

Cytogenetical analyses of some species of the genus *Sisymbrium* (Brassicaceae) in Turkey

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Türkiye'de *Sisymbrium* (Brassicaceae) cinsinin bazı türlerinin sitogenetik analizleri

Abstract: In this study, karyotype analyses of three species belonging to the genus *Sisymbrium* L. (Brassicaceae) and grown naturally in Turkey were conducted. These taxa are *S. officinale* (L.) Scop., *S. runcinatum* Lag. ex DC. and *S. orientale* L. The somatic chromosome number of $2n = 14$ was reported for all species. Total chromosome lengths are between 1.33 and 2.43 μm in *S. officinale*, 1.30 and 2.48 μm in *S. orientale*, 1.02 and 2.18 μm in *S. runcinatum*. The karyotypes are as follows: *S. officinale* consists of 12m + 2sm, *S. orientale* consists of 10m + 4sm and *S. runcinatum* consists of 10m + 4sm chromosome pairs. *S. runcinatum* is the most asymmetrical karyotype based on all index values.

Key words: *Sisymbrium*, chromosome, karyotype, Turkey

Özet: Bu çalışmada, Türkiye'de doğal olarak yetişen *Sisymbrium* L. (Brassicaceae) cinsine ait üç türün karyotip analizleri yapılmıştır. Bu taksonlar *S. officinale* (L.) Scop., *S. orientale* L. ve *S. runcinatum* Lag. DC. taksonlarıdır. Tüm türler için somatik kromozom sayısı $2n = 14$ olarak bildirilmiştir. Toplam kromozom uzunlukları, *S. officinale*'de 1.33 ve 2.43 μm , *S. orientale*'de 1.30 ve 2.48 μm , *S. runcinatum*'da 1.02 ve 2.18 μm arasındadır. Karyotipler aşağıdaki gibidir: *S. officinale* 12m + 2sm, *S. orientale* 10m + 4sm ve *S. runcinatum* 10m + 4sm kromozom çiftinden oluşur. *S. runcinatum*, tüm endeks değerlerine göre en asimetrik karyotiptir.

Anahtar Kelimeler: *Sisymbrium*, kromozom, karyotip, Türkiye

1. Introduction

The family Brassicaceae is the richest in the United States (616 species, 148 endemic) and the second richest in Turkey (606 species, 39 subspecies, 18 varieties, and 226 endemics) in terms of species number (Al-Shehbaz et al., 2007; Al-Shehbaz, 2010; Mutlu, 2012; Mutlu and Karakuş, 2015). Forty species belonging to the family Brassicaceae in Turkey were published as new species in the last decade (Mutlu, 2012; Mutlu and Karakuş, 2015), and this number has continued to increase. The family Brassicaceae has many species of economic importance and consumed as vegetables. These species are *Brassica nigra* (L.) Koch. (black mustard), *Sinapis alba* L. (white mustard), *B. oleracea* L. var. *oleracea* (cabbage), *B. oleracea* L. var. *acephala* DC. (black cabbage), *B. oleracea* L. var. *gemmifera* DC. (Brussels cabbage), *B. oleracea* L. var. *botrytis* L. (cauliflower), *B. rapa* L. var. *rapa* (cole-seed), *Eruca sativa* Miller (rocket), *Raphanus raphanistrum* L. (wild radish), *R. sativus* L. var. *radicula* (red radish), *Lepidium sativum* L. (cress).

Brassica napus L. (rape) and *B. rapa* L. var. *oleracea* DC. (oil turnip) are species cultured to obtain oil from the seeds in family Brassicaceae. *Isatis tinctoria* L. (woad) is an important dyeing agent and *Cheiranthus cheiri* L. (gillyflower) is an important ornamental plant (Seçmen et al., 1998).

Sisymbrium is one of 98 genera within the family Brassicaceae (tribe Sisymbrieae DC.) in Turkey. The genus is represented by 11 species in Turkey. These

species are *S. altissimum* L., *S. confertum* Stev., *S. elatum* K.Koch, *S. irio* L., *S. loeselii* L., *S. officinale* (L.) Scop., *S. orientale* L., *S. polyceratum* L., *S. runcinatum* Lag. ex DC., *S. septulatum* DC. and *S. malatyanum* Mutlu & Karakuş (Hedge, 1965; Al-Shehbaz et al., 2007; Mutlu, 2012; Mutlu and Karakuş, 2015).

