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Production Dynamics of *Phragmites longivalvis*, *Carex scabrifolia* and *Zoysia sinica* Stand of a Sand Bar at the Nagdong River Estuary[1]

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洛東江 河口 砂洲의 갈대, 천일사초 및 갯잔디群落의 生産動態

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ABSTRACT

Net production, dead material increments were measured, and annual respiration loss was simulated through a year to determine the gross production at the *Phragmites longivalvis*, *Carex scabrifolia* and *Zoysia sinica* stand on Okryudeung, a sand bar of the Nagdong river estuary. The maximum live biomass for aboveground organs of the three stands occured in October, i.e., 1,985, 744 and 1,013g/m^2, and belowground net productions were estimated to be 650, 440 and 412g/m^2, respectively. Materials died or shedding from live aboveground organs during the growth season were estimated to be 167, 81 and 0 g/m^2. From the results of simulation, annual variation of respiration was primarily dependent on the annual variation of temperature through a year. For annual respiration loss in three stands, 21.893, 6.147 and 5.036kg CO_2/m^2 were calculated, respectively. Corresponding gross productions were 72,203, 22,109 and 19,909kcal/m^2. Respiration of belowground organs corresponded to 65%, 66% and 37% of the total plant respiration, and annual respiration loss accounted for 85%, 78% and 71% of the annual gross production. In view of efficiency of solar energy utilization, 5.8%, 1.8% and 1.6% of incident light energy were converted to gross production of plants during a year. With incident light energy during the growth season from April to September, energy utilizations for net production were estimated to be 1.2%, 0.4% and 0.6% at the three stands.

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INTRODUCTION

Salt marshes of coast and estuary are dynamic ecosystems which physico-chemical conditions are extremely variable under influences of regularly flooding tide. Early works at coastal estuarine ecosystems emphasized energy flow and material cyclings through trophic levels(Teal. 1962). The pattern of ecological energy flow explaines both the structure and function of the ecosystem.

Reed stand(*Phragmites longivalvis*) is evaluated to have higher productivity than any other stand in Korea. Consequently, researches in the past fifteen years have focused on matter production of this stand(Oh, 1970; Kim *et al.*, 1972; Kim, 1975; Chang and Kang, 1977; Kim *et al.*, 1982; Kim and Min, 1983; Min and Kim, 1983; Oh and Ihm, 1983; Mun, 1984; Kang and Chang, 1985) and on the energy flow(Kim *et al.*, 1982). The energy fixed tends to be balanced by the energy cost of self-maintenance as community becomes to be mature (Odum, 1969). Odum(1969) suggested that the ratio of gross photosynthesis to community respiration should be an excellent functional index of the relative maturity of ecosystems. Mun(1984) demonstrated that Odum's hypothesis could be applied to the stands of marsh plants. In our research, annual respiration loss was determined by using simulation technique with our observed and reference data.

The present study is to estimate not only the production of live organs but respiration loss and dead materials shedding from live organs at the *Phragmites longivalvis, Carex scabrifolia* and *Zoysia sinica* stand during growth season.

STUDY AREA

This study was conducted on the Okryudeung, one of the several sand bars of the Nagdong river estuary, from September, 1984 to August, 1985(Fig. 1). Okryundeung represents an intact vegetation scarcely damaged by men and storms. A major part of the sand bar is composed of mud marsh with narrow sand along the east and south margins of it. Two tidal drainage channels extend toward the south and north of the sand bar. The study area located at southern portion of Okryudeung(Fig. 1). This area is flooded twice daily by brackish water through the channels. At spring tide, the marsh is flooded over 1 meter and the plants in the marsh are submerged for over 8 hours a day. At neap tide, however,

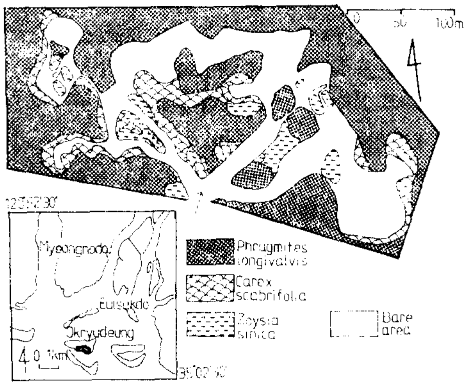

Fig. 1. Geographic location (black area) and actual vegetation map (upper) of the study area at Okryudeung of Nagdong river estuary. Dotted arrow indicates the high-tidal current.

the marsh is not inundated with the water. The study area is almost flat and is predominated with dense growth of *P. longivalvis* and interspersed with mosaic patches of *C. scabrifolia* and *Z. sinica* around the bare area(Fig. 1).

