Production Characteristics of Short Grass Pastures

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Introduction

Each pasture has its own character, reflecting growth characteristics of plant species constituting it. To know what type of pasture can give high productivity without a risk of causing soil erosion on sloping land, these characteristics must be studied.

Perennial grasses can be classified into 2 types; tall grasses and short grasses which have rhizomes or stolons. Pastures dominated by tall grasses are called the tall grass pasture, while pastures dominated by short grasses the short grass pasture.[3] It is considered that short grasses are suitable to mountain regions in Japan, because they are capable of covering ground surface.[6] However, production characteristics of the short grass pasture have seldom been studied. As we have conducted a series of experiments on the short grass pasture for several years, the results[2,3,4,5] are outlined in this paper.

In Experiment I, the process of developing 2 sward types: the tall grass pasture or short grass one, starting from a sward composed of tall and short grasses was analyzed.[4]

In Experiment II, the production characteristics and competitive relationships among constituted grasses were clarified.[3,5]

In Experiment III, a short grass pasture was actually established as a model example of the short grass pasture, and on which herbage and animal productions, and relationship between them under continuous grazing were made clear.

These experiments were carried out at the experimental field of Alpine Region Branch of National Grassland Research Institute. The Branch at an altitude of 1,000–1,300 m is located on the southern hillside of Mt. Asama in the central mountain region of Japan. Annual mean temperature, annual precipitation and mean solar radiation there are 8.3°C, 942 mm and 353 cal/cm^2·day, respectively.

Experiment I
Process of changing into the short grass pasture and tall grass pasture

An experimental sward was established by sowing short grasses (SG); Kentucky bluegrass (*Poa pratensis* L., Kb) and redtop (*Agrostis alba* L., Rt) together with a tall grass (TG); orchardgrass (*Dactylis glomerata* L., Or). The treatment given to the sward (hereafter referred to mixed sward) was 3 different levels of fertilizer application combined with 3 different intervals of cuttings. The fertilizer levels were 5, 15 and 30 kg/10 a/yr of N with equivalent amount of P_2O_5 and K_2O. The cutting intervals were determined as follows: Whenever the relative light intensity at 3 cm above the ground surface reached 5% (long interval cutting), 20% (medium interval cutting) and 50% (short interval cutting), the grasses were cut at 3–4 cm above the ground surface. The cutting intervals thus determined on the basis of relative light intensity on ground surface are most reasonable, because the decline of light intensity inside the canopy is closely connected with building of the sward canopy. The light intensity was measured with the new portable solarimeter devised by

Plate 1. External appearance of the portable solarimeter newly devised by the author and his co-workers

us.[2] This solarimeter makes it possible to survey photosynthetically active radiation at many points inside densely grown grasslands simultaneously and quickly (Plate 1).

Yearly changes of plant species composition in dry matter are shown in Fig. 1. The ratio of Rt was higher than 90% in spring of the first year after the sward establishment, and decreased rapidly in summer and autumn. The ratio of Or increased and took the place of Rt in summer in the first year. Since then, the ratio of Kb increased in the plots with heavier fertilizer application and shorter interval of cutting. Thus, the ratio of Kb attained to more than 90% in the plot with short interval cutting under heavy fertilizer application in the fifth year, whereas in the plot with short interval cutting under light fertilizer application, Kb could not dominate but Or dominated. Relationships between cutting interval and Or, and Kb are given in Fig. 2, which clearly shows that annual mean Crop Growth Rate of Or (G-$\overline{\text{CGR}}$) decreased linearly with the reduction of cutting interval, while that of Kb increased almost linearly with the reduction of cutting interval under the heavy fertilizer application. The line for Or and that for Kb intersect each other. To analyze these phenomena, plant height, relative light intensity at the top of each grass, number of tillers, Leaf Area Index (LAI, above 4 cm from ground surface) and residual LAI (within 4 cm from ground surface) were measured. As a result, it was made clear that the transition of the mixed sward to the short grass pasture by the short interval cutting proceeded as follows under a condition without greatly limited fertilizers: No. of tillers of SG increases by short interval cutting → SG-LAI of lower layer increases → SG-DM production in early regrowth becomes large → DM production of SG is superior (under short regrowth) ⇒ Forming of SG-sward. The process of transition to the tall grass pasture caused by long interval cutting is: TG-plant becomes high → TG-LAI of upper layer increases → TG-DM production in later regrowth becomes large due to better performance in the competition for light → DM production of TG is superior (under long regrowth) ⇒ Forming of TG-sward.

