Influence of harvesting techniques on forage production in alpine regions

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Abstract

During the whole working process of forage harvesting, different options contribute to keep forage quality at a high level. Different ground adaptation techniques by front mowers were measured. The bearing pressure of front mowers ranges between 50 and 180 kg m^{-1} of working width and was influencing the ash content (with active frame compared to classical frame 71.3 to 81.0 g ash kg DM). The variability of mowing height differs between 25% (mower with active frame) and 41% (mower with classical frame) on an uneven ground. Conditioning of forage shortens the field drying process by 1-4 hours and reduces the fermentation losses. Therefore, harvesting of artificial drying hay needs only one day. Tedding intensity and tedding frequency may also impact on forage quality (crop losses increase from 7.5 to 17% when the tedding frequency is enhanced from 3 to 6 times by field hay drying).

Keywords: harvesting techniques, mower, tedder, permanent grassland, forage losses

Introduction

Agriculture in alpine regions requires high forage quality. Beside a well-balanced plant stand and the right moment of harvest, forage quality is also influenced by harvesting and conservation techniques. In this paper, forage harvesting is analysed from a technical point of view and relevant parameters are quantified on the basis of several individual experiments.

Materials and methods

In a first trial (1999), two fixed mowers on the rear of a tractor, with and without tine conditioner, were deployed on a temporary meadow (Pöllinger *et al.*, 2001). The following adjustments were made: working width 2.45 m, number of revs 540 U min^{-1}, rotation speed at the conditioner 720 U min^{-1}, and driving speed 12 km h^{-1}. After the mowing the forage was variably turned by means of a rotary tedder (0-6 times). The silage was brought in on the same morning as the forage was cut; the artificial dried hay was brought in after midday and the field hay on the evening of the following day.

The field losses were measured after swathing. For this purpose, 10 plots of 1 m^2 each spread on the field were treated by means of a special vacuum cleaner. Ash content and dry matter weight of the collected material were determined. The drying process on the field was characterised by the measurement of the dry matter content of the forage at different points of time. The data were statistically evaluated as a regression analysis by the program LSMLMW PC-1 Version after Model 1.

In a second trial (in 2005), two front mowers with 3.0 m working width each were deployed with different ground adaptation techniques (Paar *et al.*, 2006). The ground pressure was set at 160 kg m^{-1} (mower with 'active' frame - Alpha Motion) and 340 kg m^{-1} (mower with 'classic' frame). The experiment took place on a permanent meadow with uneven ground surface. On 10 plots of 1 m^2 each, the cutting height was measured five times in the direction of driving and five times transverse to this direction. Forage samples were taken in order to determine the ash content.

In the third trial (in 2010), a rake with single rotor and large working width (diameter 3.60 m) was compared with a twin rotor rake with side swath (diameter 3.30 m). The field losses after swathing were measured at different driving speeds (8 to 12 km h^{-1}) on flat and uneven areas.

Results and discussion

First experiment. Ensiled forage, which was cut by the conditioner and tedded twice, could be harvested with a DM-content of 32% one hour earlier than the forage which was cut without conditioner. Artificial dried hay was brought in with a DM-content of 60%. This target value was obtained three hours earlier with the conditioner than without it. In terms of leaf shatter losses, clear differences were shown between the harvesting procedures (Table 1). The influence of the rotary tedder can best be reproduced with the harvesting system No. 3 'field hay'. Especially the variant No. 43 'without mowing conditioner and tedding 6 times' produced 394 kg DM ha^{-1} (13.7%) leaf shatter loss and differed significantly from the variant No. 13 'with mowing conditioner and tedding 3 times' with only 216 kg DM ha^{-1} (7.5%).

