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Hang, Ngyen Thi Thu
Graduate School of Bioresource and Bioenvironmental Science, Kyushu University

Miyajima, Ikuo
Institute of Tropical Agriculture, Kyushu University

Ureshino, Kenji
Department of Subtropical Agro-production Sciences, Faculty of Agriculture, University of the Ryukyus

Masuda, Jun'ichiro

他

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Comparison of Morphological Characteristics of *Rhododendron simsii* Planch. distributed in Vietnam and Japan

Nguyen Thi Thu HANG[1], Ikuo MIYAJIMA[2]*, Kenji URESHINO[3], Jun-ichiro MASUDA and Hiroshi OKUBO

Laboratory of Horticultural Science, Department of Agro–environmental Sciences, Faculty of Agriculture, Kyushu University, Fukuoka 812–8581, Japan
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The morphological variations of leaf and flower and flower color variations of *Rhododendron simsii* Planch. distributed in Vietnam and Japan were compared. The leaf length of Japanese accessions were smaller than those of Vietnamese accessions though the leaf thickness was almost the same in both populations except the accessions in Amamioshima Isld. The leaf shape index (leaf length / leaf width) of Hoang Lien Son accession showed the largest value in all of the Japanese and Vietnamese accessions. The flower size of Vietnamese accessions is a little smaller than those of Japanese accessions. The flower color variation showed almost the same range from vermilion to red (41 to 51 in R.H.S.C.C. number) in both of Japanese and Vietnamese populations. Positive C^* values were observed in Vietnamese accessions, indicating that Vietnamese accessions have vivid flower colors in comparison with Japanese population.

Rhododendron simsii distributed in Vietnam seems to furnish high potential as breeding materials for azalea cultivar development because of its vivid flower color.

INTRODUCTION

The genus *Rhododendron* consists of about 800 species belonging to the family of *Ericaceae*. The evergreen azaleas, belonging to the subgenus *Tsutsusi* in the genus *Rhododendron*, are considered to be an Asian origin (Chamberlain and Rae, 1990). The subgenus *Tsutsusi* comprises 66 species, and they are nearly all evergreen and non–winter hardy (Cox and Cox, 1997).

Rhododendron simsii Planch., an evergreen azalea, is one of the most important pot plants in Western Europe, USA and Japan, and it is native to the temperate regions of southern and central China, Taiwan, Vietnam and Ryukyu Archipelagos of Japan. This species was introduced to Europe in the end of the 18th century and the breeding was started (Galle, 1985).

Rhododendron simsii is much branched semi–deciduous shrubs of 1–2 m tall. Its leaf shape is obovate–elliptic or obovate–oblong and leaf apex is obtuse to sub–acute. The flower, having 10 stamens, is broadly funnel form and generally red with dark red blotches on inside above (Yamazaki, 1996). The Vietnamese *R. simsii* grows in central and northern parts of Vietnam above 800–1400 m altitude (Ho, 1991), whereas Japanese *R. simsii* distributes in sunny thickets, on rocks or steep grassy slopes from sea level to 300 m in Amamioshima Island, Okinawajima Island, Iriomotejima Island and their surrounding small islands (Yamazaki, 1996).

Wild species having new morphological characteristics have always been of great interest to breeders, who are constantly on the lookout for new sources of variation to extend their range of cultivars (De Schepper *et al*., 2001). However, the breeding of *R. simsii* native in Vietnam has not yet been done.

This experiment was carried out to compare the morphological characters of leaves and flowers and flower color variation between *R. simsii* distributed in Vietnam and Japan and the horticultural values of Vietnamese populations are assessed.

MATERIALS AND METHODS

Plant materials

Thirty–one accessions in two populations, Hoang Lien Son mountain and Than Uyen mountain of *R. simsii* in northern Vietnam, were used for the investigation of leaf and flower characterisitcs, and 14 accessions of a population of central Vietnam (Bach Ma) were added for leaf survey (Fig. 1). Forty–two accessions of three populations, Amamioshima Island, Okinawajima Island, and

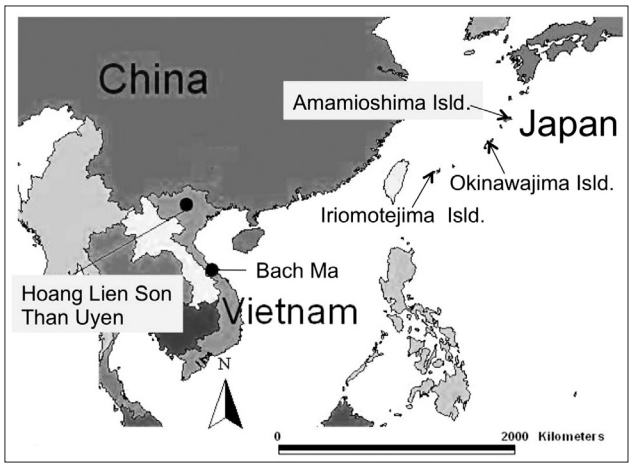

Fig. 1. Sampling sites of *R. simsii* in this study.

