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Defoliation of sugar beets – assessment of quality and gain in delivered beet mass

Scalping was so far the standard procedure for elimination of beet leaves disregarding that there is a mass loss of beet as the beet crowns are left in the field. In case the add on in beet mass of 3-4 % shall be gained by the farmers, another defoliation method must be applied. There is since two years an implement for defoliation offered by a beet harvester manufacturer, which will be introduced and evaluated in this article. Coincidental a classification for the quality assessment of defoliation is introduced and the results of a field test will be presented.

Keywords
Defoliation, topping losses, topping quality, mass losses, add on in yield, assessment method

Abstract
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Sugar beets are grown commercially for production of crystalline sugar. Beet leaves are not harvested since farmers stopped using them to feed cattle. In the past two decades a procedure involving a feeler and a rigid blade became widely accepted. In the process leaves get chopped off until there is only a brush of petioles left, afterwards the blade cuts off the crown. Sugar refineries do not process the crown since it is high in soluble nitrogen compounds which decrease sugar yield. However, by chopping the crown from the root the farmer looses both beet mass and sugar which is why the growers are interested in delivering the overall beet mass to the refinery. Therefore the objective of the experiments was to determine the difference in yield between topped and defoliated beets and to evaluate the quality of defoliation.

Defoliation technique

In the US, devices for defoliation of sugar beets have been in use for many years. Steel flails remove the leaves and subsequent soft rubber flails then clean the beet top. The manufacturer of agricultural machinery Grimme adapted this technology to a mono phase harvest procedure, which is commonly applied in Europe. The American implements use three shafts to first chop up the foliage by steel flails and afterwards remove the bases of the leaves from the top by polyurethane flails (**figure 1**).

In contrast, the Grimme type features only two shafts. The first shaft carries polyurethane flails above the rows and shorter steel flails between the rows. It rotates backwards at 900 rpm. The second shaft, only equipped with polyurethane flails, rotates in direction of travel at 1000 rpm and hits leaves that can not be removed by the flails of the first shaft.
Compared with the three-shaft model the two shaft model is shorter and can therefore be attached to front hitches of tractors or serve as part of the header of six row tankers. On the other hand, the two shaft model does not clean the beet tops as intensively as the three-shaft model, particularly because there is no third shaft.

Evaluation of defoliation quality

The device must remove beet leaves including petioles from the crown completely without injuring the beet's epidermis. The entire beet should be harvested, avoiding respiration caused by lesions from defoliation. The evaluation of defoliation quality must reflect these requests. Since there is no technical procedure to evaluate defoliation a visual method was used. This method was based on the IIRB standard which is commonly applied to topped beets. The standard was modified by defining defoliation classes. For the visual evaluation 5 classes were defined as illustrated in **figure 2:**

- Class 1: leaf bases with parts of leaves
- Class 2: leaf bases with lesions
- Class 3: explicit petioles
- Class 4: correctly defoliated without lesions
- Class 5: correctly defoliated with lesions

Experimental setup

In 2009 a field test was prepared on the experimental farm Campus Klein-Altendorf about 15 km south of Bonn (coordinates: 6° 59' 32 E, 50° 37' 51 N, soil type: loamy silt). To compare the standard harvest with the newly introduced defoliation method a 4 ha plot was divided into stripes of 36 rows (245 m long) to obtain 4 repetitions of each method.

At first the morphological data of the beets in the test plots were determined. The stand density was 82700 per ha, plant spacing: 26.98 cm, top height: 5.21 cm, the maximum beet diameter above the soil surface in direction of travel was 11.35 cm and the leaf mass was 40 t • ha^{-1}.

For the standard harvest a six row tanker (Holmer Terra-Dos) was used. The defoliator Grimme FM 330 was operated by a 90 kW tractor (**figure 3**). Both machines worked at speeds of between 5.5 and 6 km • h^{-1}

To harvest the defoliated beets the same six row tanker was used with its topping device lifted.

The beets were left in two piles on the headland for 5 days. From each bunker random samples were taken to evaluate the topping quality according to the IIRB standard [1].

Results

The plant population was characterized by a high proportion of missing plants. As a result, at each end of a gap there were very big beets shading very small beets. The leaf mass was 40 t • ha^{-1} (4.9 t • ha^{-1} dry matter) which led to a beet-leaf-ratio of 1:0.425 (results from manual harvest).

The evaluation of the defoliation quality showed that 37.7 % of the beets had been treated correctly (class 4) while 50.7 % had been defoliated correctly but had lesions (class 5). 7.5 % of the beets still had minor leaf bases (class 3) which means that the flails were adjusted too high. Further 3.3 % had not only been defoliated incompletely but also carried explicit petioles (class 1) while less than 1 % of the beets had both leaf bases and lesions (class 2) **(figure 4)**.

Figure 5 shows the results of the scalping quality associated with the results of the harvester test in Seligenstadt 2006. It is obvious that the scalping cut was higher in 2009 than in 2006. However it was below the maximum value of the machines tested in 2006.

The scalping method yielded 81.0 t • ha^{-1} while 83.8 t • ha^{-1} were harvested when the defoliation methods was used which equals a mass gain of 3.4 %. The mass gain is even 4 % when root breakage is considered. The sugar content of the beets delivered to the factory was not significantly different independent of which harvest method was used.

To explain the differences in mass yield 500 defoliated beets were sliced between the top and the root's largest diameter. Both the 1 cm wide discs and the remaining root were weighed.

Table 1 shows the added masses of the beet discs from up to 3 cm below the top. 5 classes for different beet masses were defined. A cutting height of 2 cm roughly equals the standard cutting height in the field. According to **table 1** scalping of sugar beets could result in a mass loss of between 2.5 and 5.0 % if the cutting height was 2 cm.

