Productivity Rating of Vegetation Unit in *Miscanthus sinensis* Grassland (Tonomine) in the South-Western Part of Japan

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Introduction

The main part of this thesis is based upon an investigation conducted in the Tonomine grassland (IBP. subarea) from 1968 to 1972 and the author has already reported on it in the IBP Report (VOL 13: 1975). An additional investigation was made over the two years from 1974 to 1975. Its data, together with the ones from the previous survey, were studied carefully.

The purpose of these investigations was measuring more precisely the standing crop of *Miscanthus sinensis* grassland in a specific area.

First of all, the author did the vegetation investigation of *Miscanthus sinensis* grassland and completed its vegetation map. Using this map be isolated those areas where *Miscanthus sinensis* was most prominent and then measured its standing crop for each season. The information from the maps and the results of the measurements indicate that the total production of *Miscanthus sinensis* for those areas considered are significant.

I. Climate of Tonomine grassland

Tonomine grassland is located in the south-western part of Japan in latitude 38°8′N and longitude 134°44′E (Fig. 1) and its altitude is 800–830 m.

Because of lack the climate data for Tonomine, the data of Ichinomiya (located about 1.2 km west of Tonomine and its altitude 170 m) was cited as a reference.

Fig. 2 is the Hythergraph shown by the data collected during the past thirty years. Besides the climate research data of Ichinomiya, Fig. 2 data also contains two other climate diagrams for comparison: that of Toyooka city located in a seaside of the Japan Sea, and that of Kobe city located in Seto Inland seaside. Concerning the climate of Toyooka city, it has much rain in winter January. This phenomenon is characteristic of the so-called Japan Sea climate. The climate of Tonomine grassland is estimated to be nearly the same as that of Ichinomiya. According to the Fig. 2 data, it rains a great deal in the summer season and especially during the four months of June, July, August and September. In winter the rainfall is small. Thus the climatic conditions of Tonomine are the opposite of Toyooka city and, to some extent, similar to that of Seto Inland Sea. The main cause is that Tonomine grassland is situated at the southern side of Chugoku mountain range.

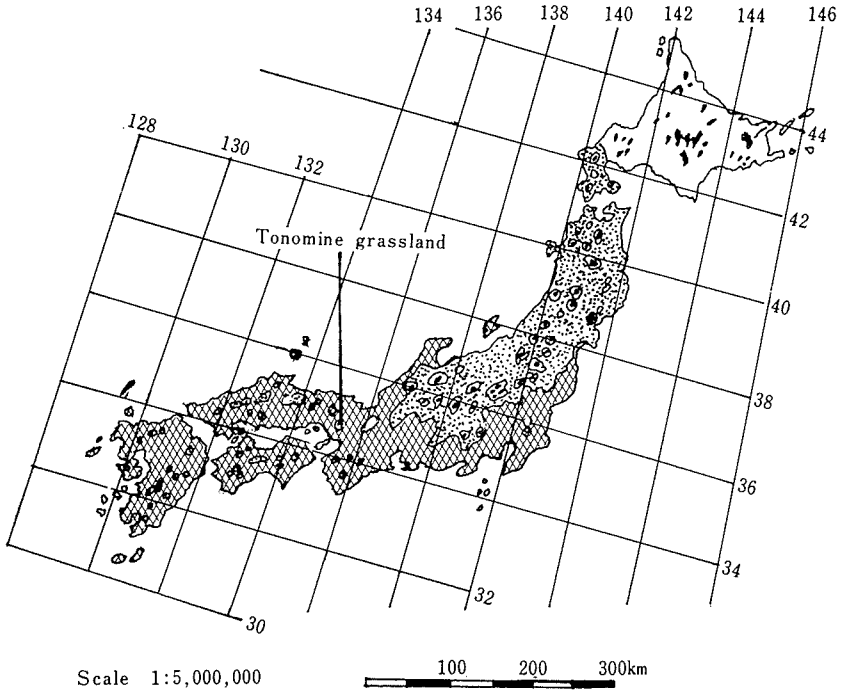

Fig. 1. Vegetation of Japan. (from Y. Horikawa: 1968)

The climate measurement index of Ichinomiya need to be revised to get those of Tonomine grassland due to the altitudinal difference between the two places. Thus, the warmth index of Tonomine grassland is concluded to be 77.5, coldness index 19.1 and Aridity/Humidity index 18.54. From these climatic conditions, Tonomine grassland can be explained to belong to Saseto kurilensis-Fagion crenatae.

