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Determining the Cutting Time for Maximum Yield and Quality of Alfalfa Swards

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Alfalfa 單播草地의 最高生産과 質的向上을 為한 刈取適期의 決定

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Summary

The cutting schedule for the maximum yield of DM and quality was applied to alfalfa swards. Harvesting at the cutting time for the maximum total yield tc (Chang 1971) was selected as the criterion which provided the highest DM yield in accordance with high consistent levels of CP and IVD as well as persistance of the species in the pure stands. On the same theoretical basis, ceiling LAI and 25% bloom stages proved most satisfactory for harvesting pure stands of alfalfa.

I. Introduction

Cutting schedules based on theoretical analysis by the Chang's total yield equation are important in attaining the highest total yield of DM (Chang 1971).

Generally, this species is grown during the growing season and could be harvested according to visibly morphological development of alfalfa swards.

The number of cuts influences yield (Baumgardt and Smith 1962, Meyer and Jones 1962) and cutting during the autumn rest period markedly reduces persistance of *Medicago sativa* L. (Kurst and Smith 1961. Twamey 1960).

The quality of the DM product decreases with advancing maturity (Brown et al. 1968. Mowat et al. 1965) but some quality must be sacrificed in order to obtain satisfactory yields (Fulkerson et al. 1967) Fulkerson et al. (1967) suggest harvesting alfalfa at the very first flower. Baumgardt and Smith (1962) reported that harvesting alfalfa at 10% bloom stage have resulted in high yields of high quality alfalfa. The purpose of this study was to determine the influence of harvest schedules based on the theoretical analysis and morphological development of alfalfa on DM yield, LAI, in vitro DM digestibility (IVD) and content of crude protein (CP). The measurements were made on pure

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stands of alfalfa.

II. Experimental Methods

1. Theoretical analysis

In the case of the forage crops, the total yield in the several harvests during the growing season must be increased extremely by the method of the selection of the cutting schedule. This basic concept is obtained from the Chang's total yield equation (Chang 1971, Chang and Yoshida 1973). If the harvest time of the forage crops is t, the total yield equation is given by

$$Yt = \frac{T}{t}\int_o^t g'(t)\,dt \quad \ldots\ldots \quad (1)$$

where Yt, T and $g(t)$ are total yield the period of the growing season, and growth rate equation, respectively. If the growth rate equation is treated statistically to fit for $y = -at^2 + bt + c$, the maximum harvest time is calculated the following procedures.

$$Yt = \frac{T}{t}\int_o^t (-at^2 + bt + c)\,at$$

$$= T\left(-\frac{1}{3}at^2 + \tfrac{1}{2}bt + c\right) \quad \ldots\ldots \quad (2)$$

and then

$$\frac{dYt}{dt} = T\left(-\frac{2}{3}at + \tfrac{1}{2}b\right) \quad \ldots\ldots \quad (3)$$

When dYt/dt is zero, the cutting time for the maximum total yield, tc, is

$$tc = \frac{3b}{4a} \quad \ldots\ldots \quad (4)$$

Since the time in the case of the maximum value of the equation

$y = -at^2 + bt + c$ *is* $b/2a$, the tc is

$$tc = \frac{3}{2}tm \quad \ldots\ldots \quad (5)$$

The cutting time for the maximum yields some important chemical compositions, such as crude protein, in forage crops can be selected by the equation (5), too.

2. Experiments

A field experiment was shown on April, 1978, at Kon-Kuk University and was carried out from, April, 1979 to 21, October.

Alfalfa used was *Medicago sativa* L.

A split-plot arrangement of treatments in a randomized complete block design with 3 replications was selected. The plots were composed of pure sowings of alfalfa.

Measuring lm x lm quadrat was used for the 18 harvest schedules. Ten harvest schedules were based on the cutting time intervals from, week to 10 weeks and over. Eight schedules were based on the morphological development of alfalfa under heads emerged (H.E.) medium bud (M.B.), 10%, 25,%, 50%, 75%, 100% bloom, and seed formation (S.E.) stages.

Leaf area index (LAI), percentage of the bloom, tillers dry matter yield of roots and root lengths were determined.

Dry matter (DM) yields were estimated from the weight of a lm x lm quadrat cut through each plot. Random samples were removed from each quadrat, dried in a forced-draft oven at 80°C and used to correct for moisture and for crude protein (CP) and in vitro DM digestibility (IVD) analyses. After drying, the samples were ground through a 0.8mm screen in a mill and analysed for CP and IVD, using the procedures described by Mowat et al. (1965) and Winch et al. (1970).

Table 1. The percentage of bloom stages in alfalfa swards according to the cutting schedules.

