Dieter von Hörsten, Wolfgang Lücke and Henning Hage, Göttingen

New development of a combine straw chopper

Results of spreading range- and chopping length experiments

Today, leaving straw on the field is virtually the only possibility of straw utilization. As a result of the transition to cultivation techniques with reduced and even zero tillage, the demands on the treatment and distribution of the straw have grown considerably. Given current technological standards, choppers cannot satisfactorily comminute and in particular distribute straw. For this reason, an entirely new chopping concept has been developed which could meet the requirements. Initial tests showed that the prototype can reach a spreading range of up to 14 m, produces small particle sizes, and fulfills the conditions for even distribution.

Dr. Dieter von Hörsten is a lecturer at the Institute of Agricultural Engineering of the University of Göttingen, Gutenbergstr. 33, D-37075 Göttingen. Prof. Dr. Wolfgang Lücke is director of the same institute, and Henning Hage M.Sc. studied for his master's degree there; e-mail: *uaat@gwdg.de*

Keywords

Combine straw chopper, straw distribution, chopping length

The transition to cultivation techniques with reduced or even zero tillage often causes difficulties in practice, which must mainly be attributed to the insufficient treatment of material other than grain (MOG) during the grain harvest. Therefore, the optimized treatment of MOG requires more attention today than in the past when the plough was used. The main component of the MOG is straw. It must be the objective of treatment to comminute these quantities sufficiently and to distribute them evenly over the entire working width of the combine in order to promote quick rotting and to prevent problems during subsequent tillage and the sowing of the successive crop. Many straw choppers are unable to achieve good chopping quality and to distribute chaff and straw evenly over the initial width after threshing [1]. Cutting widths of more than 6 m are critical [2]. In the future, the right treatment technique will be an important argument for the purchasing decision.

Chopping length has a direct influence on microbial straw degradation. With diminishing chopping length, the straw surface available for microbial degradation increases. As a result, shorter chopped straw is degraded faster by microorganisms than longer material [3]. Chopping lengths under 5 cm should be striven for. A length of 2 to 3 cm is optimal. For these requirements to be met, straw choppers are necessary which distribute the straw evenly under all conditions and additionally reach an average straw chopping length of 2 cm [4]. Initial results show that a chopper prototype newly developed in Göttingen is coming closer to this goal [5, 6].

Experimental set-up

Winter wheat straw from the 2002 harvest was used as material for the trial. The requirement was that a mass of 2 to 4 kg of straw per second was supplied to the chopper at a rotational speed of the rotor of 630 and 1 000 rpm. A conveyor belt was used in order to supply the tested chopper evenly. In the trial, the outlet of the chopper was 30 cm above the ground. In order to determine straw distribution, representative samples of the chopped straw were taken at distances of 1, 2, 4, 6, 8, 10, and 12 m. Chopping length was determined at the Institute for Production Engineering and Building Research of the Federal Agricultural Research Centre (FAL) in Braunschweig. There, image analysis equipment was used to measure the treated straw samples. This instrument is able to determine the position, number, length, and surface of comminuted straw particles.

Spreading range

The measured spreading range values show that the new chopper is able to distribute straw over large widths (*Table 1*). Due to ejectors, the spreading process was so efficient that a spreading range of significantly more than 10 m was able to be reached. With regard to wind sensitivity, the position of the outlet point, which is deep as compared with conventional choppers, also has a positive effect. The alteration of the rotational speed of the rotor from 630 to 1 000 rpm resulted in a larger spreading range. If the newly developed chopper were equipped with two

Table 1: Maximum spreading range of the prototype chopper

Rpm [min^{-1}]	Straw throughput [kg/s]	Spreading range [m]
630	2	10,5
630	4	10,5
1000	2	12,5
1000	4	14

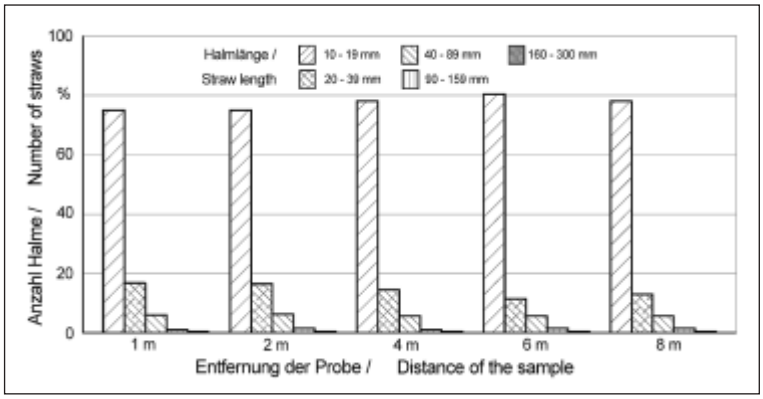

Fig.1: Chopping length distribution of the prototype (rotational speed: 630 rpm; straw throughput: 2 kg/s)

counterrotating, vertical rotors, the spreading range could even be doubled. Even if the chopper still needed to be optimized in order to guarantee even distribution of the chopped straw over the spreading range, these alterations would allow the straw to be distributed over total working widths of approximately 15 to 20 m.

