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Karyotype Asymmetry Based on the Centromere Position in *Aloe vera* (Liliaceae)

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Abstract

The centromere-targeted biotechnology applications and the chromosome engineering experiments of plant centromeres are widely used in precision synthetic plant breeding and genetically improving crops. In this respect, the centromere is the most important chromosomal region in the transition from chromosome structure to genetic engineering and biotechnology applications. The variations of centromere position and karyotype formula are common in *Aloe vera* and in the present study, it is focused on the karyotype asymmetry calculation by the symmetry/asymmetry index (S/A_I) based on the centromeric position. The different S/A_I values were calculated from 2.43 to 2.71. Despite the differences in S/A_I values, *Aloe vera* had only one karyotype type, which was between symmetric and asymmetric. As a result, it is possible that the karyological variations observed in *Aloe vera* can also be seen in other *Aloe* species. The results will provide the important contributions on the cyto- and biotechnological data of the genus *Aloe*.

Keywords: Biotechnology, Chromosome, Centromere

Özet

Sentromer hedefli biyoteknoloji uygulamaları ve bitki sentromerlerinin kromozom mühendisliği deneyleri hassas sentetik bitki ıslahı ve ürünlerin genetik olarak iyileştirilmesinde yaygın olarak kullanılmaktadır. Bu bağlamda sentromer, kromozom yapısından genetik mühendisliği ve biyoteknoloji uygulamalarına geçişte en önemli kromozomal bölgedir. Sentromer pozisyonu ve karyotip formülü varyasyonları Aloe vera'da yaygındır ve bu çalışmada sentromerik pozisyona dayalı simetri/asimetri indeksi (S/AI) ile karyotip asimetrisinin hesaplanmasına odaklanılmıştır. Farklı S/AI değerleri 2,43 ile 2,71 arasında hesaplanmıştır. S/AI değerlerindeki farklılıklara rağmen Aloe vera'nın yalnızca simetrik ve simetrik arasında olan bir karyotip tipi vardı. Sonuç olarak, Aloe vera'da gözlenen karyolojik varyasyonların diğer Aloe türlerinde de görülebilmesi mümkündür. Sonuçlar Aloe cinsinin sito- ve biyoteknolojik verileri hakkında önemli katkılar sağlayacaktır.

Anahtar kelime: Biyoteknoloji, Kromozom, Sentromer

1. INTRODUCTION

The centromere-targeted biotechnology applications and the chromosome engineering experiments of plant centromeres are widely used in precision synthetic plant breeding and genetically improving crops. In this respect, the centromere is the most important chromosomal region in the transition from chromosome structure to genetic engineering and biotechnology applications (Zhou et al., 2022). Therefore, the centromeric DNA in genomic studies and the centromeric position in chromosomal studies provide valuable data for all organisms (in here *Aloe vera* L.).

Aloe vera is the most prominent species of the genus *Aloe* L. The genus *Aloe* belongs to the family Liliaceae and consists of more than 500 species (Radha and Laxmipriya, 2014). The genus has rich medicinal ingredients and active components such as sugars, amino acids, enzymes, minerals, vitamins, salicylic acids, saponins, and lignin (Jahan et al., 2014; Sánchez

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et al., 2020) and grows in the warm regions of Asia, Europa, Africa, and America (Chaudhari and Chaudhary, 2012). *Aloe vera* has a strong history of use in many fields such as nutrition, cosmetics, medicine, and dentistry (Taheri et al., 2011). In addition, *Aloe vera* has antioxidant, antibacterial, antiviral, anticancer, anti-inflammatory, antiallergic, therapeutic, and UV protection properties (Choi and Chung, 2003; Sánchez et al., 2020).

In *Aloe vera*, the diploid chromosome number was $2n = 2x = 14$, but polyploidy with $2n = 4x = 28$ (tetraploidy) was also seen. In the species, in addition to variation in ploidy level, there was also variation in the centromere position and karyotype formula (Yongzhong et al., 1998; Das et al., 2010; Gunjan and Roy, 2010; Chaudhari and Chaudhary, 2012; Haque and Ghosh, 2013; Nejatzadeh-Barandozi and Akbari, 2013; Jahan et al., 2014; Devi et al., 2019). In the present study, it is focused on the karyotype asymmetry calculation by the symmetry/asymmetry index (S/A_I) based on the centromeric position.