MATERIALS AND METHODS

Estimation of production From randomly selected sites, aboveground organs and materials within a(50×50)cm quadrat for *P. longivalvis* and a(20×20)cm quadrat for *C. scabrifolia* and *Z. sinica* were clear-cutted and collected at the sediment surface and separated into the live and dead components. Rhizomes and roots of the three stands were excavated at 60cm depth with the same preceding quadrats. The collected materials were washed and oven-dried to a constant weight at 80°C. Five quadrats were taken in each stand.

In aboveground organs, net production was estimated with the Smally method(Reimold and Linthurst, 1977; Ryu and Kim, 1985) as follow: If there is an increase in the standing crop of both live and dead plant materials, the production will be the sum of the increments. If the standing crop of live materials increases and that of dead materials decreases the production will be equal to the increment in the live components. If the amount of dead materials increases and that of live materials decreases the production will be zero(Reimold and Linthurst, 1977). Consequently, differences between the maximum and minimum standing crop of dead materials account for the amounts died or shedding during the growth season.

In belowground organs, net production was estimated to be differences between maximum standing crop at later growth season and minimum at early growth season (Kim and Ryu, 1985). Annual net production is calculated as the sum of aboveground and belowground net production and gross production as annual net production plus annual respiration.

Measurement of respiration Plant materials were enclosed within a temperature and humidity controlled respiration chamber. CO_2-free air passing through the chamber, CO_2 released from the materials was measured with a infra-red gas analyzer (Yanaco air-200). CO_2-free air could be obtained as the air flow passed through two KOH solution bottles. Humdity in the chamber was maintained enough for the measurement with moisture monitoring assembly. Air flow rate was regulated constantly as 1 liter/min at the ambient temperature. Temperature of materials was controlled

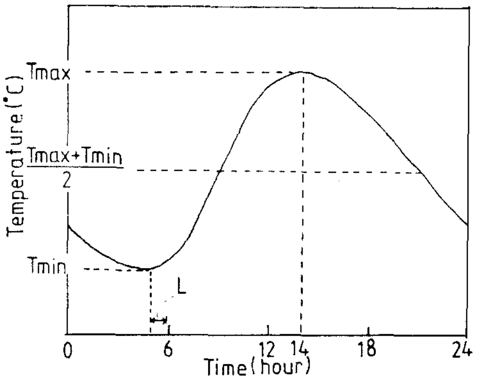

Fig. 2. Diurnal air temperature cycle based on both the day length and solar time. L is the difference of time between 6 : 00 a.m. and sun rise.

with the chamber being immersed in the water bath. Temperature inside the chamber was continuously monitored with a thermocouple sensor connected to the recorder through operation.

Simulation of annual respiration It would be actually difficult to measure respiration of intact plants *in situ*, therefore, simulated as following procedures.

Diurnal variation of temperature The variation of temperature is largely deterministic in that it follows well defined cycles of both daily and annual periodicity. Diurnal temperature can be divided into three phase(Fig. 2). The first phase is from sun-rise time to 14 : 00 culminating in air temperature, and air temperature(T) at a given time in hour on a day is expressed as following sine curve,

$$T=\frac{T_{MAX}-T_{MIN}}{2}\sin\left(\frac{\pi}{8+L}\left(H-10+\frac{L}{2}\right)\right)+\frac{T_{MAX}+T_{MIN}}{2}\ (6-L\leqq H\leqq 14)\ \cdots(1)$$

The second is from 14 : 00 to 24 : 00 and T is expressed as

$$T=\frac{T_{MAX}-T_{MIN}}{2}\sin\left(\frac{\pi}{10-L}\left(H-6-\frac{L}{2}\right)\right)+\frac{T_{MAX}+T_{MIN}}{2}\ (14<H\leqq 24)\ \cdots\cdots\cdots(1')$$

The third is from 24 : 00 to the sun-rise time on the next day and T is defined as

$$T=\frac{T_{MAX}-T_{MIN}}{2}\sin\left(\frac{\pi}{16-L}\left(H-14+\frac{3L}{2}\right)\right)+\frac{T_{MAX}+T_{MIN}}{2}\ (0<H<6-L)\ \cdots(1'')$$

