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Chop Length Capability and Wearing Qualities for Two Types of Straw Chopper Knives at Combine Harvesting

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Abstract: There are different types of reciprocating knives for combine harvester straw choppers available on the market. The aim of this study was to investigate performance differences between smooth and serrated knives with respect to chop lengths and wearing.
Before harvest, new reciprocating knives and counter knives were mounted on a combine harvester. During the harvest season this combine was used for harvest of more than 200 hectares of grain and rape in fields in central Sweden. Chopped straw from each type of knife was sampled on nine occasions and analysed for chop length.
After the harvest season, each reciprocating knife was weighed. The mass loss was used as a measure of the wear on each knife.
On average over the entire harvest season, the difference in chop length was negligible. Both types of knives achieved average chop lengths of 31 mm. Correspondingly, negligible differences in knife wear were observed.
In parallel with the Swedish studies above, additional tests were conducted in Germany. In these trials performance differences between the tested system arrangements were also marginal.
Key words: Combine, harvest, straw, chop, cut, knife, wear

INTRODUCTION

Recent years have seen extensive development of crop residue treatment systems on combine harvesters. For example the improved performance of straw choppers has made it possible to cut straw into very short lengths. At Swedish trials with modern straw choppers average chop lengths of about 2 to 3 cm have been achieved (Lundin, 2001).

The performance of a straw chopper depends on several parameters. For example varying weather conditions can make straw brittle and thus easier to cut up. Meanwhile, application of fungicides causes the straw to be relatively immature at harvest time. In this way, cutting is made more difficult and power demand for the process increases.

Wear on a straw chopper's reciprocating knives is another factor that is considered important. According to manufacturer specifications, their sharpness considerably affects energy demand for chopping.

Knife design is further considered to be important, and there are several types on the market, for example smooth or serrated. Although more expensive to manufacture, serrated knives are common, suggesting that customers consider them to have superior performance to smooth ones. Whether or not performance differences actually exist between the types has not been sufficiently investigated previously. An evaluation therefore of the differences in performance and wearing between smooth and serrated knives is the subject of this study.

MATERIAL AND METHODS

Swedish trials

Before harvest 2001, new reciprocating knives and counter knives were mounted on a conventional combine harvester, Massey-Ferguson 36, Figure 1. The same knives were kept on the straw chopper for the entire harvest season. All knives as well as the straw chopper itself were manufactured by Rekordverken Sweden AB. A total of 28 smooth reciprocating knives were mounted on the left hand side of the straw chopper with the same number of serrated knives mounted on the right hand side. The original weight in grams of each knife according to manufacturer's specifications were as follows:

Smooth	243	+- 1,5
Serrated	241	+- 1,5

Figure 1. A total of 28 smooth reciprocating knives were mounted on the left hand side of the straw chopper and an equal number of serrated knives were mounted on the right hand side.

During harvest season, 219 hectares of grain and rape were combine harvested of which on 211 hectares the straw was chopped. The harvest was conducted with normal weather and crop conditions.

During harvest of winter wheat and barley, chopped straw from each type of knife was sampled on nine occasions. The samples were collected in boxes of dimension 100 x 700 x 700 mm placed beside the combine steering wheel. On each sampling occasion, 3 separate boxes of sample were collected. On each measurement occasion the moisture content of the straw and of the kernels was determined.

The chop length of the collected samples were analysed at JTI. This was achieved with a special instrument for assessment of the length distribution built in accordance with specifications from the Silsoe Research Institute (Gale & O`Dogherty, 1982). With this equipment the straw sample was divided into fractions according to length. Each fraction was weighed and the mass median length of each sample was calculated. The meaning of this term is that half of the sample mass amounts to particles shorter than the mass median length. The other half therefore amounts to particles longer than the mass median length.

After the harvest season, every knife was cleaned and weighed. From these weighings and the mass of new knives given by manufacturer's specifications, weight decrease of the knives during the harvest season was calculated. The mass loss was used as an indicator of knife wear.

German trials

Parallel to the Swedish studies, the performance for different types of knives was compared at field trials in Bietikow, 100 km northeast of Berlin. The field trials took place on August 15 and were coordinated with a trial and exhibition activity carried out by John Deere, Inc. with some of their combine harvester models.

At this trial, smooth knives were compared with serrated, both types manufactured by Rekordverken Sweden AB. In addition, how the number of knives in the straw chopper affected performance was investigated. In the study the number of knives was between 60 to 90 % higher than for standard straw choppers, Table 1.

