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Development of Mechanical Soil Stress by Sugar Beet Harvesters

Sugar beet harvesters are often held responsible for soil damage, because they are similar in size to combine harvesters [1], To analyze this problem area, some typical sugar beet harvester systems and machines from the last three decades were evaluated on their frequency of crossings and average ground contact pressure.

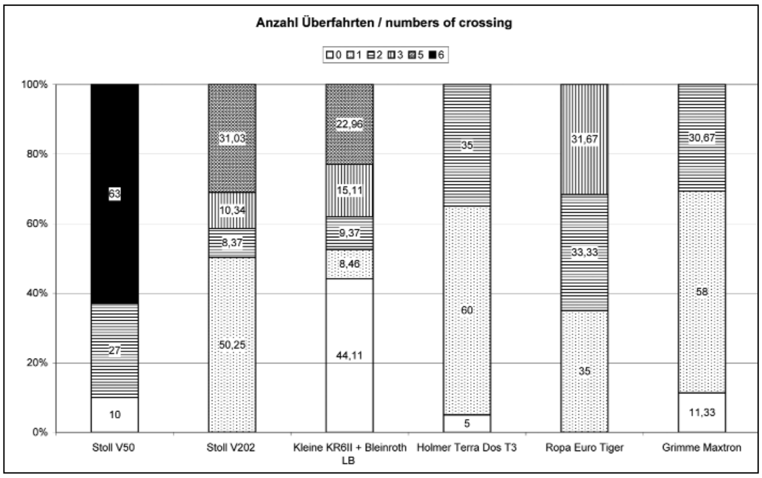

Fig 1: Frequency of crossings

In the last decades agricultural engineering is characterized by the use of more and more powerful and heavier working machines due to general economic and organisational conditions. Especially for sugar beet harvesters the mechanical soil stress by the carriage is seen as one of the main reasons for subsoil compaction in plant production [2].

By comparing different systems and machines for sugar beet harvesting the different effects on selected parameters should be demonstrated.

Material and method

Six types of sugar beet harvesting systems of the construction years between 1981 and 2007 are compared to demonstrate the development of soil stress on the basis of the frequency of crossings, total track area and the contact area pressure (*Table 1*). The analysed sugar beet harvesters have different harvesting systems. Stoll V50 and V202 are pulled tanker harvesters. The combination of Kleine KR6II and Bleinroth LB20 is an intermittently working system. In the first working step the beets are topped and harvested and in a second working step the beet windrow is picked up from the tank loader and cleaned. The three harvesters from Holmer, Ropa and Grimme are self propelled tanker harvesters. Differences exist in the construction of the carriage. The Holmer is four-wheeled, the Ropa six-wheeled and the Grimme has a combination of rubber track undercarriage and steering wheel.

To analyse the exogenous subsoil stress factors a row distance of 50 cm is assumed.

Results

An essential factor for the mechanical soil stress of sugar beet harvesters is the fre-

Tab 1: Data regarding soil compaction of the sugar beet harvesters examined

Modell model	Baujahr Construction year	Reihen row	Leistung power [ha/h]	Masch.arbeitsgewicht leer Weight of machine empty [t]
Stoll V50 + Fendt 308	1981	1	0,13	6,32
Stoll V202 + Fendt 308	1990	2	0,3-0,4	7,77
Kleine KR6II + Bleinroth LB20 + Fendt 612	1992	6	1,2	8,5 + 14,08
Holmer Terra Dos T3	2007	6	1,2-1,5	26,8
Ropa Euro Tiger V8	2007	6	1,2-1,5	33
Grimme Maxtron 620	2007	6	1,2-1,5	29,5

