass direction was in each case diagonal to the working direction of the combine harvester.

Fig. 1

Profile meter to evaluate soil surface with Notebook

Fig. 3



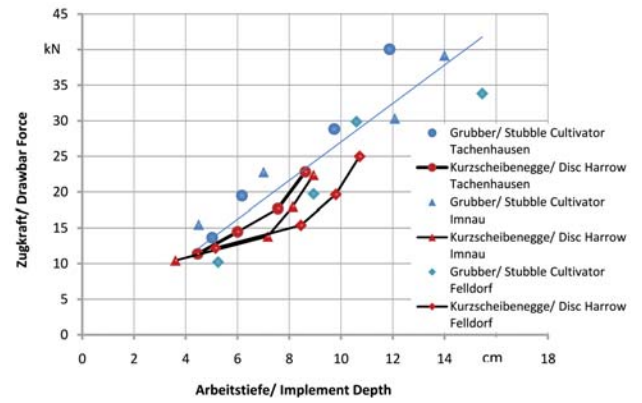
Vertical force of compact disc harrow and cultivator versus implement depth

For measuring working depth and assessing work quality of the respective implements, a laser profile-measuring instrument was developed and constructed at the HfWU Institute for Technology (**figure 1**). This worked fully automatically over a width of 3.4 m and transmitted the measured results wirelessly to the computer.

With a transmission rate of 2 Hz there resulted around 500 measurements per profile that represented a resolution of approx. 7 mm in the length. The measurement precision of the laser sensor at ±1.5 mm (2 σ standard deviation) exceeded requirements.

Applied for assessing straw incorporation and distribution was the mesh raster method [2] and straw index [3]. In accordance with the soil profile measurement scoring over the total working width took place. Because of the almost complete freedom of stones in the soil the levelling off of profile wall in the trench could be done through manual cutting with a bread knife.

Fig. 2



Drawbar force of stubble cultivator and disc harrow versus implement depth

Results and discussion

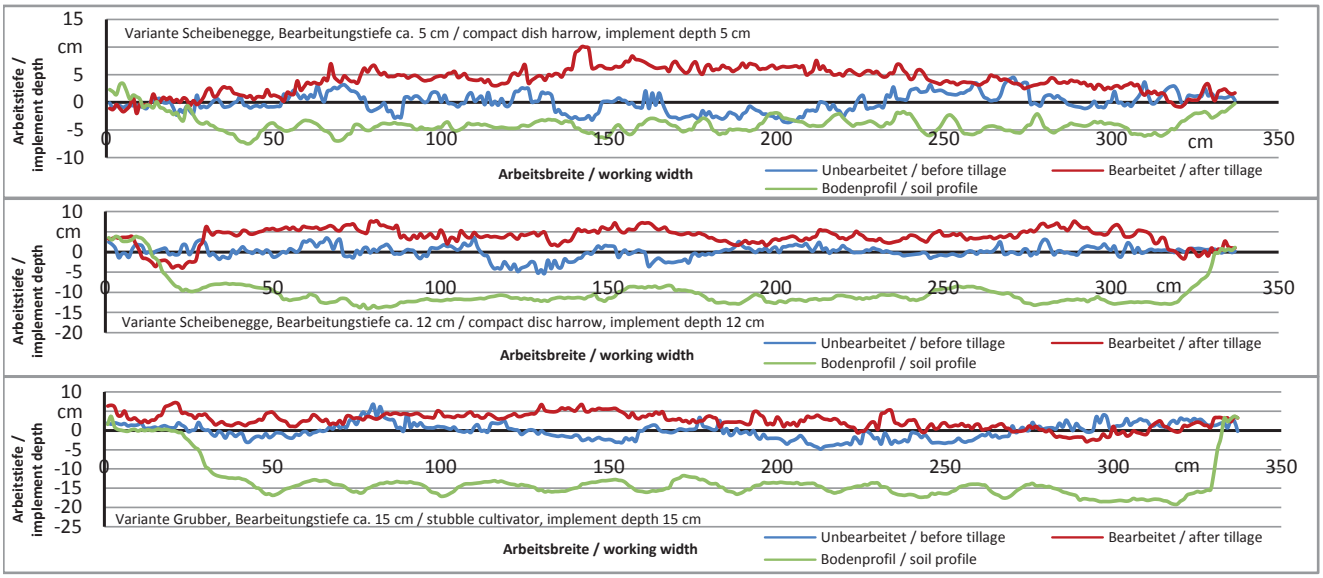
Every point in **figure 2** represents a variant on one of the three locations, each being calculated from the averages of 6 measurement passes. It is clear to see that the compact disc harrow tends to require around 16 % less draught power than the cultivator. In practice, the draught requirement of the disc harrow was subjectively estimated as clearly less, a result apparently due to the targeted working depth not being followed. If the measurements from the individual locations for the compact disc harrow were linked with a line, the clear progressive rise in draught with increasing working depth is recognisable. Because of the dry soil conditions the compact disc harrow achieved a maximum working depth of only around 12 cm.

