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Decay Rate and Changes of Nutrients during the Decomposition of *Zizania latifolia*

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ABSTRACT: Decomposition of *Zizania latifolia* was investigated with litterbag method for 13 months from November in 1998 to December in 1999, at the fringe of stream at Boryeong, Chungnam Province in Korea. After 13 months, remaining mass of leaves, culms and rhizomes was 16.9, 14.7, and 10.1%, respectively. Mass loss of the rhizomes was higher than those of the leaves and culms. The decay rate of leaves, culms and rhizomes was 1.86, 2.00 and 2.36 per year, respectively. Initial concentration of N, P, K, Ca, and Mg of leaves, culms and rhizomes was 18.0, 14.5, 44.0 mg/g for N, 0.18, 0.12, 0.67 mg/g for P, 14.1, 14.2, 14.8 mg/g for K, 3.6, 1.5, 0.3 mg/g for Ca, 1.1, 0.5, 0.5 mg/g for Mg, respectively. Concentrations of N and P in rhizomes were higher than those in leaves and culms. Except for Mg in rhizomes, there was no immobilization period during the decomposition. Most of the N, P and Mg were lost during the first 3 months. In case of K and Ca, most were lost within 1 month.

Key Words: Decay rate, Decomposition, Immobilization, Macrohydrophytes, Nutrients, *Zizania latifolia*

INTRODUCTION

Wetlands dominated by emergent macrohydrophytes, such as reed, cattail, wild rice, are known as the most productive in the world (Brinson *et al.* 1981, Richardson 1995). There are many reports on the production of salt marsh and freshwater wetland vegetation in Korea (Kim *et al.* 1972, Cho 1992). Mun *et al.* (1999) reported that the maximum above-ground standing biomass of reed, cattail and wild rice stand in a small water course was 3,504, 2,834 and 3,125 g/m^2, respectively.

One of the important ecological functions of wetlands is their ability to immobilize nutrients. After Grant and Patrick (1970) reported that the water flowing out from the wetland contained much less N and P than the water flowed into the wetland, many authors have confirmed the water purification function of wetlands (Sweet 1971, Gosselink *et al.* 1974, Hammer 1995, Mun *et al.* 1999). Wetlands are able to filter and hold 60 to 90% of the suspended solids and sediment from the inflowing wastewater (Richardson 1995). In Korea, Kim *et al.* (1989) and Mun *et al.* (1999) reported that emergent macrohydrophytes can immobilize large quantities of N and P in wetlands environment.

However, the above-ground parts of these macrohydrophytes die back annually, and enter detrital systems in wetland. Therefore, nutrients and organic matter can be released into the water during decomposition of submersed aquatic vegetation (Carpenter 1980). Mun *et al.* (2000 a, b) reported that substantial amount of nutrients are released during decomposition of cattail and reed at the stream.

Zizania latifolia is one of the major emergent hydrophytes in Korea. The purpose of the present study is to investigate the decay rate and nutrient changes during decomposition of *Z. latifolia*.

MATERIALS AND METHODS

Litterbag preparation

Wild rice was collected in a small stream, 7-8 m in width and 5 km in length, located at Boryeong, Chungnam Province, in October, 1998. They were divided into leaves, culms and rhizomes, and used for litterbag preparation after dried at 80°C for three days. Litter bags, 15 x 15 cm, were made of nylon mesh with 2mm^2 holes. We prepared 40 litterbags in each organ. Each litterbag enclosed about 5 g of litter and an aluminum tag, which gives the exact weight of the litter. Leaf litterbags and culms litterbags were submersed in the stream water, and rhizome litterbags were burried at 10cm depth in the sediment in November, 1998.

Litterbag retrieval and chemical analysis

The first retrieval of litterbags was done on December 1998, 1-month after installation, and then retrieved every two months till

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December, 1999. Five-litterbags of each organ were retrieved on each sampling. Adhering material on the outside of the litterbags were removed with tap water. Remaining litter was weighed individually after drying for 72 hr at 80°C. Each sample was ground with a mixer for the chemical analyses.

Weight loss and changes of nutrients during decomposition were determined by measuring the remaining weight and nutrient concentration of litter in the litterbags. Weight loss of the litter was expressed as % of the initial sample weight. The annual decay rate, k, is derived from the exponential decay formula,

$-k = \ln(X/X_0)/t$,

where X_0 is the initial dry weight and X is the dry weight remaining at the measurement, t in years (Brinson *et al.* 1981).

