

紀伊半島におけるチガヤ(*Imperata cylindrica* (L.) BEAUV.
var. *koenigii* (RETZ.) DURAND et SCHINZ)の内陸集団お
よび海岸前線砂丘集団の差異

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The Differences between Inland and Fore-dune Populations of
Imperata cylindrica (L.) BEAUV. var. *koenigii* (RETZ.)
DURAND *et* SCHINZ in the Kii Peninsula

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Synopsis

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To compare the morphological characters and pollen fertility of the clones from inland populations with those from fore-dune ones of *Imperata cylindrica* var. *koenigii*, 33 clones from 17 inland and 16 fore-dune populations in the Kii Peninsula were studied and five ramets from one clone per one population were planted in about 6000 cm³ pots filled with clay loam on June, 1984. Plant length, dry matter weight of each organ, length and diameter of rhizome, number of shoots and rhizomes were measured in mid-November. A series of pot experiments was practiced at the Subtropical Plant Institute of Kyoto University in the Kii-Ohshima Island, located at the southern extremity of the Kii Peninsula. The seed set percentage of each population was investigated in the original habitat in mid-June, 1984.

Under cultivated condition, the significant differences between inland and fore-dune populations were detected in the plant size and morphology. The clones from inland populations were significantly longer in plant length, larger in the diameter of rhizome, heavier in leaf, rhizome and total dry matter weight than those of fore-dune populations. Fore-dune populations had smaller anther and longer glume than those of inland populations. The seed set percentage of inland populations in original habitat indicated 4.3 to 73.3%, though those of fore-dune populations were less than 3.6%, because of the male sterility.

These genetic differences may be the results of the selection such as cutting, competition with the other species, or salt spray from the sea.

Key words : Adaptation, Differentiation, Fore-dune population, *Imperata cylindrica*.

Introduction

Though the gene-cological studies in which the relations between the intraspecific variation

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in the morphology and/or reproductive strategy and the adaptive mode to each habitat are clarified may be helpful to utilize useful wild grasses for livestock feed and a soil binder, only a few such studies have been reported.

MATUMURA *et al.*³⁻⁵⁾ reported the biotype of *Imperata cylindrica* (L.) BEAUV. var. *koenigii* (RETZ.) DURAND *et* SCHINZ which had glabrous node, large caryopsis, and early flowering habit in the Nohbi Plain, Central Japan. TOMINAGA *et al.*¹⁰⁾ found the genetic differences among populations but not within population in the Kii-Ohshima Island.

In this study, the morphological differences between the inland and the fore-dune populations of *I. cylindrica* var. *koenigii* in the Kii Peninsula were clarified through the pot experiment. This species is protandrous and wind pollinated plant. The seed set percentage was investigated in natural population. On the basis of the differences in the plant size, morphology, and reproductive strategy between inland and fore-dune populations, the adaptive mode to each habitat was discussed.

Materials and Methods

Collection of clones

To clarify the morphological differences between the inland and the fore-dune populations, 17 and 16 populations were sampled from inland and fore-dune of the Kii Peninsula, respectively (Fig. 1). Five clones as apart as possible from one another in one population were collected by 1983. The clones of inland populations were obtained in the abandoned fields, boundary of rice fields, orchard garden, rhododendron garden, and road-sides located in the mountainous regions which are remote more than 4.7 km upcountry from the seashore. The clones from fore-dune populations were collected within 50 m from the shoreline, where they were exposed to salt spray from the sea. These clones were planted in the clay pots (20 cm diameter \times 19 cm depth, about 6000 cm³) individually at the Subtropical Plant Institute of Kyoto University (33° 28' N, 135° 50' E) in the Kii-Ohshima Island located at the southern extremity of the Kii Peninsula and

