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Response of Alfalfa Cultivars to Frequent Cutting on Forage Yield and Plant Persistence

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Synopsis

One grazing-type cultivar, Alfagraze, and two hay-type cultivars, Maya and 5444, were measured for the influence of frequent cutting on forage yields and plant persistence. The cutting treatment was carried out 6 times per year, when plant heights reached about 30 cm.

The results demonstrated that Alfagraze was superior to the other two hay-type cultivars in forage yields and plant persistence under frequent cutting. However, its forage yield was about 1/3 of that under the usual 3 cuttings per year. The higher plant persistence of Alfagraze was related to the higher TNC reserves of roots and higher stubble weights on crowns after defoliation.

Key words : Frequent cutting, Grazing-type cultivar, *Medicago sativa* L., Stubble weight, Persistence.

Introduction

Alfalfa (*Medicago sativa* L.) is a high quality forage for livestock [11, 22], and thus it has attracted interest of dairy farmers in Hokkaido. Nevertheless, today the acreage under alfalfa cultivation in this area is only 2 % of the total of improved grasslands. The limiting factors for the cultivation are mainly difficulties in establishing seedlings and persisting swards, due to the humid weather conditions during the growing season, severe cold in winter, acidic soil and scarcity of indigenous root nodule bacteria (*Rhizobium meliloti*) [9, 10]. However, owing to the development and introduction of adaptive cultivars and improvements in cultivation management for plant growth, present circumstances for the cultivation of alfalfa are favorable [18]. Additionally, due to a rise in the price of concentrates and a fall in the price of milk, self-sufficient in high quality forages has become very important for farmers' business.

Today, in Hokkaido, alfalfa is used for hay and silage with three cuttings per year, using hay-type cultivars. The optimum period for the 1st cutting, at the 1/10 bloom stage, is often delayed by heavy rain. Accordingly, forages with leaf loss and relatively low nutrients have to be harvested late in the optimum period [6, 15]. This problem is attributed to few variations in the flowering time among hay-type cultivars. If alfalfa cultivars tolerant to frequent cutting [4, 5, 12, 20] and grazing by dairy and beef cattle [3, 5, 16~18], are proven to suit in this area, the opportunity for alfalfa cultivation will increase largely.

This study was carried out to measure the influence of frequent cutting on forage yields and plant persistence of the grazing- and hay-type alfalfa cultivars.

Materials and Methods

One grazing-type cultivar, Alfagraze [2] which was developed by the Georgia Agricultural Experimental Station, USA, and two hay-type cultivars, Maya and 5444 which were recommended for cultivation in Hokkaido, were used in this study. These seeds were inoculated with root nodule bacteria by the vacuum processing method [9], and sown at a rate of 1.5 kg/10 a using the drill method in May, 1992, in a experimental field in Obihiro, Hokkaido. Magnesium ammonium phosphate (60 kg/10 a) was applied to the experimental field, and the soil acidity was adjusted to pH 6.5. Fertilizers (4 kg N, 10 kg P_2O_5, 6 kg K_2O and 2 kg MgO /10 a) were applied prior to sowing.

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The plot design was a randomized block with three replications. Each plot was consisted of 8 rows, 3 m in length, spaced 0.3 m apart.

Three cuttings per year were employed from 1992 to 1995, using the usual cutting schedule for hay production in this area. In 1996, six cuttings per year were conducted ; on 31 May (1st), 21 June (2nd), 19 July (3rd), 6 Aug. (4th), 2 Sept. (5th) and 9 Oct. (6th), when the plants reached about 30 cm in height. At each cutting, all plants in each plot were clipped to a 5 cm stubble height. The dry matter yields at every cutting, plant numbers (/ m²) at the 1st and 6th cuttings, root weights (/plant) and total nonstructual carbohydrate (TNC) concentrations at the 1st, 3rd, 5th and 6th cuttings, regrowth bud numbers (/plant) at the 1st, 3rd and 5th cuttings, and stubble weights (/10 plants) at the 6th cuttings were measured.

The roots were dug up to a depth of 15 cm below ground level, and dried at 70 ℃ for 48 h. They were used to measure root weight, and then separated into tap roots and crowns. The tap roots were ground and used for TNC determination by the Somogyi method. The regrowth bud numbers were counted for all buds with a length over 0.5 cm on the crown after cutting. The stubble weight was measured by clipping residual leaves and stems on the crown after cutting at 5 cm above ground level.

