No. B-6.1.2 Quantitative Analysis of Carbon Cycling in Pasture

Contact Person Hiromitsu Kirita
Dep. of Ecology , National Grassland Research Institute
Sembonmatsu 768,Nishinasuno,Nasu,Tochigi, 329-27 Japan
Tel 0287-36-0111(Ext.272) Fax 0287-36-6629

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Abstract An attempt is being made to measure the flow rates of carbon pathways in grazing pastures to make a simulation model of carbon cycling.According to the prototype model,it was calculated that the amount of CO_2 emitted from the grassland ecosystem to atmosphere were larger than the amount of CO_2 taken in from atmosphere to the grassland ecosystem on annual basis.On the other hand,CO_2 gas fluxes in grazing pastures are measured directly by eddy correlation method.The amount of CO_2 absorbed by grassland were larger than the amount of CO_2 emitted to atmosphere per diem when they were measured at fine days.

Key Words Pasture, Carbon Budget, Soil Respiration, Simulation Model, Eddy Correlation Method

1.Introduction

Greenhouse effect gases such as carbon dioxide and methane had been balanced in the global ecosystem.But its balance has been upset by the human activities such as consumption of fossil fuel,felling of forests and farming. Now the atmospheric concentrations of CO_2 and other trace gases that induce climate warming are increasing year by year.

So it is necessary to clarify the mechanism of carbon cycling in the grassland ecosystem to know whether grassland is a sink or a source of carbon. It is also necessary to evaluate how much the climatic changes will influence the carbon budget of grassland ecosystems.

2.Research Objective

In this study,an attempt is being made to measure the flow rates of carbon pathways in grazing pasture to make a simulation model of carbon cycling. By using this model,the carbon budget of pasture and its contribution to climate warming will be clarified.Moreover,CO_2 gas fluxes in grazing pastures are measured to verify the model.

3.Research Method

(1)A compartment model of carbon cycling in grazing pasture was examined and the main pathways of carbon cycling were determined(Fig.1).

(2)To obtain the data required to analyze the carbon flows of grazing pasture,biomass of herbage,root biomass,amount of litter and amount of herbage intake etc. were measured regularly.

(3)To measure the CO_2 gas fluxes directly in grazing pastures,an ultrasonic anemometer and a CO_2-H_2O fluctuation meter are settled above the vegetation.Fluctuations of wind speed,temperature,atmospheric carbon dioxide and water vapor were measured and gas fluxes were calculated.

4.Results and Discussion

(1)According to the compartment model,a prototype simulation model was made for calculating the amount of carbon budget of each compartment per day.This model was based on the simulation model of energy flow on grazing pasture[1].

A.An outline of the simulation model

Decomposition rates of soil organic matter,litter and feces and respiration rates of roots and cattle were combined to the energy flow model so that the budget of CO2 on grazing pasture could be estimated.

B.Execution of the simulation

The result of calculations are shown in Table 1.

In spring and autumn CO_2 flows has a tendency to be absorbed to the grassland from atmosphere,which has a reverse tendency in summer.

Totally,the amount of CO_2 emitted from the grassland ecosystem to atmosphere were larger than the amount of CO_2 taken in from atmosphere to the grassland ecosystem on annual basis.

(2)Analysis of soil respiration rate

The relationship among soil respiration rate,temperature and water content was examined by using the data formerly obtained by the sponge absorption method[2].

a.CO_2 evolution rate from the soil surface(Fig.2)

CO_2 evolution rate from the soil surface(SRM:g CO_2/m^2/day) was mainly dependent on the soil temperature and well approximated by the next exponential function of average soil temperature at 5 cm depth(T_0:° C).

$SRM=3.371*\exp(0.068*T_0)$ ・・・(1)

b.CO_2 evolution rate from litter(Fig.3,4,5)

CO_2 evolution rate from litter (SRL: g CO2/kg/day) was dependent not only on the temperature(T:° C) but also on the water content of litter intensively.SRL was approximated by the next formula.

$SRL=1.264*\exp(0.065*T)*W^{1.224}$ ・・・(2)

(3)CO_2 gas fluxes measured directly in grazing pastures by eddy correlation method was shown in Fig.6.

