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Phytomass Production of Grasslands in Xilin River Basin, Xilingol, Inner Mongolia, China*

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Synopsis

The grasslands in the Xilin River basin, Inner Mongolia were classified based on land use and land from. Ten stands dominated by different species were recognized according to land use on different land forms: *Festuca dahurica-Artemisia frigida* stand, *Aneurolepidium chinense-Artemisia commutata* stand, *Iris typhifolia-Achnatherum splendens* stand, *Stipa grandis-Aneurolepidium chinense* stand, *Aneurolepidium chinense-Stipa grandis* stand, *Aneurolepidium chinense-Koelaria cristata* stand, *Filifolium sibiricum -Allium condensatum* stand, *Populus davidiana-Betula platyphylla* stand and *Typha angustifolia-Scirpus orientalis* stand. The stands used for grazing were dominated by *Aneurolepidium chinense* and *Artemisia commutata* on the slope and *Festuca dahurica* and *Artemisia frigida* on the summit of hills. The dominant species of meadow were *Stipa grandis, Aneurolepidium chinense* and *Koelaria cristata*. The most common stand in Xilinhot River basin was *Aneurolepidium chinense-Artemisia commutata* community and the stand sampled contained 48 species. The phytomass of the *Aneurolepidium chinense-Artemisia commutata* stand was 1.44 tons in dry weight and 3.44 tons in fresh weight per hectare. The plants of the grassland contained 2 tons of water per hectare. The plant litter and dung of livestock were 1.22 and 0.09 tons per hectare. The floristic composition of the lightly grazed site changed little when the site was protected from grazing for 7 years though average plant height was lessened.

Key words: Inner Mongolia, grassland, phytomass production land use.

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Introduction

In this paper, we described the floristic composition and phytomass production of grasslands in Xilin River basin, Xilingol, Inner Mongolia. The grassland exists under semi-arid conditions in temperate latitude of the Asian interior and has been used as pasture and meadow for sheep, horses and cattles over a period of several thousand years. In earlier times, experienced use by Inner Mongolian peoples kept the pasture good condition. Recently, however, the grasslands have been over grazed by livestocks for commercial production of sheep for wool and meat. As a result, a part of the grasslands is showing a signs of degradiation.

Many studies on ecology of Inner Mongolian gtrasslands have been carried out by Chinese researchers (LI et al. 1962, JIANG et al 1985). Recently, floristic composition, phytomass and phytomass production of the grasslands have been studied as well as soil and climatic conditions in the grasslands (CHEN and WONG 1985, JIANG et al 1985, LI 1985, WONG 1985, LI 1986, LI et al. 1988, LI 1988, CHEN 1988).

Study sites and methods

The study area is located at 43° 43′ N and 116° 38′ E and 1200m in elevation (Fig. 1). According to CHEN (1988), mean annual temperature and total annual precipitation are −0.4℃ and 358.4mm. The grassland has chestnut soil, whose organic content is less than 4% (WONG and CAI 1988).

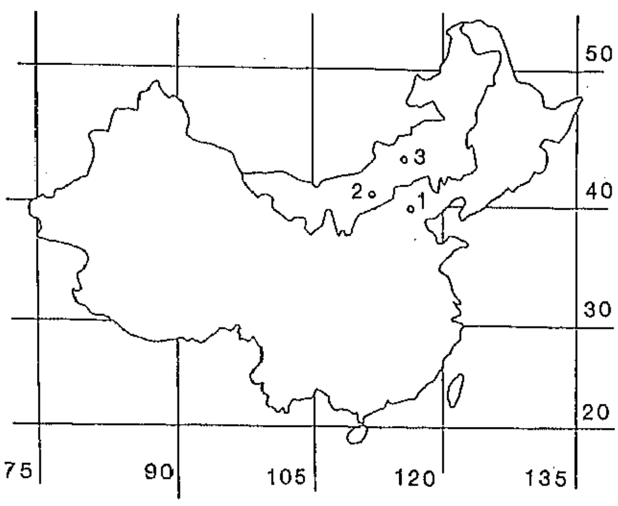

Fig. 1. Locations the studies were carried out in Inner Mongolia, China. 1: Beijing, 2: Huhohot and 3: Xilinhot

A general reconnaissance survey of the grasslands in the Xilin River basin was condacted over several days with the use an automobil. After observation of the several types of grasslands we decided the site for intensive study.

