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# Ability of three temperate grasses to compete with *Phalaris arundinacea* L.

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## Introduction

Weeds with rhizomes have become an ever-increasing problem in the grasslands of Hokkaido in northern Japan. Many meadows in the Tenpoku region, located in the northernmost part of Hokkaido, have been invaded by *Phalaris arundinacea* L., a grass with aggressive colonising ability known as the primary and most difficult to control weed in the Tenpoku region. However, dairy farmers in the grasslands of the Tenpoku region most commonly cultivate *Phleum pratense* L., in spite of its low competitive ability. The Tenpoku region frequently experiences years of low rainfall or drought, but *P. pratense* has low tolerance to drought (Okamoto *et al*., 2012; Okamoto and Furudate, 2010). *Lolium perenne* L. and *Dactylis glomerata* L. are also cultivated in the Tenpoku region, where they are used as rough forages; however, they are much less commonly cultivated than *P. pratense*. These species are thought to possess not only higher competitive ability than other grasses, but also higher drought tolerance than *P. pratense*, and thus may be more suitable for cultivation in some parts of the Tenpoku region. Therefore, we suggest that farmers choose a grass species suitable for their land. To further develop this concept, it is necessary to elucidate the differences among the abilities of these species to compete with invading *P. arundinacea*. Therefore, the objective of this study was to evaluate and compare the competitive ability of these temperate grass species (*L. perenne*, *D. glomerata*, and *P. pratense*) with those of *P. arundinacea*.

## Materials and Methods

A field experiment was conducted in 2013 on the brown forest soil field at the Tenpoku Sub-station in Hamatombetsu, Japan. Three grass species (*L. perenne*, *D. glomerata*, and *P. pratense*) were used in this experiment. Two renovation seasons were studied. This study investigated sward renovations carried out at two different times 7$^{th}$ June and 2$^{nd}$ August in 2013. During each renovation in this experiment, we planted 20 kg of seeds for each grass and 4 kg of *P. arundinacea* seeds. Each treatment included four replicate plots. In 2014, all species were harvested twice a year. Harvests were conducted on 23$^{rd}$ June and 19$^{th}$ August. However, in the Tenpoku region *L. perenne* and *D. glomerata* are commonly harvested 3 times per year; therefore, we included additional treatments for these species, in which harvesting was carried out 3 times (on 11$^{th}$ June, 30$^{th}$ July, and 22$^{nd}$ September) per year.

The grass, harvested as herbage, was cut to 5 cm above the ground, and fresh weights were measured. About 350 g of harvested fresh sample from each plot was separated into 3 groups, *i.e.*, experimental each grass species (*L. perenne*, *D. glomerata*, and *P. pratense*), *P. arundinacea*, and other herbaceous plants. Then, the others and fresh weight of the material in the different categories was used to calculate the botanical composition of it was calculated each plot. Crown covers of the plots were observed during each harvest, as well as at the beginning of the snow season (in November), and from the end of the snow season to the first harvest (in April and May). On 30$^{th}$ October 2014, the roots of the experimental plants were excavated and removed, down to 10 cm below ground. These root samples were washed to remove soil and dust, and the roots of each experimental grass species (*L. perenne*, *D. glomerata*, *P. pratense*, and *P. arundinacea*), and the others those of non-grass species were sorted according to their morphological traits. Each root sample was dried and weighed, and its rhizome composition calculated as a function of dry weight.

Differences between the different treatment plots' botanical and rhizomatic compositions of the plant variables in the different treatments were evaluated by ANOVA and Tukey's multiple-range test. Data were arcsine transformed prior to analysis.

## Results and Discussion

In November 2013, the *P. arundinacea* crown cover in the June-renovated *L. perenne* and *D. glomerata* swards was less than 10%; however, in the *P. pratense* sward its coverage was 41% (Fig. 1). In the August-renovated sward, the crown cover was about 20% in the *P. pratense* and *D. glomerata* swards, but less than 10% in the *L. perenne* swards.