Samples of chopped straw were collected using a similar method to that used in the Swedish trials, with the addition that in these trials the samples also included crop residues from the shoe.

The straw samples were analysed for chop length at the Federal Agricultural Research Centre Braunschweig-Völkenrode (FAL), Institute of Production Engineering and Building Research.

RESEARCH RESULTS

Swedish trials

Table 2 shows the date for each sampling of chopped straw, harvested acreage and moisture contents of the harvested crops. The average moisture content in kernel and straw was calculated from these data to be 18 and 27 % respectively.

Achieved chop lengths on each measurement occasion are illustrated in Figure 2. Which of the knife types gave the shortest chop lengths alternated between the two types for different sampling occasions. The greatest measured difference in average chop length was 5 mm.

Table 1. Specifications of John Deere combine harvesters used in the trials. Models, types of grain-straw separation and number of reciprocating knives in the straw choppers (standard version and the number used in the trials)

Model	Grain-straw separation	Number of knives at version		
		standard	trial	trial/ standard, %
JD 9600	Straw shaker	68	108	160
JD 9600	Straw shaker	68	132	190
JD CTS	Rotor	56	88	160

Table 2. Data for sampling of chopped straw, cumulative harvested acreage and moisture content of kernels and straw

Measure-ment No.	Date	Harvested acreage, ha	Crop	Moisture content, %	
				kernel	straw
1	23 Aug.	48	Wheat	20	35
2	24 Aug.	75	Wheat	16	16
3	25 Aug.	91	Wheat	18	38
4	1 Sep.	140	Barley	19	34
5	6 Sep.	148	Barley	19	20
6	6 Sep.	161	Barley	18	21
7	7 Sep.	176	Barley	17	21
8	16 Sep.	195	Barley	22	39
9	18 Sep.	219	Barley	16	17

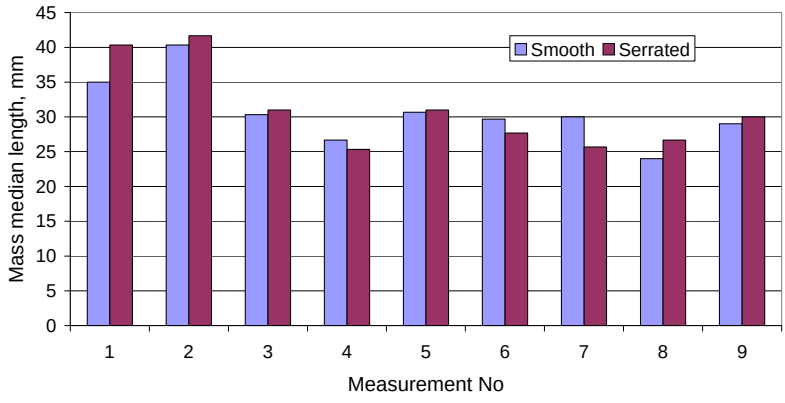

Figure 2. Mass median lengths for straw chopped with smooth and serrated knives respectively for all measurement occasions.

On average, the difference in chop length over the entire harvest season was negligible. Both types of knives achieved mass median lengths of about 31 mm, Figure 3.

Figures 4 and 5 show the weight loss of each individual reciprocating knife.

The compiled results in Table 3 show that the average decrease in weight loss was approximately 2 grams for both types of knives during the harvest season. This corresponds to 0.8 % of the initial mass.

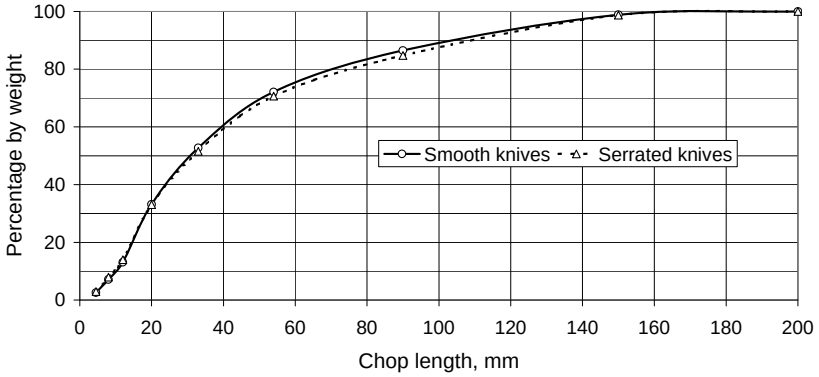

Figure 3. Cumulative length distribution by weight for straw chopped with smooth and serrated knives respectively. The mass median length (at 50 % by weight) was about 31 mm for the both types of knives. Data compiled from all measurement occasions.