On the other hand, under light fertilizer application, Or became dominant, irrespective of the intervals of cutting.

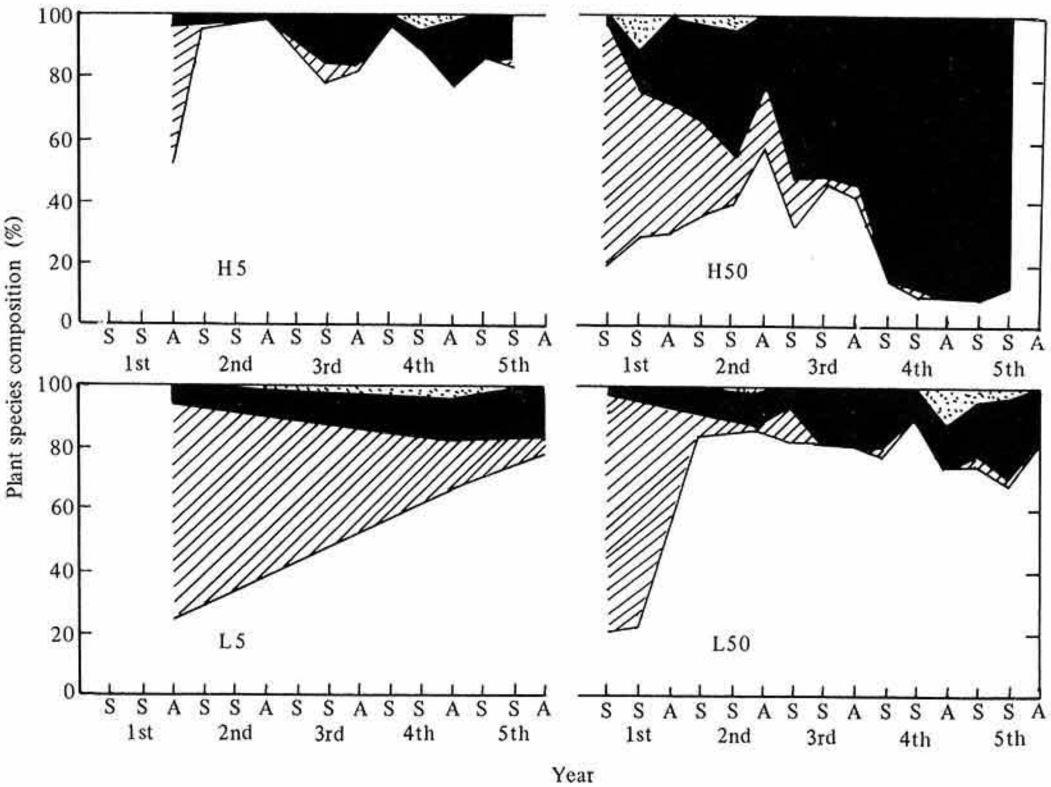

Fig. 1. Transition of plant species composition (in % of dry weight) of a mixed sward in relation to different management

□: Orchardgrass, ▨: Redtop, ■: Kentucky bluegrass, ▩: Weed

L, and H: Light and heavy fertilizer application (5 and 30 kg for each of N, P_2O_5 and K_2O/10 a·yr, respectively).

