An investigation of the karyotypes of four species from the genera *Setcreasea*, *Spironema* and *Tradescantia* (Commelinaceae)

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Abstract

An investigation was conducted on the number and morphology of the chromosomes of four species from the family *Commelinaceae*: *Spironema fragrans* Lindl., *Setcreasea purpurea* Boom, *Tradescantia albiflora* Kunth. and *Tradescantia blossfeldiana* Mildbr. It was found that the karyotype of *Spironema fragrans* Lindl. was $2n = 12$ chromosomes whose total length was 6.9-13.7 μm and the formula of the karyotype was: $2m + 2sm + 2m + 2t + 2st^{\text{sat}} + 2st$. *Setcreasea purpurea* Boom. had $2n = 24$ chromosomes, 9.1-12.1 μm in length and the centromere positioned as represented by the formula $24m$. The karyotype of *Tradescantia albiflora* Kunth. had $2n = 60$ chromosomes whose lengths ranged from 1.4 to 4.5 μm , and is described by the formula: $4sm + 6m + 10st + 10sm + 10m + 20sm$. The complex of chromosomes from *Tradescantia blossfeldiana* Mildbr. consisted of $2n = 60$. Their length was 1.3-4.8 μm . The morphological types of the chromosomes are represented by the formula $6st + 2m + 2sm + 6st + 2sm + 12m + 10M + 14m + 6sm$. It is suggested on the basis of morphological analysis of chromosomes that *Setcreasea purpurea* Boom is a tetraploid species and *Tradescantia albiflora* Kunth. and *T. blossfeldiana* Mildbr. are decaploids.

Key words: karyotype, *Commelinaceae*, *Setcreasea*, *Spironema*, *Tradescantia*

INTRODUCTION

The number and morphology of chromosomes belong to cytotaxonomical traits characterizing a given karyotype. They play a very important role as comparative data in taxonomy, alongside morphological and anatomical traits. They often enable the phylogenetic relationships among various species within a family to be established.

The karyotypes of four species belonging to three genera from the family *Commelinaceae* have been analysed. No information is available in the pertinent literature on the number of chromosomes in the species *Tradescantia blossfeldiana* Mildbr. The results of earlier studies on the karyotypes of the remaining listed species, often conducted many years ago, differ significantly among each other.

Most authors list a chromosome number $2n = 12$ for the species *Spironema fragrans* Lindl. (Darlington 1929, Richardson 1934, Anderson and Sax 1936, Wu 1942, Mitsukuri and Kobayashi 1962). The observations of the listed authors on the morphology of the chromosomes of this species differ considerably among each other. Only Celerier (1955) found a higher chromosome number, $2n = 24$, in *Spironema fragrans* Lindl.

The chromosome number given for *Setcreasea purpurea* Boom is $2n = 12$ (Bose 1958) and $2n = 24$ (Mehra et al. 1961, Mitsukuri and Kobayashi 1962, Guervin and Le Coq 1966). Bose (1958) as well as Guervin and Le Coq (1966) distinguished chromosomes in the studied karyotypes with centromeres in median and submedian positions.

Various results can be found in studies on the number of chromosomes in *Tradescantia albiflora* Kunth.: Anderson and Sax (1936) observed $2n = 72$ chromosomes, Tschermak-Woess and Doležal (1953) $2n = 48$ chromosomes, while Briggs (1966) $2n = 60$ chromosomes. Anderson and Sax (1936) made a generalized statement that small chromosomes made up the karyotype. Briggs (1966) identified 5 pairs of large chromosomes and classified the remainder as small.

The objective of this study was to determine the number and morphology of the chromosomes in the somatic cells of the named species.

MATERIAL AND METHODS

The karyotypes of the following species were studied: *Spironema fragrans* Lindl., *Setcreasea purpurea* Boom, *Tradescantia albiflora* Kunth. and *Tradescantia blossfeldiana* Mildbr. These plants belong to the family *Commelinaceae*. They come from Central and South America and are cultivated in Europe as decorative plants. The main decorative value of these vines is their multi-colored leaves. Material from potted plants was used in this study. The chromosomes of the studied species were taken from root apical meristem cells.