In above equation, T_{MAX} and T_{MIN} indicate the maximum and minimum air temperature at Pusan district, H indicates ith hour in 24 hours on a day, and L is differences between 6:00a.m. and sun-rise time in hour. Raw data of T_{MAX} and T_{MIN} are ten-year data (1975~1984) from Pusan Meteorological Station(Fig. 3). Sine curves fitting to the raw data are summarized in Table 1. Annual variations of T_{MAX} and T_{MIN} are function of time in day(D). D indicates ith day in 365 days of one year. As a consequence, air temperature at a given hour on a day corresponds with the T_{MAX} and T_{MIN} variation as well as D and H. In case of estimation of belowground respiration, daily mean temperature at 30cm depth under ground was used because diurnal temperature variation at that depth was ranged from 0.1°C to 0.5°C(Fig. 3).

To determine the L, the day length through a year would be evaluated. By using the altitude of sun and the earth's rotation and revolution, day length (L_D) is modelled as following equation:

$$L_D=\frac{24}{\pi}\arccos(-\tan\phi\times\tan(23.45\times\frac{\pi}{180}\sin(\frac{2\pi}{365}(D-81))))\ \cdots\cdots\cdots\cdots\cdots\cdots\cdots\cdots(2)$$

In this equation, ϕ is radian value of the north altitude(35°N) at Pusan district and unit used in above trigonometric function is radian. Therefore, difference in hour(L) between the 6:00a.m. and the sun-rise time is defined as $L=L_D/2-6$. L would be zero under condition of 12 hours day and 12 hours night, but would have positive values for longer days and negative for shorter days.

Estimation of annual respiration The diagrams illustrated in Fig. 4 were designed to simulate the respiration loss of the three plants. Respiration rate at a given time in hour can be determined by combining by respiratory exponential function (Fig. 6

Table 1. Fitting sine eqations for maximum air, minimum air and belowground temperature, representing the function of day(D), and its correlation coefficients

Temperature	Fitting equation	Correlation coefficient
Maximum air temperature	$23.4286-8.3293\sin(0.0172\times(D+63))$	$r=0.9365$
Minimum air temperature	$6.0518-14.1106\sin(0.0172\times(D+67))$	$r=0.9720$
Belowground temperature at 30cm depth	$15.7252-10.5332\sin(0.0172\times(D62))$	$r=0.9935$

and Table 3) and temperature at a given time on a day. For *Phragmites* and *Carex* aboveground organs, respiration activities measured at April were applied to the calculation of respiration loss from March to May. Those measured at July and August were applied to the calculation after July. For aboveground organs of *Zoysia* and belowground organs of the three plants, the mean respiration activity data were used in evaluation of respiration loss through a year as there were no significant changes in activities through the growth season. Respiration amounts for an hour are produced from multiplying the respiration rate at a given time by plant biomass. These amounts were separately calculated for aboveground, belowground and sum of the both. Diurnal respiration loss was determined with sum of the value each an hour during a day. Annual respiration amount is sum of the diurnal respiration during a year.

To estimate theoretically a standing crop of each organ, the fitting polynomial equations were applied to observed data as a function of day (D) (Fig. 5 and Table 2). In case of belowground organs of *P. longivalvis*, the average biomass, 3,485g/m^2, was used through the respiration determination. All above-mentioned procedures to model various components and to simulate the respiration were performed with the basic language computer program.

RESULTS AND DISCUSSION

Growth and production The majority of growth occurred during May and June at *P. longivalvis* and *C. scabrifolia* stand, however, during April at *Z. sinica* stand (Fig. 5). The growth rate of the three stands were lower during July-August than the remaining season. Such summer depression in growth was evident at *Carex* and *Zoysia* stand in comparison with *Phragmites* one. High evapotranspiration coupled with high soil temperature during mid-summer results in high interstitial salinity, which would be extremely enough to reduce photosynthesis, to stimulate respiration and to inhibit the growth in the marsh (Gallagher *et al.*, 1980).