CO_2 gas fluxes were dependent mainly on solar radiation,temperature and wind speed.In the daytime,CO_2 absorption fluxes to grassland (downward) were observed (0.456 $g/m^2/hr$) and on the contrary at night CO_2 emission fluxes to atmosphere (upward) were observed (0.211 $g/m^2/hr$).And the amount of CO_2 absorbed by grassland were larger than the amount of CO_2 emitted to atmosphere per diem (0.86 g/m^2).Therefore it is suggested that grassland has possibility of being a sink of carbon.

CO_2 gas fluxes measured in cutting grasslands were shown in Fig.7.CO_2 absorption fluxes (1.410 $g/m^2/hr$) were observed in the daytime and CO_2 emission fluxes (0.141 $g/m^2/hr$) were observed at night.

Both the fluctuations of CO_2 gas fluxes in grazing pasture and cutting grasslands were smaller than ones measured in the paddy field[3] in the summer.

References

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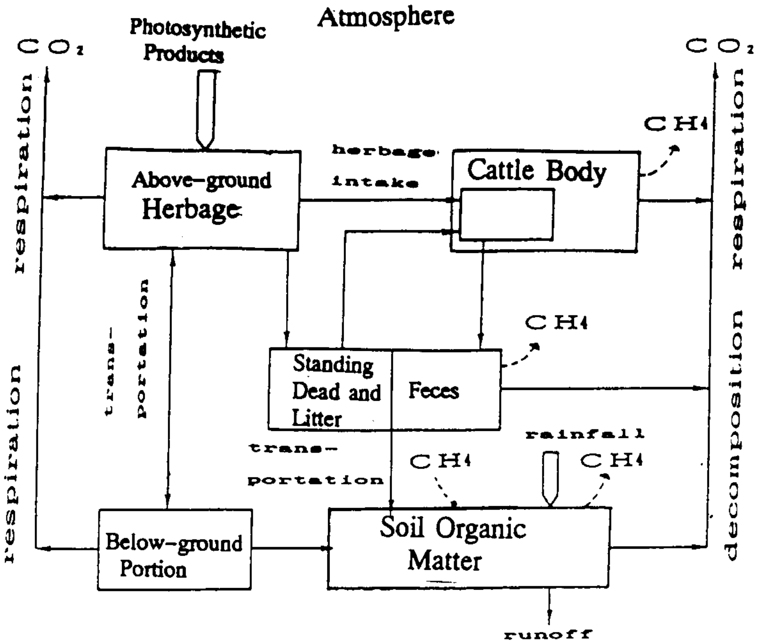

Fig.1 A Compartment Model of Carbon Cycling in Grazing Pasture

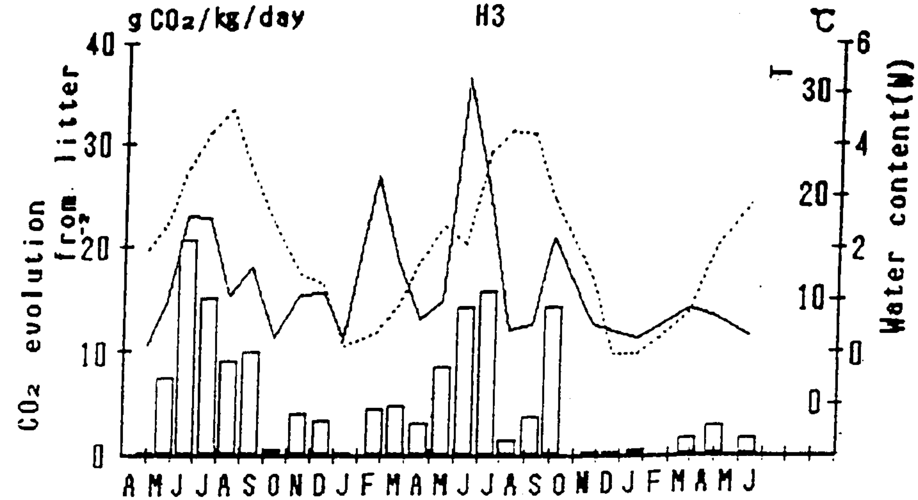

Fig.3 Sasonal variation of CO_2 evolution rate from litter,temperature and water content
solid line : water content (W:dry matter basis)
dashed line : temperature(T)
white bars : CO_2 evolution rate from litter (SRL: g CO2/kg/day)