Table 1. Leaf shatter losses by using different mowing systems (with or without mower conditioning) and conservation systems (silage, artificial dried hay, field dried hay) on a temporary grassland (DM-yield 2870 kg ha^{-1}, 1999)

	working-intensity (WI)				harvesting-system (HS)			WI×HS[1)]							*P*-value		
field losses	1	2	3	4	1	2	3	11	12	13	41	42	43	S_e	WI	HS	WI×HS
%	5.9^a	7.1^a	6.7^a	7.7^a	2.5^c	7.3^b	10.8^a	2.3^c	7.9^b	7.5^b	2.9^c	6.4^b	13.7^a	2.1	0.084	0.000	0.004
kg DM ha^{-1}	169	204	193	221	71^c	210^b	309^a	67	225	216	84	185	394	60	0.085	0.000	0.004

Working-Intensity (WI): 1 = with mowing conditioner, less tedding, 2 = with mowing conditioner, normal tedding, 3 = without mowing conditioner, normal tedding, 4 = without mowing conditioner, high tedding intensity
Harvesting-System: 1 = silage, 2 = artificial hay drying, 3 = field-dried hay
[1)] The Interactions 21 to 33 are not included, because of less place and the focus to the tedding intensity

The results from Experiment 2, comparing two models of front mowers, are presented in Table 2. The coefficient of variation is the criterion of evaluation for the consistency of the cutting height. The front-mounted mower with classic headstock obtained a coefficient of variation of 41%. The front-mounted mower with 'active' supported frame achieved a coefficient of variation of 25%. The ash values of 81.0 and 71.3 g kg DM^{-1} indicate very good harvesting conditions, but they also show a small advantage for the mower with active frame.

Table 2. Mean mowing height, coefficient of variation and ash content in the forage with classically fixed front mower in comparison to a front mower with special soil adaption of the mower bar, permanent meadow, 1st cut at the AREC Raumberg-Gumpenstein, 2006.

Parameter	Unit	Mower with Classical frame	Mower with Active frame	Number of replications
Cutting height (mean)	cm	6.8	6.9	90
Coefficient of variation	%	41	25	90
Ash content	g/kg DM	81.0	71.3	4

In Experiment 3, the comparison of both rotor rakes was done with measurement of losses (Table 3). The rake with a single rotor caused higher losses (46.8 g DM m^{-2}) compared to the twin-rotor rake with side swath (32.5 g DM m^{-2}). The topography conditions showed a clear influence of the raking losses, as expected: 14.3 (flat land) to 64.9 g (uneven land) DM m^{-2}.

Table 3. Raking loss in g DM m^{-2} from rakes with single rotor and twin rotor rake with side swath, permanent meadow, at the 1st and 4th cut 2010, with different driving speed and site

Parameters		mean value	number = n	*P*-value
System	Rake with single rotor	46.8	36	0.0039
	Twin rotor rake with side swath	32.5	35	
Surface	flat land	14.3	48	0.0000
	uneven land	64.9	23	
Speed	8 km h^{-1}	42.5	39	0.2106
	12 km h^{-1}	36.8	32	
Cut	1st cut	45.0	23	0.0277
	4th cut	34.3	48	

R^2 = 69.2; Standarderror = 18.6 (regression analysis, Harvey, 1987)

Conclusion

Harvesting techniques have influence on forage quality. A conditioner can, depending on the harvesting procedure (silage, hay), shorten the drying process by 1-4 hours and hence can reduce the fermentation losses. Under difficult topographic conditions (uneven ground surface), a meliorated management of the mower bar can reduce the danger of contamination. With a good management of the tedding, it is possible to decrease the leaf shatter losses by 5 to 10%. A low PTO shaft speed is clearly important in reducing the leaf shatter losses when the DM-content of the forage is higher than 60%.

By swathing an impact of surface could be found, but no impact of driving speed. The limits of working width, which can be achieved by means of a rotor, are already being obtained on areas with permanent meadows. Swathers with a rotor diameter of more than 3.30 m cannot adequately adjust themselves to the ground surface in conditions with difficult topography.

References

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