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Autecology of the Dominant Species in Early Stages of Secondary Succession: on *Miscanthus sinensis* ANDERSS.*

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Synopsis

Miscanthus sinensis is the dominant of the final stage in a secondary succession of herbaceous communities following forest clearance in Japan. Changes were followed during the course of its growth, in the ratios of the weight of belowground organs, leaves and stems to the weight of the whole plant. The plant weight increased from 0.733 g (the initial wt. of the rhizome bud when planted) to 11.1 g (wt. of the young plant after 182 days). In the later periods, the ratios of the weights of organs to the total plant weight are 0.48 for the belowground organs, 0.23 for leaves and 0.24 for stems. The relationship between the belowground parts (root+rhizome+bud: R) and the aboveground parts (T)is described as $R = 0.94T^{1.18}$. The ecological characteristics of this species are compared with those of *Chenopodium album* L. and *Artemisia princeps* PAMPAN., which are the dominants at the pioneer and perennial herb stages in the secondary succession.

Key words: Ecological characteristics, *Miscanthus sinensis*, secondary succession, type of life history

Introduction

The present paper describes the changes during the course of growth, in the proportions by weight of belowground parts, leaves and stems in relation to total plant weight of *Miscanthus sinensis*. These ratios represent a quantitative aspect of growth-form which amounts to an expression of the life history of the species. *M. sinensis* is a dominant species of grasslands at a final stage of the secondary succession of herbaceous communities following forest clearance in Japan (HAYASHI 1977).

In order to explain why this species dominates at this stage of the successtion, the type of life history of this species is compared with those of *Chenopodium album*, a dominant at the pioneer stage, and *Artemisia princeps*, a dominant at the perennial herb stage of the secondary succession (NAKAYASU and HAYASHI 1975, FUKUDA and HAYASHI 1982). The studies from a similar point of view have been carried out by BAZZAZ (1974), RAYNAL and

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BAZZAZ (1975a; 1975b), WERNER (1976), ROOS and QUINN (1977), PETERSON and BAZZAZ (1978) and NEWELL and TRAMER (1978).

Materials and Methods

In Sugadaira, Central Japan, a plant of *Miscanthus sinensis* forms many buds on the rhizomes in autumn. Thirty buds of *M. sinensis* were collected from the campus of the Sugadaira Montane Research Center of the University of Tsukuba, Nagano Prefecture, on 14 April 1969 and grown in pots. The buds were grown from 14 April to 13 October 1969 in the pots of 18 cm in diameter and 21 cm deep containing the soil of the stand where the plants of *M. sinensis* were obtained. The average dry weight of the buds, whose leaves and stems were not yet visible was 0.733 g.

The pots were placed in the open with sufficient space between them to avoid interference among plants in adjacent pots. Apart from watering at regular intervals they were subject to the natural climatic condition of Sugadaira, as follows. The mean annual temperature and total annual precipitation of Sugadaira in 1969 were 6.7 C and 1,523 mm, respectively. The loss of ignition of the surface soil used in this experiment was 30. 1 %. The contents of total nitrogen and phosphorous in the dry soil were 0.69 % and 0.20 %, respectively. Five plants were harvested on each on the following dates; 24 May, 23 June, 31 July, 26 August, 23 September and 15 October, 1969. Plants of *M. sinensis* of an area of 0.5 m × 0.5 m and 0.5 m in soil depth were collected from the field in Sugadaira on 23

