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DYNAMICS OF LITTER DECOMPOSITION AND SEASONAL DYNAMICS OF PHOSPHORUS IN DECOMPOSED RESIDUA OF *Calamagrotis augustifolia* IN THE WETLAND OF THE SANJIANG PLAIN

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ABSTRACT: During the period of May to October in 1999, systematical studies were given to the rate of decomposition of *Calamagrostis angustifolia* litter, the phosphorus content and weight in decomposed residua of litter, and phosphorus content in the corresponding soil in the Sanjiang Plain. At the same time, the simulation models were listed in the paper. The results showed that the rate of weight lost of decomposition of *Calamagrostis angustifolia* litter is 29. 80% and the maximum of daily rate of weight lost is 0. 25%, which appeared in July. The change trend of phosphorus content and weight in the decomposed residua of litter is to reduce with the decomposing process, when it comes to the day of 157, the decrement amount of the both were respectively 57. 69mg/kg and 1. 6199mg, which were 72. 80% and 76. 30% of its previous amount. In addition, there is a polynomial minus correlationship of phosphorus content between the variation in corresponding soil and the decomposed residua of litter at the corresponding period. The study will be helpful to further understand the process and mechanism of biochemical cycling of nutrient elements in wetland ecosystems, in addition, it will also be helpful to the restoration and rebuilding of retrogressive wetlands and reasonable development and utilization of wetlands in the Sanjiang Plain.

KEY WORDS: *Calamagrostis angustifolia* litter; decomposed residua; phosphorus; seasonal dynamics; Sanjiang Plain

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Elements cycling and energy flow are the important research contents in ecosystem fields, and residua decomposition is the key process of nutrimental elements circulation (SWIFT *et al.*, 1979). The residua decomposition rate plays an important role in deciding the productivity and biomass of ecosystem. In this paper systematical studies were given to the rate of decomposition of *Calamagrostis angustifolia* litter, the phosphorus content and weight in decomposed residua of litter, and phosphorus content in the corresponding soil. This research will promote the study of biogeochemical cycling of elements and the cycling mechanism further in typical wetland ecosystems in the Sanjiang Plain of China, and some suggestions to the restoration

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and reestablishment of the deteriorated wetlands in this area will be introductive.

1 NATURAL ENVIRONMENTAL CONDITIONS IN THE RESEARCH FIELD AND MAIN STUDY METHODS

1.1 Natural Environmental Conditions

The Sanjiang Plain is an alluvial plain formed by the three rivers, whose name are Heilongjiang River, Songhuajiang River and Wusulijiang River. Sanjiang Plain lies in the northeast part of Heilongjiang Province of China, the total area of the plain is about 5.13×10^6ha, and it is the most wide spread areas of freshwater wetlands in China with 21% areas were mires (YANG, 1989), in addition, mire wetlands of fresh water are wide spread and quite typical in this area (Department of Mire, Changchun Institute of Geography, 1983). *Calamagrostis angustifolia*, which belongs to the gramineous generation and Deyeuxia, is one of the most prominent plants in the plain (YI *et al.*, 1982; ZHOU *et al.*, 1992). The *Calamagrostis angustifolia* can be used for good materials in the making of feedstuff, fibre and soil conservation.

This located research site was carried out at the ecological experimental area in Ecological Experimental Station of Mire-Wetland of the Sanjiang Plain of Chinese Academy of Sciences, which belongs to one of the fundamental stations of Chinese Ecosystem Research Network (CERN for short). The research area lies in Honghe Farm, Tongjing City, Heilongjiang Province, and its location is that 133°31′E and 47°35′N with the area about 100ha.

The study area belongs to temperate zone, and continental monsoon climate dominates in the area with the average annual temperature 1.9℃ and average annual rainfall is about 600mm which concentrates from July to September and during this period rainfall accounts more than 70% of the total year. Geomorphy in the selected area is typical depression and main vegetation communities include *Carex lasiocarpa*, *C. pseudocuraica*, *C. meyeriana*, *Glyceria spiculosa*, *Calamagrostis angustifolia*, *Phragmites communis*. Main soil types are meadow mire soil, humus mire soil, peatland mire soil, peatland and gley albic bleached soil.