In agreement with [4] the cultivator tines in **figure 3** developed a vertical force with increasing working depth. This put more load on the tractor and possibly also the packer roller. Conversely the disc harrow showed a vertical force which, with increasing working depth, acted upwards on the tractor. At the Felldorf location shallow stubble cultivation had taken place before the trial that influenced the vertical forces with both implements.

In order to record a complete soil profile three measurements were carried out at the same location. For the first measurement before the cultivation work, the profile measurement instrument was positioned upon an iron plate anchored into the ground outwith the cultivation track. After the cultivation pass the instrument was once again positioned on the iron plate that had been left in position and the soil profile with soil surface curvature measured. After the cultivated soil in the measurement area had been moved to the side a third measurement was made, this time of the undisturbed soil horizon.

Figure 4 shows, above and in the middle, a profile of the disc harrow work. The middle curve shows the original profile of the soil before cultivation. The line over this describes the ground contour after cultivation; this expresses the extent of the loosening effect or how good the reconsolidation via packer roller is. The lowest curve shows the undisturbed soil profile with average working depths of approx. 5 cm or 12 cm. In the

Fig. 4



Typical soil profile of compact disc harrow and stubble cultivator before and after tillage

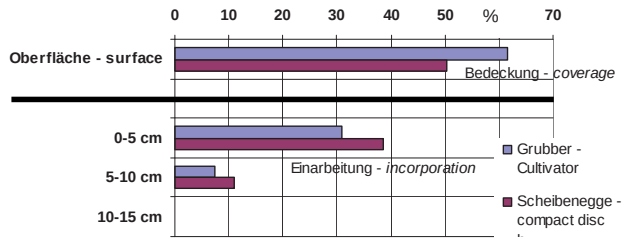
middle presentation the discs have cut through the soil to give an almost level horizon. Conversely, the positions of the 11 individual tines of the cultivator as seen in the lower figure at an average working depth of around 15 cm can be readily seen. Only on the right margin is the soil completely broken away between the last and the second last tines. This typical soil profile image is, other than with the disc harrow, to be seen with every depth worked at and retains to a great extent its basic form. With shallower cultivations (topmost graph) the compact disc harrow leaves a clearly more uneven profile that in part nears the blue line where no soil cultivation has occurred.

With the cultivator, both the upper lines lie closer together than those of the disc harrow which indicates a better reconsolidation.

These results correlate with the earlier mentioned vertical forces as recorded by the power measurement frame. With increasing working depth, the weight of the compact disc harrow is supported by the discs and is thus less available for reconsolidation. The cultivator, however, pulls into the soil more strongly with increasing depth and adds to the load on tractor and packer roller. The increase in packer rolling resistance associated with this is part of the reason for the increased draught requirement of the cultivator.

Figure 5 presents the vertical incorporation of the straw after stubble cultivation (approx. 5 cm). The topmost pair of bars indicates the amount of straw still lying on the surface after cultivation. The further pairs of bars show straw mixing extent in the observed horizons. The cultivator leaves more straw on the surface than the compact disc harrow, which, on the other hand, makes a comparatively better job of taking straw into the deeper layers of soil. Even when the average working depth is approx. 5 cm, the discs occasionally attained a deeper horizon and took straw down to that level too.

Fig. 5



Straw incorporation in the evaluation layers

Literature

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