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Evaluation of belowground seasonal dynamics of *Typha angustifolia* after cutting treatment

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ABSTRACT: *Typha angustifolia*, an emergent macrophyte, shows different growth characteristics under the influence of external forces. In this study, the growth characteristics of *T. angustifolia* were investigated after cutting the shoots (treatment area: 3m×4m). The treatment is considered as an external force. Two stands, one in a sterile zone and the other in a fertile zone, were cut at the end of June 2001 and the subsequent re-growth characteristics were observed. The difference of response, after cutting their shoots in the fertile zone and sterile zone was prominent. Shoot re-growth in the sterile zone was almost 100%, but it was only 10% or less in the fertile zone. A re-growth model was developed to evaluate the belowground dynamics by calibrating the shoot height and aboveground parameters. The belowground biomass of cut area after one year was simulated to be about 80% of that of uncut area. The results were verified using the belowground biomass observed in April 2002. The buds in the cut area are shorter than those of the uncut area. Moreover, the cut area in the fertile zone generated thinner buds than that of the sterile zone. The belowground biomass and re-growth strategy after cutting were supposed to cause the differences of their buds the year after.

Key Words: belowground dynamics, cutting treatment, fertile zone, sterile zone, *Typha angustifolia*

Introduction

The growth of emergent plants such as *Typha angustifolia* and *Phragmites australis* is sometimes restricted by flow velocity and fluctuation of rivers or ship wave motion. Various studies have been conducted to investigate the influence of cutting the aboveground biomass, which is one of external influences on such plant stands (Shekhov, 1974; Ulrich and Burton, 1985). In general, cutting in autumn (October) has been suggested as a safe treatment when the belowground biomass is still sufficient for plant recovery (Sakou et al., 2000). However, it has also been pointed out that it is difficult to specify the best cutting season (Hosoi et al., 1998). Conversely, the influence of cutting *Phragmites australis* in July on the belowground organs has been reported not to be considerable (Yutani et al., 2002). Moreover, when the cutting is done twice or more in a year, the influence of cutting affects the belowground organs in the subsequent year (Ulrich and Burton, 1985). Tanaka et al. (2001a) explained the necessity of setting on the cutting day by which growth is considered. Thus, there are a lot of obscure passages as for the best timing for cutting emergent plant stands and its influence on growth in the next year.

Tanaka et al. (2001b) proposed a model to describe the growth dynamics of *Typha angustifolia* that considered the difference of the productive structure, water depth and nutrient condition (Tanaka et al., 2002a, 2002b, 2002c). In the present study, a model to analyze the re-growth of the *Typha angustifolia* after cutting is developed based on the model of Tanaka et al. (2001b). This model validated using the results of a field experiment and the re-growth characteristics of *Typha angustifolia* is discussed.

Materials and Methods

The governing equations for the present model are based on the growth dynamic model of *Phragmites australis* proposed by Asaeda & Karunaratne (2000), and further developed for *Typha angustifolia* by Tanaka et al. (2001b, 2002a).

Lifecycle of emergent plants

Asaeda & Karunaratne (2000) detailed the phenology of *Phragmites australis* using the Julian day. For *Typha angustifolia*, almost same life cycle as *Phragmites australis* was assumed, because of the similarity in the phenology (Fiala, 1978; Beule, 1979). In this study, we consider the re-growth phase after cutting. According to Fiala (1978), the most distinct difference between *Typha angustifolia* that begins to grow in early spring and that begins to grow after it (May or June) is the growth period from start to peak biomass. For example, *Typha angustifolia*, which begins to grow up in May, has a peak in August. On the other hand, *Typha angustifolia* in June start has a peak also in August. Thus, it is thought that *Typha angustifolia* grows up by a similar life cycle although there is a difference for the growth period.

Mobilization of stored material from rhizomes to shoots

The amount of material flow from rhizomes to shoots was assumed to be proportional to its initial belowground biomass by Asaeda & Karunaratne (2000). As for the re-growth after cutting, *Typha angustifolia* is considered to have a similar life cycle even if the start day of growth is different. Then, the amount of material flow from rhizomes to shoots after cutting (*Rhif'*) can be expressed by the same equation as that for the initial growth period before cutting (Takemura et al., 2002).

$$Rhif' = \alpha_R \cdot a' \cdot {B_{rhi0}}^{b'} \cdot \theta^{(T-20)} \cdot B_{rhi}$$

Table 1. Parameters on cutting used in the model

Parameter	Value	Dimension	Comments
Coefficient introduced into the life cycle after cutting (k_l)	0.89	-	
Fraction of shoot biomass for elongation (q)	0.86	-	Initial regrowth season
	0.60	-	Photosynthetic growing season
Initial regrowth period (*Rday*)	38	day	
Coefficient depending on cutting day (a_R)	0～1	-	

The values of a' and b' are 0.133 and 0.58 with a correlation coefficient (R) of+0.87. θ is the Arrhenius constant (=1.09).