Cutting date \ Cutting intervals (week)		1	2	3	4	5	6	7	8	9
9	April	0								
16		0	0							
23		0		0						
30		0	0		0					
7	May	0				0				
14		0	0	0			0			
20		0						0		
27		0	0		0				24.8	
3	June	0		0						30.1
10		0	0			5.4				
17		0								
24		0	0	0	0		42.2			
1	July	0								
8		0	0					50.6		
15		0		0		15.7				
22		0	0		0				51.1	
29		0								
5	August	0	0	0			54.8			88.5
12		0								
20		0	0		0	17.3				
26		0		0				46.3		
2	September	0	0							
9		0								
16		0	0	0	0		0		34.6	
23		0				0				
30		0	0							
7	October	0		0						25.9
14		0	0		0			2.7		
21		0	0	0	0					
Total		0	0	0	0	38.4	97.0	99.6	110.5	144.5
A.V.		0	0	0	0	7.7	24.3	24.9	36.8	48.2

III. Results and Discussion

1. DM yield

When pure stands of alfalfa were harvested according to the cutting time intervals from 1 week to 14 weeks, DM yield during the growing season are shown in Fig. 1. As the DM yield goes up to the cutting time of 6 week intervals, DM total yield increases steadily and shows a maximum value at 6 week interval harvesting but as the cutting time interval rises up to 14 weeks, then DM total yield decreases gradually. This result suggests that Chang's total yield equation (1971) was validated by the experiment of alfalfa swards. Application of cutting schedule of 6 week interval for the maximum total yield of alfalfa swards results in equivalent yield of $tc = 3/2\ tm$. As shown in Table 1, the highest seasonal yield from alfalfa occurred under average 24.3% bloom of the alfalfa schedule. This result is in accordance with the 25% bloom of the experiment of Winch et al. (1970). With pure sowings of alfalfa the highest yield, 2571.2 g/m^2, were obtained where the harvests occurred at the 24.3% bloom stage. DM yields at other bloom stages were all lower than at 24.3% bloom stage.

Changes of LAI of alfalfa during the growing season had the same tenderly to DM yields.

As shown in Fig. 1 ceiling LAI occurred under the 6 week interval schedule.

This harvest schedule should be considered from the same stand point of the ceiling LAI stage of orchardgrass sward (Midamura 1972, Chang et al. 1983).

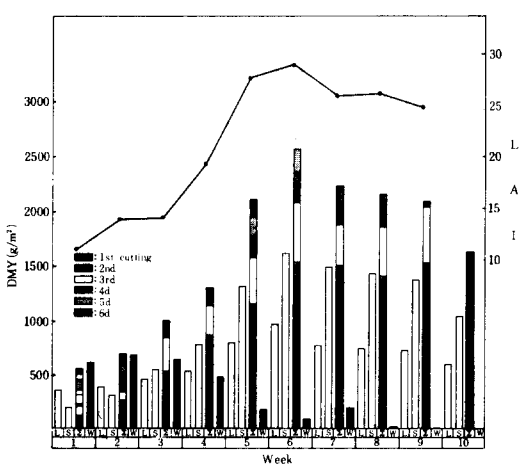

Fig. 1. Seasonal yield of DM (g/m^2) and LAI from alfalfa swards under 10 week interval cutting schedules: 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10 weeks and over.
L: Leaf, S: Stem, Σ: above ground parts, W: weeds

2. Relationships among DM yield, productivity and cutting time

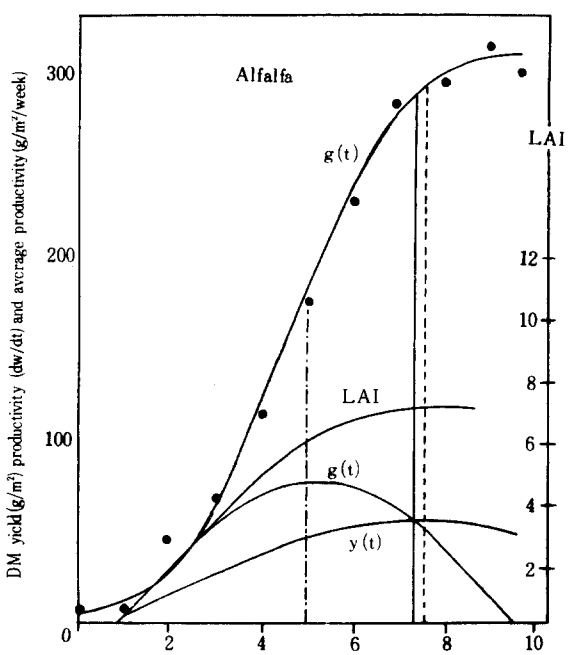

Fig. 2. Relationships among DM yields, *g(t)*, productivity, g'(t), total yield, *Yt(t)*, LAI, *tm* and *tc* of alfalfa swards.

Relationships among DM yield, productivity and cutting time for the maximum yield are presented in Fig. 2. The weighted growth and LAI curves showed sigmoid patterns, respectively. The growth rate and total yield equation curves had a maximum value respectively.