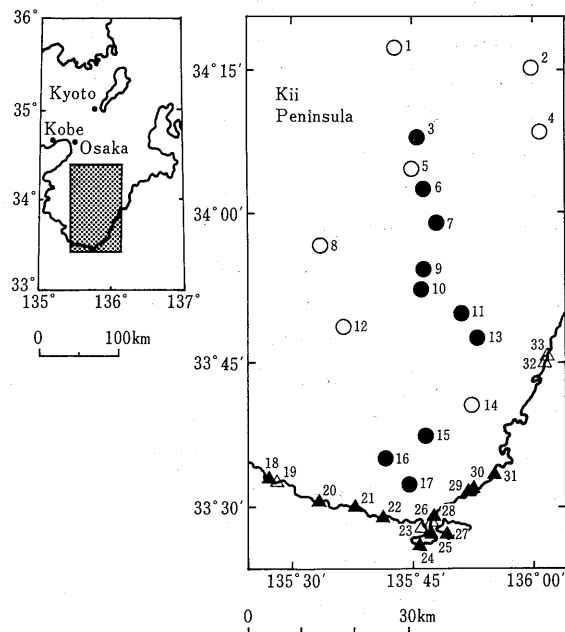


Fig. 1. Collection location of *Imperata cylindrica* var. *koenigii*.

●, ○: Inland population; ▲, △: Fore-dune population. Solid symbols indicate the populations of which seed set percentage in original habitat was investigated.

the ramets from these clones were used in the following genecological studies.

Determination of number of clones per population

To determine the number of clones per population for the measurement of the morphological characters, the intra-population variation in the plant length, total dry matter weight, and glume length of four inland (Nos. 1, 6, 10 and 15) and three foredune populations (Nos. 23, 28 and 33) was investigated preliminarily in 1983. At the experiment, five clones in one population, in total 35 clones were used.

The rhizomes of each clone were cut into about 10 cm long with 10 to 12 nodes on April 18, 1983 and raised on the vermiculite bed in a greenhouse. Five ramets with shoot of 10 cm length per one clone, in total 175 ramets were transplanted in 6000 cm³ clay pots filled with clay loam on June 10, individually. Fertilizers, N 10, P 10 and K 10 kg/10a, were basically applied. Plant length was measured on November 14, and after that all ramets were dug up and dried up at 80°C for 48 hours. Then dry matter was weighed individually. The length of ten glumes per clone planted in the clay pot was measured on June 27.

Morphological differences between inland and foredune populations

Based on the results obtained in the above preliminary experiment, five ramets per clone and one clone per population were enough material number for assessing morphological differences between populations. At the experiment in 1984, to detect morphological differences between the inland and the foredune population, one clone was randomly selected in one population and five ramets per clone were planted as in the same way as the preliminary experiment in 1983. In total, 85 ramets from 17 clones in inland and 80 ramets from 16 clones in foredune populations were used for this pot experiment. Plant length, number of shoots and rhizomes, diameter and length of rhizome, dry matter weight of leaves, roots and rhizomes of each ramet were individually investigated.

Pollen fertility, size of anther and glume

The pollen fertility, the length and width of anther and glume of 50 to 125 florets per one clone in cultivated condition were measured in the middle of May, 1984. The pollen fertility was observed by aceto-carmine staining. For these studies, six clones (Nos. 1, 2, 6, 10, 15 and 17) of inland and five clones (Nos. 21, 23, 28, 29 and 33) of foredune populations, which were planted in the clay pots by 1983, were used. The pollen fertility, the size of anther and glume were also investigated in the original habitat.

Seed set percentage in natural population

The seed set percentages of five panicles per one population in the original habitat were investigated in late June, 1984. This investigation was conducted at the 10 inland and 11 foredune populations of the Kii Peninsula (Fig. 1).

Results

Determination of number of clones per population

After the experiment, significant differences in plant length, total dry matter weight and glume length were detected among populations, but were not observed within population (Table 1). This result was consistent with that obtained in the 11 populations of the Kii-Ohshima Island¹⁰⁾.