The root apical meristems were cut off and placed in a saturated aqueous solution of alpha-bromonaphthalene. After 3 hrs. they were transferred to Carnoy's fixative, where they remained for 1 hr. The roots were then subjected to hydrolysis in 1 n HCl at a temp. of 60°C for 15 min. The chromosomes were stained with acetic carmin in crushed preparation slides. The number and

morphology of the chromosomes were established for each species on the basis of 10 metaphase plates taken from different roots. The measurements were based on 2-3 drawings of the chromosomes for each plate and on photomicrographs. The terminology proposed by Levan et al. (1964) was used to describe the position of the centromere. This was based on the r-index, that is, the ratio of the long to short arm. The position of the centromere in respect to the value of "r" and types of chromosomes were established in agreement with Table 1.

Table 1

Chromosome types according to Levan et al. (1964) based on the position of the centromere

Chromosome type	Centromere position	r Value
M	median point	1.0
m	median region	1.0-1.7
sm	submedian region	1.7-3.0
st	subterminal region	3.0-7.0
t	terminal region	7.0- ∞
T	terminal point	∞

RESULTS

SPIRONEMA FRAGRANS LINDL.

The karyotype of this species is composed of $2n = 12$ chromosomes. Their mean lengths and types are compiled in Table 2. Figure 1 illustrates the somatic metaphases and karyotype and Fig. 4a an idiogram of the chromosomes.

Table 2

Mean chromosome lengths and types in *Spironema fragrans* Lindl. $2n = 12$ (lengths in μm)

Chromosome pairs	Arm length		Total chromosome lengths	r-Index $\frac{\text{long arm}}{\text{short arm}}$	Chromosome type according to Levan	Relative chromosome length's %
	long	short				
1	8.3	5.4	13.7	1.54	m	22.9
2	8.1	4.4	12.5	1.84	sm	20.9
3	5.9	3.9	9.8	1.51	m	16.4
4	7.7	1.0	8.7	7.70	t	14.6
5 SAT	6.9	0.9+0.3	8.1	5.75	st	13.6
6	5.9	1.0	6.9	5.9	st	11.6
	—	—	59.7	—	—	100.0

Fig. 1. The chromosomes of *Spironema fragrans* Lindl., $2n = 12$. a, b — somatic metaphases (x 1440); karyotype (x 2600)

SETCREASEA PURPUREA BOOM

In the somatic cells of this species, $2n = 24$ chromosomes were found. Fig. 2 illustrates the somatic metaphases and karyotypes of the studied plants. Table 3 gives a comparison of the mean lengths and types of chromosomes. The pair ordering was based on the total lengths of the chromosomes. The karyotype is composed of both long chromosome with a total length of 12.1 to 9.1 μm representing the same morphological type with a centromere positioned medially. The presence of SAT chromosomes was not found. A similar morphology of the chromosome listed below was observed due to similar lengths and r-index values: 1 and 2, 3 and 4, 5 and 6, 7 and 8. It appears that among the remaining pairs, 9 and 12 as well as 10 and 11 have similar morphologies (Table 3, Fig. 4b).

On the basis of the similarity of the listed pairs of chromosomes, it can be judged that the studied species is a tetraploid (Fig. 2d). In general it may be stated that the karyotype of *Setcreasea purpurea* Boom is poorly differentiated morphologically.

