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The effect of wide swathing on wilting times and nutritive value of alfalfa haylage

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ABSTRACT

On 3 consecutive cuttings, alfalfa from a single field was mowed with a John Deere 946 mower-conditioner (4-m cut width; Moline, IL) to leave narrow swaths (NS) ranging from 1.2 to 1.52 m wide (30–37% of cutter bar width) and wide swaths (WS) ranging from 2.44 to 2.74 m wide (62–67% of cutter bar width). Samples were collected from windrows and dry matter (DM) was monitored during wilting until a target of 43 to 45% DM was obtained. Forage from random windrows (n = 4–6) was harvested by hand, chopped through a forage harvester before being packed in replicated vacuum-sealed bags, and allowed to ensile for 65 d. There was no swath width × cutting interaction for any parameter tested. Over all cuttings, the resulting silage DM was not different between the NS silage (43.8%) and the WS silage (44.9%). However, wide swathing greatly reduced the time of wilting before making silage. The hours of wilting time needed to reach the targeted DM for the NS silage compared with the WS silage at cuttings 1, 2, and 3 were 50 versus 29, 54 versus 28, and 25 versus 6, respectively. At the time of ensiling, the WS silage had more water-soluble carbohydrates (5.1%) than did the NS silage (3.7%). The WS silage had a lower pH (4.58) than did the NS silage (4.66), but swath width did not affect fermentation end products (lactic acid, acetic acid, and ethanol). The NS silage had more NH_3-N (0.26%) than did the WS silage (0.21%). Wide swathing did not affect the concentration of ash or the digestibility of NDF, but it lowered the N content (NS = 3.45%; WS = 3.23%) and increased the ADF content (NS = 39.7%; WS = 40.9%) of the resulting silage. Wide swathing can markedly reduce the time that alfalfa must wilt before it can be chopped for silage, but under good conditions, as in this study, the resulting silage quality was generally not improved.
Key words: alfalfa silage, wide swath, forage

To minimize the risk of clostridial fermentation, alfalfa should be wilted to achieve a DM greater than 30% before it is ensiled. Clostridia are less likely to dominate the ensiling process in drier forages because they do not tolerate high osmotic pressures. However, during wilting in narrow windrows, a large portion of the plant material is shaded from exposure to wind and solar radiation, which slows the loss of moisture from the plant. Prolonged wilting expends water-soluble carbohydrates and increases the risk of the crop being rained on. Swath inversion (Rotz and Savoie, 1991) and chemical drying agents (Panciera and Krause, 1997) are among the methods that have been used to reduce the time that alfalfa lies in the field before being harvested. Past research has also shown that laying alfalfa in wide swaths can reduce the time of wilting before harvest (Shearer and Turner, 1989; Jahn et al., 2003). Recent interest has centered on laying mowed alfalfa into wide swaths to minimize the time plants are respiring in the field (Kilcer, 2006; Undersander, 2006). The objective of this experiment was to determine the effects of wide swathing on drying time in the field and on the subsequent nutritive value of the crop ensiled as haylage.

Alfalfa (*Medicago sativa*) was mowed, wilted, and harvested from the same field (>90% alfalfa) at 3 successive cuttings (June, July, and August, 2006) on days without rain at the University of Delaware Farm (New Castle County, DE). The alfalfa was mowed in the morning after the dew was visibly gone (between 0900 and 1100 h) with a John Deere 946 Center-Pivot Rotary Disk mower (Moline, IL) with an impeller conditioner and a 4.16-m cutter bar to achieve narrow swaths (**NS**) ranging from 1.2 to 1.52 m in width (30–37% of cutter bar width) and wide swaths (**WS**) ranging from 2.44 to 2.74 m in width (62–67% of cutter bar width). Between 4 and 6 rows (each about 100 m in length) for each swath width were mown at each cutting with a residual stubble height of approximately 5.6 cm. The narrow width was the widest between the tractor tires without driving over the windrow. Immediately after mowing, 4 to 5 samples were randomly and manually collected from the windrows. Samples from each treatment were composited and chopped, and the DM content was estimated using a microwave oven. Periodic samples were

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Table 1. Weather conditions during wilting[1]

Item	Mean temperature (°C)	Maximum temperature (°C)	Mean relative humidity (%)	Mean solar radiation (MJ/m^2 per day)	Average wind speed (km/h)
Cutting 1					
Day 1	16.11	23.17	73.0	17.6	3.22
Day 2	14.61	19.78	78.4	14.2	12.07
Day 3	13.28	20.06	84.9	12.4	5.63
Cutting 2					
Day 1	16.50	22.11	62.6	15.5	1.61
Day 2	20.33	27.17	63.9	29.2	3.70
Cutting 3					
Day 1	28.56	34.72	65.7	27.1	2.57
Day 2	28.00	35.39	70.6	26.0	3.54

[1]Data obtained from a weather station on the Newark, Delaware, farm (39°40′N, 75°45′W; elevation = 32.3 m). http://www.deos.udel.edu/agirrigation_retrieval.html; Accessed Nov. 30, 2009.

taken in the same manner until representative samples reached a target of about 43 to 45% DM. At the targeted DM, 4 (cut 1) to 6 (cuts 2 and 3) representative samples were harvested by hand and fed through a field chopper. There was no mechanical raking or merging of windrows during harvest. Approximate yields of DM in cutting 1, 2, and 3 were 3.58, 5.82, and 2.26 t/ha. Chopped forages (about 400 g) were packed in 3.5-mil nylon–polyethylene standard barrier micro-layered pouches (15.2 × 30.5 cm; Doug Care Equipment Inc., Springville, CA) and vacuum-sealed with a Best Vac vacuum machine (distributed by Doug Care Equipment Inc.). The samples were stored between 23 and 25°C and ensiled for 65 d.