The different chromosome numbers have been reported in the genus *Sisymbrium* till now. In genus *Sisymbrium*, the most frequent chromosome number is $2n = 2x = 14$. The chromosome numbers of the species belonging to the genus *Sisymbrium* varies from $2n = 14$ to $2n = 42$ such as $2n = 14, 18, 20, 22, 26, 28$ and 42 (Chromosome Counts Database, <http://ccdb.tau.ac.il/home/>; Missouri Botanical Garden, <http://mobot.mobot.org/W3T/Search/ipcn.html> and Index to Chromosome Numbers in the Brassicaceae, <http://www-brassicaceae.cla.kobe-u.ac.jp/index.html>). In the present study, new chromosomal data and detailed chromosome measurements are reported in three species of genus *Sisymbrium*.)

2. Materials and Method

The species were collected from different localities in Turkey. Collection information is listed below.

S. officinale – A1 Çanakkale: Gökçeada, stony slopes, 40°14'01"N–25°54'05"E, 24 m, 05.V.2012, Asef. 349!

S. orientale – A1 Edirne: beside 80. Yıl Anadolu Lisesi, wasteland, 41°40'09"N–26°34'12"E, 49 m, 30.IV.2012, Asef. 317!

S. runcinatum – C7 Şanlıurfa: Sırrın neighborhood, wasteland, 37°09'35"N–38°48'45"E, 489 m, 20.IV.2012, Asef. 292!

The habitat and flower photos of three species are given in Figure 1. Voucher specimens have been deposited at the herbaria of Necmettin Erbakan University, Faculty of Science, Konya in 2015.

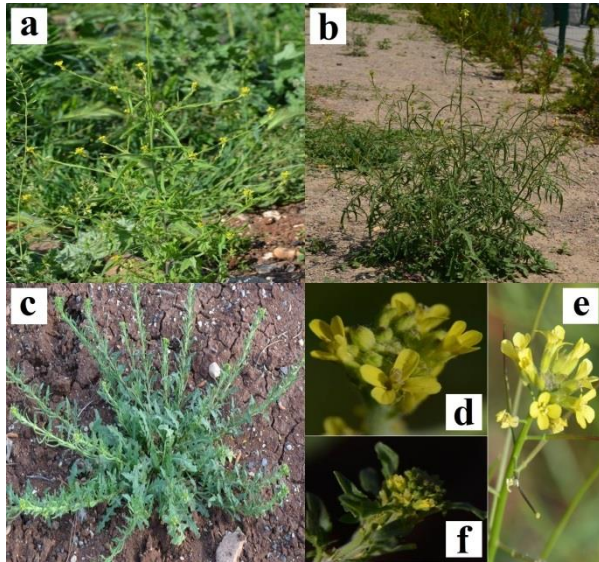


Figure 1. Habitat and flower of three species: a- *Sisymbrium officinale* (habitat), b- *Sisymbrium orientale* (habitat), c- *Sisymbrium runcinatum* (habitat), d- *Sisymbrium officinale* (flower), e- *Sisymbrium orientale* (flower) and f- *Sisymbrium runcinatum* (flower).

Karyotypes analysis were carried on somatic metaphases using Image System Analysis. Root meristems from germinating seeds collected in the wild were used. Root tips were pretreated with α -monobromonaphthalene at 4°C for 16 h and were fixed with Carnoy for 24 h at 4°C. Before staining, the materials were hydrolyzed with 1N HCl for 12 minutes at room temperature, then stained with 2% acetic orcein and mounted in 45% acetic acid. Permanent slides were made by using the standard liquid nitrogen method.

Photographs were taken through BX51 Olympus microscope. The ideograms were prepared with measurements taken on enlarged micrographs of ten well spread metaphase plates. The classification of chromosomes, the length of long and short arm, arm ratio, centromeric index and relative chromosomal length were measured by Software Image Analysis (Bs200ProP). Chromosomes were classified using the nomenclature of Levan et al. (1964). The karyotype asymmetry was determined as the interchromosomal asymmetry with parameters of Rec, A2 and CV_{CL} and the intrachromosomal asymmetry with parameters of AsK, TF, Syi, A1, A and M_{CA} (for details see Paszko, 2006; Eroğlu et al., 2013; Peruzzi and Eroğlu, 2013).