Total N was determined by a modified micro-Kjeldahl method (Allen *et al.* 1974). P was determined by a molybdenum blue color method (Allen *et al.*, 1974). K, Ca and Mg were determined with an atomic absorption spectrophotometer (Perkin-Elmer 3110).

Remaining nutrients in the litterbag at each sampling was calculated using the concentration of nutrient in the litter and the weight of the remaining litter in the litterbag. Remaining nutrients was expressed as a percentage of the amount contained in the initial litter.

Comparisons of mean weight loss among the three organs were carried out using Student's *t* test with SPSS 8.0 program for Windows.

RESULTS AND DISCUSSION

Weight loss

Weight loss of rhizomes was significantly higher than those of leaves and culms in *Z. latifolia*. Rhizomes lost 65% of initial weight over the first 5 months. However, leaves and culms lost only 36.0% and 53.2% of their initial weight during the same period. After 13 months, the remaining weight of leaves, culms and rhizomes was 16.9° ±1.0%, 14.7° ±4.7% and 10.1° ±0.6% of the initial weight, respectively (Fig. 1). The annual decay rate of leaves, culms and rhizomes was 1.86, 2.00 and 2.36yr^{-1}, respectively.

The difference of decay rate among the organs seemed to associated with rigidity and nutrients content of substrate. Rhizomes of wild rice are softer than culms, and N and P concentration of rhizomes are greater than those of leaves and culms (Fig. 2). In case of reed (Mun *et al.* 2000b), remaining weight of culms was 57.4% after 13 months. Culms of reed are much more rigid than those of wild rice. Decay rate correlate positively with initial nitrogen content. High levels of nutrients in the litter have been found to give rise to a high weight loss (Davis and van der Valk 1978, Berg *et al.* 1982, Mun *et al.* 2000a, b). Initial N concentration of wild rice culms and rhizomes

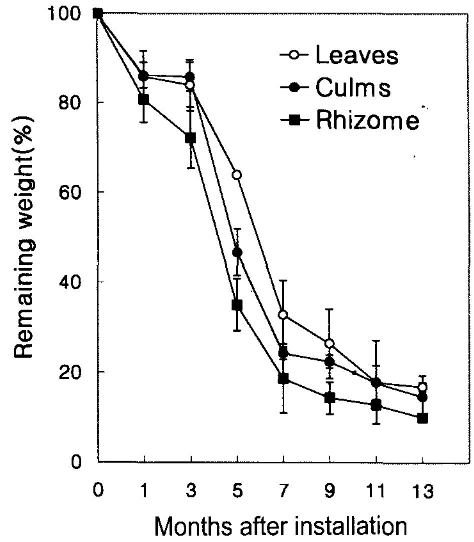

Fig. 1. Mean percent remaining weight in the decomposing organs of *Z. latifolia*. Bars indicate standard deviation.

(14.5 and 44.0 mg/g, respectively. Mun *et al.* 2000b) was greater than that of reed (9.0 and 15.5 mg/g, respectively). Decay rates of leaves and culms of cattail were lower than those of wild rice (Mun *et al.* 2000a). Initial N contents of leaves and culms of wild rice were greater than those of cattail. Leaves and culms of cattail were more rigid than those of wild rice.

Mun *et al.* (2000a, 2000b) reported that decay rates of leaves, culms and rhizomes were 1.06, 0.52 and 2.63 yr^{-1} for cattail, 1.21, 0.42 and 1.48 yr^{-1} for reed. Mason and Bryant (1975) reported that the annual decomposition rate of *P. communis* leaves was 1.26 yr^{-1}. Decay rate of each organ of wild rice was greater than those of cattail and reed except for rhizome. From these results, it was known that decay rate of herbaceous plant was largely determined by rigidity and nitrogen content of the tissue. Polunin (1982) reported that the loss of soluble matter through leaching is particularly significant in aquatic habitats because the material is in continual contact with water (Brinson *et al.* 1981, Polunin 1984).