1.2 Study Methods

1.2.1 Samples collection and decomposition measuration

Dead litters and standing litters of *Calamagrostis angustifolia* was gathered monthly in the sampling sites, and in the laboratory they were drying under the constant temperature of 80℃ and their dried weight were got. Dead litters of *Calamagrostis angustifolia* is measured with the methods of nylon sack measuring (JIANG *et al.*, 1988). Aperture diameter of the used nylon sacks is 1mm and areas is $20 \times 20cm^2$. Some samplings were characterized their chemical properties in the lab and the other samplings were put into the nylon sacks with the same weight and were put on the simulated natural surface of the ground. During the growing seasons of the *Calamagrostis angustifolia* two decomposed nylon sacks were gathered monthly, and in the laboratory the sacks were cleaned in order to remove earth, and under the constant temperature of 80℃ they were dried and their dried weight were got. After this process the decomposition ratio of *Calamagrostis angustifolia* could be calculated and the decomposed residuals were used in the contents analysis of the nutrimental elements.

1.2.2 Chemical analysis of samples

Dead residuals of *Calamagrostis angustifolia* and soils samples were decomposed and cleared up by thick $H_2SO_4 - HClO_4$ at high temperature, and the total phosphorus of the samplings were measured with spectrophotometer of molybdenum, stibium and scandium, which was made in Shanghai, China, named 7230 spectrophotometer.

2 RESULTS AND ANALYSIS

2.1 Description of Dead Litters

Dead litters mean the dead or fallen parts of the frond and according to practical circumstances they can be divided into two parts: standing dead litters which

means dead but still not fallen litters and fallen dead litters which are separated from the frond. Standing dead litters varied in their mass with growth of the frond and fallen dead litters can be divided into ground fallen dead litters and underground ones. In this study we only discussed the ground fallen dead litters of *Calamagrostis angustifolia.*

Both standing and fallen dead litters are materials returned to the soils from the frond. The study of formation, accumulation and decomposition of litters and variation of the nutrimental elements can be helpful to the study of cycling of nutrimental elements and related cycling mechanism.

2.2 Seasonal Variations of Standing Dead Litters and Fallen Dead Litters

Calamagrostis angustifolia germinates at the bottom of April, blossomes during June to July. The standing dead litters and fallen dead litters appears at the beginning of May and their mass become greater with the temperature becomes lower. So the litters grow only at the middle and late life period of *Calamagrostis angustifolia*. The leaves and sheathes near the ground witheres first and they become the earlier standing litters, then from the bottom to the up of the frond, litters get more. The seasonal variations of the *Calamagrostis angustifolia* are shown in Fig. 1.

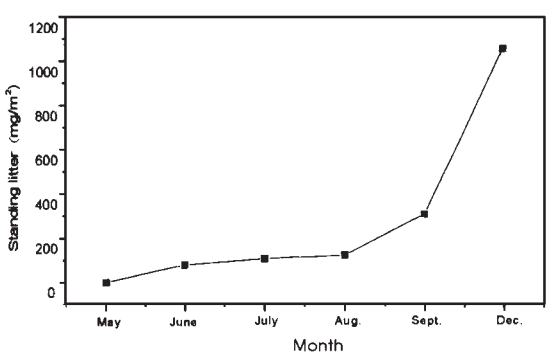

Fig. 1 Seasonal dynamics of standing litters of *Calamagrostis angustifolia*

From Fig. 1 we can see that seasonal variation of litters of *Calamagrostis angustifolia* is not prominent in June, July and August. From August on, the biomass of litters increases rapidly and until December reaches 1052.78g/m^2. This seasonal variation trend can be simulated by exponential increase model and the simulated curve is shown in Fig. 2, from this figure it is clear that the simulation is credible and the mathematical model is shown in Table 1.

