Chapter 5
Distribution of Phosphorus and Nitrogen in *Phragmites australis* Aboveground Biomass

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Abstract The objective of this study was to evaluate nitrogen and phosphorus compartmentalization in the aboveground biomass of *Phragmites australis* and its seasonality. The study was carried out at four sites in the littoral zones of two fishponds near Prague, Czech Republic. The aboveground biomass was harvested in early July and late August and the biomass was divided into thirds and stems and leaves. Besides dry weight of the biomass, concentrations of nitrogen and phosphorus were determined. The results revealed that the proportion of biomass formed by stems increases during the season. The concentrations of both nitrogen and phosphorus were higher in July and higher in leaves. Phosphorus standing stock is higher in stems then leaves while nitrogen standing stock is higher in leaves then in stems. The highest N and P standing stocks were found in upper leaves both in July and August.

Keywords Standing stock • Nitrogen • Phosphorus • *Phragmites australis*

5.1 Introduction

Nitrogen and phosphorus are taken up and assimilated by growing plants throughout the growing season. However, the highest concentrations in live plant tissue occur early in the growing season and decrease as the plants mature and senesce (Tyler 1971; Johnston 1991). The length of growing season varied widely among macrophytes with senescence occurring between July and September in temperate regions (Dykyjová 1973).

Total storage of a substance in a particular compartment is called standing stock. Nutrient standing stocks in the vegetation are commonly computed by multiplying nutrient concentrations in the plant tissue by dry mass per unit area and are expressed

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as mass per unit area (usually g m^{-2} or kg ha^{-1}) (Johnston 1991; Richardson and Vymazal 2001). The standing stock is affected both by dry mass and concentration of a particular element of interest. However, it has been shown that the biomass is the more important factor as it changes during the growing season more than nitrogen and phosphorus concentrations in stems and leaves (e.g. Boyd 1970; Eid et al. 2012). The nutrient standing stock seasonality has been documented many times in the literature (e.g. Dykyjová 1973; Vymazal 2005), however, the information how is the nutrient standing stock distributed among leaves and stems during the season is very limited. The objective of this study was to evaluate nitrogen and phosphorus compartmentalization in the aboveground biomass of *Phragmites australis* and its seasonality.

5.2 Materials and Methods

The experiments were carried out at four sites in the littoral zones of two fishponds near Prague, Czech Republic. The aboveground biomass was sampled on July 5 and August 29, 2014. Aboveground biomass of *P. australis* was harvested from the 0.25 m^2 (50 × 50 cm) quadrants in four replicates at each site. The shoots were clipped at the ground or sediment level, and all the shoots were divided into thirds and divided into leaves (L, including leaf sheaths), stems (S) and flowers (if present). The lower parts were labelled S1/3 and L1/3, middle parts S2/3 and L2/3 and upper parts of the shoots were labelled S3/3 and L3/3.

The biomass was dried at 60 °C to a constant weight and weighed. For the further analyses the biomass was ground using the cutting mill Pulverisette 15 (Fritsch, Idar-Oberstein, Germany) and analyzed for nitrogen and phosphorus. Total nitrogen was measured directly by using the Primacs SNC analyzer (Skalar, Breda, The Netherlands). Phosphorus was analyzed following the $HNO_3/HClO_4$ method of Sommer and Nelson (1972). NIST 1547 Peach Leaves were used as the standard (National Institute of Standards and Technology, Gaithersburg, MD, USA).

Statistical analysis of variance (ANOVA) followed by post-hoc Tukey HSD test was used to test differences between biomass and nutrients standing stocks of various plant parts. The significance level was set at $p < 0.05$.

5.3 Results and Discussion

5.3.1 *Distribution of Aboveground Biomass of* P. australis *Between Stems and Leaves*

The distribution of biomass among stems, leaves and flowers is shown in Fig. 5.1.