Table 3

Mean chromosome lengths and types in *Setcreasea purpurea* Boom $2n = 24$ (lengths in μm)

Chromosome pairs	Arm length		Total chromosome lengths	r-Index	Chromosome type according to Levan
	long	short			
1	6.2	5.9	12.1	1.05	m
2	6.3	5.7	12.0	1.10	m
3	6.2	5.2	11.4	1.19	m
4	6.2	4.7	10.9	1.31	m
5	5.8	4.9	10.7	1.18	m
6	5.9	4.6	10.5	1.28	m
7	6.2	4.0	10.2	1.55	m
8	5.8	4.4	10.2	1.31	m
9	5.1	4.8	9.9	1.06	m
10	5.8	4.0	9.8	1.45	m
11	6.0	3.6	9.6	1.66	m
12	5.2	3.9	9.1	1.33	m

Fig. 2. The chromosomes of *Setcreasea purpurea* Boom, $2n = 24$, a, b, c, — somatic metaphases (x 1100), d — karyotype (x 2800)

TRADESCANTIA ALBIFLORA KUNTH.

The number of chromosomes in the studied material equalled $2n = 60$ (Fig. 3a). Their mean lengths fell within the range of 1.4 to 4.5 μm . The positions of their centromeres puts them into various morphological classes: "m", "sm" and "st". Taking into account their lengths and position of the primary structure, 6 groups of chromosomes with similar morphologies were distinguished in this karyotype (Table 4, Fig. 4c). The first two groups contain the

Table 4

Mean chromosome lengths and types in *Tradescantia albiflora* Kunth. $2n = 60$ (lengths in μm)

Chromosome pairs	Arm length		Total chromosome length	r-Index	Chromosome type according to Levan
	long	short			
1	3.2	1.3	4.5	2.46	sm
2	2.9	1.0	3.9	2.90	sm
3	1.8	1.6	3.4	1.12	m
4	1.9	1.4	3.3	1.35	m
5	1.6	1.3	2.9	1.23	m
6	3.3	0.7	4.0	4.71	st
7	3.4	0.5	3.9	6.80	st
8	3.0	0.8	3.8	3.75	st
9	3.0	0.5	3.5	6.00	st
10	2.5	0.8	3.3	3.12	st
11	1.8	1.0	2.8	1.80	sm
12	1.8	0.9	2.7	2.00	sm
13	1.8	0.8	2.6	2.25	sm
14	1.9	0.7	2.6	2.71	sm
15	1.8	0.7	2.5	2.57	sm
16	1.4	1.0	2.4	1.40	m
17	1.2	1.1	2.3	1.09	m
18	1.2	0.9	2.1	1.33	m
19	1.2	0.8	2.0	1.50	m
20	1.0	0.9	1.9	1.11	m
21	1.5	0.8	2.3	1.87	sm
22	1.5	0.7	2.2	2.14	sm
23	1.5	0.5	2.0	3.00	sm
24	1.3	0.6	1.9	2.16	sm
25	1.3	0.5	1.8	2.60	sm
26	1.2	0.6	1.8	2.00	sm
27	1.2	0.6	1.8	2.00	sm
28	1.1	0.5	1.6	2.20	sm
29	1.0	0.5	1.5	2.00	sm
30	0.9	0.5	1.4	1.80	sm
	—	—	78.7	—	—

longest chromosomes. The chromosomes from pairs 1-5, type "sm" and "m" with total lengths from 2.9 to 4.5 μm , were assigned to the first group. The second group was formed by chromosomes of pairs 6-10, representing type "st" with lengths 3.3-4.0 μm . The chromosome pairs from 11-14 were placed in group 3. They were of the "sm" type, 2.5-2.8 μm in length, group four contained chromosomes of pairs 16-20, type "m" with lengths from 1.9 to 2.4 μm . Chromosomes of the "sm" type were found in groups 5 and 6 and formed pairs 21-30, whose lengths were in the ranges of 1.8 to 2.3 μm and 1.4 to 1.8

Fig. 3. Somatic metaphases: a — *Tradescantia albiflora* Kunth., $2n = 60$; b — *T. blossfeldiana* Mildbr. $2n = 60$ (x 1650)

Fig. 4. Idiograms of the genomes of the studied species: a — *Spironema fragrans* Lindl., $n = 6$; b — *Setcreasea purpurea* Boom, $n = 12$; c — *Tradescantia albiflora* Kunth., $n = 30$; *Tradescantia blossfeldiana* Mildbr., $n = 30$ ($\times 3000$)

μm , respectively. The distinguishing of 6 morphological chromosome types, of which each is represented by 10 chromosomes within the karyotype suggests that polyploidization has occurred in this species. The basic number is probably $x = 6$. It can be assumed that this is a polyploid $10x$ form.

