

Yoshikane Iwatsubo¹ and Noriyasu Saitoh^{1, 2}: Karyotypes of Y chromosome mutants of *Rumex acetosa* (Polygonaceae)

Rumex acetosa L. (Polygonaceae), a dioecious perennial plant with sex chromosomes, has XX chromosomes in plants with pistillate flowers (female plants) and X Y₁Y₂ chromosomes in plants with staminate flowers (male plants) (Kihara and Ono 1923a, 1923b, 1925). In this species, the two Y (Y₁ and Y₂) chromosomes are both polymorphic in the centromeric positions (Wilby and Parker 1986), but their lengths are nearly equal (Kuroki and Kurita 1969, 1970; Wilby and Parker 1986). In addition, the mean lengths relative to the X chromosome are as follows: the Y₁ chromosome relative to the X chromosome is ca. 0.83, and that of the Y₂ chromosome is ca. 0.75 (Iwatsubo 2014). In *R. acetosa* occurring in Japan, an occasional male plant had an unusual Y₁ chromosome or an unusual Y₂ chromosome (Kuroki and Kurita 1969, 1970) or unusual chromosomes for both Y₁ and Y₂ (Iwatsubo 2015). The present article presents findings for two male plants with two extremely different Y chromosomes.

Materials and methods

The two plants used in the study were collected at Shibukawa, Shibukawa City, Gunma Prefecture (Plant 1), and Kagoto, Nanto City, Toyama Prefecture (Plant 2). Both plants were cultivated in plastic pots at the experimental garden of the University of Toyama. New root tips collected from the two plants were pretreated in a 1.9 mM 8-hydroxyquinoline solution at room temperature for one hour, and then kept at 5°C for 15 h. After being fixed in a mixture of glacial acetic acid and absolute ethyl alcohol (1:3) at room temperature for 1 h, their root tips were macerated in 1N hydrochloric acid at room temperature for 1 h and then 60°C for ten minutes. After being washed in tap water, their root tips were stained and

squashed in 1% lacto-propionic orcein, and the cells with fully-spread metaphase chromosomes were used for the study. Chromosome form was expressed according to the nomenclature of Levan et al. (1964).

Results and discussion

Plants 1 and 2 each had an X chromosome, two Y chromosomes and 12 autosomes (Fig. 1), showing the same chromosomal composition as an ordinary male *R. acetosa*.

Karyotypes of Japanese *R. acetosa* are typically classified into 10 forms: AA, AB, AC, AD, BB, BC, BD, CC, CD, and DD (Ono 1935, Iwatsubo 2014) based on combinations of the two forms of the A5 and A6 chromosomes. Plant 1 had a CD karyotype with supernumerary segments on the short arms of its two A5

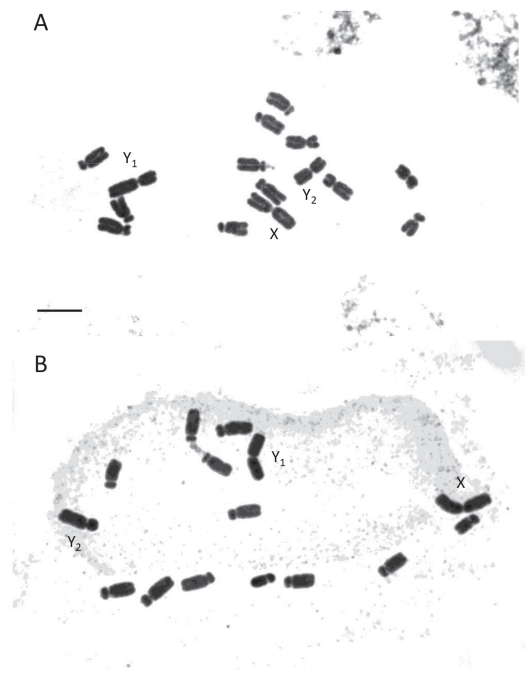


Fig. 1. Somatic metaphase chromosomes of Plant 1 (A) and Plant 2 (B).

autosomes (Fig. 2A, Nos. 9 and 10) and one A6 autosome (Fig. 2A, No. 11). Plant 2 had an AA karyotype with no supernumerary segments in its autosomes.