Chopping lengths

With the aid of image analysis, the blades were counted according to their lengths in a range from 10 to 300 mm, and the number of blades in the different length classes was indicated. For evaluation, size classes of 10 to 19 mm, 20 to 39 mm, 40 to 89 mm, 90 to 159 mm, and 160 to 300 mm were chosen. Particles smaller than 10 mm were not counted because image analysis is not able to distinguish straw from dust, seeds, grains, or other foreign matter. *Figure 1* shows the percentage of the blades counted in the individual size classes at a rotational speed of 630 rpm of the rotor.

By means of chopping length distribution, the distribution characteristics of the experimental chopper were examined. Based on the evaluations, the distribution of the individual blade lengths over the spreading range can be established. If the chopped straw were to unmix after leaving the outlet and the spreading range of the straw were to vary depending on chopping length, the new chopping principle would not allow even distribution to be reached. In the case of the experimental chopper, the distribution of chopping lengths proved to remain the same over the spreading range (Fig. 1). A tendency towards a varying spreading range of the chopped straw depending on length cannot be discerned. Thus, the new chopping concept has fulfilled another important prerequisite with regard to even chopping length distribution.

However, even straw distribution also requires even straw mass distribution over the spreading range. The measurement of chopping length alone, which has been carried out here, is no suitable method of examination which would enable the straw mass distribution of the experimental chopper to be evaluated because it does not determine the straw mass, but only the number and length of the blades.

Nevertheless, the realized trials showed that straw mass distribution was not yet satisfactory. This was obvious even without mass measurement because no straw was distributed in the immediate vicinity of the experimental chopper due to the air flow. Even distribution could not be expected because in the trials carried out here for the first time the experimental chopper did not feature any equipment which would have allowed straw to be spread evenly. Equipment which may be suitable for this purpose is an oscillating outlet or an outlet with straw baffle plates.

Conclusions

While the chopping principle of the known conventional mounted combine chopper has been studied and optimized numerous times, the experimental thresher is a new development which had not been used for MOG treatment before. Initial tests of this prototype were only intended to show which advantages the new chopping principle offers and which alterations are still necessary.

The trials show that the described new chopping concept is able to solve the mentioned problems caused by insufficient straw distribution by conventional choppers. However, it also becomes clear that many different technical changes and trials remain to be carried out on the way from the experimental chopper to the mounted combine chopper ready for use. These trials will show which rotational speed of the rotor, which number of auger flights, which kinds of ejectors and which design of the treatment path in the lower part of the chopper are necessary in order to meet the mentioned demands (throughput, chopping quality, straw distribution) while keeping the power requirements of the machine as low as possible.

Literature

Books are identified by •

[1] • *Kämmerer, D.*: Der Schneid- und Fördervorgang im Mähdrescherhäcksler. Dissertation, TU Braunschweig, 2003

[2] *Voßhenrich, H.-H.*: Strohverteilung und Häckselqualität auf Praxisflächen. Landtechnik 54 (1999), H. 5, S. 306-308

[3] • *Koch, H.-J.*: Pflanzenbauliche Risiken und erosionsmindernde Wirkungen von Strohmulchdecken im Getreidebau. Dissertation, Universität Göttingen, 1990

[4] *Voßhenrich, H.-H., H. Kluge und J. Wilcke*: Strohmanagement im pfluglosen Pflanzenbausystem - Grundlage für eine erfolgreiche konservierende Bodenbearbeitung. RKL, Kiel, 2002

[5] *Lücke, W., D. von Hörsten und H. Hage*: Mähdrescherhäcksler - Neuentwicklung mit großer Wurfweite und Beschädigung des Verlustgetreides. Landtechnik 59 (2004), H. 1, S. 30-35

[6] *Lücke, W., und D. von Hörsten*: Design and Development of a new Combine Straw Chopper with huge Spreading Range. AgEng 2004, 12 - 16 September, Leuven, Belgien, Book of Abstracts Part 1, S. 454-455