During the whole growth seasons, variations of *Calamagrostis angustifolia* litters are very little and compared with the seasonal variations of standing dead litters the former is less significant. Fallen dead litters begin at the middle of August with very little amount of only 1.2g/m^2, and in October they get their peak as 18.9g/m^2. The mass amount of litters is related to the weather conditions as wind, precipitation, hail and activities of animals.

2.3 Dynamics of Decomposition Ratio of the Litters

Standing dead litters and fallen dead litters are finally decomposed join the soil humus. Seasonal and daily variation of decomposition rate of the litters of *Calamagrostis angustifolia* in the whole growth seasons are shown in Fig. 3 and Fig. 4 respectively. Weight losing rate of the decomposition is high in the beginning 80 days and then decreases, this is determined by the

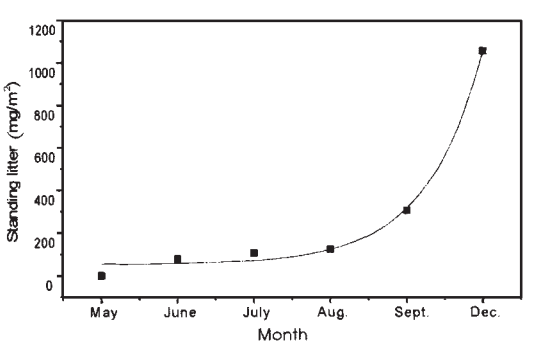

Fig. 2 Simulation of seasonal dynamics of standing litters in *Calamagrostis angustifolia*

variation of the temperature and the activities of the microbes. The daily variation of the losing weight rate conforms the seasonal variation with the highest losing rate of 0.25%. Dynamics of the seasonal variation of the weight losing rate can also be shown in Table 1.

Decomposition rate of the litters of *Calamagrostis*

Table 1 Simulation models of litters of *Calamagrostis angustifolia*

Items	Simulation models of seasonal dynamics	R^2	n
Standing litter	$Y = 52.42902 + 0.59224\, e^{(x-0.43068)/0.74953}$	0.99374	6
Rate of weight losing	$Y = -11.37333 + 11.62856X - 0.67127X^2 - 0.02269X^3$	0.99124	6
Daily rate of weight losing	$Y = -0.37 + 0.48171X - 0.11798X^2 + 0.00889X^3$	0.99411	6
Phosphorus content in DR*	$Y = 198.5 - 61.55603X + 12.0556X^2 - 0.95694X^3$	0.99291	6
Phosphorus weight in DR	$Y = 8.5619 - 3.16158X + 0.58218X^2 - 0.04147X^3$	0.99854	6
Phosphorus content in soil	$Y = 172.06167 + 135.11309X - 23.69195X^2 + 1.25838X^3$	0.92065	6

* DR: decomposed residua

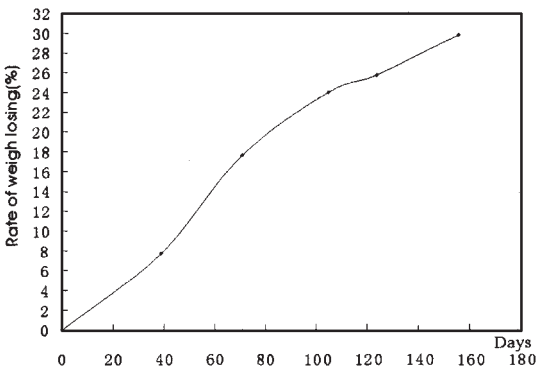

Fig. 3 Seasonal dynamics of weight losing rate of litters of *Calamagrostis angustifolia*

