Clonal Variation in Salt Tolerance of *Imperata cylindrica* (L.) Beauv. var. *koenigii* (Retz.) Durand et Schinz

Tohru Tominaga, Hisao Kobayashi* and Kunikazu Ueki**

Synopsis


To clarify the differences in salt tolerance between the common (C-) and fore-dune (F-) type of *Imperata cylindrica* var. *koenigii*, three clones of C-type collected from mountainous regions, the other three C-type clones from coastal plains, and three clones of F-type from fore-dunes of Kii Peninsula were used in the experiment. The concentration of NaCl treated was 0.0, 1.5 and 3.0%. Each treatment had five ramets derived from each clone. In each treatment, 200 ml of NaCl solution was poured into each pot at intervals of two weeks from August 4 to November 10, 1987. On November 24, 1987, the ramets were dug up and their plant length, number of shoots and rhizomes, rhizome length and dry matter weight of each organ were measured. The plant length and total dry matter weight of each clone were decreased with the increase of NaCl concentration. Total dry matter weight of F-type clones was smaller than that of C-type clones in control, but the reverse was observed under NaCl treatment. The decrease of total dry matter weight by NaCl treatment of F-type was smaller than C-type. As for number of shoots, the different clones reacted to increasing NaCl concentration in different ways. The root dry matter production of eight clones except F-type clone No. 8 was reduced by NaCl treatment, but that of clone No. 8 was not. The differences between C- and F-type clones in the response to NaCl treatment were especially clear in rhizome production. The decrease of rhizome weight and length by NaCl treatment was smaller in F-type than C-type. F-type of *L. cylindrica* var. *koenigii* is probably well adapted to the habitat where plants have been exposed to salt spray.

**Key words**: Adaptive differentiation, Fore-dune type, *Imperata cylindrica*, Salt tolerance.

Introduction

*Imperata cylindrica* (L.) Beauv. is useful wild grass. This rhizomatous grass is used as livestock feed, paper making material, thatching and soil binder*. Various mode of variation in this grass of Japan was reported7–10,12,13. Tominaga

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Faculty of Agriculture, Shinshu University, Minamiminowa, Kamiina, Nagano 399-45, Japan
* Faculty of Agriculture, Yamaguchi University, Yoshida, Yamaguchi 753, Japan
** The Ishikawa Agricultural College, Suematsu, Nonoiichimachi, Ishikawa 921, Japan
et al. reported the fore-dune (F-) type of *I. cylindrica* var. *koenigii* (Retz.) Durand et Schinz, which distribution is confined to the fore-dune, where plants have been exposed to salt spray from the sea, in the southern part of the Kii Peninsula. This type is male sterile and smaller in plant size than common (C-) type.

As Ashraf et al. pointed out, breeding for salt tolerance is an agriculturally desirable aim. The present experiment was designed to clarify the differences in salt tolerance between C- and F-type of this grass species. It was conducted at the Subtropical Plant Institute of Kyoto University, located at the southern extremity of the Kii Peninsula. The adaptive mode of F-type to its habitat was discussed from the viewpoint of salt tolerance.

![Collection location of *Imperata cylindrica* var. *koenigii*.](image)

- **Fig. 1.** Collection location of *Imperata cylindrica* var. *koenigii*.  
  - **: common type, **: fore-dune type
Materials and Methods

At the nine sites of the Kii Peninsula (Fig. 1), five clones per one site, a total of 45 clones of *I. cylindrica* var. *koenigii* were collected in 1981 and 1982. They have been maintained individually in the experimental field of the Subtropical Plant Institute of Kyoto University. Among them, one clone per one site, a total of nine clones were used in this experiment. Clone Nos. 1, 2 and 3 were collected from roadside, orchard and abandoned field in mountainous regions, respectively. Clone Nos. 4 and 5 were sampled from roadside and No. 6 clone were collected from the abandoned field in coastal plain, respectively. These six clones belong to C-type. Clone Nos. 7, 8 and 9 were originated in fore-dune and are F-type. They were within 50 m from shoreline, where plants were exposed to salt spray from the sea.