The graphical *tm* and *tc* resulted in the theoretical analysis of the Chang's total yield equation on the weighted growth curve. This result indicates that the cutting time for the maximum yield is in accordance with the ceiling LAI stage, 24.3% bloom stage and the 6-week interval cutting.

3. Persistance

The DM yields and lengths of alfalfa roots were affected by the harvest schedules (Table 2). The alfalfa roots died according to 1, 2, and 3 week-interval cutting. The root DM yields were increased form 4 week interval cutting time to 6 week-interval and were steadily from 7 week interval to 9 week interval cuttings. As shown in Table 3, the average number of the branch per an alfalfa increased from the 1 week interval cutting to the 8-week interval and then was steadily.

Table 2. DM yields and lengths of alfalfa according to the cutting time schedules.

Cutting interval (week)	1	2	3	4	5	6	7	8	9
Root length (cm)	–	–	–	33.4	37.7	44.3	43.1	44.2	45
DM yield (g/plant)	–	–	–	0.60	2.21	3.00	3.22	2.49	2.36

In the case of the 6 week schedule, an alfalfa shooted out average 13.2 branchs.

4. Quality

The date of the first cutting strongly influenced the IVD of alfalfa (Fig. 3); the later the date of the first cutting, the lower the digestibility of the material.

In this study the high values of IVD, 60-65%, mere obtained from the first harvest of alfalfa when the heads-emerged schedule was employed.

Taking the first cutting of the alfalfa on the basis of the maximum total yield state, *tc*, for DM as compared to the *tc* for CP, reduced the digestibility by 5% IVD units in alfalfa.

In general, the 2nd and 3rd harvests of all

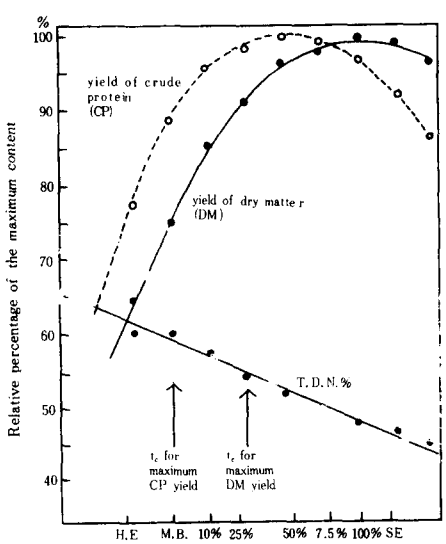

Fig. 3. Cutting time for the maximum yield of CP and DM yield of alfalfa swards under H.E., M.B., 10%, 25%, 50%, 75%, 100% bloom and S.E. stages.

grass-based schedules tended to have an IVD below that of the first harvest in all species. On the other hand, when the schedule was based on the morphological development of alfalfa, the 2nd and 3rd had a higher IVD value than the first harvest (Winch et al. 1970).

The morphological *tc* for DM and for CP were medium bud and 25% bloom stages respec-

Table 3. The number of tillers in alfalfa swards (the number per plant).

Date \ Cutting intervals (week)		1	2	3	4	5	6	7	8	9
9	April	2								
16		2	3							
23		2		6						
30		2	4		7					
7	May	2				8				
14		2	3	7			11			
20		2						13		
27		2	5		7.5				16.5	
3	June	2		6.5						18.5
10		2.5	4			10.5				
17		2.5								
24		2	4	6.5	9.5		14			
1	July	2.5								
8		2	4					22		
15		2		6.5		14.5				
22			3		9.5				24	
29										
5	August		3				18			26
12										
20			3		9.5	13.5				
26								19		
2	September									
9										
16					5		13		20	
23						9				
30										
7	October									18
14					4.5			12		
21						7	10			
Total		31.5	36.0	32.5	52.5	62.5	66.0	66.0	60.5	62.5
A.V.		2.1	3.6	6.5	7.5	10.4	13.2	16.5	20.2	20.8

tively. The application of the 25% bloom criteria to alfalfa swards produced the highest DM yield.

There was considerable similarity in the DM yield among *tc* for DM, 25% bloom stage and Ceiling LAI stage.

The fore, since a notable feature of CP content and of IVD value was the very narrow ranges, ofter less than 3% and 5% the *tc* for DM of alfalfa swards was determined as the harvesting schedule.

The 25% bloom schedules resulted in the highest DM yield.

Ⅳ. 摘　　要

alfalfa 單播草地에 있어서 最大總乾物 生産과 質的 向上을 위한 刈取適期가 硏究되었다.

最大總生産收量을 위한 刈取期 *tc* (張, 1971)가 alfalfa 草種의 永続性과 동시에 CP 및 IVD의 높은 水準을 수반하는 最大乾物生産 收量의 適期로 選択되었다. 이와 同一한 理論的 근거에 입각하여 極大 LAI 및 25% 開花期가 alfalfa 單播草地에서가장 適合한 形態学的 刈取期임이 判明되었다.

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