In July, the stems constituted 55.8 % (±2.3) of the aboveground biomass while the contribution of leaves was only 44.2 % (±2.5) ($p < 0.05$). In August, stems

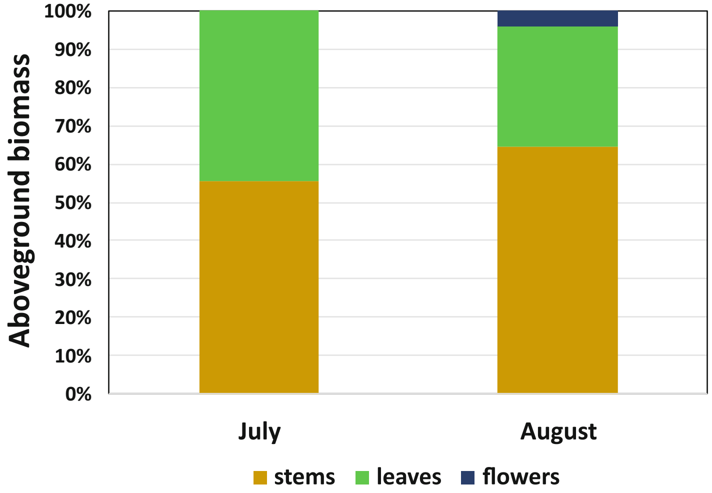

Fig. 5.1 Distribution of *P. australis* aboveground biomass among stems, leaves and flowers in July 4 and August 29, 2014

increased their contribution to 64.4 % (±1.5) while leaves formed only 31.7 % (±0.66) of the biomass ($p<0.05$). In addition, flowers comprised 3.9 % (±1.1) of the biomass. Both the increase of stem biomass and decrease of leaf biomass were statistically significant ($p<0.05$).

5.3.2 *Distribution of Phosphorus in Aboveground Biomass*

Concentrations of phosphorus in various *P. australis* parts are shown in Fig. 5.2. The data presented in Fig. 5.2 indicate that (a) P concentrations are higher in July than in August for both leaves ($p>0.05$) and stems ($p<0.05$), (b) phosphorus concentrations differ significantly ($p<0.05$) in the lower, middle and upper leaves while there is no significant difference for stems. The highest concentrations of phosphorus were found in upper leaves both in July and August. In July, the difference from most other compartments was not significant ($p>0.05$) while in August the upper leaves concentration was significantly higher than all other compartments ($p<0.05$).

The major compartments for phosphorus storage are upper leaves and lower parts of the stems (Fig. 5.3). There is significant difference ($p<0.05$) in standing stocks among lower, middle and upper parts of leaves and stems but there is no significant difference among values found in early July and late August. The highest P standing stock was found in upper leaves in July (33.1 %) and in lower stems in August (28.7 %).

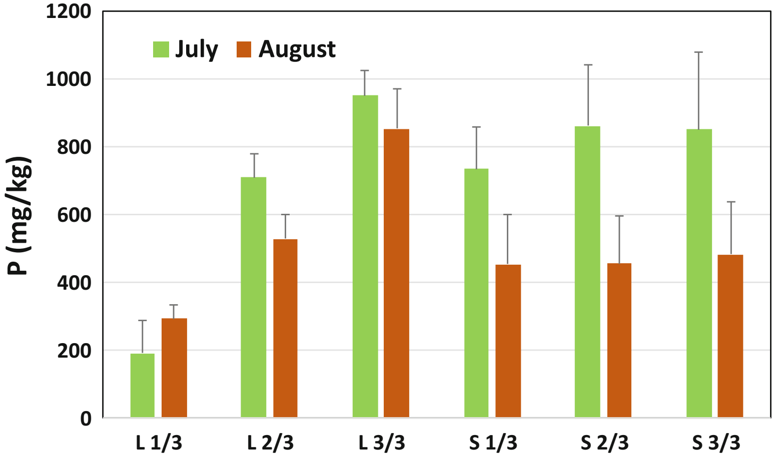

Fig. 5.2 Concentration of phosphorus in various parts of *P. australis* biomass. *Bars* represent standard deviation

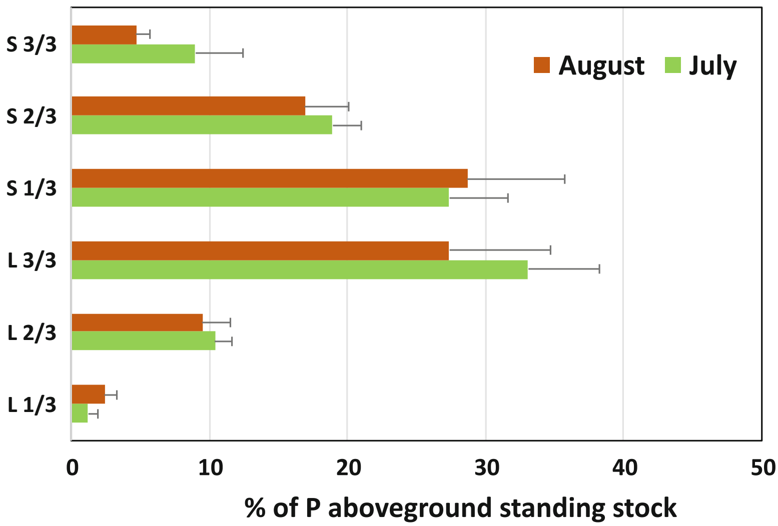

Fig. 5.3 Distribution of P standing stock in various compartments of *P. australis* shoots. *Bars* represent standard deviation