Rhizomes of the nine clones were dug up on April 20, 1987, and cut into 10 cm length with 10 to 12 nodes. The pieces of rhizome were put on the vermiculite beds in a greenhouse. On June 10, the ramets of 12 cm length with three leaves, which were derived from cut rhizomes, were transplanted individually in 1/5000 a Wagner pots filled with vermiculite. The plants were grown in a greenhouse. From June 22 to November 19, 1987, at the intervals of ten days, 200 ml of liquid fertilizer containing 0.02% N, 0.01% P and 0.01% K was poured into each pot.

NaCl treatments were started on August 4, 1987. The concentrations of NaCl used were 0.0 (control), 1.5 and 3.0%, respectively. Each NaCl treatment had five ramets for each clone. A total of 135 ramets, five ramets × nine clones × three NaCl concentrations, were treated in this experiment. In control, 200 ml of deionized distilled water was poured into each pot at intervals of two weeks from August 4 to November 10, 1987. In 1.5 and 3.0% NaCl treatments, 200 ml of each concentration NaCl solution was applied in the same way as in the control.

On November 24, 1987, the ramets were dug up to measure their plant length, number of shoots, number of rhizomes and rhizome length. The dry matter weight of each organ was investigated after plant materials were sufficiently dried at 80°C for 48 hours.

Since the variance among five ramets within a clone was small, the average values of five ramets were calculated.

Results

Plant length of each clone was reduced by increasing NaCl concentration (Fig. 2-a). These of Clone Nos. 1 and 2 were remarkably reduced. At 3.0% NaCl concentration, the reduction rate to control of plant length of F-type clone No. 8 was the smallest (11.7%) among nine clones. Shoot number of each clone reacted to increasing NaCl concentration in different ways (Fig. 2-b). At 1.5% NaCl concentration, shoot number of clone No. 8 showed the maximum value, but those of clone Nos. 3, 4 and 9 showed the minimum number among all treatment.

Total dry matter weight of each clone was significantly decreased by NaCl treatment and clear differences in response to NaCl treatment were shown between C- and F-type clones (Fig. 2-c and d). By 1.5 and 3.0% NaCl treatment, total dry matter weight of C-type was more decreased than that of F-type. The mean total dry matter weight of six clones of
C-type in control was larger than three clones of F-type, but in both 1.5 and 3.0% NaCl treatments, the reverse situation was true. The total dry matter weight of F-type clone No. 8, which was the smallest in the control, was the largest in 3.0% NaCl treatment.

As shown in a) and b) of Fig. 3, the dry matter weight of leaf-blade and leaf-sheath of each clone was decreased as NaCl concentration increased. In root and rhizome dry matter production, significant different effect of NaCl treatment was observed among clones (Fig. 3-c and d). Increasing concentration of NaCl had a significant inhibitory effect on root dry matter production of eight clones, Nos. 1–7 and 9, but in F-type clone No. 8 there were no differences in root dry matter weight among three NaCl treatments. The decrease of rhizome
dry matter weight by NaCl treatment was smaller in the F-type clones, especially No. 8 clone, than the C-type clones. Rhizome number of clone No. 1 remarkably decreased as NaCl concentration increased (Fig. 4-a). Clone No. 2 had the largest number of rhizomes in 1.5% NaCl treatment. The reduction of total rhizome length by NaCl treatment was smaller in F-type clones than in C-type clones. As for the dry matter weight of 1 m length rhizome, different clones reacted in different ways. This value of five clones, Nos. 3-6 and 9, was decreased with the increase of NaCl concentration. Clone Nos. 1 and 2 had the smallest weight of 1 m length rhizome in 1.5% treatment but clone No. 7 had the largest one in 1.5% treatment. No differences were found in No. 8 clone among NaCl treatments.