The experimental site chosen for intensive study was on the gentle slope of the hill and was lightly grazed. The stand was dominated by *Aneurolepidium-chinense*, *Stipa grandis* and *Artemisia commutata*. The investigation was carried out from 21st, July to 3rd, August in 1987.

In the experimental site, we laid out a total of 80 quadrats each 50×50 cm on a side. These were located every 10m along 8 parallel lines of 100m which were also spaced 10m apart (Fig. 2).

Fig. 2. The study site phytomass measurement was carried out.

Plants in the quadrat were cut at the base, and each species was kept in a separate plastic bag. The litter and dung of livestock were collected from the quadrats. In the laboratory, we weighed the plants, plant litter and dung after drying them in a oven regulated at 80℃ for 48 hrs.

In order to learn the floristic composition of grazed and protected stands, we did a vegetation survey in the above mentioned grazed stand and another protected from grazing for 7 years. We measured plant height of the tallest plant and coverage for each species in 1m×1m quadrat. A total of 10 quadrats were laid out at 2m interval along two lines 10m apart.

The floristic composition is described with NUMATA's Summed Dominance Ratio (SDR).

Results

Combining the landform and land use, we recognized following 10 stands dominated by different plant species: *Festuca dahurica -Artemisia frigida*, *Aneurolepidium chinense-Artemisia commutata*, *Iris lactea-Achnatherum sibiricum*, *Stipa grandis-Aneurolepidium chinense*, *Aneurolepidium chinense-Stipa grandis*, *Aneurolepidium chinense-Koelaria cristata*, *Chenopodium album-Artemisia* spp., *Filifolium sibiricum-Allium condensatum*, *Populus davidiana-Betula platyphylla* and *Typha angustifolia-Scirpus* sp. (Table 1).

Table 1. Stand classification of the grasslands in Xilin River Basin Xilingol, Inner Mongolia

Land use	Land form I. Summit	 II. Slope	 III. Valley
A. Pasture	*Festuca dahurica* *Artemisia frigida* stand	*Aneurolepidium chinense* *Artemisia commutata* stand	*Iris lactea* *Achnaterum splendes* stand
B. Meadow	*Stipa grandis* *Aneurolepidium chinense* stand	*Aneurolepidium chinense* *Stipa grandis* stand	*Aneurolepidium chinense* *Koeleria cristata* stand
C. Crop land		Spring wheat *Chenopodium album* stand	Vegetable garden
D. Unutilized	*Filifolium sibiricum* *Allium condensatum* stand	*Populus davidiana* *Betula platyphylla* *Ulmus pumila* stand.	*Typha angustifolia* *Scirpus sp.* stand

These dominant grass species belong to subfamily of Pooideae. And their dispersal from is clitochore with awn.

The basic land from of Xilin River basin is a hill with long slope, shallow valley and broad summit area. The Inner Mongolian people have selectively utilized various landsurface for grazing, mowing and the cultivation of wheat. The summit, slope and a part of valley were used for grazing and foot hill was used as a crop lands. Places distant from water for livestock (ponds, river and lakes) have been used for the meadow. The most wide spread stand on the slope of hills was *Aneurolepidium chinense-Artemisia commutata* community. Therefore the intensive survey, including phytomass measurement, was conducted in this stand. The relationship between sample size and coefficient of variance of the above-ground phytomass is given Fig. 3. The coefficient of variance decreased exponetially with increase of sample size and was about 30 percent with 80 samples.

The weight ratio of dry to fresh materials for each species, litter and dung is shown in Table 2. The ratios vary from 0.19 to 0.52 for plants, and were 0.86 for the litter and 0.90 for the dung. The mean, maximum and minimum dry weights of above-ground are given in Table 3 for above-ground phytomass, litter and dung. The mean weight of phytomass was 36.1g per 50×50cm sample with maximum and minimum weights of 83g and 15g. The mean weights of litter and dung were 36.6g. and 2.5g for

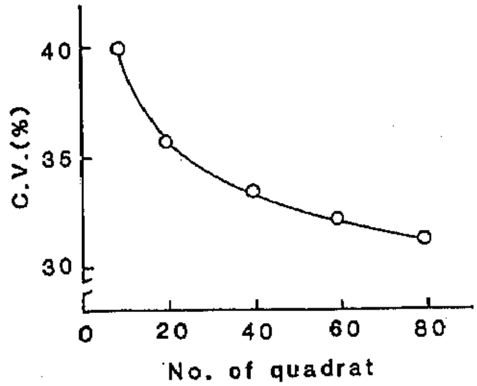

Fig. 3. Relationship between sample size and coefficient of variation (C.V.%)