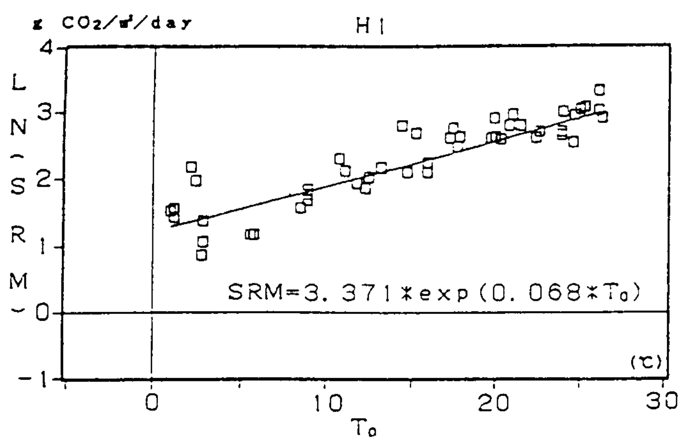

Fig.2 The relationship of CO_2 evolution rate from the soil surface and soil temperature (H1 paddock,1983.6–1986.6)
SRM : CO_2 evolution rate from the soil surface(g CO_2/m^2/day)
T_0 : soil temperature(°C)

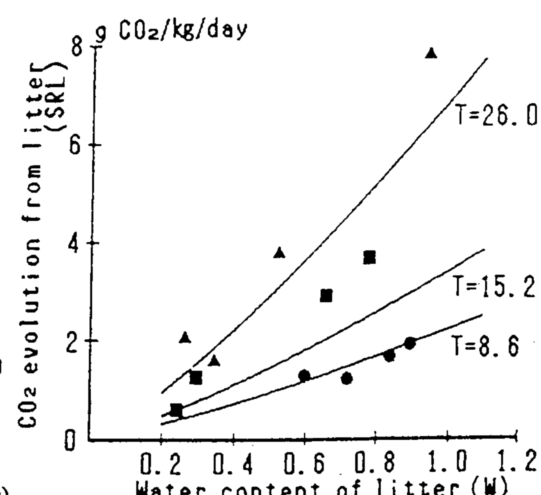

Fig.4 The relationship among CO_2 evolution rate from litter,temperature and water content
solid line : calculated CO_2 evolution rate from litter by equation (2)
dots : observed CO_2 evolution rate from litter

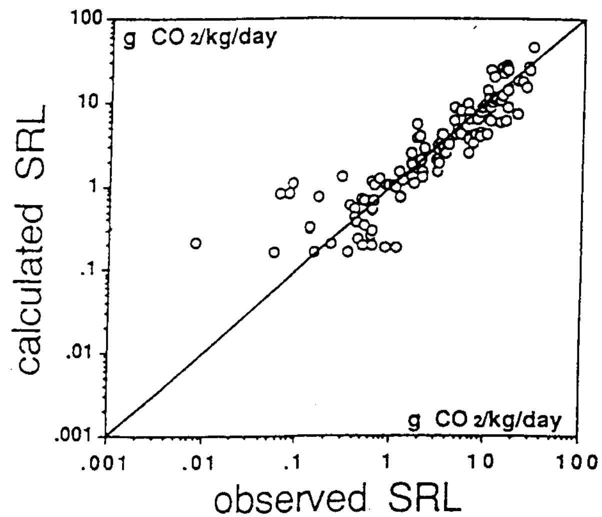

Fig.5 Comparison of calculated SRL and observed SRL

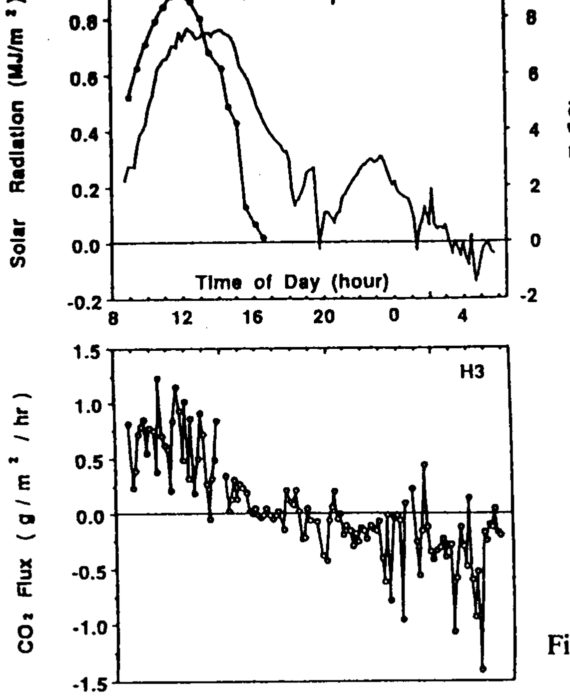

Fig.6 Time variation of CO_2 fluxes,solar radiation and temperature in grazing pasture (H3 paddock)