[1] Graduate School of Bioresource and Bioenvironmental Science, Kyushu University, Fukuoka 812–8581, Japan
[2] Institute of Tropical Agriculture, Kyushu University, Fukuoka 812–8581, Japan
[3] Department of Subtropical Agro–production Sciences, Faculty of Agriculture, University of the Ryukyus
* Corresponding author (E–mail: imiyajima@agr.kyushu–u.ac.jp)

Iriomotejima Island in Ryukyu Archipelagos, Japan, were used.

Investigation of phenotypic characteristics of flowers and leaves

Length and width of leaves were measured for five leaves per individual and 10 individuals per population for calculating leaf shape index (leaf length/leaf width). A thickness of leaf–blade was also measured. Corolla diameters 1 and 2, and corolla length were determined by five fully expanded flowers per individual (Fig. 2).

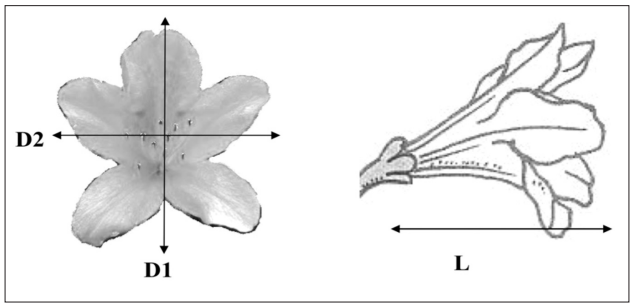

Fig. 2. Measurement of corolla diameter (D1, D2) and corolla length (L).

The color of the flowers was identified according to the Royal Horticultural Society Colour Chart (R.H.S.C.C) and their lightness (L^*) and two chromatic components a^* and b^* of the CIE $L^*a^*b^*$ color coordinate (Gonnet, 1995) were measured by a handy spectrophotometer (NF–333, Nippon Denshoku Industries Co. Ltd.). L^* values indicate lightness (0= black, 100= white). The a^* and b^* values which shift from negative to positive values indicate to shift from bluish–green to purplish–red and blue to yellow, respectively. Chroma (C^*) represents the vividness of color, and it was calculated by $(a^{*2} + b^{*2})^{1/2}$ (McGuire, 1992).

RESULTS AND DISCUSSION

The leaves of Vietnamese accessions were longer than those of Japanese accessions, whereas the leaf thickness were almost the same in both populations (Table 1). The leaf length of Than Uyen accessions in Vietnam was two times longer than that of all the Japanese accessions and also they showed the largest values among Vietnamese populations (39.7–63.4 mm). Leaves of Hoang Lien Son population were narrower than those of all other populations in Vietnam and Japan among which there were no distinct differences. Significant differences were found in leaf shape indices between the populations of Vietnam and Japan. High leaf shape index values of Vietnamese accessions (3.4–5.2) compared with those of Japanese accessions (2.0–2.5) indicated that the leaves of the former accessions were narrower than those of Japanese accessions.

The amount of light available to the lower part of canopy of trees in dence stands is greatly restricted because of shading by neiboring trees (Kozlowski *et al.*, 1991). Light intensity in a forest canopy may be approxymately 50 to 80% of full sunlight in leafless deciduous for-

Fig. 3. Growth conditions of wild *R. simsii* in Vietnam (top) and Japan (bottom).

Table 1. Comparison of leaf characters of *R. simsii* distributed in Japan and Vietnam

	Populations	Leaf size (mm)			Leaf shape index[2)]
		Length[1)]	Width[1)]	Thickness[1)]	
Japan	Amamioshima Isld.	21.5±1.06d	10.2±0.59c	0.28±0.016a	2.2±0.08de
	Iriomotejima Isld.	24.5±0.86d	10.0±0.42c	0.23±0.008b	2.5±0.05d
	Okinawajima Isld.	28.6±3.20d	14.9±1.13ab	0.24±0.002b	2.0±0.18e
Vietnam	Bach Ma	47.1±1.01b	13.8±0.27b	0.20±0.005b	3.4±0.03c
	Hoang Lien Son	39.7±1.39c	7.7±0.24d	0.23±0.005b	5.2±0.14a
	Than Uyen	63.4±2.36a	16.4±0.71a	0.22±0.005b	3.9±0.11b