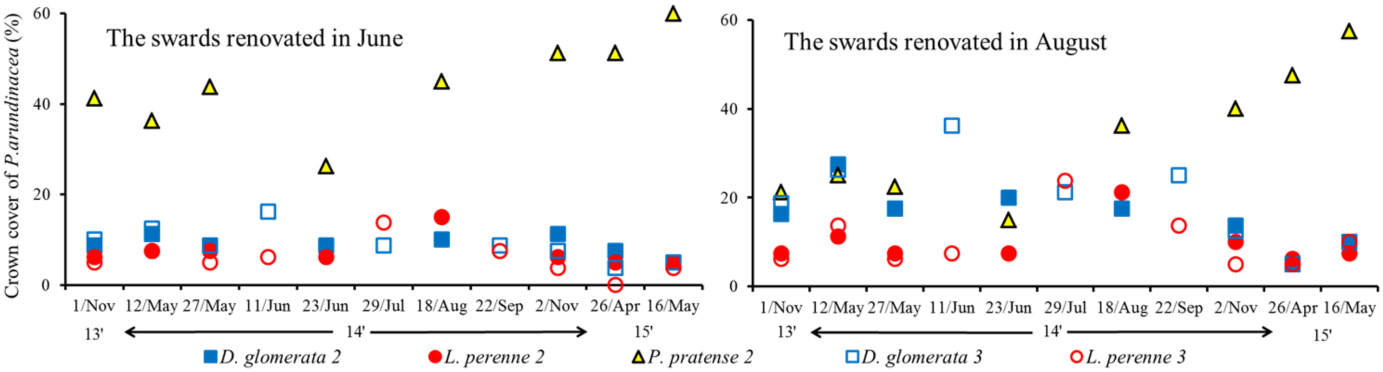


**Fig. 1:** Crown covers of *P. prundinacea* in each sward and its changes over time after each renovation. The number following each species indicates harvest times per year.

Similar crown cover results have been reported since 2014 (Fig. 1). *P. arundinacea* crown-cover in the June-renovated swards was less than 16% in *L. perenne* and *D. glomerata* swards throughout this period; however, in *P. pratense* swards, *P. arundinacea* crown cover increased to more than 50% since November 2014. *P. arundinacea* crown cover in *L. perenne* swards was low in the August-renovated plots, but higher in the June-renovated plots. In the August-renovated *D. glomerata* swards, *P. arundinacea* crown cover was 21-36% - much higher than that in the June-renovated swards. In the August-renovated *P. pratense* swards, *P. arundinacea* crown cover was similar to that observed in the June-renovated swards. In 2015, *P. arundinacea* crown cover was less than 10% in *L. perenne* and *D. glomerata* swards; however, in the *P. pratense* sward it was >50%. *L. perenne* or *D. glomerata* comprised more than 80% of the botanical composition of the June-renovated *L. perenne* and *D. glomerata* swards, while *P. arundinacea* comprised almost less than 10% (Table 1). However, in the June-renovated *P. pratense* swards, the botanical composition of *P. pratense* was much lower, at 67%, during the 1st harvest and 48% during the 2nd harvest. During the 2nd harvest, the botanical composition of *P. arundinacea* during the 2nd harvest was equivalent to that of *P. pratense* during the same period. In the August-renovated *L. perenne* swards, the botanical composition of each harvest was more than 80%. During the 1st and 3rd harvests of the August-renovated *D. glomerata* swards, *D. glomerata* comprised less than 80%, and *P. arundinacea* comprised 17-28%. *P. arundinacea* was higher in the August-renovated *P. pratense* swards, the botanical composition of which was 67% and 32% for *P. pratense* and *P. arundinacea*, respectively, during the 2nd harvest.