2. MATERIALS AND METHOD

After a detailed literature review, karyological data of *Aloe vera* was obtained. The data consists of diploid chromosome number, ploidy level, and karyotype formula (Table 1).

Table 1. The karyological data consisting of chromosome number, ploidy level, and karyotype formula of *Aloe vera*.

Karyotype number	2*n* (ploidy)	Karyotype formula	References
1	14 (diploid)	8SM + 6ST	Yongzhong et al., 1998
2	14 (diploid)	6SM + 8ST	Das et al., 2010
3	28 (tetraploid)	12SM + 16ST	Das et al., 2010
4	14 (diploid)	6SM + 8ST	Gunjan and Roy, 2010
5	14 (diploid)	6SM + 8ST	Chaudhari and Chaudhary, 2012
6	14 (diploid)	6SM + 8ST	Haque and Ghosh, 2013
7	14 (diploid)	6SM + 8ST	Nejatzadeh-Barandozi and Akbari, 2013
8	14 (diploid)	8SM + 6ST	Jahan et al., 2014
9	14 (diploid)	6SM + 8ST	Jahan et al., 2014
10	14 (diploid)	4SM + 10ST	Jahan et al., 2014
11	14 (diploid)	6SM + 8ST	Devi et al., 2019

The symmetry/asymmetry index based on the centromere position and karyotype formula was calculated with the following formula.

$$S/A_I = (1 \times M) + (2 \times SM) + (3 \times ST) + (4 \times T) / 2n$$

In the formula, the abbreviations, which are M, SM, ST, and T refers to the concepts of metacentric, submetacentric, subtelocentric, and telocentric, respectively. In the S/A_I value, there are five karyotype types: (i) full symmetric ($S/A_I = 1.0$), (ii) symmetric ($1.0 < S/A_I \leq 2.0$), (iii) between symmetric and asymmetric ($2.0 < S/A_I \leq 3.0$), (iv) asymmetric ($3.0 < S/A_I < 4.0$), and (v) full asymmetric ($S/A_I = 4.0$) (Eroğlu, 2015).

3. RESULTS AND DISCUSSION

Aloe vera showed the karyological variations. The chromosome numbers were $2n = 14$ with ploidy level of $2x$ and $2n = 28$ with ploidy level of $4x$. There were four different karyotype types, which were 4SM + 10ST, 6SM + 8ST, 8SM + 6ST, and 12SM + 16ST (Table 1). The variations in karyotype formulae were also reflected in karyotype asymmetry and different S/A_I values were calculated. Karyotype asymmetry ranged from 2.43 to 2.71. Despite the differences in S/A_I values, *Aloe vera* had only one karyotype type, which was between symmetric and asymmetric (Table 2).

Table 2. The S/A_I values and karyotype types of *Aloe vera*

Karyotype number	S/A_I	Karyotype type
1	2.43	Between symmetric and asymmetric
2	2.57	Between symmetric and asymmetric
3	2.57	Between symmetric and asymmetric
4	2.57	Between symmetric and asymmetric
5	2.57	Between symmetric and asymmetric
6	2.57	Between symmetric and asymmetric
7	2.57	Between symmetric and asymmetric
8	2.43	Between symmetric and asymmetric
9	2.57	Between symmetric and asymmetric
10	2.71	Between symmetric and asymmetric
11	2.57	Between symmetric and asymmetric

In Table 2, karyotype asymmetry values were quite close (between 2.43 and 2.71) and the karyotype type was between symmetric and asymmetric. This range, which corresponds to a single karyotype type, is within the expected variability for any species. Gunjan and Roy (2010) determined the karyotype asymmetry on the basis variation in chromosome length and centromeric position in *Aloe vera*, *Aloe indica*, and *Aloe ferox*. They investigated the karyotype asymmetry by eight parameters, which were TF%, AsK%, Stebbins' classification, Rec-Syi indexes, A1-A2 indices, A value, DI and AI and recorded that *Aloe vera* had asymmetric karyotype composed mostly of subtelocentric chromosomes. Nejatzadeh-Barandozi and Akbari (2013) used the total form percentage (TF) and reported the asymmetrical karyotype of *Aloe vera* consisting of submetacentric and subtelocentric chromosomes.

As a result, it is possible that the karyological variations observed in *Aloe vera* can also be seen in other *Aloe* species. The results will provide the important contributions on the cyto- and biotechnological data of the genus *Aloe*.

AUTHORS' CONTRIBUTION

All authors contributed to the study's conception and design. All authors read and approved the final manuscript.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

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