The DM content of forages and silages was determined by drying duplicate samples in a 60°C forced-air oven for 48 h. Dried samples of fresh forage and silages were ground with a UDY Cyclone Sample Mill (UDY Corporation, Fort Collins, CO) through a 1-mm screen. Samples were analyzed for ADF and NDF using sulfite and heat-stable amylase (Robertson and Van Soest, 1981) with an Ankom[200] Fiber Analyzer (Ankom Technology, Fairport, NY). Total N was determined by combustion of the sample (Leco CNS 2000 Analyzer, St. Joseph, MI).

A water extract was collected by filtering the homogenized silage mixture through Whatman 54 filter paper (Florham Park, NJ). A portion of the filtered water extract (10 mL) was acidified with 50 μL of 50% (wt/vol) H_2SO_4 to reduce the pH of the extract to <2.0 before freezing (−20°C). Water extracts were analyzed for lactic acid, VFA, and ethanol by HPLC (Dairyland Laboratories, Arcadia, WI) as described by Muck and Dickerson (1998). Water extracts were also analyzed for water-soluble carbohydrates (**WSC**; Nelson, 1944) and ammonia-N (Weatherburn, 1967). The digestibility of NDF was determined on samples after 65 d of ensiling using the in vitro procedure described by Goering and Van Soest (1970) with some modifications. Those modifications included 1) incubation of samples in 100-mL polypropylene tubes, each sealed with a rubber stopper fitted with a glass tube and a rubber policeman (14–105A, Fisher Scientific, Pittsburg, PA) with a 5-mm slit to allow for venting of gas pressure; 2) gentle manual swirling of the tubes at 3, 6, 9, 20, and 26 h; and 3) incubation for 30 h.

The data were analyzed using the GLM procedure of SAS (version 9.1, SAS Institute, Cary, NC) according to a randomized complete block design with main effects of swath width, cutting number, and swath width × cutting number. Significance was declared at $P <$ 0.05 unless stated otherwise. Means were tested using Tukey's test.

There were differences among cuttings for some variables, but they are not shown or discussed because they were not the primary interest of this study. Only main effects between swath width are shown and discussed because there were no interactions between treatment and cutting for any variable.

Dry matters determined by microwave drying from wilting samples are shown in Table 1. A DM content of about 35% was obtained for NS alfalfa at about 29, 28, and 12 h and for WS alfalfa at about 26, 25, and 4 h for cuttings 1, 2, and 3, respectively. The savings in time between the NS and WS alfalfas would have been relatively small for first and second cuttings. Our target DM was 43 to 45%, which was achieved in about 21, 12, and 19 h less time for the WS alfalfa than for the NS alfalfa for cuttings 1, 2, and 3, respectively. Shearer et al. (1992) reported that alfalfa dried down significantly faster in a 2-m swath compared with a 1-m windrow. In the current study, the extremely short wilt time of 6 h for wide-swathed alfalfa during the third cutting suggests that caution should be taken when wide-swathing under hot conditions so as to not mow too much ahead of the capacity of the chopping operation.

The WSC content of the fresh crop at ensiling and the nutritive contents of the resulting ensiled alfalfas

Table 2. The DM content (%) of samples from narrow swaths (NS) and wide swaths (WS) of alfalfa[1] in the field determined by microwave drying

	Cutting 1		Cutting 2		Cutting 3	
Hours of wilting	NS	WS	NS	WS	NS	WS
0	16.9	16.9	20.5	20.5	22.0	22.0
3	20.1	22.2			29.7	33.9
6	23.4	26.5			32.9	46.4[2]
10					40.0	
23			26.4	32.4		
24	27.3	33.1				
25					43.8[2]	
26	30.0	37.1	30.5	36.5		
27						
28			35.4	45.6[2]		
29	35.9	43.9[2]				
33			38.8			
40			44.0[2]			
50	44.0[2]					

[1]Alfalfa from a single field was mowed with a John Deere 946 mower-conditioner (4-m cut width; Moline, IL) to leave narrow swaths (NS) ranging from 1.2 to 1.52 m wide (30–37% of cutter bar width) and wide swaths (WS) ranging from 2.44 to 2.74 m wide (62–67% of cutter bar width).