Rhizome research conducted in November 2014 implied that the rhizome composition of the August-renovated *L. perenne* and *D. glomerata* swards included a larger percentage of *P. arundinacea* than the June-renovated swards (Table 1); however, *P. pratense* showed the opposite result, as the rhizome compositions of the August-renovated *D. glomerata* swards and June-renovated *P. pratense* swards included larger percentages of *P. arundinacea*.

Table 1: Botanical and rhizomatic composition of each harvest.

| Renovating season | harvest times per year | Grass species | Botanical composition of each harvest in 2014 (% per fresh weight) | | | | | | Composition of rhizome (%)§ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1st harvest | | 2nd harvest | | 3rd harvest | | | |
| | | | each grass | P. a† | each grass | P. a | each grass | P. a | each grass | P. a |
| The meadows renovated in June | 2 times | *D. glomerata* | 89 a‡ | 9 b | 95 a | 4 b | - | - | 93 a | 6 b |
| | | *L. perenne* | 91 a | 6 b | 90 a | 8 b | - | - | 96 a | 4 b |
| | | *P. pratense* | 67 b | 27 a | 48 b | 48 a | - | - | 65 b | 33 a |
| | 3 times | *D. glomerata* | 83 ab | 13 b | 93 a | 4 b | 85 a | 8 a | 96 a | 2 b |
| | | *L. perenne* | 88 a | 7 b | 91 a | 6 b | 93 a | 5 a | 90 a | 9 b |
| The meadows renovated in August | 2 times | *D. glomerata* | 73 b | 23 a | 84 a | 15 ab | - | - | 74 b | 26 a |
| | | *L. perenne* | 93 a | 7 b | 85 a | 9 b | - | - | 96 a | 4 a |
| | | *P. pratense* | 82 ab | 16 ab | 67 b | 32 a | - | - | 84 ab | 16 a |
| | 3 times | *D. glomerata* | 69 b | 27 a | 81 ab | 17 ab | 71 b | 28 a | 66 b | 34 a |
| | | *L. perenne* | 90 a | 9 b | 92 a | 6 b | 91 a | 8 b | 76 ab | 24 a |

†Abbreviation for *Phalaris arundinacea* L.

‡Columns labelled with different letters with-season are significantly different (P<0.05).

§The rhizomes were sampled on 5th November of 2014.

Meteorological factors and the characteristics of each grass could explain the differences between the two seasons. In 2013, Hamatombetsu experienced low rainfall from mid-June to early August, and heavy rainfall occurs from mid-August to early September. Therefore, we suggest that the conditions during the June renovation were too severe to allow *P. pratense* to successfully compete with *P. arundinacea*. However, *D. glomerata* is less moisture-tolerant and ceased growth in preparation for overwintering earlier in the autumn than the other grasses. Hence, *D. glomerata* did not dominate the August-renovated sward. We recommend that renovations using *D. glomerata* should be conducted during the earlier season.

After the 2nd harvest in 2014, *P. pratense* coverage decreased and *P. arundinacea* coverage increased in both *P. pratense* swards. Yoshikawa *et al*. (2014) reported that plant length of *P. pratense* is almost shorter than that of *P. arundinacea* throughout the year, unlike *L. perenne* and *D. glomerata*. We confirm that *P. pratense* receives less sunlight when grown with *P. arundinacea*, and thus cannot compete effectively with *P. arundinacea*.

*L. perenne* was able to compete effectively with *P. arundinacea*, in all swards included in this study. *L. perenne* exhibited faster initial growth and regrowth, and greater tillering than the other species under fertile conditions (Okamoto and Furudate, 2007). These characteristics might allow it to compete effectively with *P. arundinacea*.

**Conclusion**

This study evaluated the ability of three temperate grasses to compete with *P. arundinacea* over a course of approximately 2 years. *P. pratense* exhibited a relatively low competitive ability. The competitive ability of *D. glomerata* is initially affected by the renovation season. Of the species examined in this study, *L. perenne* exhibited the highest competitive ability.

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