Table 1. Analysis of variance for three characters in preexperiment in 1983.

| Source of variation | D.f. | Mean squares | | |
|---------------------|------|--------------|------------------|--------------|
| | | Plant length | Total dry weight | Glume length |
| Among populations | 6 | 113.89** | 99.86** | 0.755** |
| Within population | 4 | 30.77 | 14.67 | 0.012 |
| Error | 24 | 17.47 | 22.12 | 0.101 |

** : significant at 1% level.

Morphological differences between inland and fore-dune populations

The significant differences between the inland and the fore-dune populations were observed in five morphological characters (Fig. 2). The clones from inland populations were longer in plant length, heavier in leaf, rhizome, and total dry matter weight, and larger in the diameter of rhizome than those of fore-dune populations.

Pollen fertility, size of anther and glume

The pollen fertilities of the clones from inland populations were 94.80 to 99.83%, but the

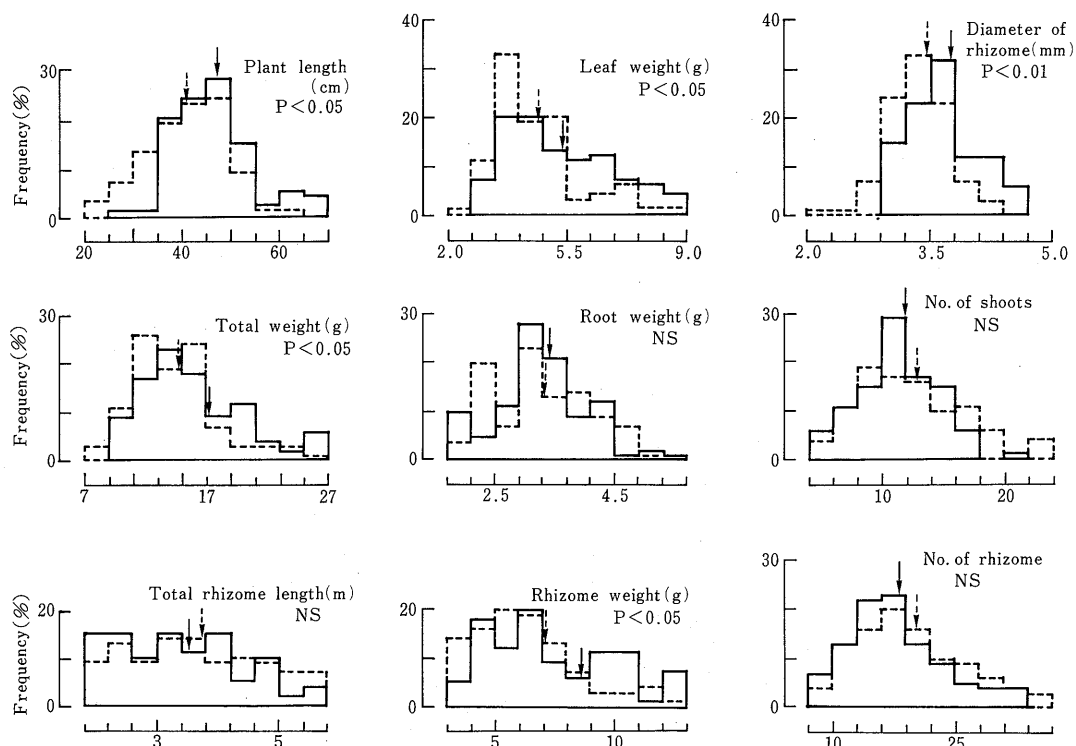


Fig. 2. Differences in nine characters between inland and fore-dune populations.

— : Inland populations ; --- : Fore-dune populations. NS : not significant. Arrow indicates the mean.