Results

1. Dry matter yield

With regard to the total dry matter yields for 4 years under the usual 3 cuttings per year from 1992 to 1995, Alfagraze was 2 % less than Maya (not significant) and 8 % less than 5444 (significant at 5 % level) (Table 1). However, when cutting frequently in 1996, Alfagraze tended to produce a higher yield than the other two hay-type cultivars at every cutting. Alfagraze produced significantly higher yields than the other two cultivars after the 4th cutting. The total yield of Alfagraze under frequent cutting was, at least, 20 % significantly higher than the others (Table 2).

2. TNC concentration and regrowth bud number

The TNC concentrations in the tap roots of all three cultivars decreased gradually with the increase in cutting, but they increased at the 6th cutting in the late fall. The TNC concentration at the 5th cutting for Alfagraze (28.0 %) was significantly higher than those of Maya (21.4 %) and 5444 (23.5 %), while there was no significant difference among cultivars at the 1st, 3rd and 6th cuttings (Fig. 1).

With regard to the regrowth bud numbers, Alfagraze at the 1st cutting was smaller than the other two hay-type cultivars. They decreased in all cultivars with the increase in cutting. At the 5th cutting, the regrowth bud number of Alfagraze was

Table 1. Yearly dry matter yields of three alfalfa cultivars from 1992 to 1995, under the 3 times of harvest per year.

Cultivar	1992	1993	1994	1995	Total	(%)
	kg/10 a					
Alfagraze	425 ^{c}	1,082 ^{b}	1,306 ^{b}	1,140 ^{a}	3,953 ^{b}	(92)
Maya	492 ^{b}	1,123 ^{ab}	1,288 ^{b}	1,156 ^{a}	4,059 ^{b}	(94)
5444	521 ^{a}	1,260 ^{a}	1,384 ^{a}	1,146 ^{a}	4,311 ^{a}	(100)

^{a}, ^{b}, ^{c} Figures within a column followed by the same letters are not significantly different ($p<0.05$).

Table 2. Dry matter yields of three alfalfa cultivars, under the 6 times of harvest per year, in 1996.

Cultivar	1 st	2 nd	3 rd	4 th	5 th	6 th	Total	(%)
	kg/10 a							
Alfagraze	157.0 ^{a}	121.2 ^{a}	51.9 ^{a}	27.7 ^{a}	41.9 ^{a}	21.1 ^{a}	420.8 ^{a}	(128)
Maya	151.7 ^{a}	121.3 ^{a}	34.6 ^{a}	17.9 ^{b}	18.3 ^{b}	10.9 ^{b}	354.7 ^{b}	(108)
5444	139.0 ^{a}	121.4 ^{a}	27.6 ^{a}	16.3 ^{b}	15.4 ^{b}	9.5 ^{b}	329.2 ^{b}	(100)

^{a}, ^{b}, ^{c} are the same as in Table 1 .