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Keywords

Sugar beet harvester, tire, soil stress, mean contact area pressure

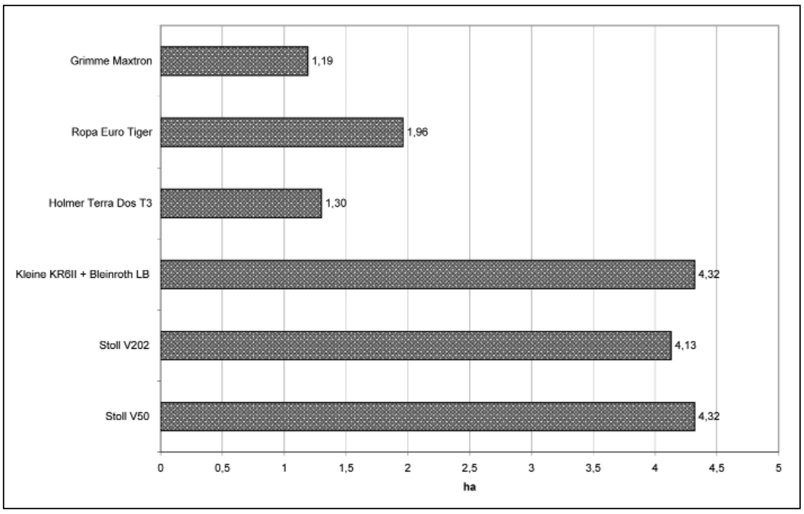

Fig 2: Area of lanes for the harvest of 1 ha sugar beets

quency of drive over. If the sugar beet harvester drives over the same area for many times the soil structure is changing depending on the subsoil stress, the structure stability and the soil specific deformation behaviour. Is the structure stability exceeded by a mechanical stress the first driving-over causes the biggest plastic compression of the soil structure. Each further drive over leads to an asymptotic approximation to the final degree of subsoil compaction [3]. The examination shows (*Fig. 1*) that there are significant changes during the development of sugar beet harvesting. With the Stoll V50 63% of the area has to be driven over for six times and 27% for two times during harvest (10 % are not driven over). The Stoll V202 drives nearly over the whole area, whereas only an area of about 31.03% is driven over for five times at maximum. The intermittent working system does not drive over 44.11% of the area but 15.11% three times and 22.96% five times. In contrast the self propelled harvesting systems drive nearly over the whole area, whereas the six-wheeler drives over 31.67% of the area three times at maximum.

With the data from the driving over frequency the track area as parameter for the drive-over intensity can be determined (*Fig. 2*). It is determined which area has to be driven over to harvest one hectare sugar beet by adding the track area of the single wheels. It can be shown that the pulled and intermittent working systems have higher amounts than the self propelled systems. The area driven over quadruples sometimes. While the self propelled machines drive over the area 1.5 times in the average, the pulled and intermittent working systems drive over the area about 4.25 times.

A further aspect of the examination is the mean contact area pressure under the wheels of the different harvesting systems (*Fig. 3*). The data have been determined by TASC [4] to attain comparable results to the examinations on combine harvesters [1]. The contact area pressure-columns are from the left to the right assigned to the single axles of the vehicles starting with the front axle. As the Stoll V202 has different tyres on the axle the first column corresponds to the left tyre and the second column to the right tyre

By the pulled and intermitted working systems a clear inconsistency in the contact area pressure of the single axles from tractor and harvesting machine can be shown. The values differ between 0.7 and 2.3 bar. These three systems show pressures which are clearly higher than those from self-propelled machines although the self-propelled machines have higher total volumes and wheel loads. The self-propelled machines range between 0.95 and 1.32 bar.

Discussion

The examination has shown that by the development of self-propelled, six-row sugar beet harvesters the frequency of drive-over as well as the mean contact area pressure could be lowered. Due to the construction of the chassis the stress is evenly spread over the whole harvesting area and not only concentrated on single areas.

The analysis of the self-propelled sugar beet harvesters has shown that an evenly quantity distribution on the single axles with an adapted tyre equipment should be aspired especially during harvesting. The six-wheeled tanker harvester has the highest total weight but the three axles lead to a better load distribution. The mean contact area pressure under the single tyres differs only about 0.07 bar and has a maximum of 1.14 bar.

Very interesting for the future development might be rubber track undercarriages, because the target function is to spread the weight to a large area. Due to their mechanical characteristics pneumatic tyres can lower the soil stress be lowering the tyre inflation pressure and therefore contribute to the protection of the soil. But chassis with pneumatic tyres meet their limits, if they want to fulfil the requirements on passageway for sugar beets and width of the chassis. An additional increase breadthways might be impossible. At this point rubber band undercarriages might become interesting as these by length growth enable a bigger contact area by keeping the width of vehicle. An advancement of the rubber band undercarriages to achieve a more evenly distribution of the contact area pressure and especially the elimination of pressure peaks can lead to a further soil protection.

Literature

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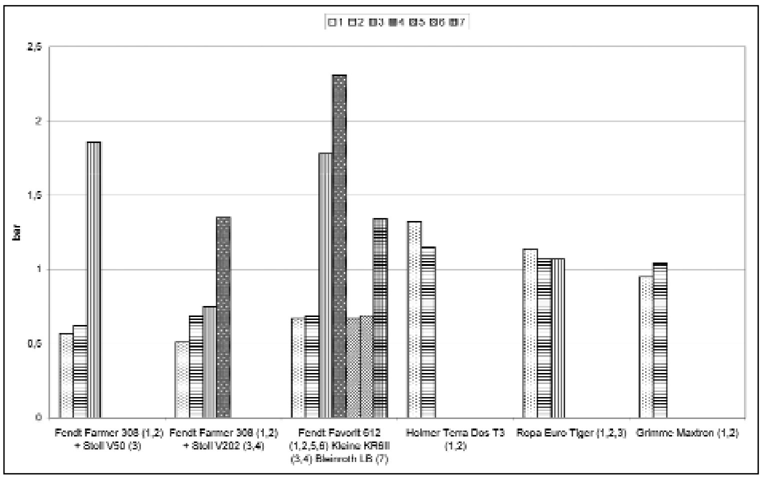

Fig 3: Average ground contact area pressure at the different axles of the machines investigated, computed with full load by TASC