Chromosome Numbers in Kiwifruit (Actinidia deliciosa) and Related Species

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Summary

Somatic chromosome numbers of Actinidia deliciosa cvs. ‘Matua’ (staminate clone), ‘Abbott’ and ‘Bruno’ (pistillate clones) and two native wild species, A. polygama and A. arguta were studied using the squash and flame-drying methods. The chromosome counts of the commercial cultivars were 2n=174, whereas those of A. arguta were 2n=58, 116 and 174 and those of A. polygama were 58. These data confirm earlier findings that the basic chromosome number is x=29(11) and that with increasing polyploidy, the number of nucleoli increased correspondingly.

Introduction

Because of the numerous forms of kiwifruit described by early taxonomists, the botanical name has been changed periodically. The genus Actinidia was placed in the Dilleniaceae until Van Tieghem established the family Actinidiaceae in 1899(16). Recently, Liang and Ferguson(12) divided the species A. chinensis into two, assigning the species name deliciosa to the stiffhaired form while maintaining the original name chinensis for the form with soft, nonpersistent hairs. Hence, the commercial cultivars are now classified under Actinidia deliciosa (Chev.) Liang and Ferguson.

Cultivars developed in New Zealand are grown in the warmer regions of Japan such as southern Honshu, Shikoku and Kyushu because they are subject to winter injury, short for optimum temperature period and frost damage in spring. There are major two cold-hardy native species, A. polygama and A. arguta which thrive in northern to southwest Japan. Means of vegetatively propagating these species and their morphological characteristics have been described by numerous investigators(1, 3, 6, 7, 8, 10, 15, 17) but little is known about their cytology and inheritance of genetic characteristics.

To breed for cold resistance and to learn

the pattern of inheritance of bisexuality, hairiness, mesocarp pigment, etc. it is important to know the chromosome numbers and the relationship among the different species. To add and support the findings of previous reports on chromosome counts(4,13,14), we examined the chromosome numbers of somatic (root tip) cells and reproductive organs (pollen mother cells). The number of nucleoli within the nucleus of diploid and polyploid species were also counted.

Materials and Methods

Species and cultivars. A. deliciosa.

The staminate cv. ‘Matua’, and pistillate cvs. ‘Abbott’ and ‘Bruno’ were grown in Nihon University field where their samples were collected. Samples of A. polygama tissue and organs were collected in Kuma, Kumamoto Pref. and Minakami, Gumma Pref. A. arguta samples were collected at the same two sites as above and at Hayama, Kanagawa Pref. Samples of ‘Issaisarunashi’, a member of A. arguta were obtained from the Yamato Seed Co.

Somatic chromosome numbers were obtained from actively growing root tips using the squash method. Root tips were pretreated with 0.03 M 8-hydroxyquinoline for 4~6 hrs at 20°C and fixed in a 1:1:1 (v/v/v) mixture of ethanol: chloroform: glacial acetic acid for 3 hrs. Preparations were made by the flame-drying method of Hizume(9) or the
aceto-orcein method for somatic cells. Chromosome counts were made at the metaphase stage on ten cells of cv. ‘Matua’, seven of ‘Abbott’, and five of ‘Bruno’.

Chromosome numbers during meiosis were obtained from pollen mother cells (PMC) in immature anthers of cv. ‘Matua’. Flower buds were collected 2-3 weeks before anthesis when the buds were about 9 mm in length. The aceto-carmin smear method was used for staining the chromosomes.

To count the number of nucleoli in the different nuclei of root tip cells and microspores, preparations were flame dried and either stained with Giemsa dye or aceto-carmin and air-dried before dipping them in 50% silver nitrate solution kept at 60°C.

Results

1. Chromosome numbers of somatic cells

1) *A. deliciosa*. No karyological differences were observed among the cvs. ‘Matua’, ‘Abbott’, and ‘Bruno’. All cells examined at the metaphase stage contained 174 chromosomes (Fig. 1). The length of chromosomes at this stage of cell division ranged from 0.6 to 1.5 μm in these cultivars.

In the silver-stained nuclei of root tip cells of ‘Matua’, the number of nucleoli varied from one to six whereas cells of the microspores contained one to three (Fig. 2).

2) *A. polygama*. No karyological differences were recognizable between cells of plants...
collected from Kumamoto and Gunma Pref. In both specimen the number of somatic chromosomes during the metaphase stage was 58 (Fig. 3). The chromosome length was about 1 μm. No satellite (SAT) chromosomes were observed. The nuclear number in the root tip cells during the interphase stage varied from one to four.

3) A. arguta. Of the four specimen which were examined, the root tip of plants from Hayama, Kanagawa Pref. had 58 chromosomes (Fig. 4A). The average length of the chromosomes was 1 μm. Two nucleoli were observed in the somatic cells (Fig. 4B).

The two specimen collected from Kumamoto and Gunma Pref. the somatic cells contained 116 chromosomes (Fig. 5, 6). This count agrees with that reported by Bowden (4). No karyological differences were observed between cells of the two specimen. No SAT-chromosomes were evident and the numbers of nucleoli in the somatic cells ranged from one to four.

The chromosome number in the root tip cells from ‘Issaisarunashi’ was found to be 174 (Fig. 7). No nucleoli or SAT-chromosomes were observed in these cells. The karyological characteristics of somatic cells from ‘Issaisarunashi’ were similar to those of the cultivated member of A. deliciosa with chromosome counts of 2n = 174.