3. Results

3.1. *Sisymbrium officinale*

The metaphase chromosomes and idiogram are shown in Figure 2a. The karyotype formula is $2n = 2x = 14 = 12m + 2sm$. The sixth chromosome pairs are submedian and the others are median as observed at mitotic plates. The total

haploid length and mean haploid length of the chromosomes are 12.71 and 1.82 μm with single chromosome lengths ranging from 1.33 to 2.43 μm (Table 1). The intrachromosomal and interchromosomal asymmetry values are given in Table 2.

3.2. *Sisymbrium orientale*

The metaphase chromosomes and idiogram are shown in Figure 2b. The karyotype formula is $2n = 2x = 14 = 10m + 4sm$. The second and third chromosome pairs are submedian and the others are median as observed at mitotic plates. The total haploid length and mean haploid length of the chromosomes are 12.84 and 1.83 μm with single chromosome lengths ranging from 1.30 to 2.48 μm (Table 1). The intrachromosomal and interchromosomal asymmetry values are given in Table 2.

3.3. *Sisymbrium runcinatum*

The metaphase chromosomes and idiogram are shown in Figure 2c. The karyotype formula is $2n = 2x = 14 = 10m + 4sm$. The fourth and sixth chromosome pairs are submedian and the others are median as observed at mitotic plates. The total haploid length and mean haploid length of the chromosomes are 10.56 and 1.51 μm with single chromosome lengths ranging from 1.02 to 2.18 μm (Table 1). The intrachromosomal and interchromosomal asymmetry values are given in Table 2.

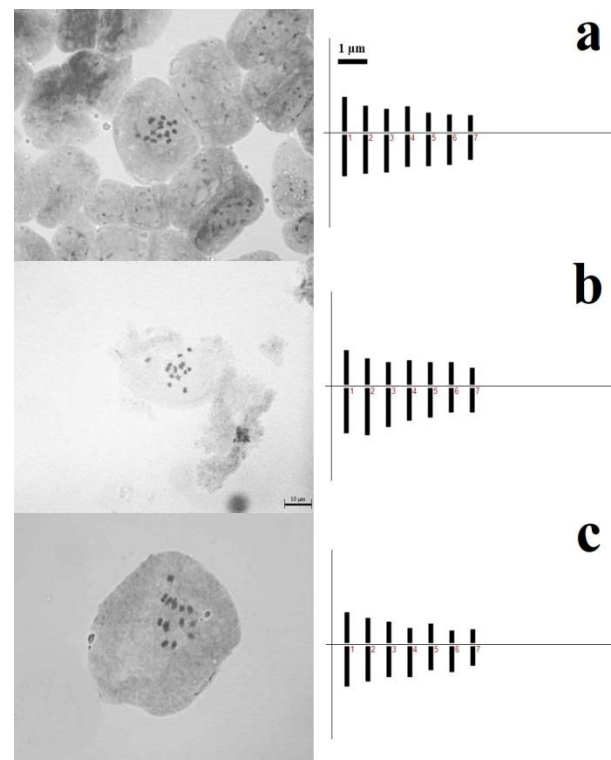


Figure 2. Somatic metaphase chromosomes and idiograms of three species: a- *Sisymbrium officinale*, b- *Sisymbrium orientale* and c- *Sisymbrium runcinatum*.

4. Discussions

Image Analysis System we used in this study made us to find the length of chromosomes and to compare different taxa more precisely. This system offers many advantages over conventional cytological and chromosomal techniques. It enables the analysis of a large number of chromosome spreads, saving the time and effort; besides,

the accuracy of the data is high and the reproducibility of the image manipulation is complete and very sensitive helping to reduce error factor to minimal.

In general, presents low level of variation in chromosome number, with $2n = 14$ in most of the species. The different chromosome numbers were reported as $2n = 14, 18, 20,$

22, 26, 28 and 42 (Chromosome Counts Database, <http://ccdb.tau.ac.il/home/>; Missouri Botanical Garden, <http://mobot.mobot.org/W3T/Search/ipcn.html> and Index to Chromosome Numbers in the Brassicaceae, <http://www-brassicaceae.cla.kobe-u.ac.jp/index.html> *Sisymbrium*).

Table 1. The karyotype data of *Sisymbrium* species. Total chromosome length (L + S), long arm length (L), short arm length (S), arm ratio (L/S), relative length (RL), centromeric index (CI), median (m), submedian (sm).