5, and 50: Cutting was practiced when the relative light intensity at 3 cm above ground surface decreased to 5 and 50%, respectively. For example H5 signifies a plot with heavy fertilization and a long interval for cutting.

Experiment II
Production characteristics of short grass pasture

Single swards were established by sowing or transplanting short grasses; Kb, Rt, creeping red fescue (*Festuca rubra* L., Cr) or *Zoysia japonica* Steud. (Zy). These swards were treated in much the same way as Experiment I.

Annual dry matter yield (AY-DM) increased as the amount of fertilizer increased, and the relationship between them gave essentially a straight line (Fig. 3). AY-DM decreased with the decrease of cutting interval in most grasses, although the rate of decrease differed with the kind of grass. The rate of decrease was large for Rt, but not for Kb and Zy. Particularly in Zy, this relationship was reversed in some cases.

Invasion of weeds was serious in the treatmental plots with heavy fertilizer application and short cutting interval of Rt, and in the plots with heavy fertilizer application and long cutting interval of Kb and Zy.

Judging from the facts described above and other investigations of growth characteristics,

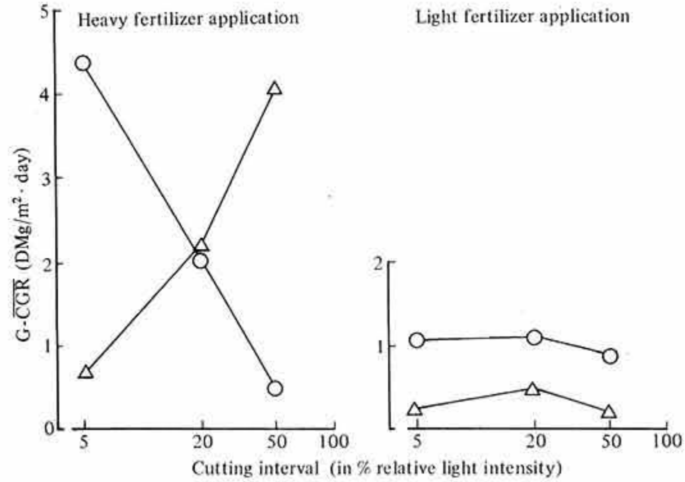

Fig. 2. Relationships between cutting intervals and annual mean CGR of each grass (G-$\overline{CGR}$) in the 5th year of a mixed sward
○: Orchardgrass, △: Kentucky bluegrass

it was concluded that Rt-sward has to be managed by long interval cutting, and Kb- and Zy-swards by short interval cutting.

Four kinds of mixed swards, i.e. 4G-sward composed of Kb, Rt, Cr and Zy, 3G-sward made of Kb, Rt and Cr, KZ-sward made of Kb and Zy, and RZ-sward made of Rt and Zy, were investigated for 5 years to make clear production characteristics of each sward and competitive relationships among the component grasses.

AY-DM was increased by heavier fertilizer application in any sward, and it was also increased by longer interval of cutting except in KZ-sward (Fig. 4). In the KZ-sward, effect of cutting interval on AY-DM was small, and it was similar to the case of a single Kb-sward. Competitive relationships among the grasses were considerably different depending on the condition of management (Fig. 5).

The dominant grass in the plots with longer cutting interval was Rt, which was superior to other short grasses in elongation property. On the other hand, Kb or Zy was dominant under the condition of shorter cutting interval, because they were able to produce a great LAI in lower layer, under shorter cutting interval. It seems that these facts are governed by the same principle as observed in the Experiment I, namely, an inevitable consequence of light competition among different species with different growth characteristics.