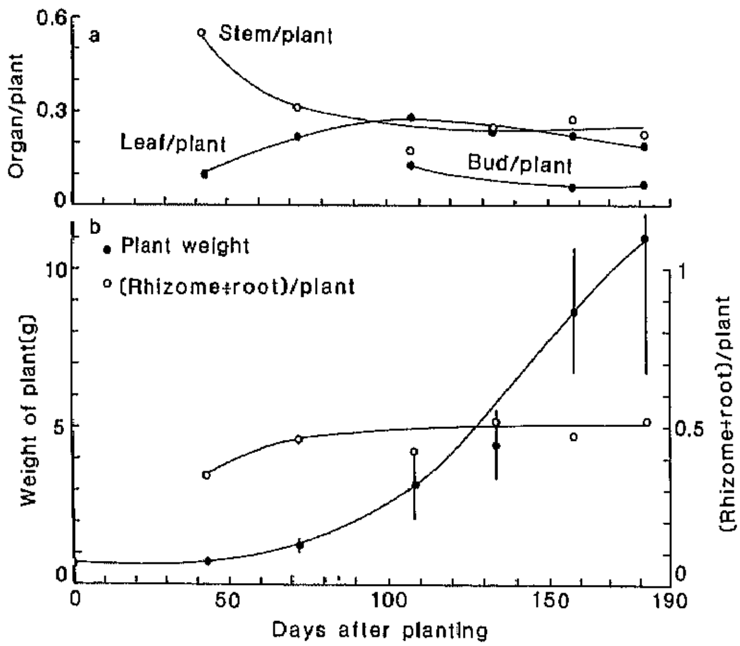

Fig. 1. The changes in weight of belowground organs, leaves and stems in relation to total plant weight in the course of growth of *Miscanthus sinensis*

August and on 14 September 1977. Nine seedlings of *M. sinensis* were also collected from the field for measurement. In the laboratory, these were divided into leaves, stems, roots, rhizomes, dead leaves, dead stems and dead roots, and dried in a ventilated oven at 85 C for 24 hours. Thus the weights of plant materials described in this paper are given as the oven dry weight at 85 C.

Results

The plant growth and the changes of weight ratios of leaves, stems and belowground parts to total plant weight are shown in Fig. 1. The plant weight increased from 0.733 g at the bud stage to 11.1 g of young plant in 182 days, and the relative growth rate (RGR) during this period was 0.028 at its maximum, and an average 0.019. Presumably the rates under natural condition vary according to changes of temperature and precipitation in the habitats (NUMATA and MITSUDERA 1969).

As shown in Fig. 2, a new bud had already formed on the rhizome by 20 July 1969. The

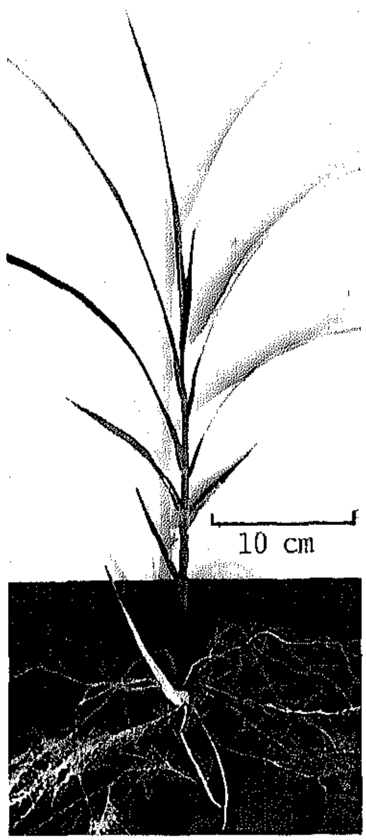

Fig. 2. The grown plant derived from a bud planted on 13 April 1969, and harvested on 20 July 1969.

individual plant of this species is reproduced by vegetative means before seed production occurs: none of the plants used in the experiment flowered even by 13 October 1969. The new primary bud formed on the plants was initiated 50 days after the planting of the original rhizome bud. According to the observation in Shizuoka Prefecture by KOBAYASHI (1979), natural population of *Miscanthus sinensis* produced new primary shoots from June to July. The changes in the ratio of the weight of belowground organs *(R')** to the total plant weight *(W)* during the growing period are shown in Fig. 1b. This ratio is constant at 0.48 at least in the later period of growth. The weight ratios of leaves *(W1)* and stems *(Ws)* to whole plant weight *(W)* are given in Fig. 1a. The ratio of $W1/W$ is low in the early growth period but rises to 0.23 in the later part of the current year. The value of Ws/W is high in the early growth period but fell to 0.24 later. The values of these ratios at the time when the maximum growth rate was recorded were 0.48 for R'/W, 0.23 for $W1/W$ and 0.24 for Ws/W. The relationship between weight of above-ground parts *(T)*. and weight of belowground parts *(R)* of all plants both grown in the pots and collected from