[1)] Mean ± S.E. Statistical analysis was performed using Tukey's HSD test. Means followed by the same letters are not significantly different at the ($P<0.05$).
[2)] Leaf shape index=Leaf length / Leaf width

Table 2. Comparison of flower characters of *R. simsii* distributed in Japan and Vietnam

	Populations	Flower size (mm)[1)]		
		Corolla diameter (D1)[2)]	Corolla diameter (D2)[2)]	Corolla length[2)]
Japan	Amamioshima Isld.	49.9±0.6b	47.3±0.7b	43.3±0.5b
	Iriomotejima Isld.	56.2±0.9a	53.9±0.7a	47.8±0.8a
	Okinawajima Isld.	59.2±1.6a	58.6±1.5a	46.8±1.4a
Vietnam	Hoang Lien Son	47.7±1.1b	51.5±1.1b	42.3±1.0b
	Than Uyen	44.2±1.0c	43.7±1.1c	36.3±0.8c

[1)] Refer to Fig. 2 for measurement.
[2)] Mean ± S.E. Statistical analysis was performed using Tukey's HSD test. Means followed by the same letters are not significantly different at the ($P<0.05$).

ests, and less than 1% in some tropical rain forests (Spurr and Barnes, 1980). Thus, in general, it is considerd that the shade leaves are larger and thiner than sun leaves (Hanson, 1917). Japanese accessions of *R. simsii* grow on the open field, whereas the populations of Vietnam distribute along streamsides in mountain area except Hoang Lien Son population that grows in sunny places along streamsides (Fig. 3). Since azaleas require fully exposed area (Galle, 1985), Japanese *R. simsii* grow in sunny and grassy slopes on the islands. However, there are few suitable areas for growing of this species since the locations of *R. simsii* in Vietnam are covered with many kind of botanies. The sreamside in the mountains seems to be the restricted area where the sun light reaches to the ground. In Japan, *R. ripense* and *R. indicum* that distribute along riverside have narrow leaves (Kobayashi *et al*., 2008; Tagane *et al*., 2008). Thus, it is considered that the relatively small leaves of *R. simsii* in Japan seemed to be the results of adaptation to the strong sunlight, whereas the relatively large and narrow leaves of *R. simsii* in Vietnam seemed to be the results of low radiation.

There was no significant difference between Amamioshima Island and Hoang Lien Son populations and between Iriomotejima Island and Okinawajima Island accessions in flower size (Table 2). However, the flowers of Japanese *R. simsii* accessions were larger than those of Vietnamese accessions. Especially, the populations of Iriomotejima and Okinawajima Islands were largest among all of the populations.

Rhododendron scabrum, having 5–5.5 cm wide and deep red flowers, distributes in these islands in Japan (Yamazaki, 1996). Though cross compatibility between *R. simsii* and *R. scabrum* have not yet been cleared, *R. simsii* in Iriomotejima and Okinawajima Islands with large flowers is possibly the result of natural hybridization with *R. scabrum*.

The accessions of *R. simsii* distributed in Vietnam and Amamioshima Island were distinguished from the populations of Okinawajima and Iriomotejioma Islands in flower colors based on the R.H.S.C.C. data (Fig. 4). However, the range of flower color variation of all of the populations in Japan and Vietnam was from vermilion to red (41 to 51 in R.H.S.C.C. number). In general, wild azalea populations having wide flower color variation from red to purple were the results of natural hybridization

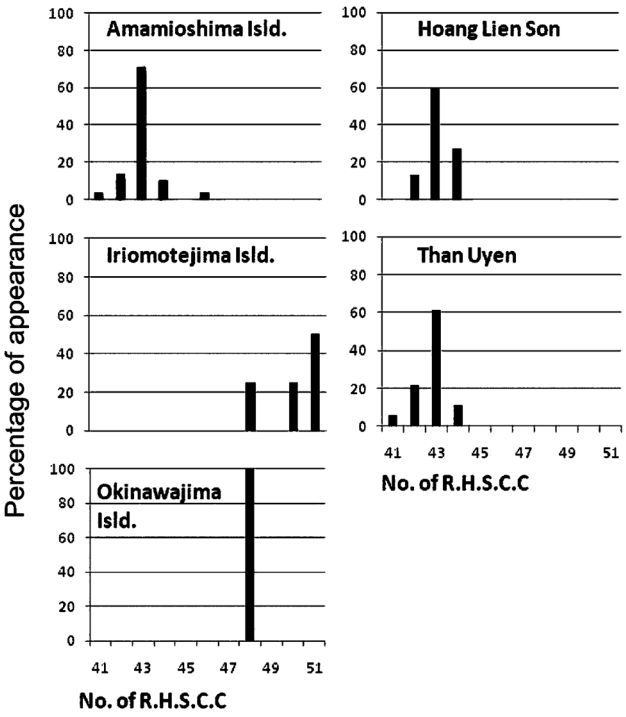

Fig. 4. Frequency distribution of accessions concerning flower color based on the Royal Horticultural Society Colour Chart.