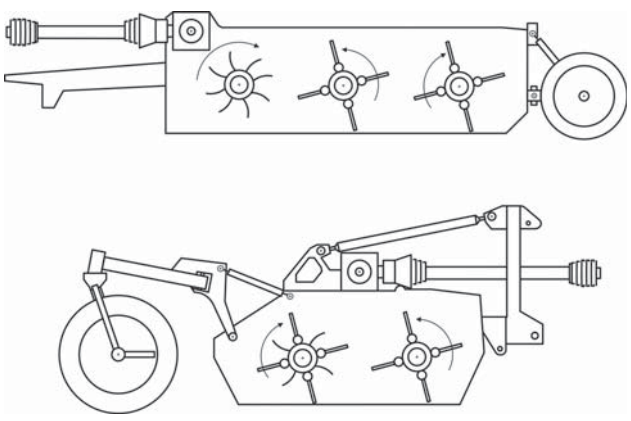
Conclusions

The harvested sugar beet mass was 3.4 to 4 % higher when the defoliation method was applied. However, it has to be considered that the result of the scalping method can be affected significantly by adjusting the cutting devices.

What is more, **table 1** suggests that the gain in yield through the defoliation method will be high if the proportion of small beets is high. Describing the defoliation quality, the Grimme FM 300 treated 90 % of the beets correctly, including beets with lesions.

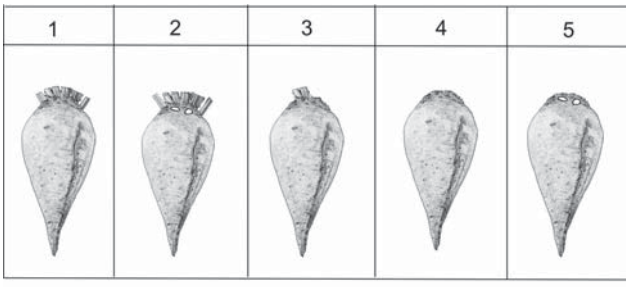
The authors note that the results presented in this paper cover only one year which was, in terms of sugar beet cultivation, an exceptional one. To confirm the results additional repetitions are planned for the next years.

Fig. 1



Top: Defoliation device as applied in US sugar beet harvest equipped with 3 shafts as trailed implement. Bottom: Unit for tractor front mounting or as header of six row harvester

Fig. 2

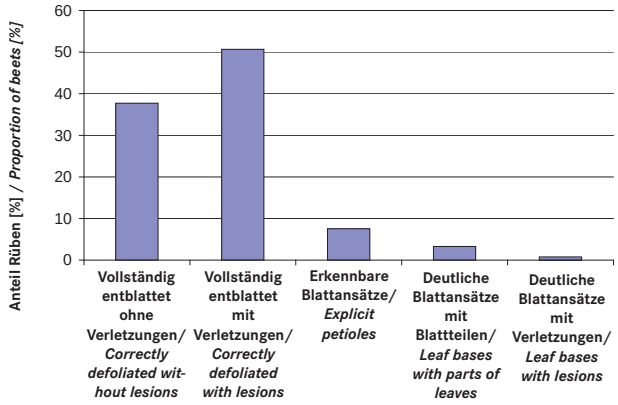


Classes of defoliation quality for sugar beets

Fig. 3

Defoliation implement, Grimme Frontmulcher FM 300

Fig. 4



Results of assessment of the system defoliation

Literature

[1] Vandergeten, J.-P.; Van der Linden, J.P.; Jarvis, P.; Leveque, E.; Guiraud de Willot, D.; Kromer, K.-H. (Coordinator) (1997): Test procedures of Measuring the Quality in Sugar Beet Production. Hg. Internationales Zuckerrübenforschungsinstitut (IIRB), Brüssel

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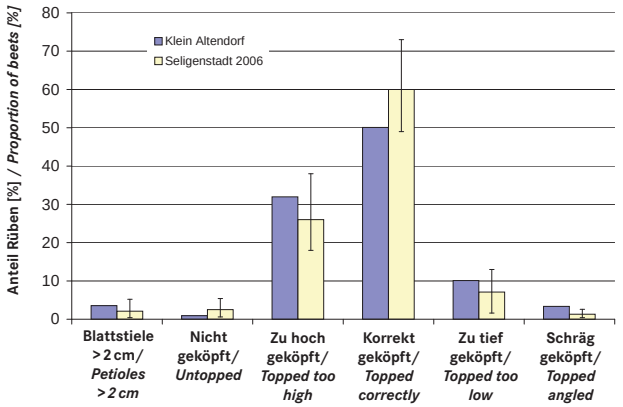
Fig. 5



Results of assessment of the system scalping (error bars for Min/ Max values for 9 harvesters tested in Seligenstadt 2006)

Table 1

Relative mass loss of beet crown related to total beet mass [%]

		Verlust an Rübenmasse, *loss of beet mass [%]*		
Rübenmasse-Klassen [g]/ *Beet mass classes [g]*	**Mittlere Rübenmasse [g]/ *Average beet mass [g]***	**Bis 1 cm Köpfhöhe/ *Up to 1 cm cutting height***	**Bis 2 cm Köpfhöhe/ *Up to 2 cm cutting height***	**Bis 3 cm Köpfhöhe/ *Up to 3 cm cutting height***
1750–2600	1900	0,5	1,9	4,5
1500–1750	1620	0,6	2,5	5,8
1600–1500	1130	0,9	3,6	8,1
750–1000	835	1,3	5,0	11,3
500–750	550	2,0	7,6	16,4