Table 1 lists the parameter used in the model after cutting. The constant (k_r) used for the life cycle after cutting was obtained from the field observation data of Fiala (1978). The fraction of shoot biomass for elongation and the initial re-growth period after the cutting were decided from field observation data (Takemura et al., 2002).

Study area

In order to verify the model, a cutting experiment was done for *T. angustifolia* at Shibakawa Pond in south of Saitama prefecture (35°51'N, 139°42'E). The colony size was 50 m×70 m and average water depth was about 30 cm in the study area. Two cutting areas were selected. The one is in the fertile zone and the other is in the sterile zone. The each area of cutting was 3m×4m. The stands were cut on June 27th, 2001 (178 Julian day), because nutrient condition in belowground biomass at this stage was considered to be most severe for the re-growth. The height of cutting was about 10 cm above the water surface. The observation was made for the central area of 1m×2m with the surrounding buffer area of 1m width. To reduce the damage to the colony as much as possible, we did not collect any sample from the cutting area. The biomass after cutting was estimated using an empirical relation obtained for another site, biotope in the Ukima golf course located in the Arakawa river terrace (35°47'N, 139°42'E). At last, we collected samples from the cut area in April 2002, and the model was validated using this field data.

Results

Figure 1 shows a photo of the field experimental site after 8 days from the cutting for the sterile zone. It is observed that *Typha angustifolia* has already re-grew after cutting. The average shoot height in the sterile zone is shown in Fig.2. The number of re-growth shoots was examined. There were considerable differences in the number of shoots emerged after cutting between the fertile zone and the sterile zone as shown in Fig.3. The number of shoots before cutting was about 60 and 100 in the sterile and fertile zones,

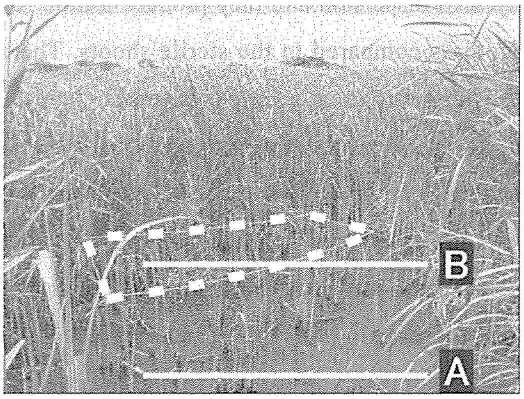

Fig. 1. The study area (Line A is the cutting height at day 178 and line B is the observed height at day 186. Broken line shows an observation area)

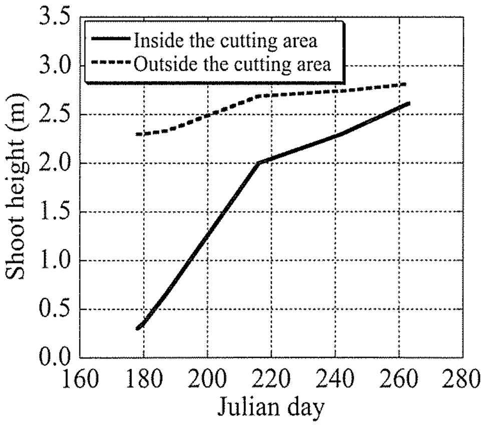

Fig. 2. Change of shoot height after cutting

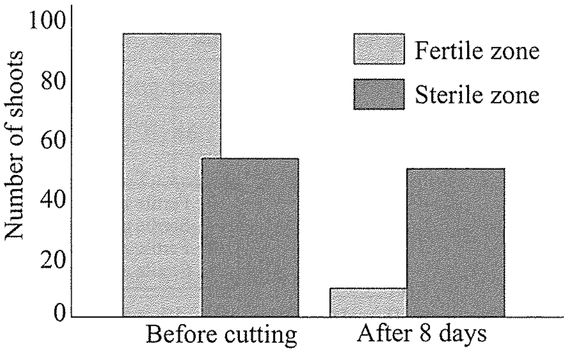

Fig. 3. The difference in the number of shoots between the fertile and sterile zone

respectively. After 8 days of cutting, the number of emerged shoots was about 10% in the fertile zone, whereas it was 100% in the sterile zone.