Changes of nutrients

Initial N concentrations of leaves, culms and rhizomes of wild rice were 18.0, 14.5 and 44.0 mg/g. N in rhizomes was much higher than those in leaves and culms. N in leaves gradually decreased to 9.8 mg/g after 7 months, but since then increased slightly. N concentration of culms and rhizomes decreased to 9.0 and 15.5 mg/g, respectively, after 1 month. In case of rhizomes, N increased to 30.0 mg/g after 3 months, since then gradually decreased (Fig. 2A). After 13 months, N concentrations of leaves, culms and rhizomes were 10.5, 9.0 and 10.9 mg/g, respectively.

An early rapid loss of nitrogen in the litter has been noted in

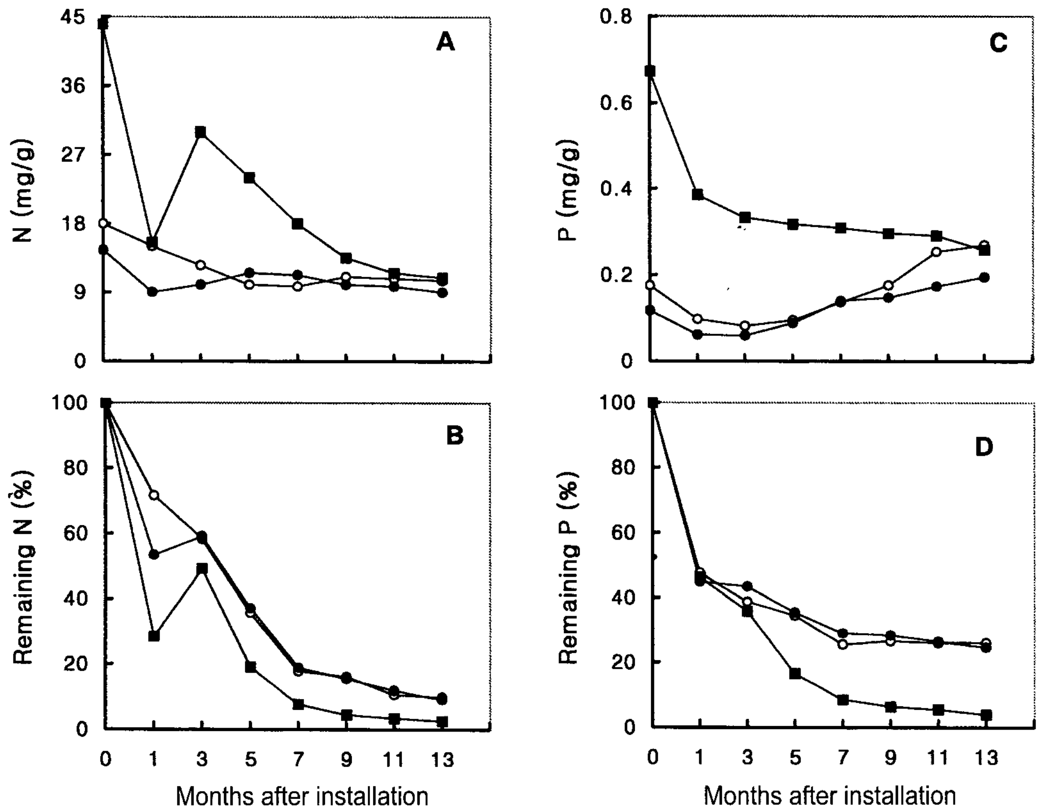

Fig. 2. Changes of N concentration (A), % of remaining N (B), P concentration (C) and % of remaining P (D) in the decomposing organs of *Z. latifolia*. Legends are the same as in the Fig. 1.

reed (Polunin 1982, Mun *et al.* 2000b) and sedges. (Chamie and Richardson 1978). The rapid loss of nitrogen within 1 month might due to the loss of soluble forms of nitrogen (Polunin 1984).

Percent remaining N in leaves, culms and rhizomes decreased during the first month to about 72, 54 and 29%, respectively, of the original N capital (Fig. 2B). N remaining in culms and rhizomes was much lower than those in reed and cattail (Mun *et al.* 2000a, 2000b). After 13 months, remaining N of leaves, culms and rhizomes was 9.9, 9.1 and 2.5%, respectively, which were lower than those in reed and cattail (Mun *et al.* 2000a, 2000b). There was no N immobilization period during the decomposition of wild rice.