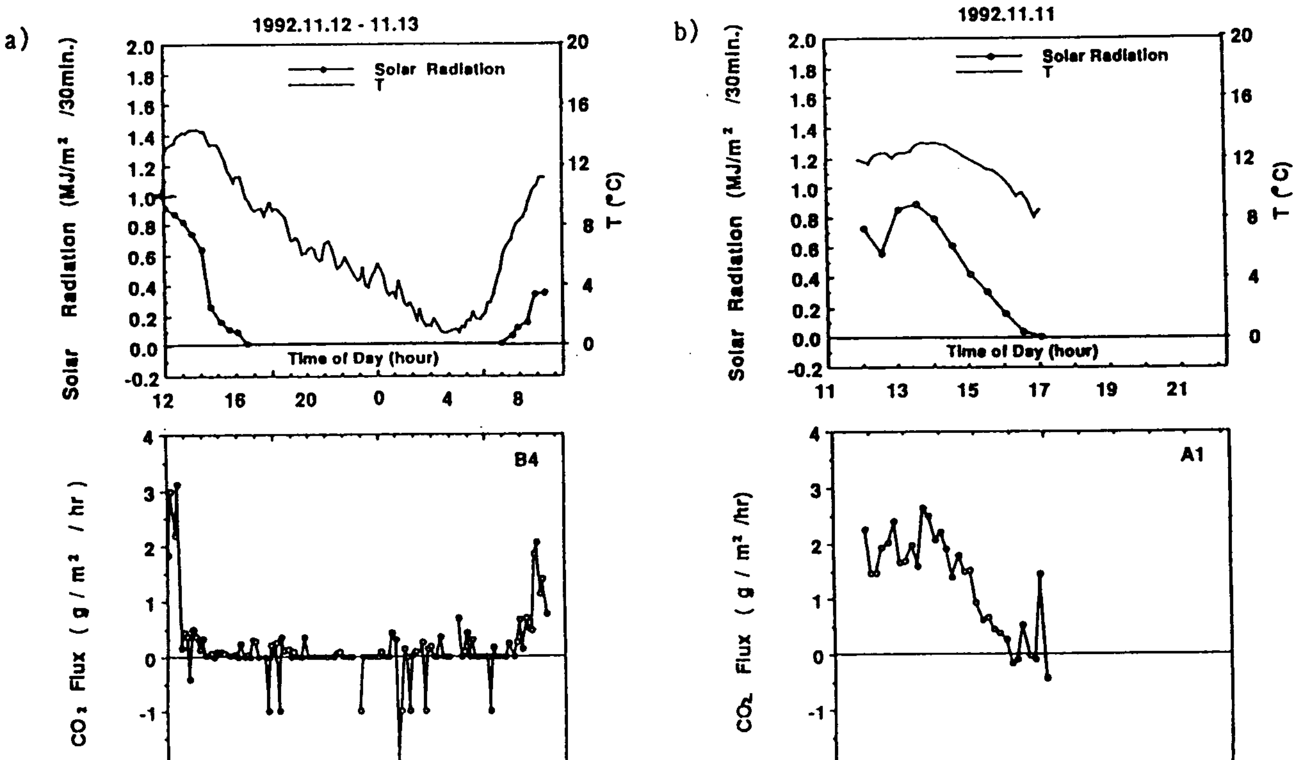

Fig.7 Time variation of CO_2 fluxes,solar radiation and temperature in ungrazing pasture a)B4 paddock b)A1 paddock

Table.1 Calculated incomings and outgoings of CO_2 from grazing pasture to atmosphere

(CO_2 g/m²/year)

	Primary Net Production	Decomposition of standing dead and litter	Decomposition of feces	Decomposition of soil organic matter	Respiration of Cattle	CO_2 emission to atmosphere
CO_2 flow	-1950	790	186	1150	150	326