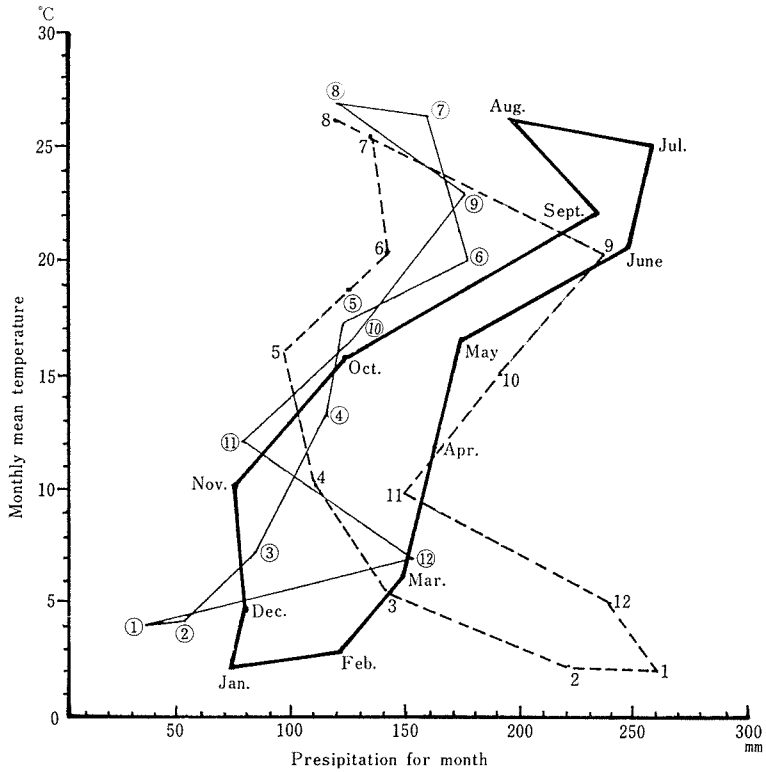

Fig. 2. Hythergraph of Ichinomiya (Tonomine), Toyooka and Kobe.
——— : Ichinomiya (Tonomine)
---------- : Toyooka (The Japan Sea)
——— : Kobe (The inland sea)

II. Vegetation of Tonomine grassland

Miscanthus sinensis extant in Japan is largely divided into two types; one is the *Miscanthus sinensis* community which is a substitute vegetation for Fagetea crenatae dominating on the temperate zone, and the other is *Arndinaria pygmaea-Miscanthus sinensis* community dominating as a substitution vegetation of Camellietea japonicae. Fig. 1 shows the distribution of Fagetea crenatae and Camellietea japonecae (*Castanopsis cuspidata* formation: Horikawa 1968).

The *Miscanthus sinensis* grassland is cared for artificially and therefore burning is done periodically so as to keep off shrub invaders. In Tonomine grassland, burning takes place annually in May.

III. Vegetation and the Vegetation map

The vegetation investigation of Tonomine grassland was done through an area of 35.3 ha. The vegetation map was compiled jointly by the prsent author, Suganuma and his collegues (1975). As the result of the vegetation investigation, one association, three subassociations, and two variants could be recognized. They are as follows:

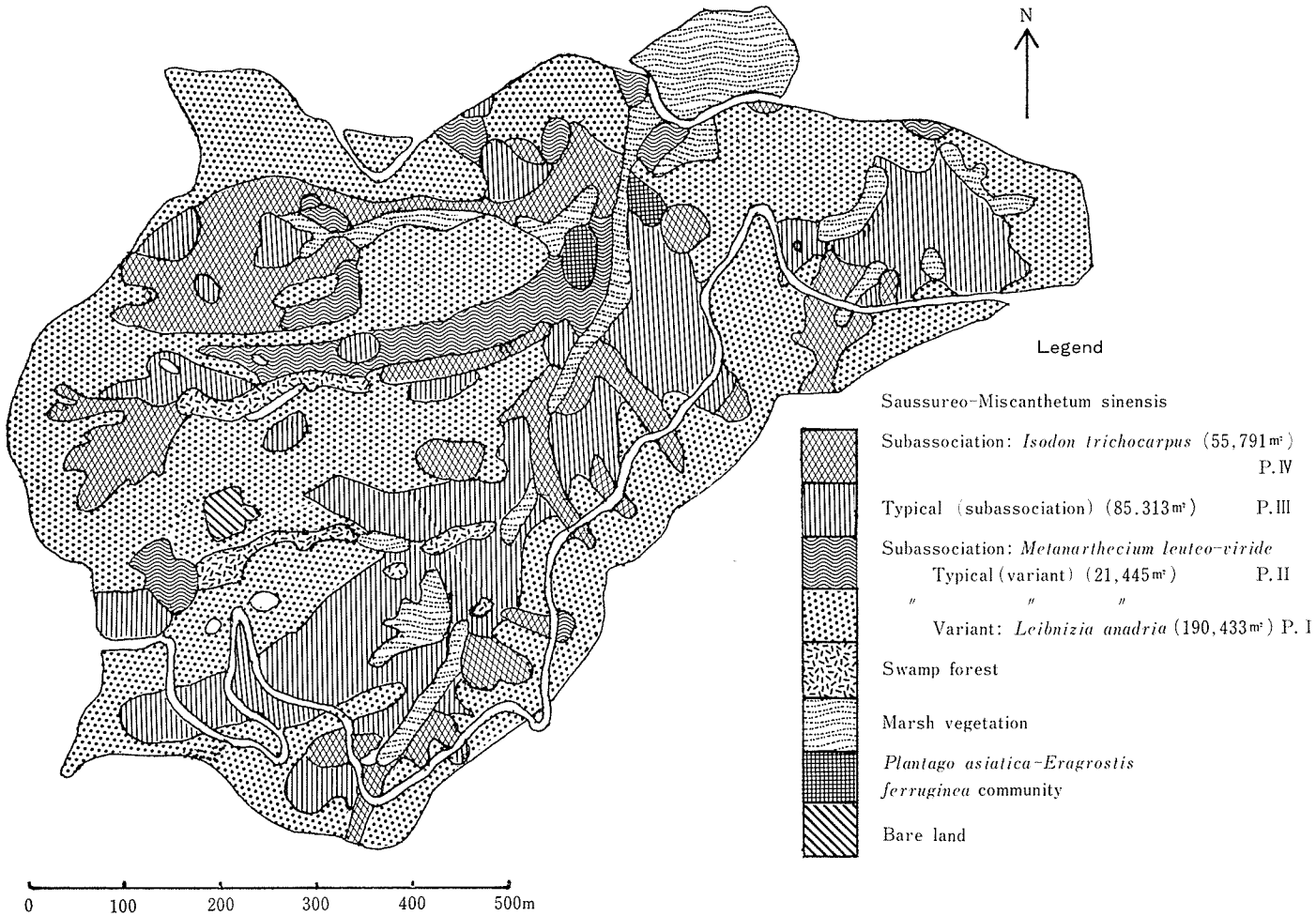

Fig. 3. Vegetation map of the Tonomine grassland.
(from N. Yano, R. Kayama and T. Suganuma: 1975)

Sausreo-Miscanthetum

1. *Metanarthecium leuteo-viride* subassociation
   1) *Leibnizia anadrica* variant : area about 19.04 ha.
   2) Typical (variant) : area about 2.15 ha.
2. Typical (subassociation) : area about 8.53 ha.
3. *Isodon trichocarpus* subassociation : area about 5.58 ha.

The sectional vegetation map (Fig. 3) was made by classifying into eight parts: swamp forest, marsh vegetation, roadside vegetation, bare land and grassland vegetation.

The vegetation map served as the basis for the measurement of the area where each vegetation exists.

Sausreo-miscanthetum is the association which has come into existence in Saseto kurilensis-Fagion crenatae around the Kinki districts. *Metanarthecicum leuteo-viride* subassociation, subordinate unit of this association, has come to dominate on and around the upper part of the sloping grassland.

Metanarthecium leuteo-viride is counted as the differential species. The *Leibnizia anadrica* variant and the typical variant are the subordinate units of this subassociation.

The *Leibnizia anadria* variant exists on the windward landform of the upper part of the slope, and as its differential species, there are *Leibnizia anadria, Parnassia palustris, Osmanda japonica, Thesium chinensis,* etc. The typical variant exists on the erosion landform of the upper part of the slope and typical subassociation is distributed from the middle to the lower part. The differential species include *Eupatorium lindleyanum, Aralia cordata, Astilbe microphylla, and Pedicularis resupinata. Isodon tricocarpus* subassociation has come into existence on the lower part of the slope or in the habitat with much moisture among ravines and around running water areas. Its differential species is *Plectranthus trichocarpus* (*Isodon trichocarpus*).

IV. The investigation of the standing crop in each vegetation unit of *Miscanthus sinensis* grassland

This investigation took place five times over the period of five months from June through November concerning plot 1, plot 2 and plot 3, and also five times concerning plot 4, twice in May and once each in June, September and December.

June is the time of growth of *Miscanthus sinensis* when the nutriments begin to move from the underorgan to the shoot; August is its accumulation period. September is the blooming time; it forms ears, and October and November are the time when nutrition moves from the shoot to the underorgan.