Initial P concentrations of leaves, culms and rhizomes of wild rice were 0.18, 0.12 and 0.67 mg/g, respectively. P concentration of rhizomes was higher than those in leaves and culms. P concentration of rhizomes decreased to 0.39 mg/g after 1 month. In case of leaves and culms, P concentration decreased till 3 months and then increased thereafter (Fig. 2C).

Percent remaining P in leaves, culms and rhizomes decreased during the first month to 45% of the initial P capital. Since then, remaining P in rhizomes decreased more rapidly than those in leaves and culms (Fig. 2D). After 13 months, remaining P in leaves, culms and rhizomes was 26.0, 24.6 and 3.9%, respectively. Mun *et al.* (2000b) reported that remaining P in decomposing culms of reed increased after 3 months but decreased to 79.5% of the initial P capital after 13 months.

P may also exhibit a rapid loss in early period of decomposition (Boyd 1970, Mason and Bryant 1975). This may also due to the loss of soluble forms of organic matter through leaching process (Polunin 1984). There was no P immobilization period in each organ during the decomposition.

Initial K concentration of leaves, culms and rhizomes of wild rice was 14.1, 14.2 and 14.8 mg/g, respectively. K in each organ decreased sharply after 1 month. And then K increased slightly (Fig. 3A). This pattern was similar to those in cattail and reed (Mun *et al.* 2000a, b). After 1 month, percent remaining K in leaves, culms and rhizomes was 8.3, 3.4 and 10.5%, respectively, of the initial K capital. Almost all of the K in each organ leached out after 3 months (Fig. 3B). The rapid loss of K was attributable to leaching. Brinson (1977) reported that about 80% of original K in *Nissa aquatica* leaves was leached out within two weeks.

Initial Ca concentration of leaves, culms and rhizomes of wild rice was 3.60, 1.47 and 0.30 mg/g, respectively. Ca in leaves