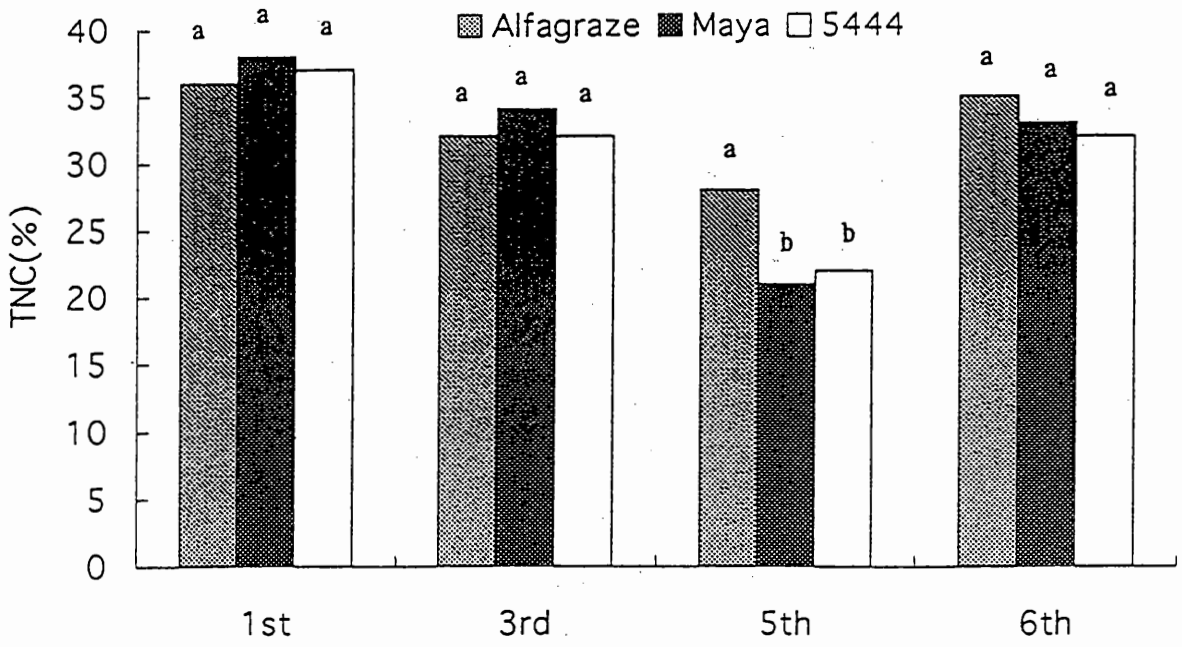

Fig. 1. Total nonstructual carbohydrate (TNC) concentrations in tap roots of alfalfa cultivars at the 1st, 3rd, 5th and 6th cuttings, under frequent cutting in 1996.

[a], [b]) Values with different superscripts are significantly different ($P<0.05$).

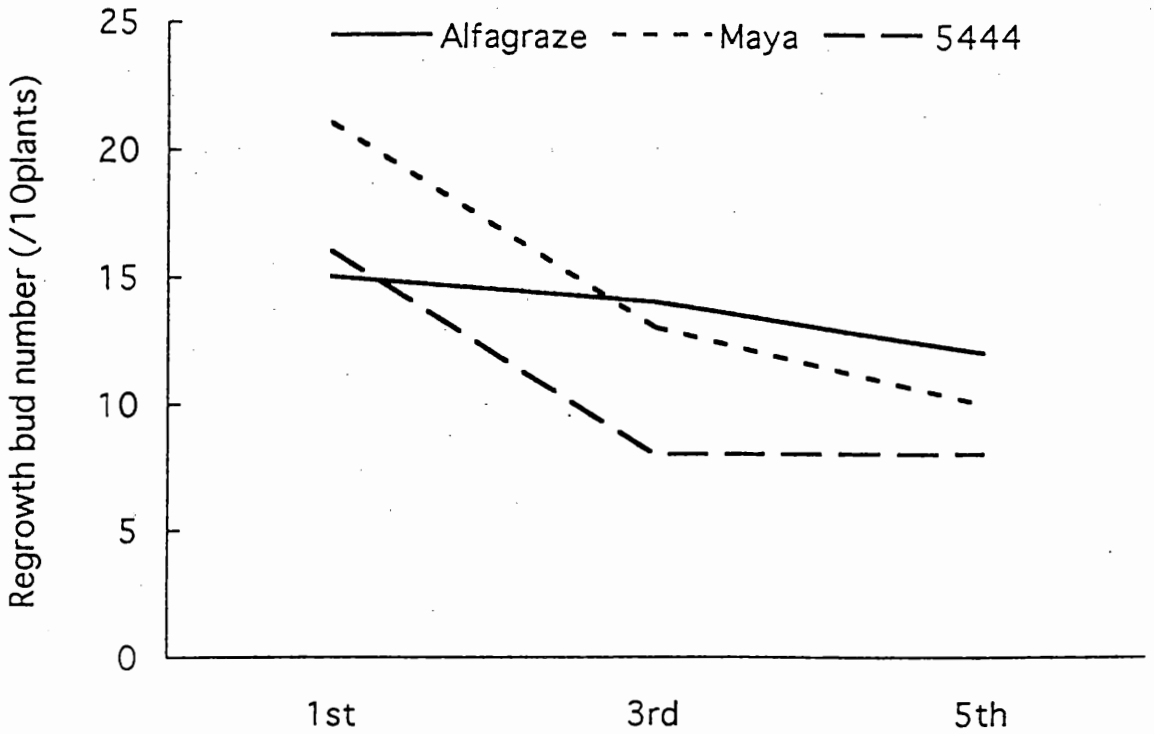

Fig. 2. Regrowth bud numbers of alfalfa cultivars at the 1st, 3rd and 5th cuttings, in 1996.

the largest among the three cultivars. The ratios of bud numbers at the 5th cutting to those of the 1st cutting were 95 % for Alfagraze, 47 % for Maya and 52% for 5444 (Fig. 2).

