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Effects of drought climate on the photosynthesis of *Aneurolepidium chinense* community in the typical steppe region of Inner Mongolia

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Abstract—Under the dry weather conditions in the typical steppe region of Inner Mongolia, the diurnal change curve of photosynthetic rate of *Aneurolepidium chinense* community is a curve of "double peaks" with midday depression. The photosynthetic rate in the morning is height than in the afternoon, which is related to the water condition at that time. The decrease range of community photosynthetic rate at noon is closely correlated with the low air relative humidity and soil moisture, the photosynthetic rate decreases less under better water condition.

The instantaneous photosynthetic rate and diurnal net photosynthesis declined in dry condition, but they rised after irrigation or nitrogen-fertilization. Thus irrigation and fertilization is a effective way to improve grasslands and to raise grassland productivity.

Keywords: *Aneurolepidium chinense*; photosynthetic rate; drought climate.

INTRODUCTION

The typical steppe of Inner Mongolia is an important base for developing animal husbandry in China. The natural grasslands provide the rich forages for domestic animals. The change of natural conditions directly effects the grass growth and is closely correlated with the development of animal husbandry.

Climatically, the region belongs to middle-temperate, semiarid zone. The dry and cold are main characteristics. The mean annual precipitation is about 300mm with a large fluctuation of 180–450mm, and 60–80% of which is concentrated on the period of July, August and September. The less rainfall in April to June is an unfavorable condition for grass growth. The annual average temperature is -0.4°C. January is the coldest month and its average temperature is −23°C. The absolute lowest temperature is −47.5°C. The non-frost period is only about 90 days.

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For exploring the effect of ecological factors on the grass growth, the photosynthesis of *Aneurolepidium chinense* community was measured in 1982 and 1984. In order to further explore the way of increasing grass yield, the experiments of irrigation and fertilization were made.

MATERIALS AND METHODS

The experiments were done in Inner Mongolia Grassland Ecosystem Research Station of Academia Sinica. The following three treatments were used to an *Aneurolepidium chinense* community: natural treatment, irrigation treatment and irrigation plus fertilization treatment. The measurements were done from June 28 to July 19, 1982 with ten-day intervals, each measurement continued for twenty-four hours. In 1984, the measurements were done from June to September i.e., during the plant growing season, there were six times in all. Each measurement continued two days for every fifteen days. The photosynthetic rate and respiratory rate of community, soil respiration rate, the photosynthetic effective radiation, air temperature, air relative humidity, the structure and biomass of plant community, soil moisture and so on were measured.

The diurnal changes of community photosynthetic rate and the ecological factors were measured using an assimilation chamber under natural condition.

RESULTS AND DISCUSSION

The effects of dry conditions on the diurnal changes of community photosynthetic rate

According to the report, the diurnal changes of plant photosynthetic rate can be divided into four types: single peak type, level type, change type and double peak type (Yoshiji, 1979). Through measurements, the diurnal change of photosynthetic rate of *Aneurolepidium chinense* community belongs to the noon descent form under dry conditions (Fig.1). The high peak appears in the morning and afternoon, respectively. The photosynthetic rate declines at noon, which can be called "noon-rest" (Qi, 1983). The photosynthetic rate increases with the increase of the photosynthetic active radiation and temperature before 9 o'clock. The photosynthetic rate decreases with the decrease of the photosynthetic active radiation and temperature after 17 o'clock. Though the photosynthetic active radiation and temperature is higher around noon, the photosynthetic rate decline because of the decrease of relative humidity at 8–16 o'clock. The lowest relative humidity is below 40% and the average relative humidity is 54.13%(Fig.1). Thus lower air relative humidity and soil moisture(6.9%) is the main cause of the community photosynthetic rate decrease around noon.

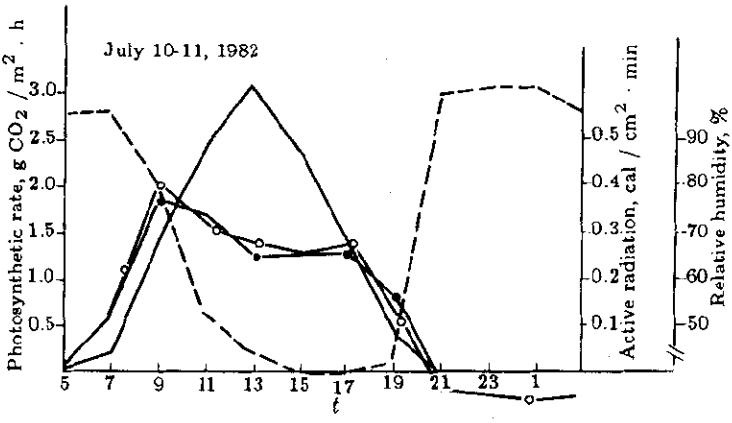

Fig.1 Diurnal change of photosynthetic rate and environmental factors
1. photosynthetic active radiation; 2. relative humidity; 3. and 4. photosynthetic rate of natural community (two times repetition). 5. photosynthetic rate of irrigation community. 6. photosynthetic rate of irrigation plus fertilization community

Fig.1 shows that the photosynthetic rate is higher in the morning than in the afternoon. The photosynthetic active radiation is similar in the morning and in the afternoon, while the air relative humidity in the morning is better than in the afternoon, thus the difference of photosynthesis is closely correlated with the water conditions.