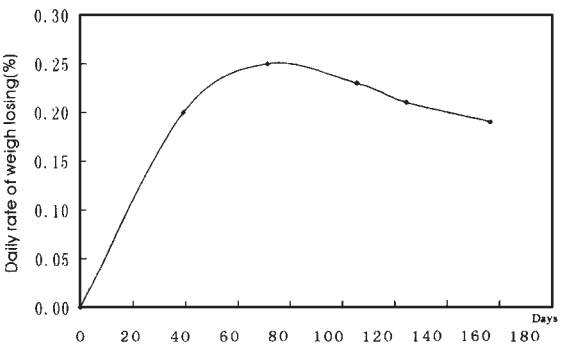

Fig. 4 Seasonal dynamics of daily weight losing rate of dead litters of *Calamagrostis angustifolia*

angustifolia is influenced by comprehensive ecological factors such as the groundplasm types, the environmental conditions and the numbers of microbes and their activities (MCC *et al.*, 1985). In the beginning period, decomposition rate is high and then gets lower. This is related to the rapid disssolution of the solvable substances of the litters at the beginning and then the proportion of materials hard to be solved (such as cellulose, fats, tannin and xylogens, etc.) gets high and causes the comparatively lower decomposition ratio.

2.4 Seasonal Dynamics of Phosphorus Content in Residua of *Calamagrostis angustifolia*

Weight of the litters and contents of ingredient elements is decreasing during the decomposition process of residua of the *Calamagrostis angustifolia*. As Fig. 5 and Fig. 6 show that contents and weight of phosphorus in the decomposed litters decreased rapidly at the beginning and then the descending ratio lessens with the time going. After 157 days of decomposing, phosphorus contents and its weight reach 57.69mg/kg and 1.6199mg respectively and which account 72.84% and 76.30% of the level before the decomposition. Causes of the variation trend are related to high contents of dissolvable phosphate in the litters and dominant microbial activities in the beginning and while the temperature gets lower, there is little microbial activities (YANG *et al.*, 1992). Simulation of the variations of contents and weight of phosphorus in the litters of *C. angustifolia* are shown in Table 1 with the valuation of R is above 0.99.

2.5 Variation of Phosphorus in Soils

Decomposed materials and elements will be shifted to the wetland soils. Seasonal dynamics of phosphorus content in the wetland soil of *Calamagrostis angustifolia* can be seen in Fig. 7. From this figure we can see that the phosphorus contents in the soil shaped an M shape. From May to June during the growth seasons of *Calamagrostis angustifolia*, phosphorus contents in soils

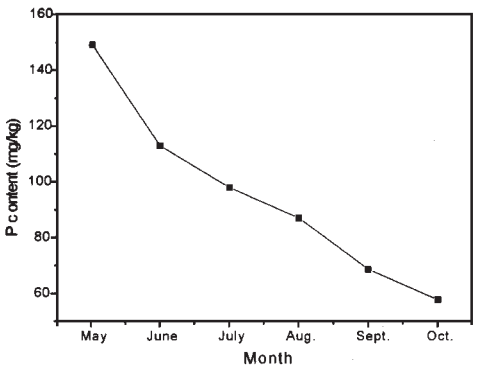

Fig. 5 Seasonal dynamics of P content in decomposed residua of *C. augustifolia*

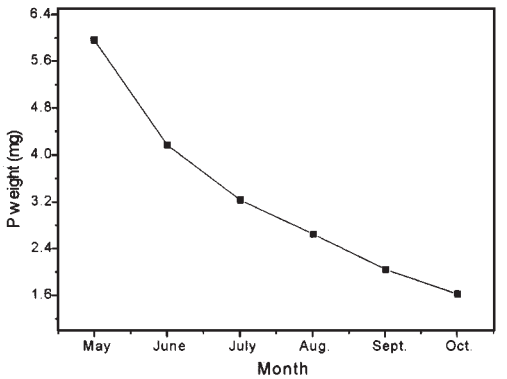

Fig. 6 Seasonal dynamics of P weight losing in decomposed litters of *C. angustifolia*

increases rapidly and this trend is correlated to the high weight losing ratio of the litters of *Calamagrostis angustifolia* in the early decomposition period. From June to the end of August, phosphorus contents in the soils decreases and then increases again. Earlier descending trend attributes to the large amount of phosphorus absorption from wetland soil by *Calamagrostis angustifolia* to grow fruits and other organisms in the early periods of this time span, and the following increasing trends is caused by the returning of phosphorus elements from litters to the wetland soils due to the decrease of the temperature. The decreasing trend of phosphorus contents in the soil is probably caused by the low decomposition ratio of litters during this period. The variation of phosphorus contents in wetland soils is very complicated and further research is still needed.