between purple and red flower species (Kunishige and Kobayashi, 1978; Sakata *et al*., 1993; Miyajima *et al*., 1995, 1997; Kobayashi *et al*., 2007). However, the flower color variation in all the populations of Japan and Vietnam in this study was narrow. This fact suggests that these populations have not been crossed with purple flowered azalea species.

The a^* and b^* values of *R. simsii* distibuted in Vietnam ranged from 49.2 to 55.5 and from 15.8 to 27.3, respectively, whereas they were respectively from 39.8 to 54.0 and from 14.4 to 25.4 in Japanese accessions; the flowers of Vietnamese accessions showed slightly positive b^* values (Fig. 5).

Chroma (C^*) values can be obtained from a^* and b^* values. Chroma represents the vividness of the color; very low values of C^* represent grays. There was no appreciable difference in L^* among Japanese and Vietnamese accessions of *R. simsii*, but positive C^* values were

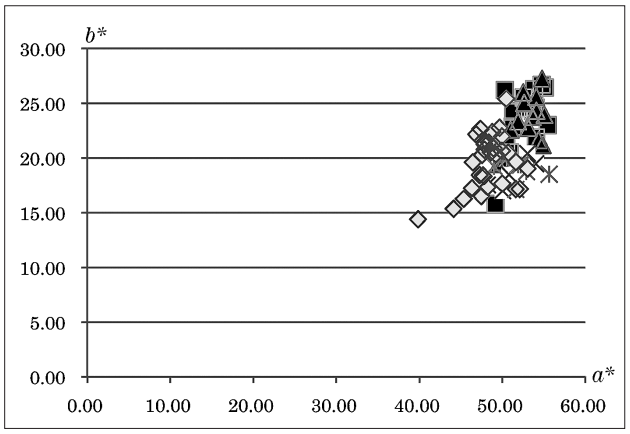

Fig. 5. Flower color variation in *R.simsii* distributed in Japan and Vietnam. Japanese population; Amamioshima Isld. (◇), Iriomotejima Isld. (＊), Okinawajima Isld. (×). Vietnamese populations; Hoang Lien Son (▲), Than Uyen (■).

observed in Vietnamese accessions compared to Japanese one (Table 3). From this point of view, Vietnamese accessions seemed to have vivid flowers in comparison with Japanese population.

The other morphological characters of *R. simsii* distributed in Vietnam and Japan are quite similar; yellow color of anther, 10 stamens and without glandular hairs on their flower bud scales. Although the flower size of Vietnamese *R. simsii* accessions were a little smaller than those of Japanese accessions, and the leaves of Vietnamese accessions were narrower than those of Japanese accessions, Vietnamese *R. simsii* seems to furnish high potential as breeding materials for azalea cultivars development because of its vivid flower color.

In Vietnam, *R. simsii* is only the wild azalea belonging to subsection Tsutsusi in the genus *Rhododendron* though 28 species of *Rhododendron* are identified in Vietnam (Ho, 1991). It is considered that the genus *Rhododendron* including *R. simsii* originated from Nepal along the line of the Himalaya Mountains into northern Burma and continues into the Yunnan and Szechuan provinces of southwestern China (Leach, 1961). Thus, the populations of *R. simsii* distributed in Vietanam seem to be a relic and southern limited populations which remaind and have been isolated from the center of its origin.

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Table 3. *L** and *C** color values of petals in *R. simsii* distributed in Japan and Vietnam

	Populations	$L^{*1)}$	$C^{*2)}$
Japan	Amamioshima Isld.	47.6±0.38c[3)]	52.2±0.41c
	Iriomotejima Isld.	57.7±0.64a	55.2±0.50b
	Okinawajima Isld.	58.9±0.75a	54.9±0.68b
Vietnam	Hoang Lien Son	52.7±0.64b	57.7±0.41a
	Than Uyen	50.8±0.60b	57.9±0.46a

[1)] Lightness

[2)] Chroma = $(a^{*2} + b^{*2})^{1/2}$

[3)] Mean ± S.E. Statistical analysis was performed using Tukey's HSD test. Means followed by the same letters are not significantly different at the ($P<0.05$).

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