Experiment III
Herbage and animal production in the short grass pasture under continuous grazing

A short grass pasture, composed of Kb (Troy), Rt, Cr and white clover (*Trifolium repens* L., Grasslands Huia, Wc), was established by using the unplowed seeding method in 1977. The area of the pasture was 1.2 ha in 1978 (the first year of grazing) and 1.4 ha from 1979 (the second year). A total amount of compound fertilizer applied was equivalent to 171 kg of N, 111 kg of P_2O_5 and 171 kg of K_2O per ha per year. The pasture was subjected to the continuous grazing by 4 heifers in the 2nd year, 6–8 steers in the 3rd–4th year, 6–8 heifers in the 5th–7th year, of Japanese Black Breed, with 544–705 cow days per ha. Grazing season was from late April to late October or early November. But the

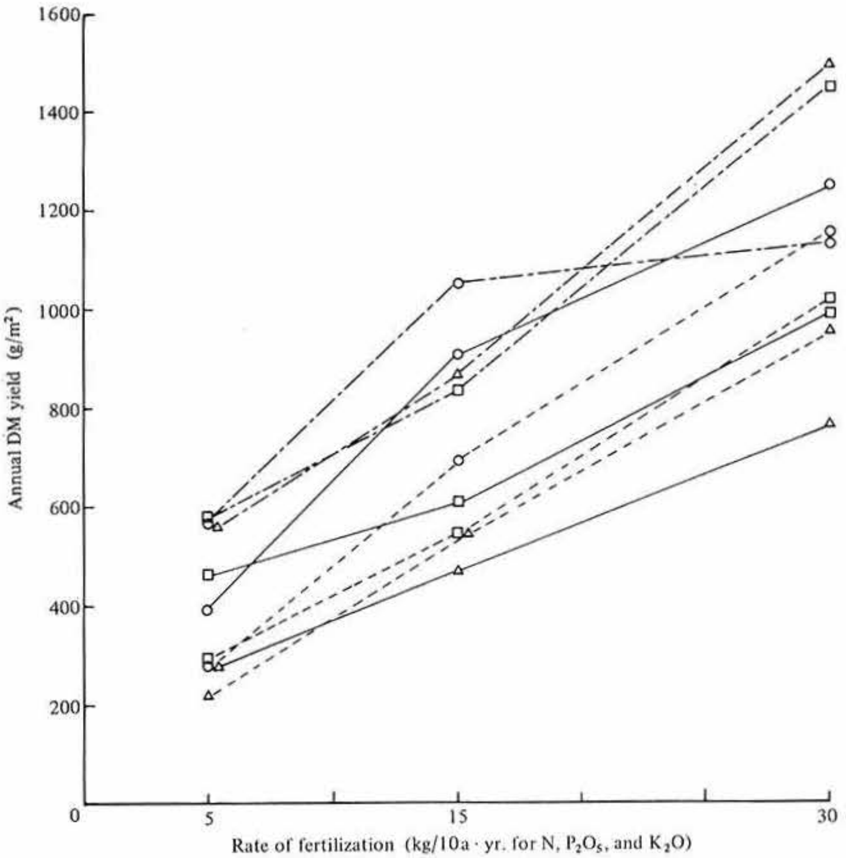

Fig. 3. Relationship between DM yield and rate of fertilizer application in a single sward
The DM yield is the mean for three years from the 2nd to 4th year after establishment.
- - - -: Kentucky bluegrass, ——: Redtop,
— - —: *Zoysia japonica*
○: Long interval cutting (cutting at 5% relative light intensity)
△: Short interval cutting (cutting at 50% relative light intensity)
□: Medium interval cutting (cutting at 20% relative light intensity)

number of the animal was reduced by 2 from early July.

Status of vegetation on this pasture after its establishment was as follows.