In July, the total P standing stock amounted to 55.3 % (±5.2) in stems and 44.7 % (±5.2) in leaves ($p<0.05$). In August, the average stem standing stock dropped to 50.3 % (±10.4) and leaf standing stock decreased to 39.3 % (±7.3). At this time, the difference was not significant ($p>0.05$). Flowers contributed with 11.4 % (±2.4) (Fig. 5.4). In the only comparable study, Dykyjová (1973) describing distribution of

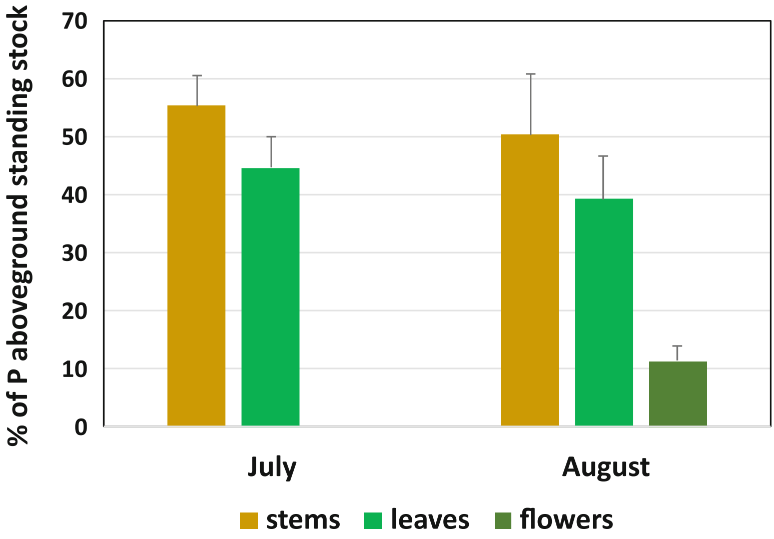

Fig. 5.4 Distribution of P standing stock among stems, leaves and flowers of *P. australis* shoots. *Bars* represent standard deviation

P standing stock in *P. australis* as follows: 67 % stems and 33 % leaves in July. In August, the respective compartments decreased to 42 % and 26 % with as much as 32 % of phosphorus being accumulated in flowers.

5.3.3 Distribution of Nitrogen in Aboveground Biomass

Concentrations of nitrogen (Fig. 5.5) followed exactly the same patter as concentrations of phosphorus. The highest concentrations were found in the middle and upper leaves and concentration of nitrogen was significantly higher in these compartments than in other compartments both in July and August ($p<0.05$). The highest nitrogen concentrations in the middle and upper leaves were also reported by Dykyjová (1973). Figure 5.6 indicates that the highest nitrogen standing stock is in upper leaves. In July it formed as much as 48.5 % of the total nitrogen standing stock, while in August it was 36.8 %. In all other compartments, the nitrogen standing stock was significantly lower ($p<0.05$).

Total nitrogen standing stock (Fig. 5.7) was distributed in opposite way to phosphorus. The higher standing stock was found in leaves (65 ± 4.0 % in July, 55 ± 3.0 % in August) than in stems ($p<0.05$). The contribution of stems to the total N standing stock was very similar in July (35 ± 4.0 %) and in August (34.4 ± 5.3 %). In August, 10.6 ± 2.7 % of N standing stock was allocated to flowers. Dykyjová (1973) observed 47 % and 53 % of N standing stock in stems and leaves, respectively in July. In August, the respective compartments decreased to 29 % and 54 % with as much as 17 % of phosphorus being accumulated in flowers.