With the printing method are observed, the result shows the stomas are closed around noon because of dry conditions. Thus the photosynthetic rate at noon declined more.

The effects of different dry conditions on the photosynthetic rate at noon

The declination of community photosynthetic rate at noon is expressed using the ratio of the lowest photosynthesis value at noon to the highest value of the day. The dry grade is expressed with the air relative humidity and soil moisture.

When the highest air temperature is above 30°C, air relative humidity is about 40%, soil moisture is below 6%, the community photosynthetic rate at noon declines above 60%(Fig.2)

When the highest air temperature is above 25°C, the lowest relative humidity is below 40%, soil moisture is between 6% and 7%, the community photosynthetic rate at noon declines between 30% and 60% (Fig.3).

When the highest temperature is about 25°C, the lowest relative humidity is between 50% and 60%, soil moisture is between 7% and 8%, the community photosynthetic rate declines

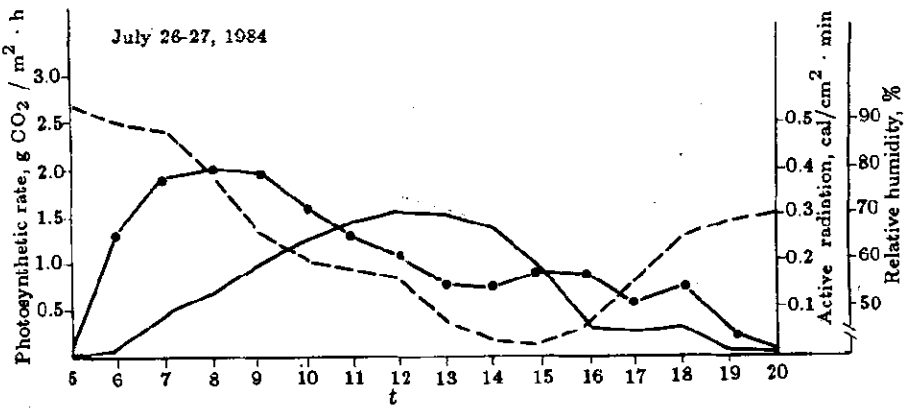

Fig.2 Diurnal change of photosynthetic rate and relative humidity (decreased above 60%)
(The legend is the same as to Fig.1)

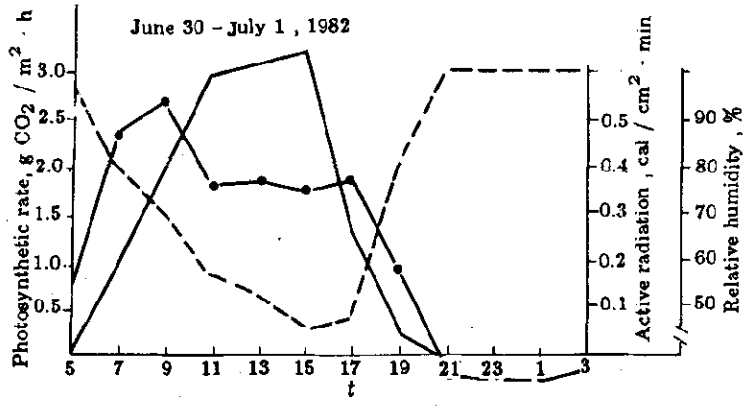

Fig.3 Diurnal change of photosynthetic rate and relative humidity (decreased 30% to 60%)
(The legend is the same as to Fig.1)

about 20%(Fig.4).

When the highest temperature is between 20°C and 25°C, the lowest relative humidity is above 60%, soil moisture is above 10%, the community photosynthetic rate declines below 10%(Fig.5).

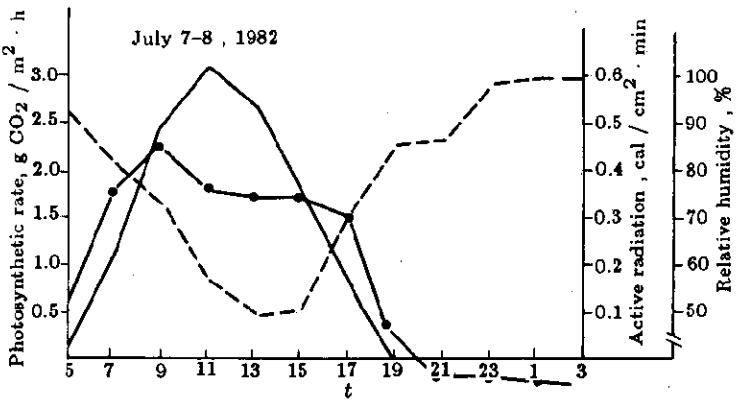

Fig.4 Diurnal change of photosynthetic rate and relative humidity (decreased 20%)
(The legend is the same as to Fig.1)