The native plants had decreased and the ratio of the sown grasses had considerably increased by the end of the grazing season in the 2nd year. At that time the summed dominance ratio (SDR_2) was ranked in the order of Kb, Cr, Cw, Rt, and the rank was almost unchanged throughout 6 years. Plant height was 10–30 cm in the mean of maximum in every measurement throughout the grazing season with annual average of 21 cm in the 5th year, and about the same in the 6th year. Relative light intensity (RLI) at 3 cm above the ground surface was 93–34% and 81–26% with the average of 54 and 53% in the 5th and 6th year, respectively. These results showed that this pasture had been managed under

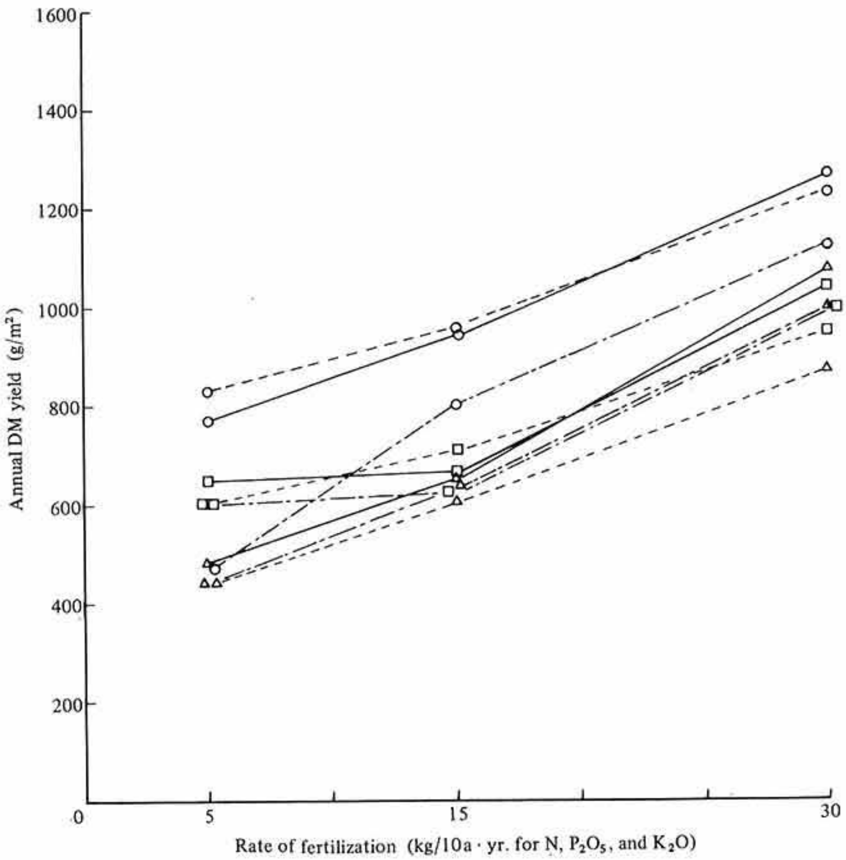

Fig. 4. Relationship between DM yield and rate of fertilizer application in mixed swards
The DM yield is the mean for 4 years from the 2nd to 5th year after establishment.
---: 3G-sward (Rt+Kb+Cr), ——: 4G-sward (Rt+Kb+Cr+Zy), —·—: KZ-sward (Kb+Zy)
Rt: Redtop, Kb: Kentucky bluegrass, Cr: Creeping red fescue
Zy: *Zoysia japonica*
○, □, △: Refer to Fig. 3.

the condition equivalent to the treatment of short interval cutting and medium-heavy fertilizer application in Experiment I or II.

DM of the standing crop was kept to be 200–300 g/m^2 throughout the grazing season in the 5th and 6th experimental years, and about 100 g corresponding to 32–78% of the total amount was distributed within 3 cm above the ground surface (Fig. 6). It was characteristic of the short grass pasture that seasonal change in standing crop was not large and considerable herbage mass existed within a lower layer near the ground.

Whole LAI fluctuated between 2.1 and 5.3 during the period of grazing season, and LAI in a lower layer up to 3 cm above the ground surface fluctuated between 0.4 and 2.5. The latter corresponded to 10–57% with the average of 36.8% of the former (Fig. 7).