The analysis of growth dynamics was done based on the field observation data. The results for α_R=0.79 are shown in Figs.4 and 5. The aboveground biomass agrees well with the field data estimated by the empirical relation with a correlation coefficient of R=0.95. The field observation data of the initial belowground biomass in 2002 are also plotted in Fig.5. The simulation result slightly underestimates.

The field observation data of height and volume of the shoots are plotted in Fig.6. The shoot volume was calculated using observed shoot height and diameter and assuming that the shoot has a conical shape. It is evident from this figure that the size of shoots in the fertile zone and the sterile zone is noticeably different.

Discussion

To understand the difference of the growth strategy between sterile and fertile shoots of the *Typha angustifolia* by cutting, we conducted a field experiment and a model analysis. As seen in Fig.3, re-growth in the sterile zone starts immediately after cutting, however not in the fertile zone. Sterile shoots have a role to expand by belowground rhizome structure during the subsequent year, therefore they must continue to be productive by an immediate re-growth after cutting. On contrary, fertile shoots have a strategy to expand by seed dispersion and they produce a little rhizome biomass compared to the sterile shoots. Therefore, fertile shoots grew a little after cutting and formed slender buds for the next year as shown in Fig.6. The strategy after cutting between sterile and fertile shoots was found quite different, thus we must take into account the percentage of fertile shoots in total area when considering the belowground dynamics.

The simulation results of cut and uncut treatments have been shown in Figs. 4 and 5. From Fig. 5, it is seen that the simulated initial belowground biomass

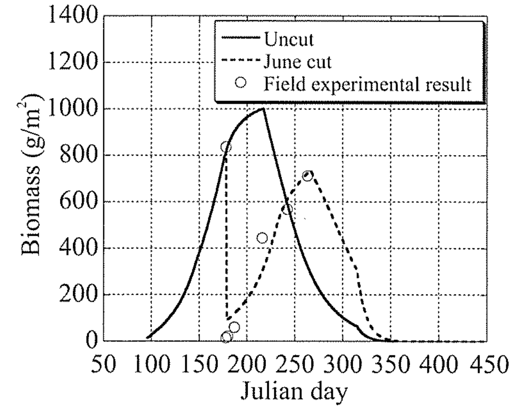

Fig. 4. Simulation of aboveground biomass based on field observation data of T. angustifolia

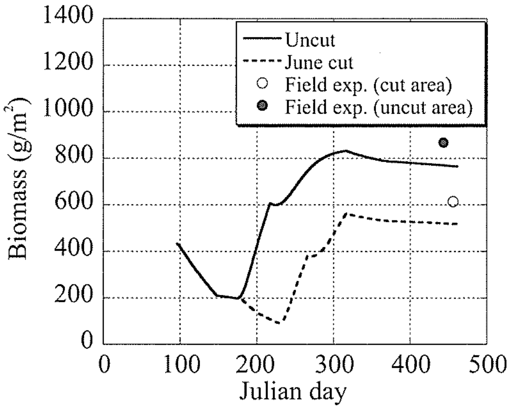

Fig. 5. Simulation of belowground biomass based on field observation data of T. angustifolia

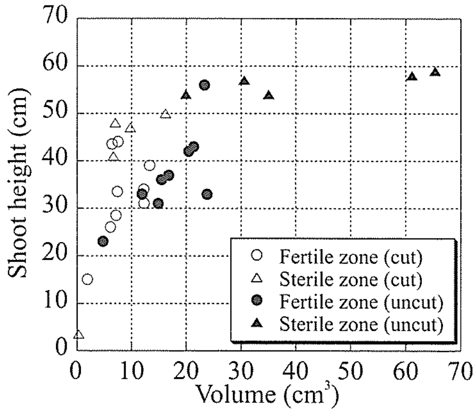

Fig. 6. Relationship between shoot height and shoot volume

is about 80% of that of uncut value. This value was verified by the field observation data of 2002. The field observation data was almost as predicted by the simulation results. This indicates the high accuracy of the model.

It is assumed that it is preferable to carry out cutting once a year considering the influence to the next year (Ulrich & Burton, 1985). However, they have not proposed the best time for cutting. The best time for cutting can be presumed using the model in this study. However, this model is formulated and validated by only one experimental result. Further investigation and verification are necessary based on cutting experiments performed at different times.

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