Table 2. The ratio of dry to fresh weights of plants, litter and dungs in the grassland in Inner Mongolia

Species	Ratio of dry: fresh weight
Aneurolepidium chinenese	0.45
Stipa grandis	0.52
Artemisia commutata	0.34
Artemisia frigida	0.45
Agropyron cristatum	0.46
Carex korshinskyi	0.45
Caragana microphylla	0.39
Allium spp.	0.19
Herbaceous plants	0.31
Grass plnats	0.46
Plant litter	0.86
Dung of livestock	0.90

Table 3. The weight of phytomass, plants litter and livestock dung in the grassland in Xilin river basin. SD and C.V. are the standard deviation and coefficient of variance (C.V.%)

	Phytomass	Litter (g per 50 x 50 cm)	Dung
Sample size	80	80	80
Maximum weight	83	220	32
Minimum weight	15	12	0
Mean weight±SD	36.1±11.1	36.6±25.4	2.5±3.8
C. V.	30.8	71.4	151.3

sample area respectively. The standard deviations are 11.1 for phytomass, 25.4 for litter and 3.8 for dung. Histograms of weight of above-ground phytomass, litter and dung are given in Fig 4. The figures show that the above-ground phytomass weight has a normal distribution, however distribution of dung in the site was contagious. The phytomass weight for each constituent species is given in Table 4. A total of forty eight species were found in sample site. The most important species are as follows: *Artemisa commutata* (973g per $20m^2$),*Stipa grandis* (635.6g per $20m^2$) and *Aneurolepidium chinense* (314.9 per m^2). On the basis of this sample the total weight converted to figure per hectare would be 1.44 tons in dry and 3.44 tons in fresh above-ground phytomass, 1.22 tons in litter and 0.09 tons in dung. The above-ground phytomass contained 2 tons of water per hectare.

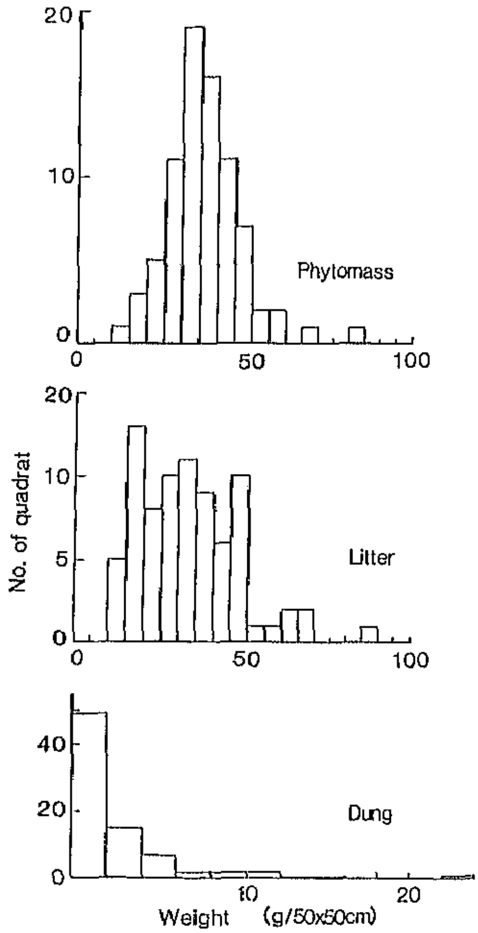

Fig. 4. Histograms of weight of above-ground phytomass, litter and dungs of livestocks in quadrat of area in 50x 50cm

Table 4. Floristic composition of the grassland based on the above-ground phytomass in the Xilin River basin, Inner Mongolia in a total sample area of $20m^2$