[2]Alfalfa was chopped and ensiled at these time points.

are shown in Table 3. The WSC content was greater for WS alfalfa than for NS alfalfa at the time of ensiling. This finding is as expected because WS alfalfa spent less time in the field wilting and thus less time respiring. The DM content of NS and WS silages were similar and within the target range of 43 to 45% DM. Total N concentration was lower but residual WSC was higher for WS alfalfa compared with NS alfalfa. The WS alfalfa had a higher concentration of ADF and a tendency for a higher concentration of NDF ($P < 0.09$) than NS alfalfa. During mowing, wheels of the tractor attached to the mower–conditioner ran over the wide but not the narrow windrows. During this time we observed leaves stuck to the wheels of the tractor. It is our belief that the lower N and higher NDF in WS silage was a result of damage to leaves from wheel traffic during mowing. The digestibility of NDF was not affected by swath width in our study. In contrast, Cherney and Cherney (2006) reported that wide-swathed forages were higher in NDF digestibility than forages drying in narrow swaths, although a probable cause for this finding was not apparent. The ash content between treatments in our study was not different. Lack of substantial effects from swath width on the nutritive value of alfalfa in our study is similar to the findings reported by Shearer et al. (1992). Undersander et al. (2008) conducted 14 trials over 3 yr comparing narrow swaths with wide swaths.

Table 3. The water-soluble carbohydrate (WSC) content (% DM) of fresh alfalfa just before ensiling and the DM (%), chemical content (% DM basis), and digestibility of NDF (% DM basis) of alfalfa silage from narrow or wide swaths[1] after 65 d of ensiling[2]

Item	Narrow swath	Wide swath	SEM
Alfalfa just before ensiling			
WSC (%)	3.7[b]	5.1[a]	0.3
Alfalfa after 65 d of ensiling			
DM (%)	43.8	44.9	0.9
Total N (%)	3.45[a]	3.23[b]	0.03
WSC (%)	1.29[b]	1.47[a]	0.07
ADF (%)	39.7[b]	40.9[a]	0.3
NDF (%)	48.3[x]	49.5[y]	0.5
Ash (%)	8.60	8.59	0.14
NDF digestability (% 30 h)	49.2	49.6	0.6

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[x,y]Means within a row with different superscripts differ ($P < 0.09$).

[1]Alfalfa from a single field was mowed with a John Deere 946 mower-conditioner (4-m cut width; Moline, IL) to leave narrow swaths ranging from 1.2 to 1.52 m wide (30–37% of cutter bar width) and wide swaths ranging from 2.44 to 2.74 m wide (62–67% of cutter bar width).

[2]Data shown are main effects of swath width averaged over 3 cuttings.

Table 4. The pH and end products of silage fermentation (% DM) in alfalfa silage from narrow or wide swaths[1] after 65 d of ensiling[2]

Item	Narrow swath	Wide swath	SEM
pH	4.66[a]	4.58[b]	0.03
Lactic acid (%)	4.18	4.28	0.22
Acetic acid (%)	1.51	1.41	0.11
Butyric acid (%)	0.05	0.02	0.01
Ethanol (%)	0.13	0.16	0.11
NH_3-N (%)	0.26[a]	0.21[b]	0.01

[a,b]Means within a row with different superscripts differ ($P < 0.05$).

[1]Alfalfa from a single field was mowed with a John Deere 946 mower-conditioner (4-m cut width; Moline, IL) to leave narrow swaths ranging from 1.2 to 1.52 m wide (30–37% of cutter bar width) and wide swaths ranging from 2.44 to 2.74 m wide (62–67% of cutter bar width).

[2]Data shown are main effects of swath width averaged over 3 cuttings.

Although they reported that wide-swathed alfalfa had less NDF and more NFC than narrow-swathed alfalfa, these differences were very small.

The end products of silage fermentation shown in Table 4 were indicative of a good fermentation in both treatments. Wide swathing resulted in silages with a lower pH, but the difference was small. Treatment had no effect on any of the fermentation acids or ethanol, but the concentration of NH_3-N was lower in the WS silage. This last finding may be a result of a faster and lower decrease in pH for the WS alfalfa, resulting in less proteolysis.

Wide swathing reduced the time alfalfa wilted in the field before an appropriate moisture content was obtained for making silage. The time saved was short if 35% DM was the target, whereas the WS alfalfa was harvested substantially earlier than the NS alfalfa if the target DM was between 43 and 45%. For the latter DM, the WS alfalfa had higher concentrations of WSC than did the NS alfalfa at ensiling, but this had minimal effects on silage fermentation, suggesting that enough WSC remained in the NS alfalfa for a good fermentation. Wide swathing resulted in lower N, higher ADF, and a tendency for higher NDF than did narrow swathing, which was a consistent finding at each cutting. At this time, we have no explanation for this finding. Many variables and interactions require addressing in future research on wide swathing, primarily because of the wide range of equipment and practices that are implemented in the field. Under the conditions of this study, wide swathing reduced drying times in the field, which improved the potential for avoiding inclement weather during the wilting of crops. However, wide swathing did not substantially improve the nutritive value of alfalfa silage under the relatively good drying conditions experienced in this study.

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