Table 2. The results of T-test for the size of anther and glume in original habitats and cultivated condition.

| | Anther | | Glume length |
|----------------------|-------------------------|-----------|--------------|
| | length | width | |
| Original habitats | 2.82±0.53 ^{a)} | 0.76±0.27 | 3.70±0.33 |
| Cultivated condition | 2.55±0.50 | 0.75±0.25 | 3.63±0.42 |
| T-value | 1.32 (NS) | 0.42 (NS) | 0.46 (NS) |

^{a)}: Mean±S. D. (mm).

NS: not significant.

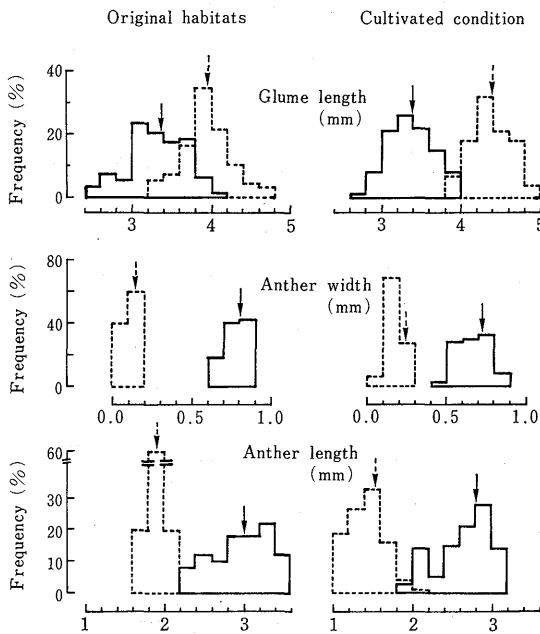


Fig. 3. Anther size and glume length in original habitat (Left) and cultivated condition (Right).

—: Inland populations, ----: Foredune populations. These three characters were significantly different at the 1% level between the two populations. Arrow indicates the mean.

showed less than 1.00%.

pollen grains of foredune populations were scarcely found out without exception.

The size of anther and glume was very stable. The significant differences between the original habitats and the cultivated condition were not observed (Table 2) and no wide variation was found within population (Fig. 3). As shown in Fig. 3, the anthers of the clones from foredune populations were very small and had few pollen grains, though the shape of the pistil was normal as those of inland populations. The glume of foredune populations was statistically longer than that of the inland populations, as observed in the natural populations.

Seed set percentage in natural population

As shown in Table 3, the seed set percentages of ten inland populations exhibited wide variation, 4.26 to 73.31%. Those of the 11 foredune populations ranged 0.18 to 3.60%. The six populations among them

Discussion

The clones from foredune populations were male sterile and had shorter plant length with

Table 3. Variation of seed set percentage in original habitats.

| Population | Number of populations | | | | | | | Mean | Range | |
|------------|-------------------------|---|----|----|----|----|----|-------------|-----------|------|
| | Seed set percentage (%) | | | | | | | | | |
| | 0 | 5 | 10 | 20 | 40 | 60 | 80 | Total | Mean±S.D. | Max. |
| Inland | 1 | 1 | 2 | 2 | 1 | 3 | 10 | 34.90±26.77 | 73.31 | 4.26 |
| Fore-dune | 11 | | | | | | 11 | 1.14± 1.14 | 3.60 | 0.18 |

Table 4. Comparison of seven characters of clones from inland and fore-dune populations.

| Characters | Clones from inland | Clones from fore-dune |
|------------------|--|-----------------------|
| Habitats | Common in roadside, orchard garden and abandoned field | Confined to fore-dune |
| Salt tolerance | Low | High |
| Pollen fertility | Normal | Sterile |
| Anther size | Large | Extremely small |
| Glume length | Short | Long |
| Plant size | Large | Small |
| Rhizome diameter | Thick | Slender |

longer glume compared with those from inland populations. They also had slenderer rhizomes (Fig. 2).