TRADESCANTIA BLOSSFELDIANA MILDBR.

The somatic cells of the representatives of this species were found to contain $2n = 60$ chromosomes (Fig. 3b). The mean lengths of the chromosomes of the particular pairs fell in the range of 1.3 to 4.8 μm . The centromeres were in various positions: "M", "m", "sm" and "st" (Table 5, Fig. 4d). The longest chromosomes (pairs 1-10) represented various morphological types. From among the remaining chromosomes, four types were distinguished, each numbering 10 chromosomes characterized by similar lengths and centromere positions (Table 5). Three types, "st", "sm" and "m" were found among the chromosomes of groups one and two (pairs 1-5 and 6-10) with lengths of 2.2 to 4.8 μm . The third group (pairs 11-15) was composed of "m" type chromosomes having their centromere positioned in the median region and lengths of 2.1 to 2.4 μm . The fourth group (pairs 16-20) contained "M" type chromo-

somes, with their centromere in the median point and length of 2.0 μm . Group five (pairs 21-25) encompassed chromosomes with lengths of 1.8 μm , classified as type "m". Groups six (pairs 26-30) contained chromosomes with lengths of 1.3 to 1.7 μm and types "m" and "sm". Because four morphological types with 10 chromosomes each were found in the karyotype, it can be supposed that the studied form is also a polyploid in which the basic number $x = 6$ was increased to $10x$.

Table 5

Mean chromosome lengths and types in *Tradescantia blossfeldiana* Mildbr. $2n = 60$ (lengths in μm)

Chromosome pairs	Arm length		Total chromosome length	r-Index	Chromosome type according to Levan
	long	short			
1	4.0	0.8	4.8	5.00	st
2	4.0	0.7	4.7	5.71	st
3	2.7	1.9	4.6	1.42	m
4	3.4	0.8	4.2	4.25	st
5	3.0	1.1	4.1	2.73	sm
6	3.0	0.8	3.8	3.75	st
7	3.1	0.5	3.6	6.20	st
8	2.0	1.1	3.1	1.82	sm
9	1.5	1.0	2.5	1.50	m
10	1.7	0.5	2.2	3.40	st
11	1.5	0.9	2.4	1.66	m
12	1.2	1.1	2.3	1.09	m
13	1.2	1.0	2.2	1.20	m
14	1.2	1.0	2.2	1.20	m
15	1.2	0.9	2.1	1.33	m
16	1.0	1.0	2.0	1.00	M
17	1.0	1.0	2.0	1.00	M
18	1.0	1.0	2.0	1.00	M
19	1.0	1.0	2.0	1.00	M
20	1.0	1.0	2.0	1.00	M
21	1.0	0.8	1.8	1.25	m
22	1.0	0.8	1.8	1.25	m
23	1.0	0.8	1.8	1.25	m
24	1.0	0.8	1.8	1.25	m
25	1.1	0.7	1.8	1.57	m
26	1.0	0.7	1.7	1.43	m
27	1.0	0.5	1.5	2.00	sm
28	1.0	0.5	1.5	2.00	sm
29	1.0	0.5	1.5	2.00	sm
30	0.8	0.5	1.3	1.60	m
	—	—	75.3	—	—