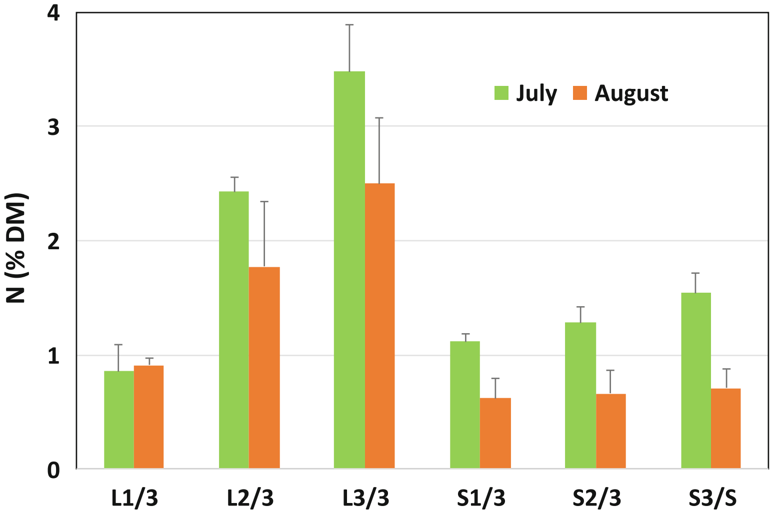

Fig. 5.5 Concentration of nitrogen in various parts of *P. australis* biomass. *Bars* represent standard deviation

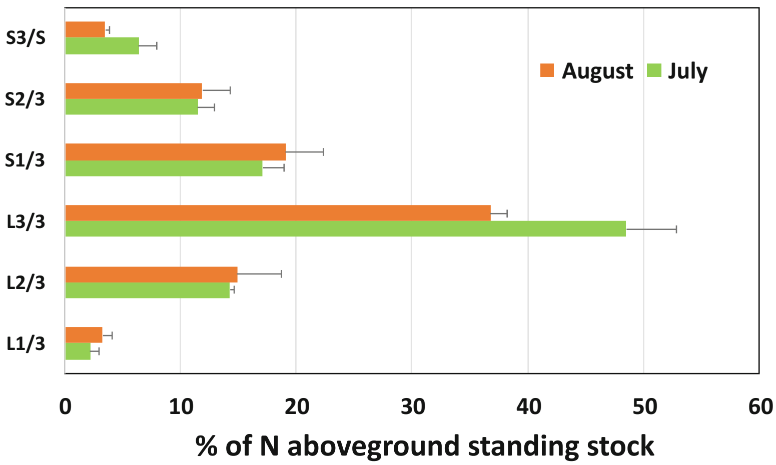

Fig. 5.6 Distribution of N standing stock in various compartments of *P. australis* shoots. *Bars* represent standard deviation

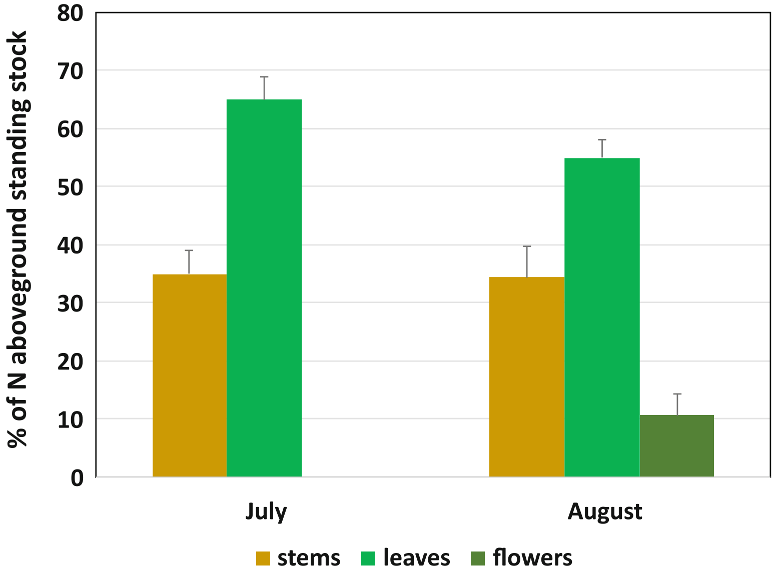

Fig. 5.7 Distribution of N standing stock among stems, leaves and flowers of *P. australis* shoots. *Bars* represent standard deviation

5.4 Conclusions

The results of our experiments revealed that the stem:leaf biomass ratio increased from 1.26 in early July to 2.03 in late August.

Concentrations of both nitrogen and phosphorus were higher in July than in August with the highest concentrations of both elements being found in upper leaves.

Phosphorus standing stock is higher in stems then leaves while nitrogen standing stock is higher in leaves then in stems. The highest N and P standing stocks were found in upper leaves.

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