Standing crops of the three stands exhibit similar seasonal patterns with peaks occurring in October (Fig. 5). The production of live aboveground organs of *P. longivalvis* is 1,985g/m^2. Aboveground production of reed stands at the Nagdong river

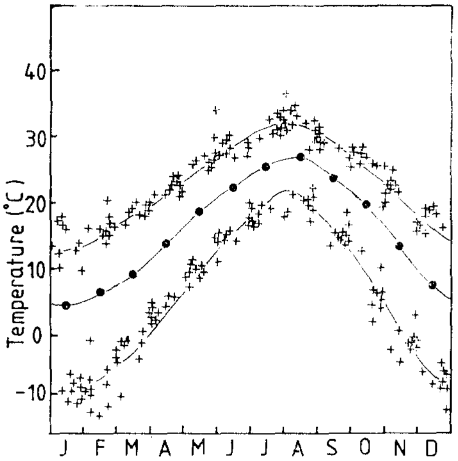

Fig. 3. Monthly maximum air (+—+) (upper), minimum air(+—+)(low) temperature and mean belowground temperature at 30 cm depth (●—●) for ten years (1975-1984) at Pusan.

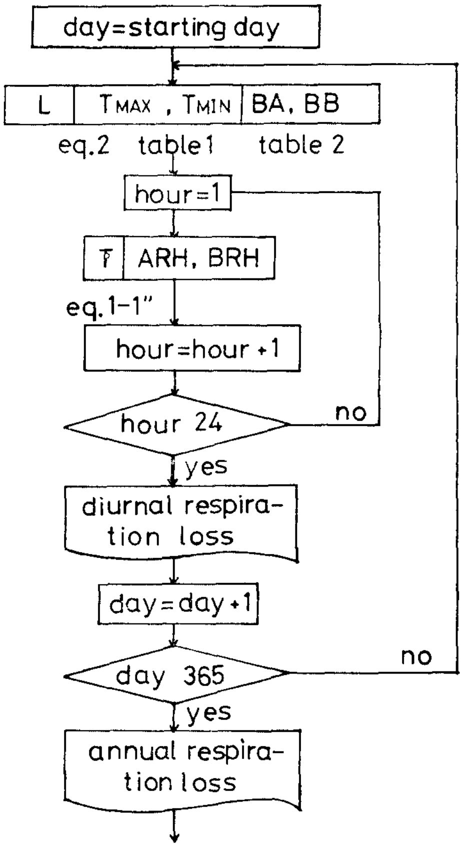

Fig. 4. Flow chart for computation of annual respiration loss. BA and BB indicate aboveground and belowground biomass, and ARH and BRH do respiration of aboveground and belowground organs for an hour, respectively.

Table 2. Fitting polynomial equations, representing the function of day(D), to estimate theoretically standing crops of the three stands

Stand	Plant organ	Fitting equation	Correlation coefficient
Phragmites longivalvis	above-ground	$18714.5674-574.3493\times D+6.4914\times D^2-0.0337\times D^3+8.3538\times 10^{-5}\times D^4-8.0133\times 10^{-8}\times D^5$	0.9920
Carex scabrifolia	above-ground	$-9142.5575+192.1971\times D-1.3999\times D^2+4.4104\times 10^{-3}\times D^3-5.0391\times 10^{-6}\times D^4$	0.9461
	below-ground	$762.8598-10.7678\times D+0.1589\times D^2-6.4049\times 10^{-4}\times D^3+8.1039\times 10^{-7}\times D^4$	0.9880
Zoysia sinica	above-ground	$-4648.0056+119.6840\times D-0.9697\times D^2+3.3512\times 10^{-3}\times D^3-4.1224\times 10^{-6}\times D^4$	0.8822
	below-ground	$523.8929-5.2069\times D+0.1000\times D^2-4.5941\times 10^{4}\times D^3+6.6275\times 10^{-7}\times D^4$	0.9710