DISCUSSION

The chromosome number determined herein for the species *Spironema fragrans* Lindl. $2n = 12$ is in agreement with the results reported by Darlington (1929), Richardson (1934), Anderson and Sax (1936), Wu (1942), Mitsukuri and Kobayashi (1962). It differs, however, from the results of Celarier (1955), who reports $2n = 24$. The presented morphology of *Spironema fragrans* Lindl. chromosomes is only partially in agreement with literature data. The differences pertain to the determination of the position of the centromere in particular chromosome pairs of this karyotype and SAT-chromosomes. In addition, the literature data lacks information on chromosome lengths for this species. Darlington (1929) and Wu (1942) described the position of the centromere of the first pair of chromosomes as submedian, Anderson and Sax (1936) as median or submedian, while in this study it was found that the centromere was in the median region. Similarly as Darlington (1929), Anderson and Sax (1936) and Wu (1942), the author of this paper classified the second pair of chromosomes as submedian. Anderson and Sax (1936) also allow a second possibility and describe the position of the centromere as median. Significant differences occurred between the classification of the morphological types of chromosome pairs 3 and 4 carried out in this study and that of literature data. The third pair of chromosomes was classified by Darlington (1929) and Wu (1942) as submedian, with an additional secondary structure on the long arm and Anderson and Sax (1936) assigned it to subterminal. The author of this study found that it was median. Darlington (1929), Anderson and Sax (1936) and Wu (1942) described the fourth pair of chromosomes as subterminal, while this author saw the centromere in these chromosomes in the terminal position. In addition Wu (1942) found that the fourth pair was the SAT-chromosomes with one of them having 2 tandem satellites on the short arm.

In respect to the position of the centromeres on chromosome pairs five and six, the literature data (Darlington 1929, Anderson and Sax 1936, Wu 1942) and the results of this study are in agreement — these chromosomes are classified as subterminal. According to this author, the chromosomes of pair five also have small satellites on their short arms, while Darlington (1929) described pair six as SAT-chromosomes.

The chromosome number determined in this study for the species *Setcreasea purpurea* Boom equals $2n = 24$. This result is in agreement with the data reported by Mehra et al. (1961), Mitsukuri and Kobayashi (1962), Guervin and Le Coq (1966). It differs, however, from that given by Bose (1958) which was $2n = 12$. All of the chromosomes of this complex were found to have centromeres in the median region, while Guervin and Le Coq (1966) reporting $2n = 24$ and Bose (1958) giving $2n = 12$, both found median and

submedian chromosomes in the studied karyotypes. The chromosome lengths recorded in this study for *Setcreasea purpurea* Boom (9.1-12.1 μm) differ from the mean values given by Guervin and Le Coq (1966) for this species – 8 μm . On the basis of comparison of the total lengths of the chromosomes and their r-indexes it can be concluded that the studied karyotype is tetraploid.

The somatic cells of *Tradescantia albiflora* Kunth. were found to be $2n = 60$. The same result was obtained in only one study – that by Briggs (1966). The results of other authors differ significantly, since the chromosome numbers for this species are reported to be: $2n = 24$ and $2n = 48$ (Tschermak-Woess and Doležal 1953) and $2n = 72$ (Anderson and Sax 1936). In the karyotype of *Tradescantia albiflora*, 6 groups numbering 10 chromosomes similar in respect to their centromere position and total length were discerned. Their lengths ranged from 1.4-4.5 μm (Table 4). Chromosome types “sm” and “m” were found in the first group, type “st” in group 2, “sm” in group 3, “m” in group 4, type “sm” in groups 5 and 6. The studied form was determined to be a polyploid containing $10x$ chromosomes. Earlier works did not report the morphology of the chromosomes of this species. Anderson and Sax (1936) giving $2n = 72$, described the chromosomes of this complex as small, while Briggs (1966) who gave $2n = 60$ classified most of the chromosomes as small discerning only 5 pairs as large.