The most typical place in the area where each vegetation unit came to existence was selected for the investigation. Concerning the shoots, two blocks (each one, 1×1 m) were mowed and divided into stems and leaves according to the classification and the average value of their dry weight was used for this investigation. Regarding rhizome of underorgan, the dry weight value of rhizome sampled

Table 1. Seasonal change of the standing crop in Sausreo-Miscanthetum sinensis (Tonomine grassland)

+ Minimum (D. W. g)
* Maximum (D. W. g)
( ) Exclusin of other species

Vegetation			Each organ		May 5	May 23	June	Aug.	Sept.	Oct.	Nov.	Dec.	Maximum (D.W.G/m²) −Minimum (D.W.G/m²)
Sausreo-Miscanthetum sinensis	Subassociation: *Metanarthecium luteo-viride*	Variant: *Leibnizia anadria* (Plot I)	Shoot		—	—	227	284	388	393*	172	—	393*
			Under organ	Rhizome	—	—	301+	603	729	824	924*	—	623
				Root	—	—	540+	992	938	1,373*	1,296	—	833
				Total	—	—	841+	1,595	1,667	2,197	2,220*	—	1,379
			Other sp.		—	—	336	173+	455	675*	400	—	502
			Sum total		—	—	1,404+	2,052	2,510	3,265*	2,792	—	1,861 (1,359)
		Typical (variant) (Plot II)	Shoot		—	—	350	336	353*	250	153	—	353*
			Under organ	Rhizome	—	—	593+	1,407	946	1,610*	753	—	1,017
				Root	—	—	509+	1,046	988	1,598*	1,474	—	1,089
				Total	—	—	1,102+	2,453	1,934	3,208*	2,227	—	2,106
			Other sp.		—	—	397	319	205+	634	996*	—	791
			Sum total		—	—	1,849+	3,109	2,492	4,092*	3,378	—	2,243 (1,452)
	Typical(subassociation) (Plot III)		Shoot		—	—	250	620	722*	582	392	—	722*
			Under organ	Rhizome	—	—	755+	1,607	945	1,972	2,291*	—	1,536
				Root	—	—	716+	1,228	1,027	1,953*	1,434	—	1,237
				Total	—	—	1,471+	2,835	1,972	3,925*	3,725	—	2,454
			Other sp.		—	—	112+	216	200	356*	335	—	244
			Sum total		—	—	1,833+	3,655	2,894	4,863*	4,452	—	3,030 (2,786)
	Subassociation: *Isoden trichocarpus* (Plot IV)		Shoot		161	319	531	—	1,251*	—	—	375	1,251*
			Under organ	Rhizome	765+	795	1,209	—	1,574	—	—	2,156*	1,391
				Root	309+	925	804	—	1,912*	—	—	1,856	1,603
				Total	1,074+	1,720	2,013	—	3,486	—	—	4,012*	2,938
			Other sp.		31+	113	198	—	267*	—	—	186	236
			Sum total		1,266+	2,152	2,742	—	5,004*	—	—	4,573	3,738 (3,502)

from one block (1×1 m) was used. Concerning roots, one soil block (50×50×50 cm) was washed in water, passed through a 1×1 mm mesh screen and after drying they were classified into species and the value excluded dead roots was used. Concerning roots under 50 cm in depth, it was calculated considering the revised value obtained in the past investigation. As regards the species other than *Miscanthus sinensis* the value used was the total one of shoot and underorgan. About the Max.–Min. (D. W. G.) value shown on Table 1 (right) only the Max. value was recorded for the shoot. For the underorgan and for other parts of *Miscanthus sinensis* the value obtained by subtracting the Min. value from the Max. value was also recorded. All these Max. and Min. values were obtained during the period of investigation.

This value is regarded to the one of net production of *Miscanthus sinensis* community. The investigated value of Table 1 is illustlated as Fig. 4–Fig. 7.

Fig. 4 (plot 1) is the diagram of the standing crop of *Metanarthecium Leuteo-viride* subassociation of *Leibnizia anadria* variant illustrated according to the