Species	Above-ground phytomass Fersh weight	Dry weight
Artemisia commutata	2162.2	973.0
Stipa grandis	1222.4	635.6
Aneurolepidium chinense	926.3	314.9
Agropyron cristataum	444.2	203.4
Caragana microphylla	583.0	198.2
Achnatherum sibiricum	218.5	100.5
Heteroppappus altaicus	255.6	79.2
Artemisia frigida	139.4	62.7
Carex korshinskyi	120.9	54.4
Serratula centauroides	169.1	52.4
Kochia prostrata	98.7	35.5
Koeleria cristata	54.8	25.2
Potentilla acaulis	62.8	22.6
Poa attenuata	24.1	11.1
Artemisia scoparia	29.7	10.1
A. tenuissimum	49.4	9.4
A. senescens	47.2	9.0
Silene jenisseensis	28.3	8.8
Cleistogenes squarrosa	23.2	7.2
Orostachys malacophyllus	23.0	7.1
Thalictrum squarrosum	22.3	6.9
Gentiana squarrosa	17.5	5.4
Potentilla bifurca	16.1	5.0
Potentilla tanacetifolia	14.8	4.6
Melissitus ruthenica	11.9	3.7
Salsola collina	7.8	2.4
Allium condensatum	11.7	2.2
Gentianopsis barbata	5.9	1.8
Artemisia sieversiana	9.5	1.8
Cymbaria dahurica	5.7	1.8
Saposhnikovia divaricata	5.7	1.8
Allium ramosum	9.1	1.7
Lappula myosotis	5.4	1.7
Dontostemon micranthus	5.2	1.6
Thermopsis lanceolata	4.6	1.4
Thalictorum petaloideum	4.6	1.4
Haplophyllum dauricum	4.1	1.3
Oxytropis myriophylla	3.8	1.2
Pedicularis striata	3.2	1.0
Astragalus adsurgens	2.8	0.9
Allium bidentatum	3.3	0.6
Leonotopodium leontopodioides	1.4	0.4
Chenopodium album	1.2	0.4
Allium anisopodium	1.2	0.2
Galium verum	0.3	0.1
Scutellaria scordifolia	0.1	0.0
Gueldenstaedtia stenophylla	0.1	0.0
Other herbs	15.5	4.8
Phytomass($g/20m^2$)	6877.3	2888.5
Phytomass(ton/hectare)	3.4	1.4
Litter($g/20m^2$)	2888.9	2896.7
Litter(ton/hectare)		1.2
Dung of livestock($g/20m^2$)	203.0	182.7
Dung(ton/hectare)		0.1

The ranking of species by above-ground phytomass weight shows a geometrical relationship (Fig. 5).

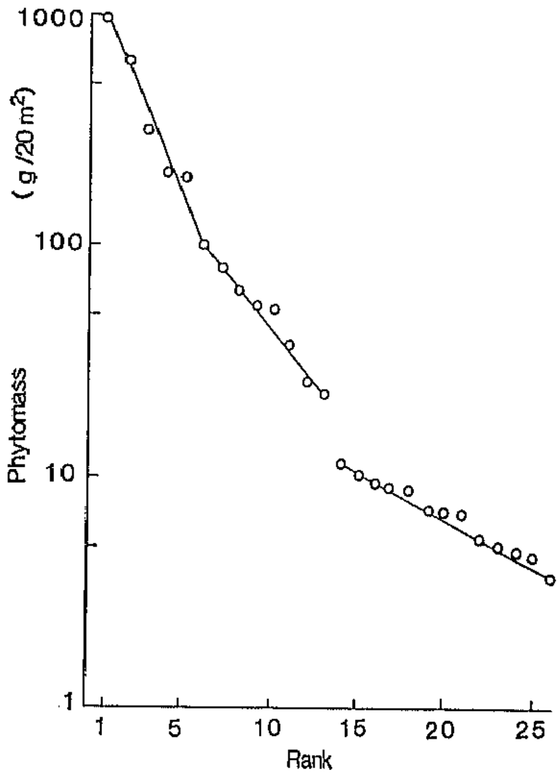

Fig. 5. Relationships between rank in order of species and phytomass of the species

The floristic composition of areas which has been grazed and those which have been protected from grazing for 7 years, is given in Table 5. The dominant species calculated using NUMATA's Summed Dominance Ratio is *Stipa grandis*, and the important constituent species are *Aneurolepidium chinense*, *Artemisia commutata* and *Achnatherum sibiricum* in the both stands. The species composition and relative importance of these stands is similar though the average plant height of protected plot is taller than that of grazed one. However, it is noticeable that *Allium senescens* disappeared in the protected stand and *A. condensatum* and *A. anisopodium* appeared.

The result, however, was obtained under condition of light grazing pressure. The same experiment would be needed under the condition of more heavier grazing pressure.