3. Plant number, root weight and stubble weight

The plant numbers at the 1st cutting were not different among the three cultivars. All of them decreased at the 6th cutting, and plant numbers of Alfagraze were over 3 times those of the other two

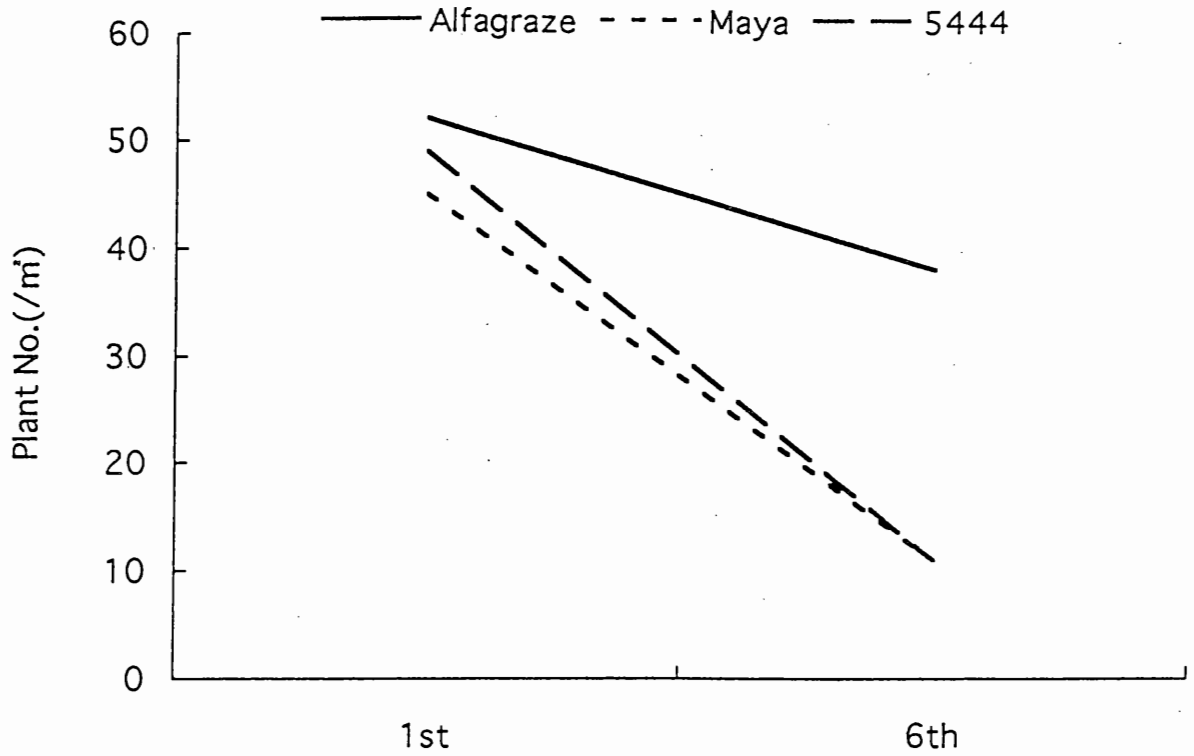

Fig. 3. Changes in plant numbers of alfalfa cultivars from the 1st to 6th cuttings, under frequent cutting.

Table 3. Root and stubble weights of alfalfa cultivars at 6th harvest, in 1996.

Cultivar	Root weight (g/plant)	Stubble weight (g/10 plants)
Alfagraze	3.3 [a]	5.5 [a]
Maya	3.4 [a]	2.8 [b]
5444	2.5 [b]	2.5 [b]

[a], [b] are the same to Table 1.

cultivars. Accordingly, the ratio of plant number for Alfagraze at the 6th cutting to the 1st cutting was 71.3 %, while those of Maya and 5444 were 25.6 % and 23.8 % (Fig. 3).