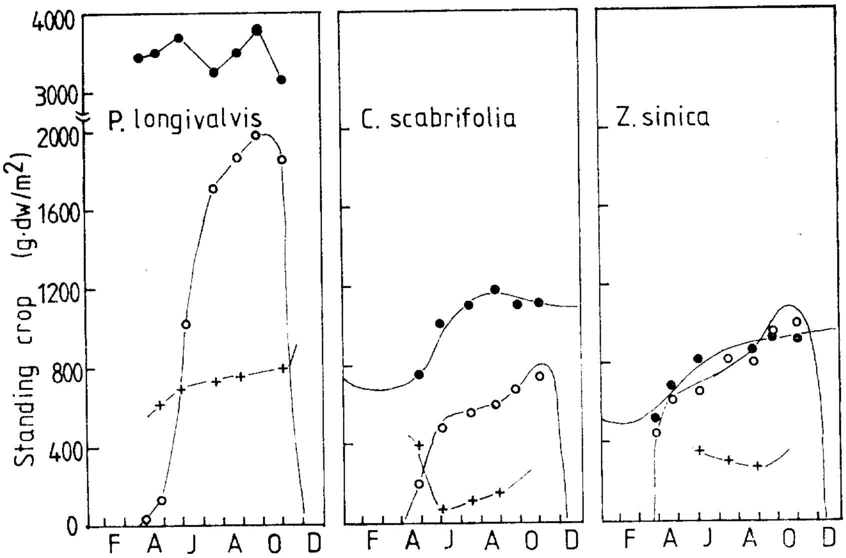

Fig. 5. Standing crops for aboveground (○—○), belowground organ (●—●) and dead materials (+—+) of the three stands.

estuary were about 3, 500g/m^2 (Kim *et al.*, 1982) and 3, 399g/m^2 (Kang and Chang, 1985) at Eulsukdo; 2, 928∼6, 124 g/m^2 (Oh, 1970) and 1, 069g/m^2(Chang and Kang, 1977) at Daemadeung; 2, 147g/m^2(Kim *et al.*, 1982) and 1, 458g/m^2(Mun, 1984) at Baekhapdeung; 2, 423g/m^2(Kim *et al.*, 1982) and 1, 464g/m^2(Mun, 1984) at Okryudeung. These data suggest that slight differences in location of sampling sites, survey year or harvest intervals may result in substantially different estimates. The further refinement of production estimates would be required.

The aboveground productions of reed stands in Korea fall within a range from 406g/m^2 at Gunja of a coastal zone at Kyunggi bay to 5, 869g/m^2 at Gupo of the Nagdong river estuary (Kim *et al.*, 1972; Kim and Min, 1983). The local differences in aboveground production might be primarily caused by the differences of saline conditions of soil(Min and Kim, 1983) and soil nutrients(Kim *et al.*, 1972; Min and Kim, 1983). The *P. longivalvis* could display a wide salt-tolerance ranged from fresh water to 1. 3 percent chlorinity of soil solution(Ranwell *et al.*, 1964). However, growth of salt marsh grasses in the high salinity was more reduced was the shoots than in the roots(Parrondo *et al.*, 1978).

The production of live aboveground organs for *C. scabrifolia* stand was 744g/m^2, which is 2-fold greater than result reported in the same area(Mun, 1984). That of *Z. sinica* stand was 1, 013 g/m^2, which is greater than that measured at Incheon coast(Kim and Min, 1983). Although *Z. sinica* is less than 30cm in height, aboveground materials per unit area would be very large amounts. Ecologically, it was emphasized pioneering role of *Z. sinica* such a colonizing the mudflat(Mun, 1984) and a nutrient sources at early succession stage(Min and Kim, 1983).

Belowground standing crop of the reed stand fluctuated with average amount of 3,485g/m^2 through the growth season(Fig. 5). It might be due to heterogeneous distribution of rhizomes. Those of the other two stands display clear seasonality(Fig. 5). Maximum standing crops of *C. scabrifolia* and *Z. sinica* were 1,200g/m^2 in August and 934g/m^2 in September respectively. Belowground/aboveground ratios were 1.76, 1.01 and 0.92 respectively at the three stands.

The standing crops of dead materials for *P. longivalvis* and *C. scabrifolia* gradually increased, but that of *Z. sinica* conversely decreased from early growth season to the later season (Fig. 5). As plants are flooded regularly by the tidal currents, dead materials would be swept off by the water or carried out to estuarine water. By this reason, standing crop of dead materials may be underestimated.

Dead material increment Dead materials shedding or died during the growth season were 167g/m^2 at the *Phragmites* stand and 81g/m^2 at the *Carex*, which correspond to 8.4% and 11.0% of the live aboveground biomass. The dead material increments were very lower than that found at herb stands of reclaimed land(Ryu and Kim, 1985) and *P. longivalvis* stand of Georgia salt marsh(Reimold and Linthurst, 1977). Because disappearing amounts(Wiegert and Evans, 1964) were ignored and tidal currents took a large dead materials out of the system, dead materials would likely be lower. Especially at *Zoysia* stand, dead materials shedding from live organs were estimated to be negative value. The tide removed 45% of the production of *Spartina alterniflora* before a change by consumers(Teal 1962).

