Intraspecific Competition among Plant Clones

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Abstract

The present study was conducted to provide information on intraspecific competition using clones of *Phragmites australis* (Cav.) Trin. ex Steudel (Common Reed). For our purpose, *P. australis* growths under single plantings with identical clones only (intra-genotypic experiments) were compared with those under mixed plantings with different clones (inter-genotypic experiments) in laboratory conditions. As the results show, there were not significant differences between growths of above-ground organs of *P. australis* clones in intra-genotypic experiments and those in inter-genotypic experiments. Negative effects, however, were shown in growths of below-ground organs of *P. australis* clones; the dry weights of below-ground organs of *P. australis* clone in intra-genotypic experiments were significantly inhibited as compared with those in inter-genotypic experiments (89.0 % of the latter). The above-mentioned results suggest *P. australis* has intraspecific competition among identical clones in the root communication. Furthermore, these results would offer meaningful information for revegetation, bio-environmental control and elucidation of succession, or biotechnology which enormously produces the plant clones.

Key words: Clone, Intraspecific competition, *Phragmites australis* (Cav.) Trin. ex Steudel

1. Introduction

Plant growth, dominance and distribution are dependent upon interspecific competition for limited resources, light, water and nutrients, and/or their allelopathic potential. Meanwhile, *Ambrosia dumosa* Payne (Asteraceae) which is one of the desert shrubs and *Miscanthus sinensis* Anderss. (Eulalia) which is one of the perennial grasses have self-nonsel self-recognition capability, and elongation of these plant roots decrease only after contact with roots of identical species which grow nearby (Mahall and Callaway 1991, 1992, 1996; Nishiwaki and Sugawara 1996). These results suggest plant growth, dominance and distribution are also decided by intraspecific competition besides interspecific competition and/or allelopathic potential.

Explanations for intraspecific competition of other plants have been also sought for many years through descriptive pattern analysis (Yeaton and Cody 1976; Yeaton *et al.* 1977; Phillips and MacMahon 1981; Cody 1986; McAuliffe 1988) and through experimental field studies (Fonteyn and Mahall 1978, 1981; Robberecht *et al.* 1983; Ehleringer 1984; Manning and Barbour 1988). These studies have revealed important questions regarding the intraspecific competition, but their resolutions have often not been fine enough to accurately support intraspecific competition in nature. Further works regarding the intraspecific competition are important to describe mechanisms which decide plant growth, dominance and distribution, and they

would also be beneficial to revegetation, bio-environmental control and so on.

The objective of this study is to provide information on intraspecific competition, using clones of *Phragmites australis* (Cav.) Trin. ex Steudel (Common Reed) which is one of the cosmopolitan Poaceae, perennial large hydrophytes. For our purpose, *P. australis* growths under single plantings with identical clones only (intra-genotypic experiments) were compared with those under mixed plantings with different clones (inter-genotypic experiments) in laboratory conditions.

2. Materials and Methods

2.1 Plant material

In the middle of July, *P. australis* culms of identical rhizome origin were, respectively, collected from three different sites, the basins of the Tokachi River, the Kushiro R. and the Shibetsu R. in Hokkaido, northern Japan. These sites are, respectively, 100-190 km apart, geographically (Fig. 1 and Table 1). The culms were then cut into several segments, 25 cm lengths with two nodes, for bioassay use.

An invisible small lateral bud is attached to each node of *P. australis* culm (Fig. 2), and the bud can grow as a clone of genetically identical individuals from the culm under moist conditions (Uchida *et al.* 2003).

2.2 Bioassay of culm segment

Five culm segments from the same site (test culms)

Table 1. Characteristics of *P. australis* communities from which culms were collected in this study.

Items	Sampling sites			<i>p</i> -value
	Tokachi R.	Kushiro R.	Shibetsu R.	
Culm length (cm)	175.6 ± 6.3 A	176.6 ± 4.2 A	171.0 ± 15.5 A	<i>p</i> =0.254
Number of leaves (No. / culm)	14.0 ± 0.7 A	13.6 ± 0.9 A	13.4 ± 0.9 A	<i>p</i> =0.531
Number of culms (No. / m ²)	126.7 ± 28.1 A	146.7 ± 19.7 A	138.7 ± 18.0 A	<i>p</i> =0.575
Basal diameter of culm (mm)	8.0 ± 0.7 A	8.0 ± 0.7 A	7.5 ± 0.9 A	<i>p</i> =0.570

Mean ± S.D. The levels of significance are also shown. Within any row, values followed by the same letter are not significantly different using a one-way analysis of variance.

Fig. 1. Locations of sampling sites in this study, in Hokkaido, northern Japan.

I, II and III indicate the basins of the Tokachi River, the Kushiro R. and the Shibetsu R., respectively. ●: Sampling site.

were placed in a plastic chamber with those from the other site (target culms) for intergenotypic experiments (Fig. 3). For intragenotypic experiments, five culm segments from the same site (test culms) were placed in a plastic chamber with five target culms from the same site. Distilled water was added to the plastic chamber, and the total volume of distilled water was maintained at 400-500 milliliters during the experimental period. Five replications were used for each experiment or all the site combinations. The prepared plastic chambers were then incubated at 25 °C with 12 h of light for ninety days.