The root weights at the 6th cutting were significantly higher for both Alfagraze and Maya compared to 5444 (Table 3). With regard to the stubble weight at the 6th cutting, Alfagraze was 2 times higher than those of the other two hay-type cultivars, 5.5 g for Alfagraze, 2.8 g for Maya and 2.5 g (/10 plants) for 5444 (Table 3).

Discussion

This research was conducted under frequent cuttings in order to simulate grazing tolerance [3, 5]. The results demonstrate that Alfagraze, a grazing-type cultivar, was superior to hay-type cultivars in forage production and plant persistence for 6 cuttings per year (Table 2, Fig. 3). However, as indicated by the other studies [4, 5, 12, 20], the yearly total forage yields of both grazing- and hay-type cultivars under frequent cutting was about 1/3 those under the usual 3 cuttings per year for hay production (Table 1, 2).

It is considered that higher plant persistence of Alfagraze under frequent cutting is related to higher TNC reserves of the roots and higher residual stubble weights on the crowns after cutting (Fig. 1, 3 and Table 3). Much of the research indicates that the lack of persistence for alfalfa was attributed to depletion of TNC from the roots [3~5, 12, 15, 19]. On the other hand, GABLRIELSEN *et al.* [7] observed that alfalfa and cicer milkvetch (*Astragalus cicer* L.), plants with more residual leaf after harvesting, can regrow utilizing current photosynthate rather than depending upon the TNC reserves of their roots. Moreover, HODGKINSON *et al.* [8] investigated the net carbon dioxide exchange rate of alfalfa stubble leaves, using a CO_2 conductimetric analyzer, and postulated that stubble leaves are a partial or complete substitute supply of carbohydrates for the stubble shoots. BRUMMER and

BOUTON [3] compared grazing- and hay-type cultivars under frequent cutting focussing on morphological and physiological traits, and found that grazing-type cultivars had superior persistence. They also pointed out that the stubble leaves after defoliation were probably important in the maintenance of TNC.

Presently, alfalfa cultivars used in Hokkaido are only hay-type with few variations in the flowering time. Accordingly, the optimum cutting time is centered around a very short period, and causes problems in cultivation management because of the concentration of works during the harvest period. There is also the possibility of poor forage quality due to rainy weather at the optimum harvest time. WOLF and BLASER [21], and ALLEN *et al.* [1] have proposed a flexible management system of alfalfa swards using grazing-type or tolerant cultivars for frequent harvesting, in order to provide high quality forage in early spring or emergency feed when other pasture land is in short supply. Introduction of grazing-type cultivars into Hokkaido will be useful in terms of (1) the proper utilization for grazing, (2) a flexible supply for feed shortages, (3) a diversification of cutting period and harvesting works.

Previously, alfalfa cultivars with tolerance to frequent cutting or grazing had relatively low yielding ability [13, 14, 20]. However, Alfagraze is a dual purpose cultivar for hay production and grazing by livestock, with both high yielding ability and tolerance to intensive utilizations [2]. Nevertheless, we observed in this research that Alfagraze is a little susceptible to one foliar disease, Lept-leaf spot caused by *Leptosphaerulina briosiana*, which is specific to regions with the cool and humid weather in the summer [18]. Further research on selecting other grazing-type cultivarswith resistance to the foliar disease will be necessory.

References

1) ALLEN, V. G., L. A. HAMILTON, D. D. WOLF, J. P. FONTENOT, T. H. TERRILL and D. R. NOTTER (1986) Yield and regrowth characteristics of alfalfa grazed with sheep. II. Summer grazing. *Agron. J.* **78**, 979-985.

2) BOUTON, J. H., S. R. SMITH, JR., D. T. WOOD, C. S. HOVEL and E. C. BRUMMER (1991) Resistration of 'Alfagraze' alfalfa. *Crop Sci.* **31**, 479.

3) BRUMMER, E. C. and J. H. BOUTON (1992) Physiological traits associated with grazing-tolerant alfalfa. *Agron. J.* **84**, 138-143.

4) CHATTERTON, N. J., S. AKAO, G. E. CALSON and W. E. HUNGERFOLD (1997) Physiological components of yield and tolerance to frequent harvests in alfalfa. *Crop Sci.* **17**, 918-923.

5) COUNCE, P. A., J. H. BOUTON and R. H. BROWN (1984) Screening and characterizing alfalfa for persistence under mowing and continous grazing. *Crop Sci.* **24**, 282-285.