Net production Annual net production for belowground organs of the three stands amounted to 650g/m^2 at *P. longivalvis*, 440g/m^2 at *C. scabrifolia* and 412g/m^2 at *Z. sinica*(Table 5). These account for 33%, 60% and 41% of live aboveground production. The average net production of rhizomes for long-term can be approximated by divided their total biomass by their age(four years) (Fiala, 1973). By this method, the annual net production of the rhizomes of reed was estimated to be 550~940g/m^2 at fish ponds of Czechoslovakia. The difference between increment of daily net photosynthesis and that of daily aboveground biomass represents the translocation of assimillates to the below ground organs(Ondok, 1978). Through this photosynthetic and translocation modelling, Ondok(1978) showed that the ratio of belowground to aboveground biomass was 0.34 at peak growth season. In outdoor hydroponic cultures for two years, the ratios ranged to 0.23~0.44(Dykyjová *et al.*, 1971). Our results for belowground/aboveground ratio falls within the ranges of the reference data. From the production of aboveground, belowground and dead materials, net production at the three stands were estimated to be 2,802, 1,265 and 1,425g/m^2/year, respectively.

Respiration rate and annual respiration loss Respiration rates for plants exponentially increase to the temperature. Respiration of aboveground organs was high in

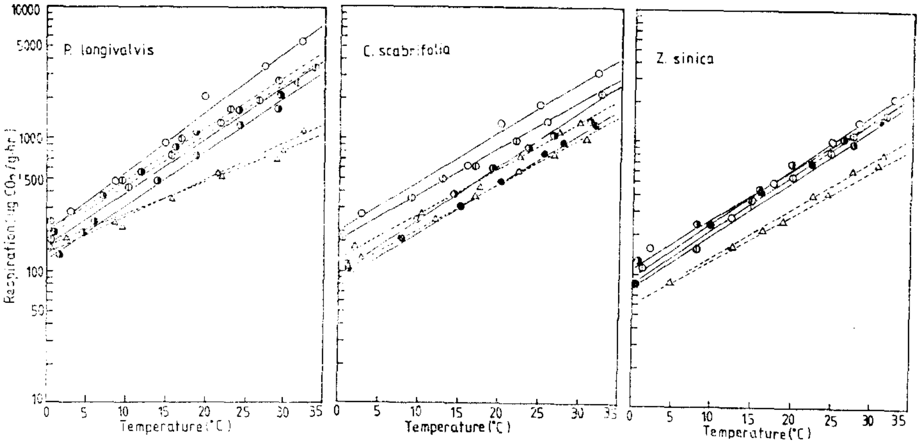

Fig. 6. Respiration, exponentially responsible to temperature, for aboveground (○–○), belowground organ (△····△) and young shoots (○--○) of the three stands. ○ : determined in April, ⦶ : in June, ◑ : in July, ● : in August.

comparison with the belowground at a given temperature(Fig. 6 and Table 3). The aboveground organs of the *P. longivalvis* and *C. scabrifolia* had clear seasonal change in respiration rate with the maximum rate in April, however, that of *Z. sinica* and all belowground organs of the three plants did not(Table 3). Among the reed materials collected at the same time, respiration rates of young shoots were higher than those of mature ones(Fig. 6). Mean respiration activities of the three stands at 20°C were 1.169, 0.751 and 0.620mg CO_2/g per hour for aboveground, and 0.550, 0.537 and 0.331mg CO_2/g per hour for belowground, respectively. Q_{10} values for aboveground organs highly ranged from 2.4 to 2.7 at early growth season(Table 3). Respiration rate for aboveground organs was not significantly changed after July.

Table 3. Exponential equations for respiration, as function of temperature (T), for the three stands.