The X and two Y chromosomes of the two male plants showed the following forms:

Plant 1

The two arms of the X chromosome in this plant were nearly the same length, at 3.5 μm and 3.6 μm (Table 1). The two arms of the longer Y chromosomes of this plant were 2.3 μm and 3.9 μm in length, while those of the shorter Y chromosome were 2.0 μm and 2.4 μm . The

lengths of the two Y chromosomes were 6.2 μm and 4.4 μm , respectively. The lengths of each Y chromosome relative to the X chromosome were 0.87 and 0.62.

Total length of the two Y chromosomes was 10.6 μm . The total length of the two Y chromosomes relative to the length of the X chromosome (7.1 μm) was 1.49.

Plant 2

The two arms of the X chromosome were 3.5 μm and 3.6 μm long (Table 2), which were the same lengths as the two arms of the X chromo-



Fig. 2. Karyograms of Plant No. 1 (A) and Plant No. 2 (B). Bar = 5 μm .

Table 1. Chromosome lengths of metaphase chromosomes of Plant 1

Chromosome	Short arm + Long arm (μm)	Total length (μm)	Arm ratio	Form
X	3.5 + 3.6	7.1	1.0	M
Y	2.3 + 3.9	6.2	1.6	m
Y	2.0 + 2.4	4.4	1.1	m
A1	0.9 + 3.7	4.6	4.1	st
A1	0.9 + 3.7	4.6	4.1	st
A2	0.8 + 3.2	4	4.0	st
A2	0.7 + 3.3	4	4.7	st
A3	t-0.6 + 3.2	3.8	5.3	st
A3	*t-0.6 + 3.2	3.8	5.3	st
A4	0.7 + 3.0	3.7	4.3	st
A4	0.7 + 2.8	3.5	4.0	st
A5 (SS5)	1.4 + 2.7	4.1	1.9	sm
A5 (SS5)	1.5 + 2.7	4.2	1.8	sm
A6 (SS6)	1.5 + 1.9	3.4	1.3	m
A6	1.0 + 2.2	3.2	2.2	sm

Total length and arm ratio do not include the satellite.

SS5: A5 with supernumerary segment.

SS6: A6 with supernumerary segment.

t: satellite.

*t: scanty satellite.

Table 2. Chromosome lengths of metaphase chromosomes of Plant 2

Chromosome	Short arm + Long arm (μm)	Total length (μm)	Arm ratio	Form
X	3.5 + 3.6	7.1	1.0	M
Y	3.0 + 3.1	6.1	1.0	M
Y	1.0 + 3.7	4.7	3.7	st
A1	0.8 + 3.5	4.3	4.1	st
A1	0.8 + 3.5	4.3	4.5	st
A2	0.8 + 3.3	4.1	4.1	st
A2	0.8 + 3.2	4.0	4.0	st
A3	t-0.6 + 3.2	3.8	5.3	st
A3	t-0.6 + 3.2	3.8	5.3	st
A4	0.7 + 3.1	3.8	4.4	st
A4	0.7 + 2.9	3.6	4.1	st
A5	0.7+ 2.8	3.5	4.0	st
A5	0.7 + 2.7	3.4	3.9	st
A6	0.8 + 2.1	2.9	2.6	sm
A6	0.8 + 1.9	2.8	2.4	sm

Total length and arm ratio do not include the satellite.

t: satellite.

some of Plant 1. In Plant 2, one Y chromosome showed arm lengths of 3.0 μm and 3.1 μm , and 1.0 μm and 3.7 μm in the other Y chromosome. The lengths of the two Y chromosomes were 6.1 μm and 4.7 μm , with ratios of 0.86 and 0.66 relative to the length of the X chromosome. The ratio of the total length of the two Y chromosomes (10.8 μm) relative to the length of the X chromosome (7.1 μm) was 1.52.