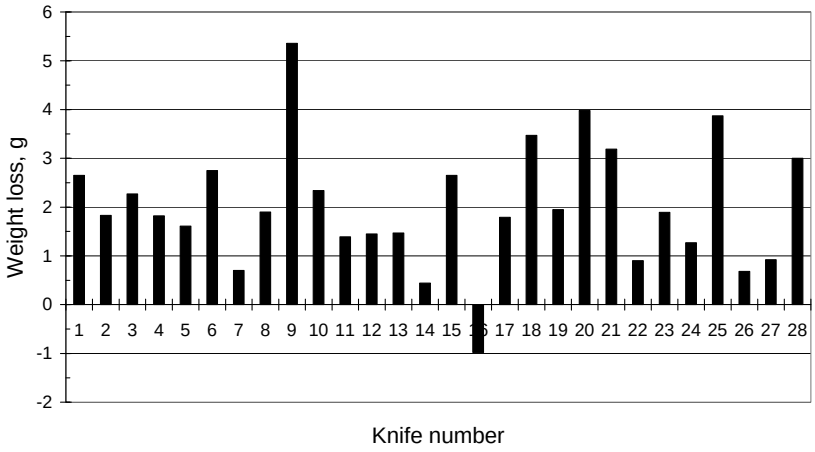

Figure 4. Weight loss over entire harvest season for each of the smooth knives.

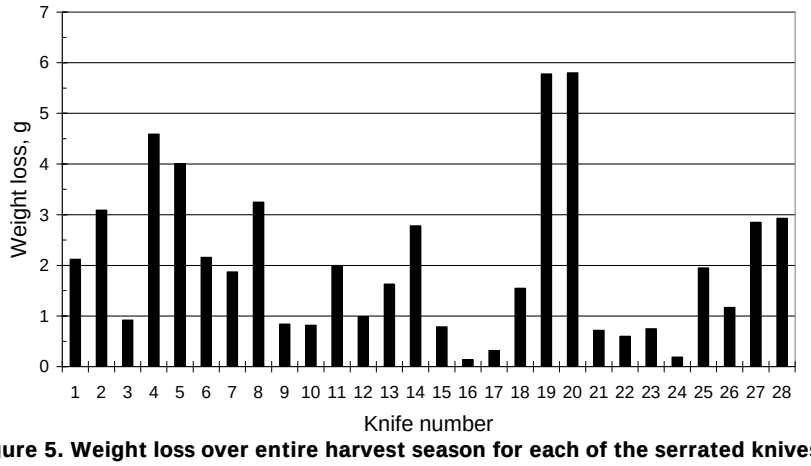

Figure 5. Weight loss over entire harvest season for each of the serrated knives.

German trials

Chop lengths achieved for the different combine harvesters and straw choppers tested are shown in Table 4. The shortest chop length was achieved with the CTS combine harvester, which was equipped with serrated knives and 60 % more knives than the standard version. The difference in mass median length compared to the other system arrangements was however only a few millimetres.

Table 3. Comprehensive result from weighing of knives at the end of the harvest season

Knife, type	Weight of new knives average, g	Weight of worn knives, g		Weight loss, average	
		Average	Standard deviation, g	g	%
Smooth	243	240,98	1,57	2,02	0,83
Serrated	241	238,98	1,27	2,02	0,84

Table 4. Mass median lengths for straw during German trials

Combine harvester, model	Straw chopper knives		Mass median length	
	type	number compared to standard, %	mm	rel.
JD 9600	smooth	160	8,5	108
JD 9600	serrated	160	8,0	102
JD 9600	serrated	190	7,8	99
JD CTS	serrated	160	7,2	91
Average			7,9	100

DISCUSSION AND CONCLUSIONS

The Swedish trials demonstrated similar performance with respect to chop length and wearing for smooth and serrated knives. No performance impairment due to wear during the harvest season was observed.

At the German trial the observed differences between the tested system arrangements were marginal. The shortest chop length was achieved by the CTS combine, which could be ascribed to the threshing system's intensive handling of the straw compared to what is achieved by a traditional shaker-equipped combine.

Both the trials in Sweden and Germany gave well-cut straw. The results from the studies in the two countries are however not directly comparable due to different conditions with respect to crop types etc. As mentioned earlier the straw samples collected in Germany also included crop residues from the shoe. Furthermore, the equipment used for chop length analysis was different in each of the trials.

ACKNOWLEDGEMENTS

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