Species	Plant organ	Sampling month	Respiration ($mgCO_2/g/hr$)	Correlation coefficient	Q_{10} value
Phragmites longivalvis	above	Apr.	$0.2251 \cdot e^{0.1006 \cdot T}$	0.9930	2.74
		Jun.	$0.1715 \cdot e^{0.0883 \cdot T}$	0.9978	2.40
		Jul.	$0.1388 \cdot e^{0.0887 \cdot T}$	0.9939	2.43
	below	Apr. Jun.	$0.1685 \cdot e^{0.0591 \cdot T}$	0.9900	1.81
Carex scabrifolia	above	Apr.	$0.1970 \cdot e^{0.0865 \cdot T}$	0.9870	2.38
		Jun.	$0.1893 \cdot e^{0.0735 \cdot T}$	0.9973	2.09
		Jul. Aug.	$0.0989 \cdot e^{0.0842 \cdot T}$	0.9965	2.32
	below	Apr. Jun.	$0.1170 \cdot e^{0.0762 \cdot T}$	0.9825	2.14
Zoysia sinica	above	Apr. Aug.	$0.1051 \cdot e^{0.0887 \cdot T}$	0.9884	2.42
	below	Apr. Jun.	$0.0558 \cdot e^{0.0859 \cdot T}$	0.9951	2.36

Daily respiration of belowground estimated by the respiration simulation models was greater than that of aboveground at the former two stands, but conversely at the *Zoysia* stand(Fig. 7). Diurnal maximum respiration occurred at all stands during July through a year. From these results, it is concluded that annual respiration patterns are primarily dependent on the annual air temperature variation regardless of biomass and respiration rate fluctuations through a year. Annual respiration loss per unit area(m^2) at the three stands are given in Table 5. Respiration loss for belowground organs of the three stands correspond to 65%, 66% and 37% of total plant respiration. The amount of carbon dioxide, released from the plant organs for a year, can be converted to caloric value with the factor, 2, 801. 8cal per gram of carbon dioxide, which is derived from 5. 5kcal/CO_2 liter(Odum, 1971) (Table 5). A factor of 0. 614 is available to convert CO_2 fixed to dry matter in gram of plant tissue(Giurgevich and Dunn, 1982). By this method, annual respiration loss at the three stands were estimated to be 13, 442, 5, 039 and 4, 517g/m^2 per year, respectively.

Caloric value of plant organ Caloric values for plant materials represent no significant differences between species, organs or seasons(Table 4). Caloric values for aboveground organs are more or less greater than those of the belowground. The average value of all the plant materials, 3, 898±174cal/g, is lower than 3, 900～4, 225 cal/g obtained at old field vegetation by Golley(1961), but within the range of 3, 080 ～5, 929cal/g of herb stands by Kim and Ryu(1985).

Gross production and energy utilization Primary productions in dry matter and caloric value are summarized in Table 5, for *P. longivalvis*, *C. scabrifolia* and *Z.*

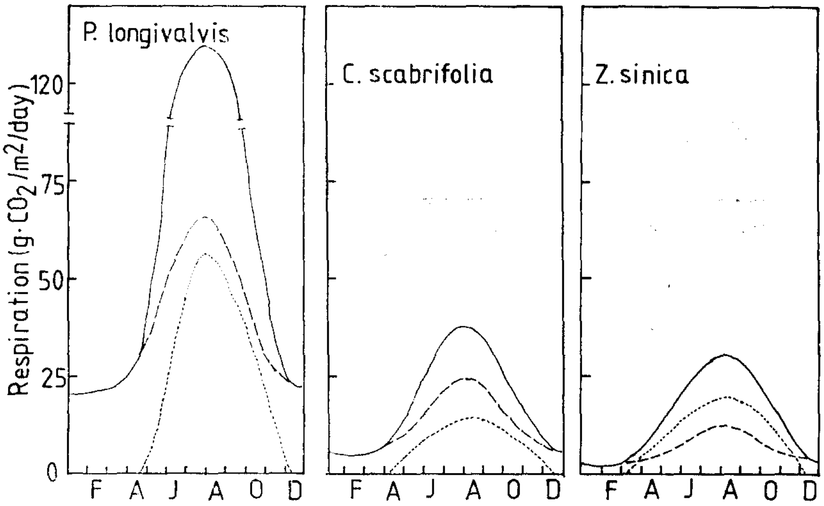

Fig. 7. Simulation data of annual respiration for aboveground (·········), belowground (———) organs and sum of the both (———) at the three stands.