The clones in fore-dune have been exposed to the stiff sea breezes accompanying with the movement of sand and have coexisted with a few number of the other species. It is presumable that the small plant type of fore-dune populations is adapted to the stiff sea breezes and the movement of sand. Those characteristics very resemble *Agrostis stolonifera* L. of maritime habitats being a small compact tufted plant with many short stolons¹⁾. Another resembling result in *Hypericum perforatum* L. was also reported by PRITCHARD⁷⁾.

In inland populations, man's impact, especially slashing has been made frequently over many years. Furthermore, this grass species of the inland populations has competed with many other species. The larger plant type of inland populations may be advantageous for competing with the other species and also their thick rhizome with abundant reserve substances for the quick regrowth after slashing. Actually, in the abandoned fields or roadsides of the southwestern parts of Japan, where slashing has been conducted several times a year, *I. cylindrica* var. *koenigii* grew densely and was dominant as described in the abandoned field of the Kii-Ohshima Island⁸⁾.

The wide variation in seed set percentage among ten inland populations (Table 3) was attributed to the density of the flowering panicles and population size, because this species is protandrous and wind-pollinated plant. On the other hand, the seed set percentages of 11 fore-dune populations were extremely low. These low values are attributable to male sterility,

for their anthers were empty, although the shape of pistil was normal. The reproduction of foredune population was made asexually through rhizomes. The descendants of the same genotype with parent may be advantageous to establish under such unstable habitat.

The differences in salt tolerance between inland and foredune populations were clarified in another study⁹⁾. The decrease in dry matter production of clones from foredune populations under salt application was smaller than those from inland populations. Such differentiation in salt tolerance has already been reported in *Festuca rubra* L.²⁾ and *Typha domingensis* PERS.⁶⁾.

The differences between inland and foredune populations of *I. cylindrica* var. *koenigii* in the Kii Peninsula detected in this experiment were summarized in Table 4. These genetic differences between inland and foredune populations may result from the different kinds of selection pressures, such as salt tolerance suggested in this study.

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koenigii (RETZ.) DURAND *et* SCHINZ) の内陸集団および
海岸前線砂丘集団の差異

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要 約

イネ科多年生草本チガヤ (*Imperata cylindrica* (L.) BEAUV.) は、世界の熱帯から温帯に広く分布し、家畜の飼料として利用されている。本研究は紀伊半島におけるチガヤの内陸集団および海岸前線砂丘集団の外部形態や花粉稔性における差異を調査したものである。なお、栽培実験は京都大学農学部附属亜熱帯植物実験所 (和歌山県串本町) において行った。

1983年までに採集し、系統維持してきた紀伊半島内陸部の路傍、果樹園、畦畔および放棄畑由来の17集団と海岸前線砂丘からの16集団について、各集団から任意に1クローンを選び、1クローンにつき5ラミートを1984年6月に8号素焼き鉢 (直径20 cm, 深さ19 cm, 容積約6000 cm³) にそれぞれ移植した。同年11月に各ラミートを掘り取り、草丈、分株数、全乾重、根茎の数、長さおよび直径を調査した。また、花粉稔性、蒴の大き

さ、苞穎長を調査した。現地においては結実率を調査した。

内陸集団は海岸前線砂丘集団と比較して、草丈、全乾物重および根茎の直径が大であり、苞穎長は小であった。内陸集団の花粉稔性は94.80~99.83%であり、結実率は4.26~73.31%の幅広い変異を示した。この幅広い変異は集団の大きさや、出穂個体の密度に起因するものと推定された。一方、海岸前線砂丘集団の蒴は著しく小型で、花粉粒はほとんど認められず、結実率は0.18~3.10%であった。

この様な両集団間の差異は、除草を目的とする地上部の刈り取り、他種との競合の程度あるいは海からの潮風の影響の有無などの選択圧の差異とうまく対応していた。

キーワード: 海岸前線砂丘集団, チガヤ, 適応, 分化。