Supposing we only consider the attribution of the decomposition of litters of *Calamagrostis angustifolia*, the simulation result of the relation of phosphorus contents in the wetland soils and the remaining phosphorus contents in the litters can be shown by the following formula as:

$$Y = -208.78271 + 20.15521X - 0.20069X^2 + 5.88911 \times 10^{-4}X^3,$$

where R^2 equals 0.91103 so that the negative polynomial relation is quite distinctive and the simulation curve is shown in Fig. 8.

3 CONCLUSIONS

1) Litters of *Calamagrostis angustifolia* are mainly composed of standing dead litters, and seasonal variation of litters of *Calamagrostis angustifolia* is not prominent in June, July and August, but from August on, the biomass of litters increases rapidly and until December reaches 1052.78g/m^2. This seasonal variation trend can be simulated as exponential increase model. The simulation result shows that the simulation is credible.

2) Weight losing ratio of *Calamagrostis angustifolia* is 29.80% and the highest daily weight losing ratio is 0.25%. which occurs in the middle of June. Seasonal dynamics of the decomposition ratio of the litters can be simulated as $Y = -11.37333 + 11.62856X - 0.67127X^2 - 0.02269X^3$ with the R^2 is 0.99124, and this shows that the simulation is successful.

3) Contents and weight of phosphorus in the decomposed litters decreased rapidly at the beginning and then the descending ratio lessens with the time going. After 157 days of decomposing, phosphorus contents and its weight reach 57.69mg/kg and 1.6199mg respectively and which account 72.84% and 76.30% of the level before the decomposition.

4) If only the attribution of the decomposition of litters of *Calamagrostis angustifolia* is considered, the simulation result of the relation of phosphorus contents in the soil and the remaining phosphorus contents in the litters show the following formula as:

$$Y = -208.78271 + 20.15521X - 0.20069X^2 + 5.88911 \times 10 - 4X^3$$ where R^2 equals 0.91103.

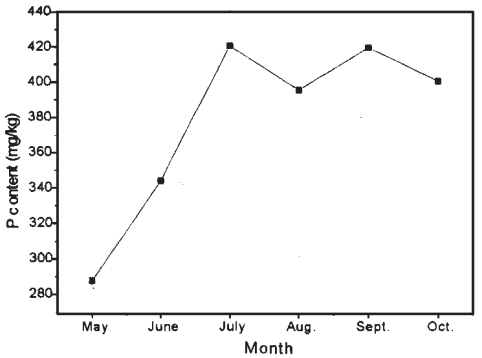

Fig. 7 Seasonal dynamics of phosphorus content in the soil of *Calamagrostis angustifolia*

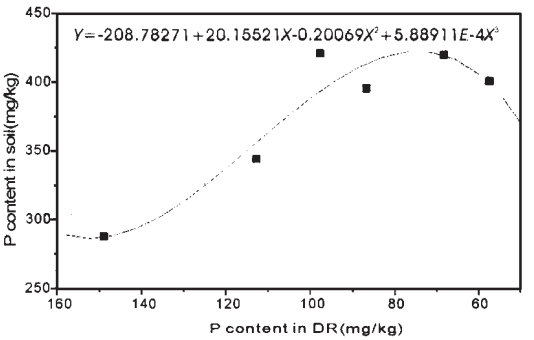

Fig. 8 Relation of phosphorus content between the soil and the decomposed residua of litter

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