This fact showed that about 40% of the whole leaves as the organ of production, existed within a layer up to 3 cm above the

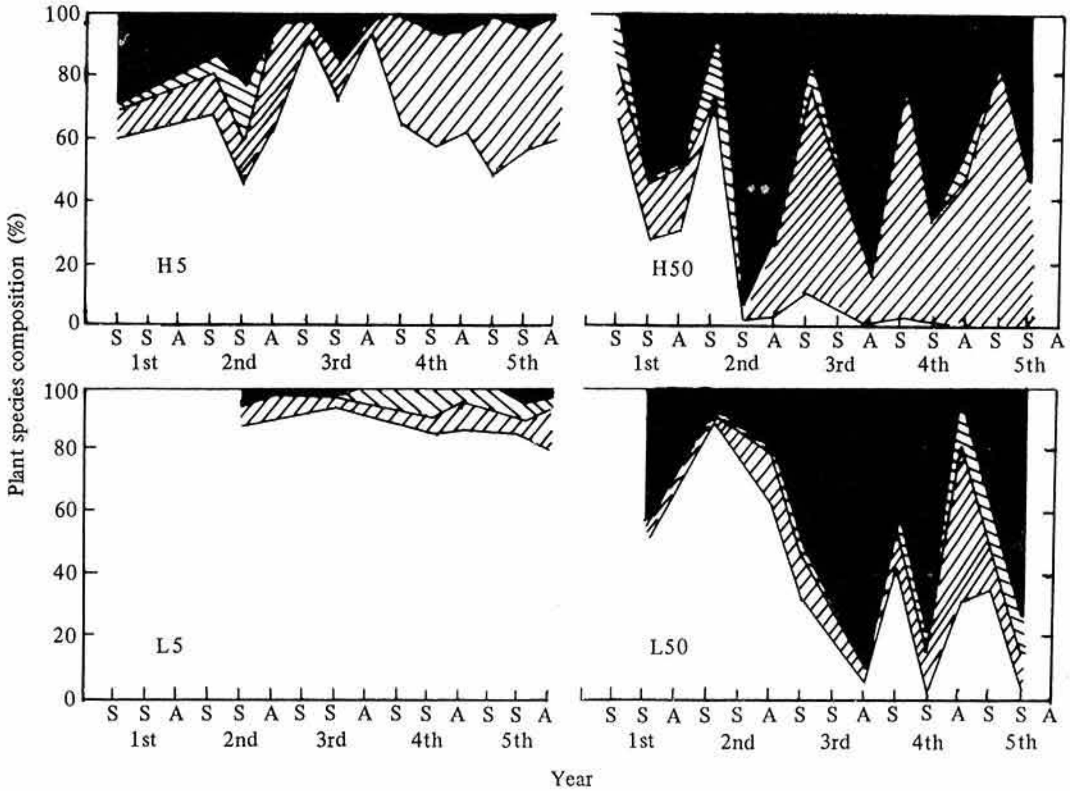

Fig. 5. Transition of plant species composition (in % of dry weight) of a 4-species sward in relation to different management

□: Redtop, ▨: Kentucky bluegrass, ▧: Creeping red fescue, ■: *Zoysia japonica*

S, S and A: Refer to Fig. 1.

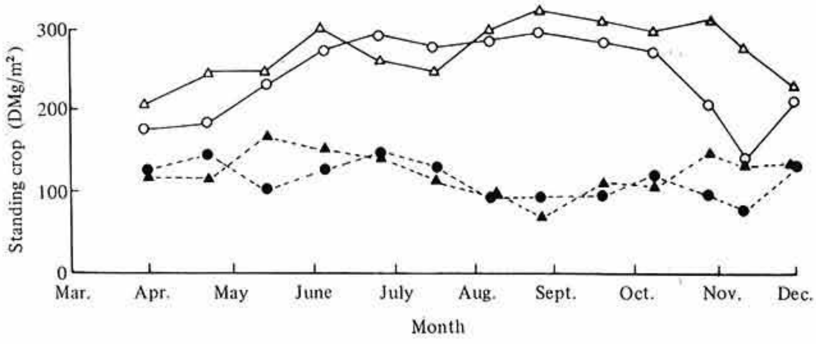

Fig. 6. Seasonal changes of DM of grass top of the short grass pasture at the 5th and 6th year