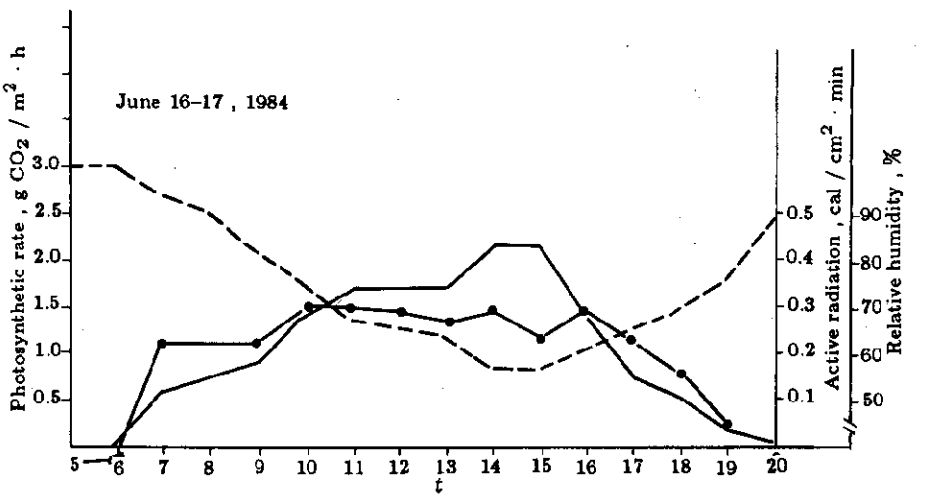

Fig.5 Diurnal change of photosynthetic rate and relative humidity (decreased below 10%)
(The legend is the same as to Fig.1)

The fall ranges at noon of community photosynthetic rate are different with the distinct difference of water conditions.

The effect of dry condition on the diurnal net photosynthesis of community

During the measurement from June 28 to July 19, 1982, the relative humidity declined from 78.17% to 44.5%, the lowest relative humidity declined from 64%to 29%, the soil moisture (average value of 50cm soil depth) decreased from 7.97% to 5.74%, the diurnal net photosynthesis fell from 27.83g CO_2m^{-2} to 4.91g CO_2m^{-2}, at a reduction of 82.36%, mainly due to decline of humidity conditions(Table 1).

Table 1 The diurnal net photosynthesis of natural community and humidity condition

Measurement data	Diurnal net photosynthesis, gCO_2m^{-2} day	Relative humidity, %	Soil humidity, %	Water content of leaves, %
28 June	27.83	78.17	7.97	169.69
11 July	16.01	58.33	7.51	144.59
19 July	4.91	44.50	5.74	114.59

The way of raising community photosynthetic rate

After irrigation and fertilization treatments, the dry condition was improved and the plants grew faster, the photosynthetic rate was raised (Table 2, Qi, 1990). The diurnal net photosynthesis of community with irrigation were raised 40.5% and 148.2% by 10 and 20 days after the treatment, respectively.

Table 2 Raising rate on diurnal net photosynthesis of *Aneurolepidium chinense* community Unit: %

	Measurement time		
Treatment No.	1	2	3
b : a	26	40.5	148.2
c : a	17	83.6	275.7

1. 1-3 days after treatment; 2. 11-13 days after treatment;
3. 21-23 days after treatment; a. natural community;
b. irrigation community; c. irrigation plus fertilization community.

The net photosynthesis of community with irrigation plus fertilization were raised 83.6% and 275.7% by 10 and 20 days after treatment, respectively. The effect of irrigation and fertilization treatments was more obvious.

The diurnal change of community photosynthetic rate is given in Fig.6.

As regards the irrigation plus fertilization treatment, the diurnal change of community photosynthetic rate is single peak type without a reduction at noon, and the photosynthetic light saturation point is raised from 0.45 cal./cm^2.min to 0.65 cal./cm^2.min. Thus the irrigation and fertilization may increase the community photosynthetic rate.

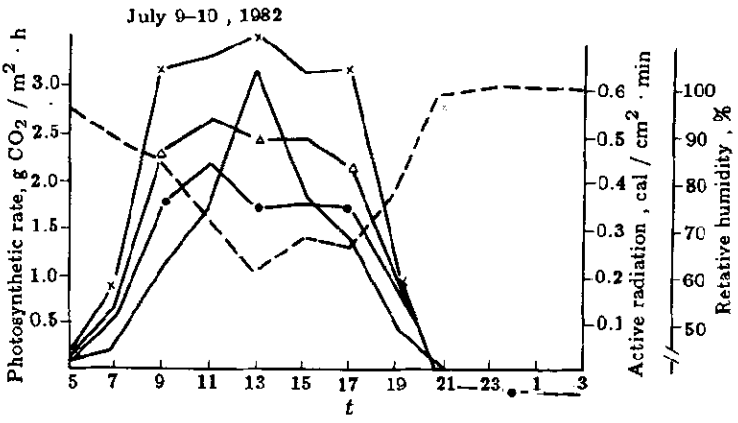

Fig.6 The diurnal changes of photosynthetic rate of different treatments (nature, irrigation, irrigation plus fertilization)
(The legend is the same as to Fig.1)

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