**Discussion**

Various mode of variation of *I. cylindrica* in Japan has been clarified. Tominaga et al. reported the morphological differences between clones collected from fore-dune and clones from inland populations, and distinguished fore-dune (F-) type from common (C-) type. In this experiment, the differences in salt tolerance between C- and F-type were clarified. F-type was more tolerant to NaCl treatment than C-type.

The response of each organ of plant to NaCl is probably different in species to species. In *Festuca rubra* L., populations, response of plant to seawater was greater in root length than total dry matter weight, and in *Typha domingensis* Pers., the degree of tolerance was assessed by the decrease in plant length with increasing salt. In this experiment, the differences between C- and F-type in the response to NaCl treatment were larger in subterranean parts, especially rhizome, than aerial parts. Under NaCl treatment, the reduction of rhizome dry matter weight of F-type was smaller than C-type. Rhizome is main reproductive organ of this grass and it occupied about 40% of the total dry matter weight. The establishment of the population of this grass depends largely on the accumulation of fixed
carbon to the reproductive organ, rhizome. Less effects of NaCl application on rhizome biomass of F-type are important for survival of this type in fore-dune.

Without NaCl application F-type had generally smaller biomass than C-type, but under NaCl treatment, the reverse was observed. This phenomenon is called "trade-off". "Trade-off" was widely known in heavy metal and herbicide tolerant biotype, such as heavy metal tolerant biotype of Agrostis tenuis Sibth., Plantago lanceolata L. and Anthoxanthum odoratum L. and atrazine resistant biotype of Senecio vulgaris L. and Amaranthus retroflexus L.2).

The distribution of F-type of I. cylindrica was restricted to fore-dune13). This suggest that F-type is probably less fit in the absence of NaCl than C-type but F-type is superior competitor to C-type in the fore-dune where plants suffer from salt spray. From the results of this experiment, the fore-dune (F-) type of I. cylindrica var. koenigii may be concluded to be well adapted to the habitat where plants have been exposed to salt spray and salt water.

References

*: In Japanese with English summary.

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チガヤ（*Imperata cylindrica* (L.) BEAUV. var. *koenigii* (RETTZ.) DURAND et SCHINZ）の耐塩性におけるクローン間変異

富永 達・小林央征**・植木邦和**

信州大学農学部（399-45 長野県上伊那郡南箕輪村）
*山口大学農学部（753 山口市吉田）
**石川農業短期大学（921 石川県野々市町末松）

要 旨

チガヤ（*Imperata cylindrica* (L.) BEAUV. var. *koenigii* (RETTZ.) DURAND et SCHINZ）の耐塩性におけるクローン間変異を明らかにするために、紀伊半島の山間、海岸平野および海岸前線砂丘由来の各々3クローン、計9クローンについて、NaCl 各処理区（0.0, 1.5, 3.0％）あたり、1クローンにつき5分株個体を供試した実験を行った。

各分株個体を1/5,000a ワグナーボットに栽植し、1987年8月4日から11月10日まで2週間ごとに200 ml の NaCl 水溶液を灌流した。同年11月24日に各分株個体を取り取り、草丈、ジュート数、根茎数、根茎長および器官別乾物重を測定した。

各クローンの草丈および全乾物重は NaCl 濃度の上昇に伴い減少した。海岸前線砂丘由来のクローン（F型）の全乾物重は対照区（NaCl 濃度、0.0％）においては他のクローン（C型）より小であったが、NaCl 処理区においては大であり、NaCl 処理による F型の全乾物重の減少率はC型より小であった。各クローンのジュート数に対する NaCl 処理の影響に関しては一定の傾向は認められなかった。F型のクローン No. 8 の根重は処理区間で差異が認められなかったが、その他のクローンでは NaCl 処理によって減少した。NaCl 処理に対する両型の反応の差異は根茎において顕著で、F型の根茎重および根茎長の減少率はC型より小であった。

F型はC型に比し、常に潮風にさらされている生育地にうまく適応している可能性があると推定された。

キーワード：海岸前線砂丘型、耐塩性、チガヤ、適応の分化。