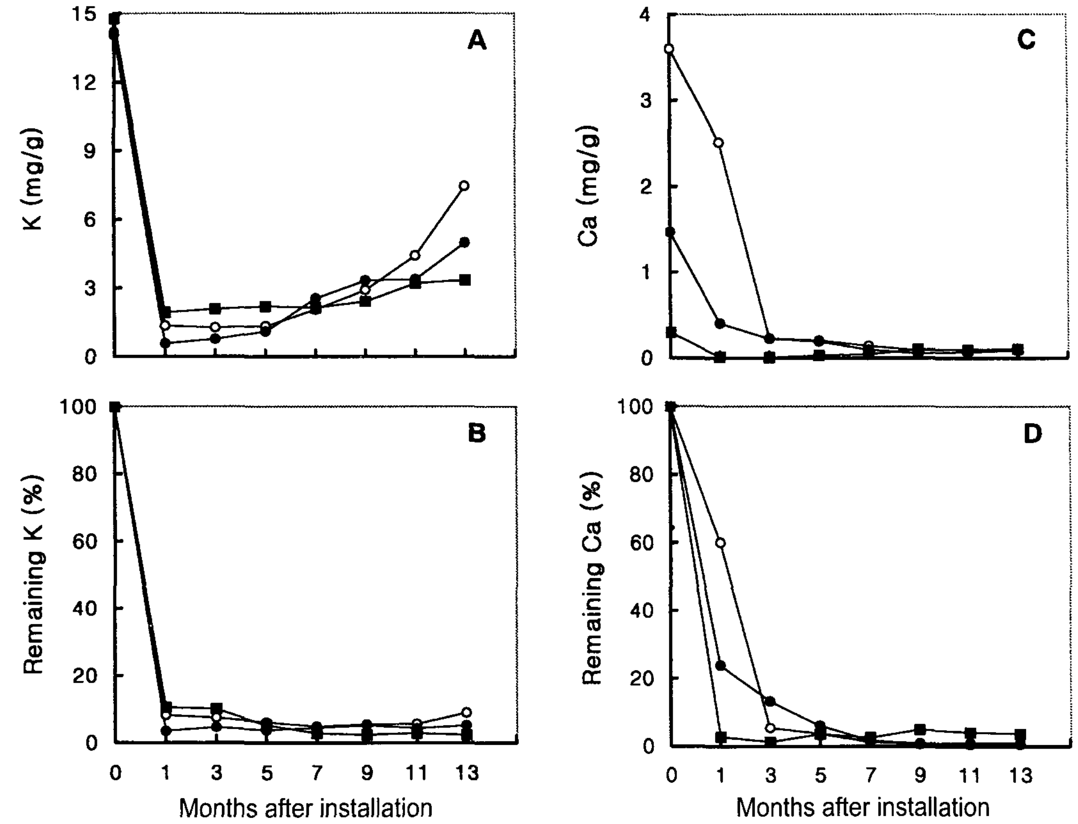

Fig. 3. Changes of K concentration (A), % of remaining K (B), Ca concentration (C) and % of remaining Ca (D) in the decomposing organs of *Z. latifolia*. Legends are the same as in the Fig. 1.

was much higher than those in culms and rhizomes. It decreased to 0.23, 0.23 and 0.01 mg/g, respectively, after 3 months (Fig. 3C). Percent remaining Ca in leaves, culms and rhizomes decreased to 5.4, 13.3 and 1.2%, respectively, of the initial Ca capital after 3 months (Fig. 3D). Ca is known not to leach as readily as potassium (Planter 1970, Davis and van der Valk 1978). However, in our experiment, most of the calcium leached out rapidly like potassium (Fig. 3D). This pattern was the same as that of cattail and reed (Mun *et al.* 2000a, 2000b).

Initial Mg concentration of leaves, culms and rhizomes of wild rice was 1.07, 0.48 and 0.53 mg/g, respectively. After 7 month, Mg in leaves decreased to 0.47 mg/g, and then showed an increasing trend (Fig. 4A). In case of culms and rhizomes, Mg increased to 0.53 and 0.67 mg/g after 1 month, and then gradually decreased till 5 months after installation (Fig. 4A). After 13 months, Mg in leaves, culms and rhizomes increased to 1.63, 1.58 and 1.63 mg/g, respectively.

Percent remaining Mg in leaves and culms decreased to 60.9 and 95.3% after 1 month. In rhizomes, however, remaining Mg increased to 102.3% after 1 month. They decreased to 15.9, 32.0 and 18.9% after 7 months, and then increased slightly (Fig. 4B). Davis and van der Valk(1978) reported that Mg leached out rapidly as K. However, Mg was more resistant to leaching than K and Ca in wild rice.

Except for Mg in rhizomes, there was no immobilization period during the decomposition of wild rice. In case of remaining K and Ca, most of them were lost during the first 3 months. Mason and Bryant (1975) reported that rapid loss of K, Mg and P in emergent hydrophytes takes place within the first month during the decomposition process. In our study, about 50% of the P in all organs, and 70% of N in rhizomes were lost during the first month. Therefore, considerable amount of N and P can be released from macrohydrophytes into surrounding water *via* decomposition process.

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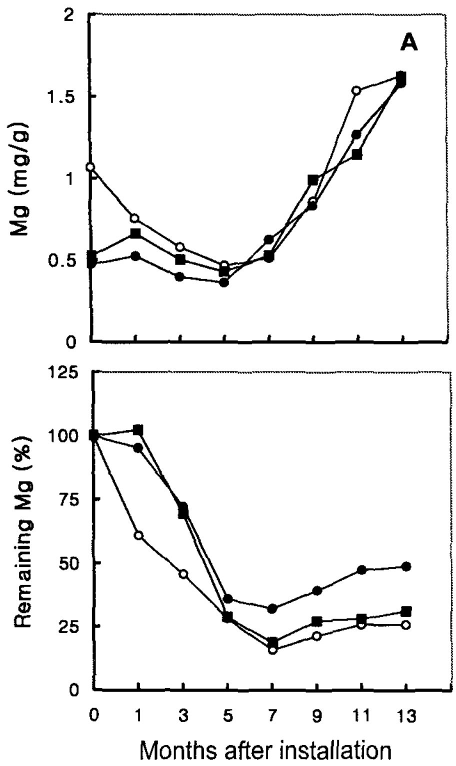

Fig. 4. Changes of Mg concentration (A) and % of remaining Mg (B) in the decomposing organs of *Z. latifolia*. Legends are the same as in the Fig. 1.

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