Table 4. Caloric values for plant materials. Unit is calorie per dry weight gram of materials

Species	Material	Sampling month				Mean
		Mar.	Apr.	Jun.	Nov.	
Phragmites logivalvis	aboveground	3, 942	3, 825	3, 921	3, 982	3, 918
	belowground	—	3, 746	3, 512	—	3, 629
	dead material	—	—	4, 178	—	4, 178
Carex scabrifolia	aboveground	—	4, 024	3, 875	—	3, 950
	belowground	—	3, 940	3, 485	—	3, 713
	dead material	—	3, 975	3, 762	—	3, 869
Zoysia sinica	aboveground	—	4, 443	3, 880	—	4, 162
	belowground	—	4, 242	3, 444	—	3, 843
	dead material	—	3, 935	3, 701	—	3, 818

sinica stand. Annual solar energy flux into the stands is about 1, 255, 000kcal/m^2 per year(Kim *et al.*, 1982). In view of efficiencies of solar energy utilization, 5. 8%, 1. 8% and 1. 6% of incident light energy during a year were converted to gross produdtion of plants, respectively: 85%, 78% and 71% of the gross production were dissipated as the plant respiration. The net production, therefore, accounted for 15%, 22% and 29% of the gross production. With incident light energy of 726, 250 kcal/m^2(Kim *et al.*, 1982) during the growth season from April to September, energy utilizations for net production were estimated to be 1. 2%, 0. 4% and 0. 6% at the three stands.

Tlabe 5. Annual net production, respiration and gross production of the three stands at Okryudeung, Nagdong river estuary

Stand	Aboveground net production				Belowground net production	
	Production for live organs	Production for dead materials	Total net production			
	(g/m^2/yr)	(g/m^2/yr)	(g/m^2/yr)	(kcal)	(g/m^2/yr)	(kcal)
Phragmites longivalvis	1, 985	167	2, 152	8, 475	650	2, 389
Carex scabrifolia	744	81	825	3, 252	440	1, 634
Zoysia sinica	1, 013	0	1, 013	4, 216	412	1, 583

	Respiration				Gross production
	Above-ground	Below-ground	Total respiration		
	(kg CO_2)	(kg CO_2)	(kg CO_2)	(kcal)	(kcal)
Phragmites longivalis	7. 565	14. 328	21. 893	61, 339	72, 203
Carex scabrifolia	2. 049	4. 098	6. 147	17, 223	22, 109
Zoysia sinica	3. 157	1. 879	5. 036	14, 110	19, 909

Respiration loss of this reed stands may be compared with 81% for *Spartina alterniflora* marsh (Teal, 1962). Respiration loss at the latter two stands was greater than 52～57% for the herb stands of reclaimed salt marsh (Kim and Ryu, 1985). Through the modelling and simulation technique, as our results are obtained under full sunlight from clear skies, the respiration loss might be overestimated. Under the natural condition, temperature shows random fluctuation due to clouds and rainfall. Another factor is assumed. The plant materials in the respiration chamber were undoubtedly more physiologically active than intact plant (Giurgevich and Dunn, 1982).

摘　　要

洛東江 河口 옥류등에서 갈대, 천일사초 및 갯잔디 群落의 年純生産量과 枯死量을 조사하고 呼吸量을 시뮤레이션함으로써 總生産量을 추정하였다. 3군락의 최대현존량이 10월에 나타났고 여름에 夏枯現象이 관찰되었다. 지상부의 年純生産量은 각각 세 조사군락에서 1,985, 744 및 1,013 g/m^2, 지하부는 천일사초와 갯잔디 군락에서 각각 650, 440 및 412g/m^{2}이었으며, 생육기간 중의 枯死量은 167, 81 및 0 g/m^{2}으로 추정되었다. 年呼吸量을 시뮤레이션한 결과, 각각 3군락에서 21.893, 6.147 및 5.036 kg CO_2/m^{2}이었고, 호흡량의 年變化는 年最高 및 最低기온의 변화 양상과 일치하였다. 열량으로 환산한 年總生産量은 72,203, 22,109 및 19,909 cal/m^{2}였고, 總呼吸量에 대한 지하부 호흡량의 비율은 각각 65%, 66% 및 37%이고, 年總生産量에 대한 年呼吸量의 비율은 각각 85%, 78% 및 71%이었다. 年總生産量의 연간 태양에너지 利用效率은 5.8%, 1.8% 및 1.6%이였고, 年純生産量의 생육기간(4～9월)중의 태양에너지 이용효율은 각각 1.2%, 0.4% 및 0.6%이었다.

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