Table 5. Floristic composition of grazed stand and protected stand for 7 years

Species	Grazed stand Height (cm)	Grazed stand SDR*	Protected stand Height (cm)	Protected stand SDR
Stipa grandis	40.5	97	67.3	100
Aneurolepidium chinense	43.8	88	53.5	83
Artemisia commutata	30.2	84	44.6	75
Achnatherum sibiricum	32.1	68	49.6	67
Agropyron cristatum	22.5	55	31.9	42
Heteropuppus altaicus	11.7	45	31.4	50
Caragana microphylla	18.0	41	29.4	52
Koeleria cristata	7.7	38	44.1	50
Orostachys malacophylus	1.8	37	1.7	11
Artemisia frigida	12.5	35	19.3	31
Poa attenuata	38.4	34	50.4	46
Gentiana squarrosa	4.6	30	7.3	11
Allium senescens	9.2	28	—	—
Gentianopsis barbata	7.7	28	12.5	16
Carex korshinskyi	12.0	28	21.8	45
Silene jenisseensis	4.6	27	45.0	22
Potentilla bifurca	5.2	26	29.0	14
Dontstemon micranthus	4.6	21	19.3	31
Cleistogenes squarrosa	5.9	21	13.1	37
Potentilla acaulis	0.9	16	3.5	15
Thalictrum petaloideum	6.8	16	39.7	19
Serratula centauroides	14.0	14	21.9	33
Alluim bidentatum	10.0	13	8.0	4
Potentilla tanacetifolia	12.0	13	34.6	18
Artemisia scoparia	9	12	32.2	34
Salsola collina	8.3	12	9.3	12
Allium tenuissimum	9.6	10	27.8	38
Lappula redowskyi	11.0	8	21.0	13
Oxytropis myriophylla	9.5	8	18.0	4
Artemisia sieversiana	4.5	8	3.0	13
Saposhnikovia divaricata	5.5	8	24.7	14
Allium ramosum	9.5	8	41.4	28
Thermopsis lanceolata	11.0	8	14.0	4
Astragalus galactites	8	8	—	—
Kochia prostrata	10.1	7	23.8	42
Melissitus ruthenica	10.0	7	29.0	20
Gueldenstaedtia verna	4	7	—	—
Draba nemorosa	20	2	—	—
Thalictrum mongolicum	7	1	—	—
Allium condensatum	—	—	41.3	17
Chenopodium album	—	—	4	11
Allium anisopodium	—	—	26.5	10
Limonium bicolor	—	—	16	9
Cymbaria dahurica	—	—	11	8
Pedicularia striata	—	—	4	4

*Numata's Summed Dominance Ratio

Discussion and conclusion

In order to study phytomass production, we have to decide the quadrat area and sample size for the grassland (SHIMADA 1959, SHIYOMI 1987). According to SHIYOMI (1987), if we harvest phytomass from the same area, large sample size of 50 × 50cm quadrat is more efficient than small sample size of 1 × 1m quadrat for precise estimation of phytomass.

In the case of Inner Mongolian grasslands, if we collect 80 samples of 50 × 50cm quadrats, the mean weight of above-ground phytomass and coefficient of variance (C. V.) were 36.1g and 30.8%. Therefore, the mean phytomass weight was estimated as from 18.3g to 53.9g per area of 50×50cm with 95% of confidence interval.

The weight of phytomass was obtained on 1st of August 1987. However, seasonal change of the phytomass weight is expected as is change from one year to next year at the same season.

LI (1986) and LI et al. (1988) reported the seasonal change of above ground-phytomass in a period from 1980 to 1987 in the grasslands of Xilin River basin. Their results showed that the maximum above-ground weight per m^2 varied from 332g in 1981 to 112g in 1983. Based on the their data, the growth curve of above-ground phytomass of the grassland was illustrated in Fig. 6. The solid circles in the figure indicate

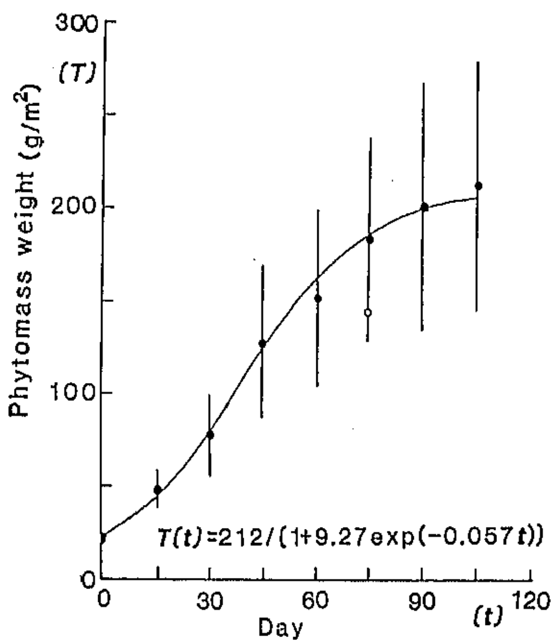

Fig. 6. Growth curve of avobe-ground phytomass in the *Aneurolepidium chinense -Artemisia commutata* community. Vertical bars are standard deviation (SD). An open circle in the figure is the data obtained by us 1st August 1987.