——: DM of top (including dead parts) distributed above 3 cm from the ground surface

- - -: DM of top distributed within 3 cm from the ground surface

○, ●: 5th year, △, ▲: 6th year

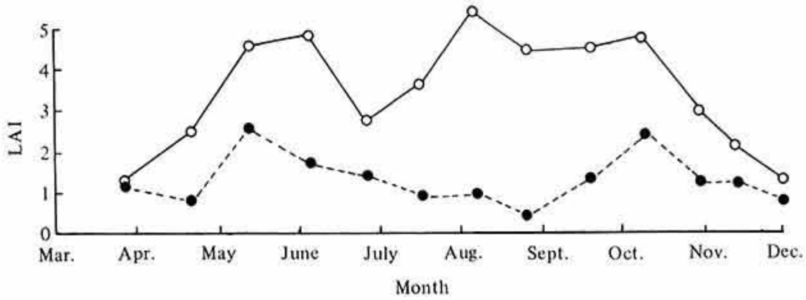

Fig. 7. Seasonal changes of Leaf Area Index (LAI) of the short grass pasture at the 6th year pasture
——○: Whole LAI, – – –●: LAI within 3 cm from the ground surface

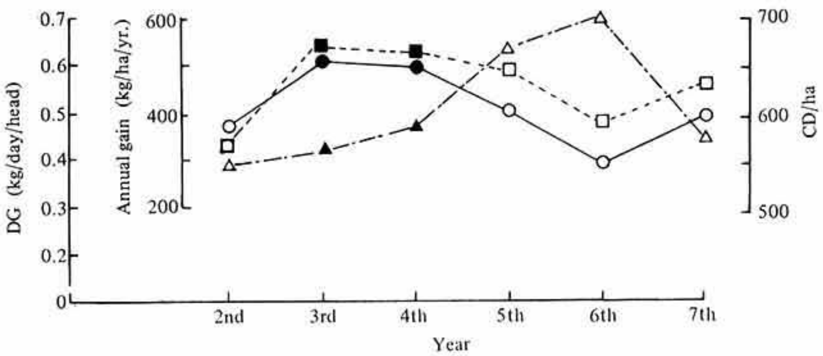

Fig. 8. Yearly changes of daily gain (DG), annual gain/ha and cow day (CD)/ha in the short grass pasture
——: DG, – – –: Annual gain/ha, —·—: Cd/ha
○, □, △: Heifer, ●, ■, ▲: Steer

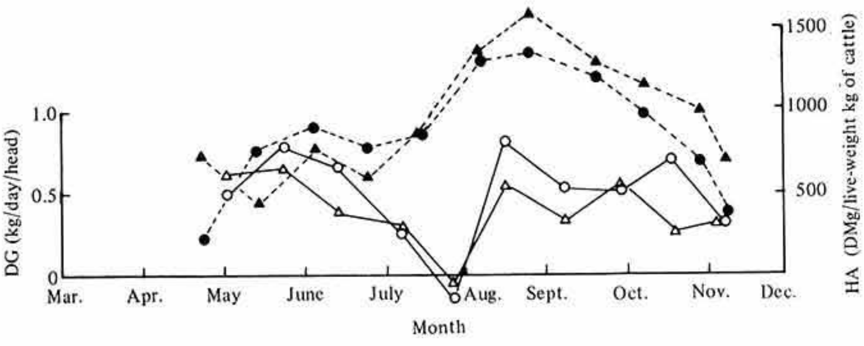

Fig. 9. Seasonal changes of daily gain (DG) and herbage allowance (HA) in the short grass pasture
——○: DG in the 5th year, ——△: DG in the 6th year
– – –●: HA in the 5th year, – – –▲: HA in the 6th year