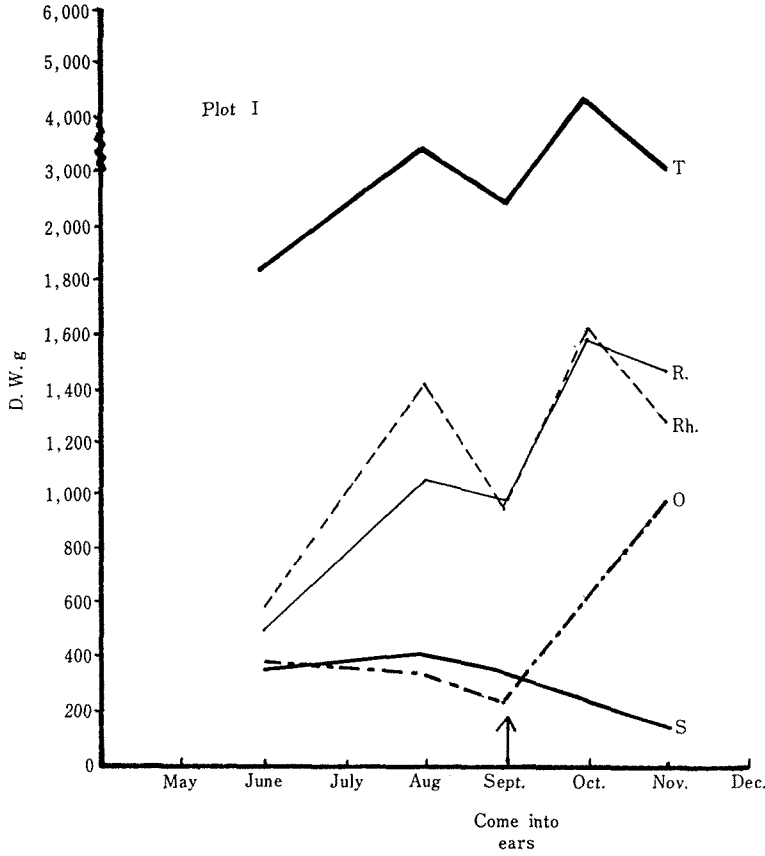

Fig. 4. Seasonal change of each organ (rhizome, root and stem) and other species in the dry weight of the Sausreo-Miscanthetum. (Subassociation: *Metanarthecium leuteo-viride*, Variant: *Leibnizia anadria*)
S: Shoot, Rh: Rhizome, R: Root, O: Other species, T: Total

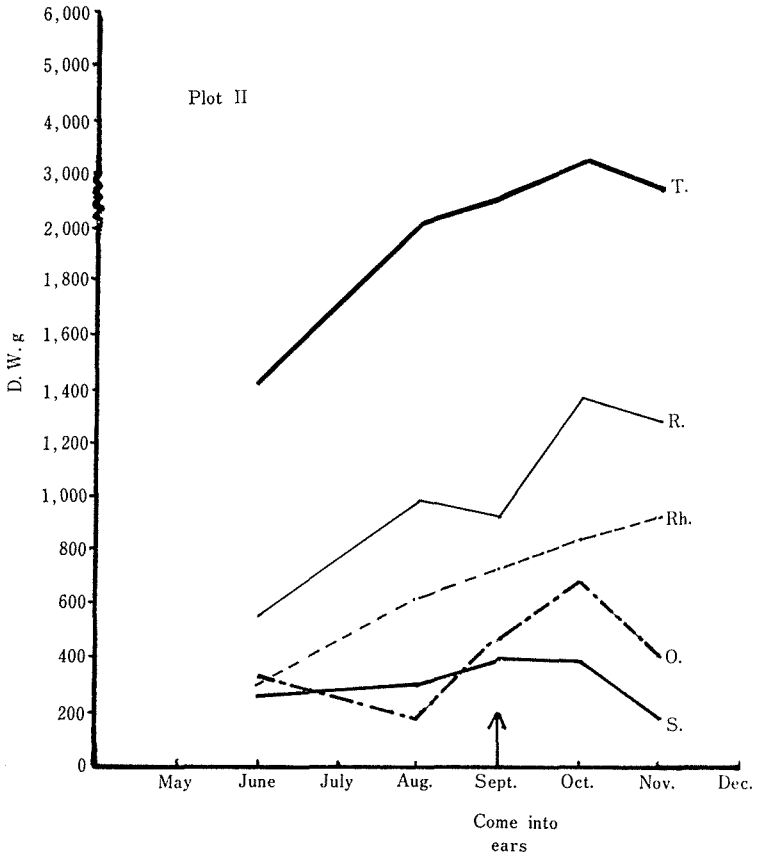

Fig. 5. Seasonal change of organ (rhizome, root and stem) and other species in the dry weight of the Saussureo-Miscanthetum. (Subassociation: *Metanarthecium leuteo-viride*, Typical variant).
S: Shoot, Rh: Rhizome, R: Root, O: Other species, T: Total

seasonal classification. In September, the time of coming into ears, the weight of the shoot increases and that of the underorgan decreases. This phenomenon is considered to be caused by the transferr of nutrients from the underorgan to the shoot for the coming into ears. The Max.–Min. value of the standing crop in total is 1, 861g/m^2 and that of *Miscanthus sinensis* alone is 1, 359 g/m^2.

Fig. 5 (plot 2) is the diagram of the standing crop of Typical variant of *Metanarthecium leuteo-viride* subassociation classified by seasons. About the increase of shoot and the decrease of underorgan in September almost the same tendency with Fig. 4 (plot 1) is observed. The Max.–Min. value of standing crop in total is 2, 243 g/m^2 and *Miscanthus sinensis* alone is 1, 452 g/m^2.

Fig. 6 (plot 3) is the diagram of the standing crop of typical subassociation classified by seasons. About the increase of shoot and the decrease of underorgan in September, almost the same tendency is observed in Fig. 5 (plot 2). The Max.–Min. value of standing crop in total is 3, 030 g/m^2 and *Miscanthus sinensis* alone is 2, 786 g/m^2.