the average weight of phystomass for 8 years from 1980 to 1987 and vestical bars are standard deviation. The growth curve in the figures is defined by following equation:

$$T(t)=212/\ [1+9.27\exp\ (-0.057t)] \quad \cdots\cdots(1)$$

where $T(t)$ is above-ground phytomass per square meter at t and t is the days from 1st of May (Zero of day). According to this equation, we are able to estimate the phytomass at the time t. For example, on 1st of August, we would expect to phytomass to be 187g because the time is 75th day from 1st of May. The actual weights obtained by LI et al. (1988), and by us on 1st of August 1988, were 183.6g. and 141g respectively. Our figure was less than that predicted by equation (1). In order to know the total phytomass in the stand, we estimated below ground phytomass using the relationship between the weighs of above-ground and belowground phytomasses. The relationship was illustrated in Fig. 7 and is based on the data from LI et al. (1988), who obtained these data from the stands of *Stipa baicalensis*, *Aneurolepidium chinense*, *Stipa grandis*, *S. krylovi*, *Artemisia frigida* and *Bromus inermis*. As shown in the Fig. 7 the relationship of

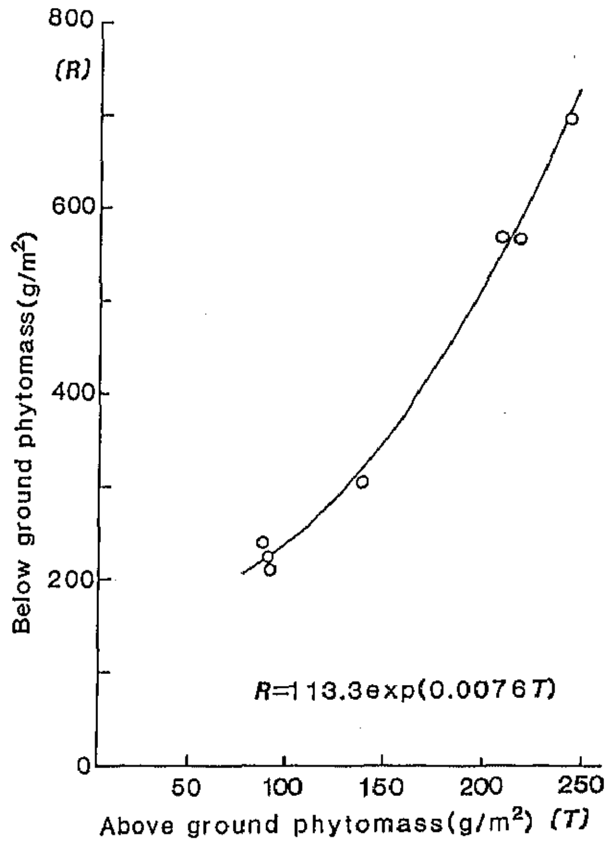

Fig. 7. Relationship between the weights of above-ground phytomass and belowground phytomass .

above-ground (T: g) and belowground (R: g) weight was exponetial and described as follows:

$$R=113.3\exp\ (0.0076\,T) \quad \cdots\cdots (2)$$

Therefore, total weight of the stand (W: g per m^2) is obtained by following equation:

$$W=T+113.3\exp\ (0.0076\,T) \quad \cdots\cdots (3)$$

Using these equations, we are able to estimate the weight of below ground phytomass and total phytomass with the weight of above-ground weight. According to equations (2) and (3), the weights of belowground and total phytomass per m^2 are expected to be 339.5g and 483.9g for the stand which we studied on 1st of August 1988. It should be noticed, however, these equations are applicable only when the stand is mature.

Concerning the grazing of the grasslands, floristic composition of grazed and ungrazed areas was very similar. However, it should be noticed that the result is obtained from the stand lightly grazed.

Because species composition of grasslands is easily changed by grazing, it may be concluded that grazed pressure on our study site must be moderate. Information on phytomass production and floristic composition of grazed stand can indicate grassland condition and be used for management.

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