Species	Pair	L + S (μm)	L (μm)	S (μm)	L / S	RL (%)	CI (%)	Type
<i>Sisymbrium officinale</i>	1	2.43	1.33	1.10	1.21	19.12	45.27	m
	2	2.08	1.25	0.83	1.51	16.37	39.90	m
	3	1.93	1.20	0.73	1.64	15.18	37.82	m
	4	1.83	1.03	0.80	1.29	14.40	43.72	m
	5	1.61	1.01	0.60	1.68	12.67	37.27	m
	6	1.50	0.96	0.54	1.78	11.80	36.00	sm
	7	1.33	0.80	0.53	1.51	10.46	39.85	m
<i>Sisymbrium orientale</i>	1	2.48	1.40	1.08	1.30	19.31	43.55	m
	2	2.29	1.47	0.82	1.79	17.83	35.81	sm
	3	1.91	1.21	0.70	1.73	14.88	36.65	sm
	4	1.78	1.01	0.77	1.31	13.86	43.26	m
	5	1.61	0.91	0.70	1.30	12.54	43.48	m
	6	1.47	0.77	0.70	1.10	11.45	47.62	m
	7	1.30	0.77	0.53	1.45	10.12	40.77	m
<i>Sisymbrium runcinatum</i>	1	2.18	1.23	0.95	1.29	20.64	43.58	m
	2	1.84	1.07	0.77	1.39	17.42	41.85	m
	3	1.60	0.95	0.65	1.46	15.15	40.63	m
	4	1.42	0.95	0.47	2.02	13.45	33.10	sm
	5	1.33	0.73	0.60	1.22	12.59	45.11	m
	6	1.17	0.78	0.39	2.00	11.08	33.33	sm
	7	1.02	0.60	0.42	1.43	9.66	41.18	m

Table 2. The asymmetry index values of *Sisymbrium* species.

	<i>Sisymbrium officinale</i>	<i>Sisymbrium orientale</i>	<i>Sisymbrium runcinatum</i>
AsK	59.64	58.72	59.75
TF	40.36	41.28	40.25
Syi	67.68	70.29	67.35
Rec	74.72	73.96	69.20
A1	0.33	0.28	0.33
A2	0.21	0.23	0.27
A	0.20	0.17	0.20
CV_{CL}	20.59	23.36	26.54
M_{CA}	20.05	16.82	20.35

In mentioned species, the karyotype analyses and detailed chromosome measurements were obtained for the first time. The karyological data confirmed that the chromosome number of *Sisymbrium* species is $2n = 14$ with the basic number of $x = 7$. It was reported that the chromosome numbers was $2n = 14$ in *S. officinale*; $2n = 14$ and 18 in *S. orientale*; $2n = 14, 18, 28, 42, 56$ in *S. runcinatum* (Chromosome Counts Database, <http://ccdb.tau.ac.il/home/>; Missouri Botanical Garden, <http://mobot.mobot.org/W3T/Search/ipcn.html> and Index to Chromosome Numbers in the Brassicaceae, <http://www-brassicaceae.cla.kobe-u.ac.jp/index.html>;

Kamari et al., 2015). The reports include both similar and dissimilar results with our results.

All *Sisymbrium* species examined in the present study show a similar karyomorphology including only median and submedian chromosomes. According to literature survey, the cytological studies on *Sisymbrium* are generally related to the chromosomal counts. The report also confirm a similar karyomorphology including only median and submedian chromosomes for *S. orientale* and *S. runcinatum* from population of Libya (Kamari et al., 2015). Despite similar karyomorphology, the chromosome numbers are different between Turkey and Libya populations.

Karyotype asymmetry is an important parameter in karyological data (Eroğlu et al., 2013). *S. runcinatum* is the most asymmetrical karyotype based on all index values. However, the symmetrical karyotypes are different. While *S. orientale* is the most symmetrical karyotype in M_{CA}, AsK, TF, Syi, A1 and A (intrachromosomal index values); *S. officinale* is the most symmetrical karyotype in CV_{CL}, Rec and A2 (interchromosomal index values) (Table 2).

Karyological knowledge needs to be used in conjunction with other sources of data to achieve a better understanding of the cytological relationship of *Sisymbrium* species, leading to their natural classification. In this regard, karyotypes were determined in three

species of *Sisymbrium* growing naturally in Turkey, and karyological attributes of selected species were evaluated for the first time.

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