Fig. 7 (plot 4) is the diagram of standing crop of *Isodon trichocarpus* subas-

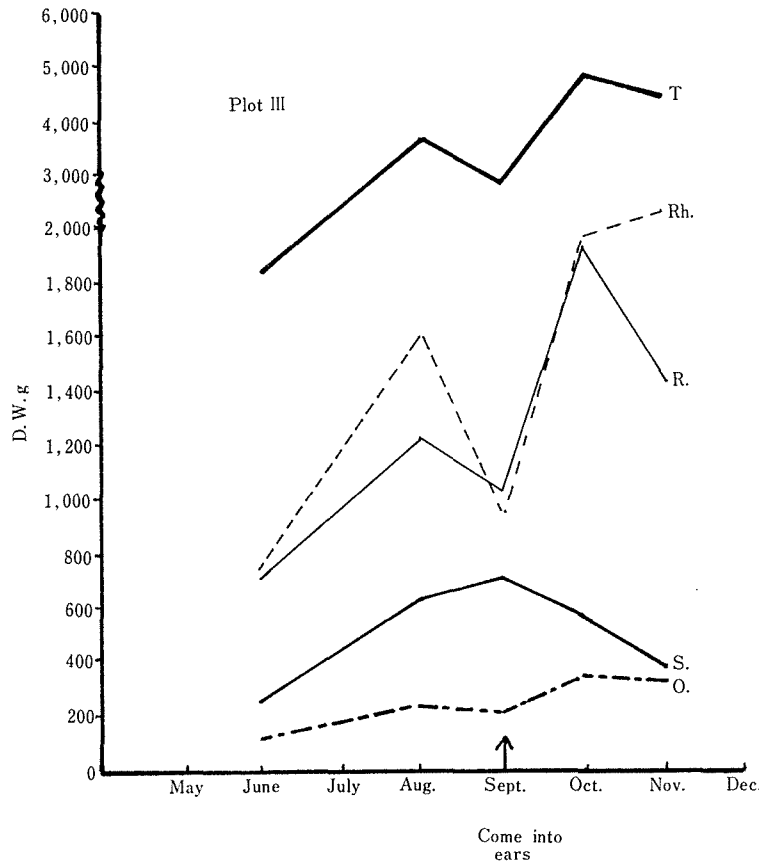

Fig. 6. Seasonal change of each organ (rhizome, root and stem) and other species in the dry weight of the Saussureo-Miscanthetum. (Typical subassociation)
S: Shoot, Rh: Rhizome, R: Root, O: Other species, T: Total

sociation classified by seasons. The cause of the decrease of underorgan in September is not clear. The Max.–Min. value of standing crop in total is 3,738 g/m^2 and *Miscanthus sinensis* alone is 3,502 g/m^2. It is to be noted that the Max.–Min. value of standing crop increases from plot 1 to plot 4, *Miscanthus sinensis* alone, has a difference of 2,143 g/m^2, between plot 1 and plot 4 while in the other species, the difference is 266 g/m^2. Consequently it is understood that there is a considerable difference between the value of standing crop and that of the Max.–Min. per each vegetation unit.

V. Standing crop of Tonomine grassland estimated based on the vegetation map

Table 2 shows the standing crop in each season by ton per hectare, utilizing the vegetation map of Fig. 3. The standing crop was calculated on the basis of the area dominated by each vegetation unit.