Iwatsubo (2014) reported that on average, the lengths of the Y_1 and Y_2 chromosomes relative to the X chromosome were 0.83 and 0.75, respectively, for 22 male plants, and total lengths of the two Y chromosomes were 1.58 times that of the X chromosome.

While the two Y chromosomes of the two male plants examined in this study differed markedly in length, the ratio of the total length of the two Y chromosomes relative to the length of the X chromosome was almost always around 1.5. This is fairly consistent with measurements taken in normal plants of *R. acetosa* occurring in Toyama Prefecture of Central Japan (Iwatsubo 2014).

The marked differences in the two Y chromosomes found in the two plants are considered to have arisen primarily due to translocation between their Y chromosomes.

References

- Iwatsubo, Y. 2014. *Rumex acetosa* (Polygonaceae) Chromosomal variations occurring in Toyama Prefecture, Central Japan. *J. Phytogeogr. Taxon.* **61**: 75-89.
- Kihara, H. and Ono, T. 1923a. Cytological studies on *Rumex* L., I. *L. Bot. Mag. Tokyo* **37**: 84-90 (in Japanese).
- Kihara, H. and Ono, T. 1923b. Cytological studies on *Rumex* L., II. On the relation of chromosome number and sexes in *Rumex Acetosa* L. *Bot. Mag. Tokyo* **37**: 147-1498 (in Japanese).
- Kihara, H. and Ono, T. 1925. The sex-chromosomes of *Rumex Acetosa*. *Zeitchr. F. ind. Abst. U. Vererb. Bd.* **39**:1-7.
- Kuroki, Y. and Kurita, M. 1969. Morphological change in Y_1 -chromosome of *Rumex acetosa* L. *Chromosome Information Service* **10**: 6-7.
- Kuroki, Y. and Kurita, M. 1970. Morphological variation of Y_2 -chromosome of *Rumex acetosa* L.

Chromosome Information Service **11**: 26-27.

Levan, A. Fredga, K. and Sandberg, A. A. 1964. Nomenclature for centromeric position on chromosomes. *Hereditas* **52**: 201-220.

Ono, T. 1935. Chromosomen und Sexualität von *Rumex acetosa*. *Sci. Rep. Tohoku Imp. Univ.* **IV**, 10, 41-210.

Wilby, A. S. and Parker, J. S. 1986. Continuous variation in Y-chromosome structure of *Rumex acetosa*. *Heredity* **57**: 247-254.

摘要

岩坪美兼¹・齋藤典保^{1,2}: スイバのY染色体突然変異個体の核型

スイバ(タデ科)は、性染色体(雌株XX, 雄株XY₁Y₂)を有する雌雄異株植物である。通常、X染色体は変異を示さないのに対して、2本のY染色体は、動原体の位置が多様である。しかし、Y染色体の長さはX染色体のそれぞれ83%および75%程度とほぼ一定している。Y染色体の長さが2本共に通常とは異なるスイバが2個体(Plant 1, Plant 2)見つかったので報告する。Plant 1は群馬県渋川市において、Plant 2は富山県南砺市で採集された。Plant 1の2本のY染色体はそのX染色体の長さの87%と62%であった。Plant 2では2本のY染色体はX染色体の長さの86%と65%であった。両個体ともにそれぞれの2本のY染色体の合計長は、X染色体のほぼ1.5倍であることから、これら2個体のY染色体は、それぞれに2本のY染色体の間の転座によって生じたと推定される。

(¹Department of Biology, Faculty of Science, University of Toyama, 3190, Gofuku, Toyama, 930-8555, Japan, E-mail: iwatsubo@sci.u-toyama.ac.jp; ²Present address: 3146-7, Fukuhara, Kasama 309-1634, Japan; ¹〒930-8555 富山市五福3190 富山大学理学部, ²現住所: 〒309-1634 茨城県笠間市福原3146-7)

(Received October 22, 2015; accepted March 3, 2017)