The number and morphology of the chromosomes of *Tradescantia blossfeldiana* Mildbr. were not described earlier. The presence of $2n = 60$ chromosomes was found in the karyotype of this species. Their lengths fell in the range of 1.3-4.8 μm (Table 5). On the basis of their lengths and centromere position they were classified into 6 groups numbering 10 chromosomes each. The first and second groups contained chromosomes with various positions of the centromeres: type “st”, “sm” and “m”, to the following “m”, “M”, “m”, respectively, with “m” and “sm” to the last. On the basis of the similarity of the chromosome morphologies of four groups it can be presumed that the studied species is a decaploid with a multiple of the basic number $x = 6$.

The idiograms of the genomes of the studied species are presented on Fig. 4. Two of the studied taxa are characterized by large chromosomes (over 6 μm), that is, *Spironema fragrans* Lindl. $2n = 12$ and *Setcreasea purpurea* Boom $2n = 24$. The chromosome lengths of the remaining two species, with the same number $2n = 60$, fall in similar ranges: 1.4-4.5 μm *Tradescantia albiflora* Kunth. and 1.3-4.8 μm *Tradescantia blossfeldiana* Mildbr. The total lengths of all of the chromosomes of both species of the genus *Tradescantia* attain similar values (Tables 4 and 5). The length of the chromosomes of *Tradescantia albiflora* Kunth. equals 78.7 μm and *T. blossfeldiana* Mildbr. – 75.3 μm . Similar types of chromosomes with a predominance of chromosomes having centromeres in median and submedian positions occur in both karyotypes. These similarities in the karyotypes described above point to the close relationship between *Tradescantia albiflora* Kunth. and *T. blossfeldiana* Mildbr.

The basic chromosome number in the four studied species equalled $x = 6$. The karyotype of *Setcreasea purpurea* Boom, characterized by the presence of chromosomes poorly differentiated in respect to length (9.1-12.1 μm) having centromeres only in the median position, can be described as symmetric. The occurrence of symmetric karyotypes in higher plants is a primitive trait (White 1966). The remaining studied species had asymmetric karyotypes because they contained chromosomes that had considerably different lengths and variously positioned centromeres. These species may be regarded as phylogenetically younger.

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Badania kariotypów czterech gatunków z rodzajów *Setcreasea*, *Spironema* i *Tradescantia* z rodziny *Commelinaceae*

Streszczenie

Przeprowadzono badania dotyczące liczby i morfologii chromosomów czterech gatunków roślin z rodziny *Commelinaceae*: *Spironema fragrans* Lindl., *Setcreasea purpurea* Boom, *Tradescantia albiflora* Kunth. i *Tradescantia blossfeldiana* Mildbr. Stwierdzono, że kariotyp *Spironema fragrans* Lindl. składa się z $2n = 12$ chromosomów, których całkowite długości wynoszą 6,9-13,7

μm , a formuła kariotypu przedstawia się następująco: $2m + 2sm + 2m + 2t + 2st^{sat} + 2st$. U *Setcreasea purpurea* Boom znaleziono $2n = 24$ chromosomy o długościach 9,1-12,1 μm , z położeniem centromerów według formuły: 24 m. Kariotyp *Tradescantia albiflora* Kunth. zawierał $2n = 60$ chromosomów, których długości mieściły się w przedziale 1,4-4,5 μm i przedstawiono go zgodnie z formułą: $4sm + 6m + 10st + 10sm + 10m + 20sm$. Zespół chromosomów *Tradescantia blossfeldiana* Mildbr. składał się z $2n = 60$. Ich długości wynosiły 1,3-4,8 μm . Typy morfologiczne chromosomów ilustruje formuła: $6st + 2m + 2sm + 6st + 2sm + 12m + 10M + 14m + 6sm$.

Na podstawie analizy morfologicznej chromosomów nasuwa się przypuszczenie, że *Setcreasea purpurea* Boom jest gatunkiem tetraploidalnym, a *Tradescantia albiflora* Kunth. i *T. blossfeldiana* Mildbr. są dekaploidami.