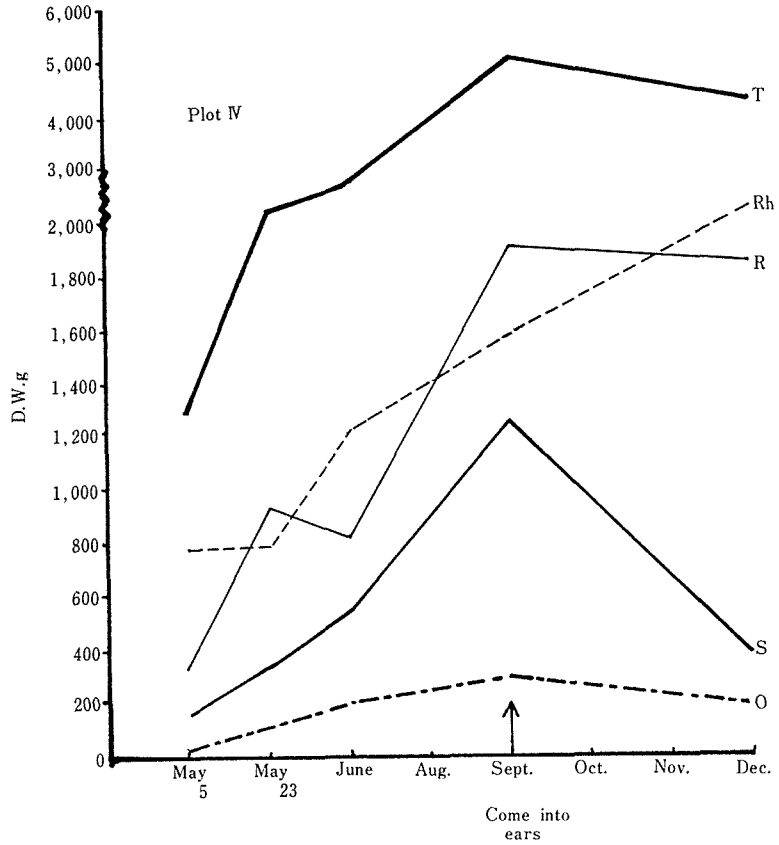

Fig. 7. Seasonal change of each organ (rhizome, root and stem) and other species in the dry weight of the Saussureo-Miscanthetum. (Subassociation: *Isodon trichocarpus*)
S: Shoot, Rh: Rhizome, R: Root, O: Other species, T: Total

The net production of shoot of *Miscanthus sinensis* in Tonomine grassland (35.3 ha in area) is 212.8 tons and it is 6.02 tons per ha. For the underorgan it is 681.04 tons/35.3 ha i. e. 19.29 tons per ha. From these figures it is estimated that the net production of underorgan is about three times that of the shoot. The net production of other species except *Miscanthus sinensis* was 111.38 tons per 35.35 ha i. e. 3.16 tons/ha. The total Max.–Min. value of the whole community is 868.54 tons/35.3 ha i. e. 24.61 tons/ha.

Calculating by the method showing the average value of stands which were investigated in the past (the number of investigated plots described here: 4 plots), the average value of *Miscanthus sinensis* per 1 m^2 per 4 plots is 2,718 gr, and in all the area (35.3 ha), it is 959.45 tons i. e. 27.18 tons/ha. This value is about 90.91 tons/35.3 ha more than the one calculated in each area dominated by each vegetation unit and it can be said that 2.57 tons/ha was overestimated.

This estimation was made on the basis of the measurement value in each vegetation unit obtained by the vegetation investigation. Since the investigation

Table 2. Vegetation units and their relation to the net production and the standing crop.

* Maximum (D. W. g)
\+ Minimum (D. W. g)
( ) Exclusion of other species

Each organ	Plot No.	Area (ha)	May 5 (ton)	May 23 (ton)	June (ton)	Aug. (ton)	Sept. (ton)	Oct. (ton)	Nov. (ton)	Dec. (ton)	Maximum (D. W. t) −Minimum
Shoot	I	19.04	—	—	43.23	54.08	73.89	74.84*	32.76	—	74.84*
	II	2.15	—	—	7.51	7.21	7.57*	5.36	3.28	—	7.57*
	III	8.53	—	—	21.33	52.90	61.60*	49.65	33.44	—	61.60*
	IV	5.58	8.98	17.80	29.63	—	68.80*	—	—	20.92	68.80*
Total											213.81t/35.3ha
Average											6.02t/ha
Uuder organ	I	19.04	—	—	160.15+	303.74	317.45	418.38	422.76*	—	262.61
	II	2.15	—	—	23.63+	52.63	41.48	68.80*	47.76	—	45.17
	III	8.53	—	—	125.50+	241.86	168.24	334.85*	317.79	—	209.35
	IV	5.58	59.92+	95.96	112.30	—	194.49	—	—	223.83*	163.91
Total											681.04t/35.3ha
Average											19.29t/ha
Other species	I	19.04	—	—	63.99+	32.95	86.65	128.54*	76.17	—	64.55
	II	2.15	—	—	8.51+	6.84	4.40	13.60	21.36*	—	12.85
	III	8.53	—	—	9.56+	18.43	17.06	30.37*	28.58	—	20.81
	IV	5.58	1.73+	6.30	11.05	—	14.90*	—	—	10.38	13.17
Total											111.38t/35.3ha
Average											3.15t/ha
Total(Shoot+Under organ+other sp.)	I	19.04	—	—	267.37+	390.77	477.99	621.76*	531.69	—	354.39t:18.61t/ha (289.84t:15.22t/ha)
	II	2.15	—	—	39.65+	66.68	53.45	87.76*	72.40	—	48.11t:22.37t/ha (35.26t:16.40t/ha)
	III	8.53	—	—	156.39+	313.19	246.90	414.87*	379.81	—	258.48t:30.30t/ha (237.67t:27.86t/ha)
	IV	5.58	70.63+	120.06	152.98	—	278.19*	—	—	255.13	207.56t:37.20t/ha (194.39t:34.84t/ha)
Sum total (*Miscanthus sinensis*)											868.54t/35.3ha: 24.61t/ha (757.16t/35.3ha: 21.45t/ha

stands were chosen at random, underestimation seems probable.