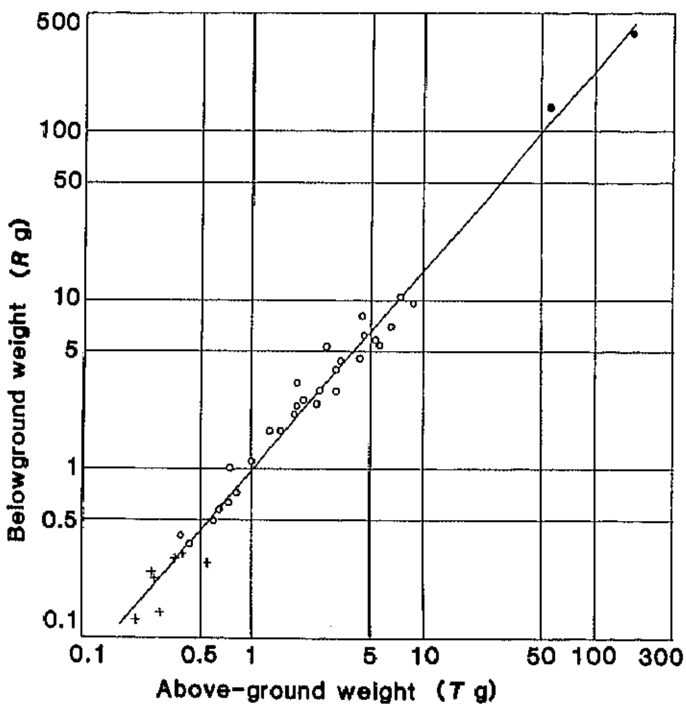

Fig. 3. The relationship between the weight of belowground parts and weight of above-ground parts of the plant of *Miscanthus sinensis*. The marks in figure are as follows; plants grown in pots (○), plants collected from field (●) and seedlings collected from field (+).

* In this paper, the belowground organs (rhizome + root: *R'*) are distinguished from the belowground parts (rhizome + root + bud: *R*)

fields is shown in Fig. 3. The relationship between R and T is described as follows;

$$R = 0.94T^{1.18} \cdots\cdots(1)$$

$$W = T + 0.94T^{1.18} \cdots\cdots(2)$$

Using equation (2), we can estimate the total plant weight produced in a given year by measuring the above-ground weight of a plant. The number of roots formed on each rhizome is given in Fig. 4. This increased from zero on 14 April to 48 on 13 October 1969. The weights of withered components both of the above-ground parts and of the root during the growing period are shown in Table 1. The withered parts did not detach from the living plant during this experiment. Therefore, the weights of withered parts (0.59 g of above ground and 0.15 of root in September) were regarded as total for the withered parts. The amounts of these are equivalent to 12% and 3% of the weight of the living plant, respectively.

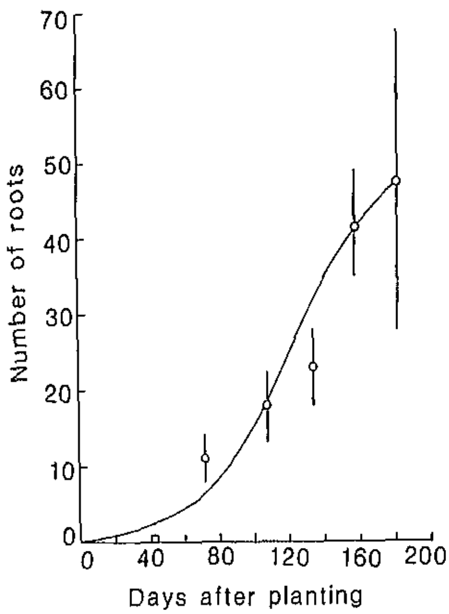

Fig. 4. Number of roots formed on the rhizomes of *Miscanthus sinensis* planted on 13 April 1969.