6) FUESS, F. W. and M. B. TESAR (1968) Photosynthetic efficiency, yields and leaf loss in alfalfa. *Crop Sci.* **8**, 159-163.

7) GABRIELSEN, B. C., D. H. SMITH and C. E. TOWNSEND (1985) Cier milkvech and alfalfa as influenced by two cutting schedules. *Agron. J.* **77**, 416-422.

8) HODGKINSON, K. C., N. G. SMITH and G. E. MILES (1972) The photosynthetic capacity of stubbles and their contribution to growth of the lucerne plant after high level cutting. *Aust. J. Agric. Res.* **23**, 225-238.

9) HORIKAWA, Y., H. OHTSUKA (1996) Effects of coating and adhesive on the inoculation of *Rhizobium meliloti* to alfalfa (*Medicago sativa* L.) seeds for nodulation and seedling growth. *Grassland Sci.* **41**, 275-279.

10) HORIKAWA, Y., K. IWABUCHI and H. OHTSUKA (1996) Establishment and yield of alfalfa (*Medicago sativa* L.) sward using lime-coated seeds. *Grassland Sci.* **42**, 211-215.

11) JUNG, G. A., L. L. WILSON, P. J. LEVAN, R. E. KOCHER and R. F. TODD (1982) Herbage and beef production from ryegrass-alfalfa and orchardgrass-alfalfa pasture. *Agron. J.* **74**, 937-942.

12) REYNOLDS, J. H. (1971) Carbohydrate trends in alfalfa (*Medicago sativa* L.) roots under several forage harvest schedules. *Crop Sci.* **11**, 103-106.

13) RUMBAUGH, M. D., J. D. COLBURN and G. SEMENIUK (1964) Registration of Travois alfalfa. *Crop Sci.* **4**, 117.

14) SHONHORST, M. H., A. K. DOBRENZ, R. K. THOMPSON and M. A. MASSENGALE (1981)

Registration of Az-ron alfalfa germplasm. *Crop Sci.* **21**, 831.

15) SMITH, D. (1972) Cutting schedules and maintaining pure stands. *In* Alfalfa Science and Technology (*Ed.* HANSON, C. H.) *Agronomy* **15**, pp. 481-496, Am. Soc. Agrn., Madison, Wisconsin, USA.

16) SMITH, S. R. JR., J. H. BOUTON and C. S. HOVELAND (1989) Alfalfa persistence and regrowth potential under continuous grazing. *Agrn. J.* **81**, 960-965.

17) SMITH, S. R. JR. and C. S. HOVELAND (1993) Selection within alfalfa cultivars for persistence under continuous stocking. *Crop Sci.* **33**, 1321-1328.

18) TAKEDA, T. and K. NAKASHIMA (1997) Characteristics of alfalfa (*Medicago sativa* L.) cultivars adapted to Konsen district, 3. Difference among cultivars in Lepto-leaf spot under the natural infecton. *Grassland Sci.* **43**, 157-163.

19) TESAR, M. B. and J. L. YAGER (1985) Fall cutting of alfalfa in the north central USA. *Agron. J.* **77**, 774-778.

20) VERONESI, F., A. MARIANI, M. FALCINELLI and S. ARCIONI (1986) Selection for tolerance to frequent cutting regimes in alfalfa. *Crop Sci.* **26**, 58-61.

21) WOLF, D. D. and R. E. BLASER (1981) Flexible alfalfa management : Early spring utilization. *Crop Sci.* **21**, 90-93.

22) WALTON, P. D., R. MARTINEZ and A. W. BAILEY (1981) A comparison of continuous and rotational grazing. *J. Range Management* **34**, 19-21.

多回刈りに対するアルファルファ品種の収量と永続性の反応

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要　旨

放牧型品種（Alfagraze）と採草型品種（Maya, 5444）を草丈約30㎝で年6回の多回刈りを行い、収量と永続性を調査した。その結果、放牧型品種は、多回刈りでは収量と永続性について採草型品種より優れていたが、慣行の年3回刈取り収量の約1／3であった。放牧型品種の高い永続性は、高い根部貯蔵炭水化物含量と刈取り時に残存する冠部葉量に関連していた。

キーワード：多回刈り、放牧型品種、アルファルファ、刈り株重、永続性.

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