Table 3 shows the correspondence between the Max.–Min. value and the production index (Pi) (N, Yano and others 1975) of *Sausreo-Miscanthetum sinensis.*

According to this table, it can be said that the production index of *Miscanthus sinensis* community in Tonomine grassland lies between V–IX. From the fact that the production index has a range from V to IX in Susreo-Miscanthetum sinensis and there is a difference of 1, 877 g/m^2 in the actual measurement value, it is concluded that on this investigation of *Miscanthus sinensis* community, the unit of the association level is too large. From the result of this investigation, it seems that the level unit of subassociation or variant association is an appropriate

Table 3. Production index of Sausreo-Miscanthetum sinensis in the Tonomine grassland.

Net production (D. W. g/m²)	Production index (Pi.)	Vegetation
Less than 250	I	
251— 500	II	
501—1000	III	Sausreo-Miscanthetum sinensis
1001—1500	IV	Subassociation: *Metanarthecium leuteo-viride*
1501—2000	V	—— Variant: *Leibnizia anadria* (Plot I)
2001—2500	VI	—— Typical (variant) (Plot II)
2501—3000	VII	
3001—3500	VIII	—— Typical (subassociation) (Plot III)
3501—4000	IX	—— Subassociation: *Isodon trichocarpus* (Plot IV)
4001—4500	X	
4501—5000	XI	
More than 5001	XII	

vegetation unit for measuring the production of herbaceous community.

VI. Discussion

The Sausreo-Miscanthetum sinensis association appears as a substitutional vegetation replacing Saseto kurilensis-Fagion Crenatae, the dominant vegetation of South-western districts of Japan. For this Sausreo-Miscanthetum sinensis, the value of the underorgan is about 3 times that of the shoot, the moving of quantity of the underorgan being great. This leads to errors in measurement, when the underorgan measurement is not taken into consideration. For the underorgan, the value of the rhizome and of the root are almost equivalent.

A comparison of the ratios of *Miscanthus sinensis* to other species of vegetation over the period of a year showed an inverse relationship as the seasons advanced: in spring other species predominated, while in autumn *Miscanthus sinensi* was most dominant. The same general type inverse relationship appears from plot 1 to plot 4. In plot 1 where the *Leibnizia anadlia* variant grew, the other species amounted to 26.9% of the vegetation. In plot 2 where the Typical variant grew, the other species had as much as 35.3%. In plot 3 where Typical sub-association grew, the amount of other species was only 8.1%. In plot 4 where *Isodon trichocarpus* sub-association grew, other species amounted to only 6.3% of the vegetation.

Disregarding the arbitrary influences of environmental factors such as light and water, the study shows that the classified vegetation unit demonstrates a type of interspecific competition.

Concerning the study on material production which has been made in the past, it is not yet clarified to what vegetation unit the investigated vegetation should belong. Consequently in case of studying the investigated data, it means next to nothing to discuss it on the basis of the common vegetation unit. It is also impossible to make a comparative study. It is necessary in future to determine how to clarify the vegetation unit for a study on the production of vegeta-

tion. In case of measuring the crop production, one must first gather underorgans, Then follows the hard works of excavating and washing. This process is especially paintaking when one is dealing with herbaceous vegetation of which rhizomes develop well. Therefore, it is needless to say that sampling is quite limited in number.

In order to acquire the most accurate data with the least sampling, the investigation must be made in the most typical case selected among vegetation units obtained by the vegetation investigation.

Summary

(1) This study was made on the productivity of grassland based on the vegetation of unit of *Miscanthus sinensis* community in Tonomine grassland located in the southwestern districts in Japan.

(2) The author estimated the seasonal change and the Max.–Min. (net production) case of the standing crop of *Miscanthus sinensis* in a fixed area using the present vegetation map.

(3) As the result of the investigation, it is recognized that underorgan is about three times that of shoot and this is cited as a characteristic of *Miscanthus sinensis*.

(4) The result of the investigation based on the vegetation unit was as follows:
Sausreo-Miscanthetum Sinensis
Metanarthecium leuteo-viride

Max.–Min. of *Leibnizia anadria*	: 1861 g/m^2
Miscanthus sinensis alone	: 1359 g/m^2
Max.–Min. of Typical variant	: 2243 g/m^2
Miscanthus sinensis alone	: 1452 g/m^2
Max.–Min. of Typical subassociation	: 3030 g/m^2
Miscanthus sinensis alone	: 2786 g/m^2
Max.–Min. of Isodon trichocarpus	: 3738 g/m^2
Miscanthus sinensis alone	: 3502 g/m^2

(5) Concerning the Tonomine grassland area of 35.3 ha, the result of calculation in case of Max.–Min. based on the vegetation map showed 868.54 tons/35.3 ha in total, i. e. 24.61 tons/ha and *Miscanthus sinensis* alone showed 21.45 tons/ha.

(6) In case of the study on the vegetation production, we are able to have a full discussion about the results of our study on the common ground only when our study is made based on the vegetation unit.

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