Table 1. The weight of withered parts of *Miscanthus sinensis* plants planted in the pots on 13 Apr. 1969

Date	g dry weight Above-ground parts	Belowground parts
Aug. 26	0.28±0.20	0.01±0.01
Sept. 19	0.59±0.21	0.14±0.11
Oct. 13	0.45±0.13	0.15±0.00

Discussion and Conclusion

In order to elucidate the mechanism of succession, I have compared the type of life history shown by the dominant species of subseral stages (HAYASHI 1977 ; 1979 ; 1984a, b). The type of life history is defined in these papers as the particular combination of those characteristics which contribute to perpetuation the species (cf. HARPER 1970 ; HAYASHI 1977). In actual cases under natural conditions, perpetuation of the species is seen as continued occupation of the ecological niches in a given community. In this context, the ecological characteristics are taken as seed weight, disseminule form, germination behaviour, shade tolerance, growth form, relative growth rate, flowering time and seed production etc. In the present paper, the ratios R/T, Wl/W and Ws/W are regarded as quantitave aspects of the growth form (ABRAHAMSON and GADGIL 1973). VAN DER VALK (1981) defined the wetland life history types by combining three life history traits of the species such as life span, propagule longevity and propagule establishment requirments.

The ecological characteristics of *Miscanthus sinensis*, for example, are anemochore seed of 0.46-0.96 mg in weight, medium shade tolerance of the seedling (HAYASHI 1977 ; 1979), a R'/W ratio of 0.48, Wl/W ratio of 0.23 and Ws/W ratio of 0.24.

The combination of these characteristics enables *M. sinensis* to occupy the dominant niche in the final stage of the secondary succession of herbaceous community.

The relationship between the weights of belowground parts (rhizome + root + bud : R) and above-ground parts (leaf + stem : T) is described as $R = aT^b$. In table 2, the parameters a and b for *Miscanthus sinensis* are compared with those for *Chenopodium album* and *Artemisia princeps*. The roots of *C. album* amount to about 21 % by weight of the above-ground parts if we regarded the power b (1.05) as nearly equal to one, whereas in the case of *M. sinensis* the power b is 1.18. These values mean that *M. sinensis* allocates more than 50 % of assimilated matter to the belowground parts, while in *C. album* the percentage is about 18. In the case of *A. princeps*, a trend similar to *M. sinensis* was observed. If the seeds of both species germinate at the same time in a denuded stand, *C. album* is undoubtedly the quickest to occupy the space of upper layer of the stand, because

Table. 2 The relationship between the weights of below-ground parts *(R)* and above-ground parts *(T)* in *Miscanthus sinensis, Artemisia princeps* and *Chenopodium album*

Species	Equations	Correlation coefficient
Miscanthus sinensis	$R=0.94T^{1.18}$	0.99
Artemisia princeps	$R=0.57\ T^{1.25}$	0.83*
Chenopodium album	$R=0.21\ T^{1.05}$	0.97**

*NAKAYASU and HAYASHI (1975), **FUKUDA and HAYASHI (1982)

M. sinensis allocates a large propotion of its assimilated matter to the belowground parts. According to a previous paper (HAYASHI 1979), the seedling of *M. sinensis* was tolerable under the light intensity of 600 lux, which is equivalent intensity at the ground surface of *C. album* stand at daytime of a fine day in August in Sugadaira (FUKUDA and HAYASHI 1982). Therefore, we may say that the seedlings of this species are endurable under the shading condition by the species of a prior stage of succession. Repeated vegetative growth under such a gloom condition leads to *M. sinensis* becoming an occupant of upper layer of the stand. The high *Wl/W* ratio in young growth stage of this species may be advantageous for assimilation under such a condition though the *Wl/W* raito of this species decreased in the later growth stage (HAYASHI 1984a).

Thus the type of life history of *M. sinensis* may be defined by combining the following characteristics: relatively heavy anemochore seeds, germination with a short period of dormancy, medium shade tolerance of seedling and high rate of allocation of assimilated matter to belowground parts and leaves. With this type of life history, *Miscanthus sinensis* dominates at the final stage of secondary succession in the herbaceous community in Japan. To elucidate the process of invasion of the species at an earlier stage of succession, however, the establishment and expansion of the population of this species should be followed as was made by KOBAYASHI (1981). Comparisons with the type of life history of other dominants as well as consideration of the environmental conditions at each seral stage will help to explain mechanisms of secondary succession.

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