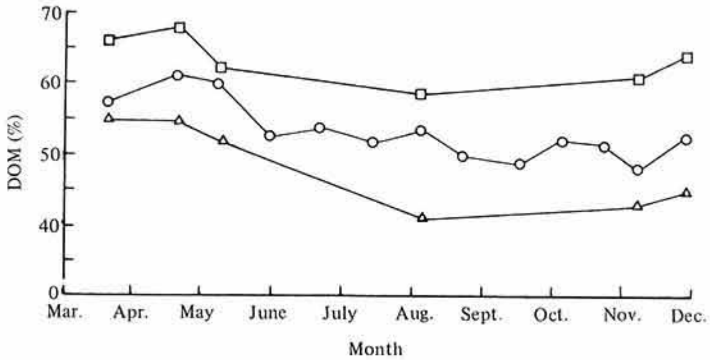

Fig. 10. Seasonal changes of digestible organic matter (DOM) in the short grass pasture
○: The whole plants located above 3 cm from the ground surface
□: Living plant parts located above 3 cm from the ground surface
△: Dead plant parts located above 3 cm from the ground surface

ground surface, where the leaves escaped from being grazed by cattle.

Annual net production of DM above 3 cm from the ground surface was 846–1,130 g/m², with the average of 1,020 g/m², and herbage consumed was 781–903 g/m², with the average of 856 g/m². Hence, annual utilization rate of herbage was 70–97%, with the average of 84%.

Comparing with the result obtained in an orchardgrass pasture in the previous report,[1] the annual net production shown above is considerably low, but herbage consumed is almost equal, because the utilization rate is much higher than that in the orchardgrass pasture. The lower utilization rate of the orchardgrass pasture was caused by trampled and soiled grasses. Namely, the orchardgrass pasture under a rotation system showed high primary production, but it gave low herbage intake, while the short grass pasture under continuous grazing (used in the present study) gave the herbage intake similar to that of the orchardgrass pasture, although its primary production is not high.

Animal production in the short grass pasture is summarized as follows:

Annual gain was 331–501 kg/ha, with the average of 421 kg, in heifer, and 525–547 kg, with the average of 536 kg, in steer, of Japanese Black Breed.

Daily gain (DG)/head/day was 0.40–0.51 kg, with the average of 0.47 kg, in heifer, and 0.60–0.61 kg with the average of 0.61 kg, in steer. These values are comparatively higher than those of Japanese Black Breed grazing on pastures in Japan without supplementary feed[7] (Fig. 8).

To analyze relationship between grass and animal, herbage allowance (HA) and digestible organic matter (DOM) were investigated.

Annual mean of HA (DM weight of herbage offered per 1 kg of animal live-weight) was 690–960 g, with the average of 852 g. HA during the grazing season changed from 200 g at the beginning of grazing to 1,500 g in September (Fig. 9). These values are sufficient for cattle, because cattle consume 20–30 g of dry matter per day per 1 kg of live-weight, corresponding to 2–3% of live-weight.

However, DG decreased at the end of July in spite of being provided with enough herbage mass (Fig. 9). This phenomenon is generally observed in Japan. Air temperature and digestible dry matter are regarded as factors of it.[8] As shown in Fig. 10, DOM was higher in spring, and gradually decreased, but not showing any depression in July. Therefore, the decrease of DG observed in the present study is not considered to be caused by decrease of digestibility. This problem has to be solved to increase animal production in future.

In conclusion, the short grass pasture is well comparable to the tall grass pasture (like orchardgrass pasture) in available herbage production, and is even better in animal production. In addition, it has an important advantage, namely, it densely covers soil surface and prevents soil erosion. Thus, the short grass permanent pasture is considered quite suitable for sloping lands.

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(Received for publication, November 14, 1984)