The number of lateral buds elongated from test culms and their heights were measured periodically. The former was expressed as a percentage, elongation rate of lateral bud (%), using the following formula (1). Furthermore, dry weights of above- and below-ground organs of lateral buds elongated from the test culms were measured after ninety days of incubation. Above-ground organs are stems, laminae and sheaths, and below-ground organs consist of adventitious roots and rhizomes.

$$\text{Elongation rate of lateral bud (\%)} = \frac{NLB}{TNN} \times 100 \quad (1)$$

Where *NLB* shows the number of lateral buds elongated from test culms per plastic chamber, and *TNN* is ten, the total number of nodes (lateral buds) of test culms per plastic chamber (Fig. 3).

Fig. 2. Lateral bud which grows as a clone.

[I]: Segment of *P. australis* culm. [II]: Node and an invisible small lateral bud. [III]: Lateral bud elongated from the culm. [IV]: Adventitious root.

Fig. 3. Schematic drawings of experimental chamber.

(I) and (II) indicate side and face views of the chamber, respectively.

2.3 Data analysis

A one-way analysis of variance or t-test was performed on the data. Probabilities less than 0.05 were considered significant.

3. Results and Discussion

3.1 Lateral bud elongations

When test culms were placed with target culms from

the same site (intra-genotypic experiments), lateral buds elongation from test culms were observed on and after eight days of incubation (Fig. 4-(1)). The elongation rate of lateral buds increased rapidly from 14.6 % at eight days of incubation to 84.1 % at twelve days of incubation, and the rate had no change afterwards. Similarly, lateral buds elongation from test culms placed with target culms from the other site (inter-genotypic experiments) were also observed on and after eight days of incubation. The elongation rate of lateral buds increased rapidly to 82.3 % at sixteen days of incubation, and no change was shown in the rate afterwards. Within each experiment, there were not significant differences between final means at ninety days of incubation in elongation rate of lateral buds ($p=0.890$).

3.2 Lateral bud heights

When test culms were placed with target culms from the same site (intra-genotypic experiments), heights of lateral buds elongated from test culms increased gradually to 22.9 cm at ninety days of incubation (Fig. 4-(2)). Heights of lateral buds elongated from test culms placed with target culms from the other site (inter-genotypic experiments) also indicated the same tendency as change of heights in intra-genotypic experiments, and they reached 20.8 cm at ninety days of incubation. Within each experiment, significant differences between final means at ninety days of incubation were not shown in lateral bud heights ($p=0.275$).

3.3 Lateral bud weights

When test culms were placed with target culms from the same site (intra-genotypic experiments), dry weights of above-ground organs of lateral buds elongated from test culms were 4.64 g per chamber at ninety days of incubation (Fig. 5-(1)). Meanwhile, dry weights of above-ground organs of lateral buds elongated from test culms were 4.82 g per chamber at ninety days of incubation when placed with target culms from the other site (inter-genotypic experiments). There were insignificant differences between dry

weights of above-ground organs of lateral buds elongated from test culms in intra-genotypic experiments and those in inter-genotypic experiments ($p=0.662$).

Significant differences, however, were shown ($p<0.001$) between dry weights of below-ground

Fig. 4. Changes of elongation rate of lateral bud (1) and lateral bud heights (2).

● : Intra-genotypic experiments ($n=15$). ○ : Inter-genotypic experiments ($n=30$). Vertical bars show standard deviation. Differences between final means in each experiment were determined using t-test, and the levels of significance are also shown.

Fig. 5. Comparison between intra-genotypic and inter-genotypic experiments in dry weights of lateral buds elongated from test culms after ninety days of incubation. (1) and (2) show above- and below-ground organs, respectively. Differences between means in each experiment were determined using t-test, and the levels of significance are also shown.

Fig. 6. Lateral buds elongated from test culm in intergenotypic experiments.
[I]: Culm segment. [II]: Above-ground organs of lateral bud. [III]: Below-ground organs of lateral bud.

organs of lateral buds elongated from test culms in intragenotypic experiments and those in intergenotypic experiments (Fig. 5-(2)); their dry weights per chamber in intragenotypic and intergenotypic experiments were, respectively, 5.52 g and 6.18 g, the former was significantly lighter (89.0 % of the latter). Meanwhile, lateral buds elongated from test culm in intergenotypic experiments are shown in Fig. 6. It is proved that lateral buds grow as clones of genetically identical individuals from culm segments.

It can not be explained whether dry weights inhibition of below-ground organs of lateral buds in intragenotypic experiments was caused by self-nonself recognition capability (Mahall and Callaway 1991, 1992, 1996; Nishiwaki and Sugawara 1996) or allelopathic potential. The findings in this study, however, would suggest growth, dominance and distribution of *P. australis* are dependent upon intraspecific competition among identical clones, especially in subterranean parts. One *P. australis* community consists of some genetically different units (Dykyjová 1978), and such phenomenon would also support existence of intraspecific competition of *P. australis* among identical clones, which was suggested in this study.

The above-mentioned results using *P. australis* clones would provide meaningful information for revegetation, bio-environmental control, elucidation of succession, biotechnology and so on. A very accurate solution on the mechanism of intraspecific competition among plant clones, however, is required for the further development of biotechnology which enormously produces the plant clones.

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