2. Chromosome number in pollen mother cells

Nuclei of PMCs in ‘Matua’ anthers were difficult to stain until the diplotene stage. Most PMC at diakinesis stage of division contained ca. 87 chromosomes exhibiting normal division figures (Fig. 8).

Discussion

Some members of the genus Actinidia are considered to be polyploids because of the
large number of small chromosomes (11). The number of chromosomes in *A. chinensis* varied among investigators; Rizet (14) reported 160 in a French study; Zhang (19) and Zhang and Beuzenberg (18) reported that the var. *chinensis* contained 2n=58 whereas the var. *hispida* contained about 174 and 170 chromosomes, respectively. Nakajima (13) reported that somatic cells of his *A. polygama* specimen contained 2n=58 whereas Bowden (4, 5) reported that 2n=ca. 116. Bowden (4, 5) also observed that diploid number for both *A. arguta* and *A. chinensis* was also 2n=ca. 116. Based on these reports Ferguson (11) proposed that in the polyploidy series the basic chromosome number for *A. deliciosa* was x=29. The data from our observations confirm that proposition.

Our studies revealed that in *A. arguta*, the specimen with a nucleus containing 58 chromosome exhibited 2 nucleoli; the one with 2n=116 had 4 nucleoli. The number of nucleoli in the nucleus of cells with 2n=174 was not ascertained but it is suspected to have six as in the case of *A. deliciosa*. Our limited study with *A. arguta* leads us to speculate that there is a step-wise increase of nucleoli with increase in ploidy. Such a correlation has been reported for *Potorous* cells grown in vitro (2). Having established a correlation, it is possible to detect polyploidy by counting the number of nucleoli rather than the tiny chromosomes in *Actinidia*.

![Fig. 7. Somatic chromosomes at metaphase in *A. arguta* cv. 'Issaisarunashi'. 2n=174. Bar=5 μm.](image)

![Fig. 8. Meiotic chromosomes at diakinesis of the staminate cv. 'Matua'. n=ca. 87. Bar=5 μm.](image)

<table>
<thead>
<tr>
<th>Species</th>
<th>Chromosome number (2n)</th>
<th>SAT-chromosome</th>
<th>Nucleolar number</th>
</tr>
</thead>
</table>
| *A. deliciosa*  
< Matua > | 174                    | 6              | 6               |
| < Abbott (pistillate cv.) > | 174                    | 6              | —               |
| < Bruno (pistillate cv.) > | 174                    | —              | —               |
| *A. polygama*  
< Kuma > | 58                     | —              | —               |
| < Minakami > | ca. 58                 | —              | —               |
| *A. arguta*  
< Hayama > | 58                     | 2              | 2               |
| < Kuma > | 116                    | —              | 4               |
| < Minakami > | 116                    | —              | 4               |
| < Issaisarunashi > | ca. 174               | —              | —               |

< >: localities collected.
Our study of *A. polygama* revealed that the somatic cells from the two specimen contained 2n=58. Bowden (4, 5) reported that the diploid number of *A. polygama* was 2n=ca. 116. Hence, it appears that this species, *A. polygama* also harbors intraspecific polyploids with 2n=58 and 116 chromosomes.  

Zhang and Beuzenberg (18) reported that a polyploid series with 2x, 4x, and 6x existed within *A. chinensis* var. *chinensis*. Zhang (19) estimated that a specimen of *A. chinensis* var. *hispida* contained 174 chromosomes. Our study with nine specimen within the three species of *Actinidia* confirm the above findings, namely, that there is a polyploid series of 2x, 4x, and 6x (Table 1). Furthermore, all members examined within the species *A. delicosa* possessed six nucleoli in the nucleus of somatic cells and three in the microspore nuclei of 'Matua'. Thus, these commercial cultivars are considered to be hexaploids with a basic genome of x=29.  

Nakajima (13) observed a heteromorphic bivalent at the metaphase I stage in the PMC of male plants of *A. polygama* and *A. kolomikta*. He interpreted that this heteromorphism to the possession of the sex genes, XX and XY, by this pair of chromosomes. Although Zhang and Beuzenberg (18) did not observe PMC undergoing meiosis, they also suggested that transmission of maleness or femaleness to offsprings was accomplished by a simple mechanism. They speculated that the diploid phenotypes carried 56 (2X28) chromosomes plus XX/XY and the heteroploid members with 170 chromosomes possessed 168 (6X28) plus XX/XY.

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**Literature Cited**


17. WATANABE, K. and B. TAKAHASHI. 1984. Flower bud differentiation and development of
キウイフルーツ及び近縁種の染色体数

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キウイフルーツ（A. delicosa）の雄性品種‘マチュア’、雌性品種‘アポット’、‘ブーノ’及びマタタビ（A. polygama）、サルナシ（A. arguta）を用いて体細胞染色体、減数分裂について観察調査を行った。キウイフルーツの3品種の体細胞染色体数は2n=174であり、マタタビの2種では2n=58、サルナシの4種では2n=58、2n=116、2n=ca. 174 と算定された。

これらの染色体数から、Actinidiaにおいてはx=29が基本数であることが認められた。

サルナシにおいては、2仁を有する 2n=58、4仁を有する 2n=116 と仁数は不明確であったが 2n=ca. 174 の2x、4x、6xの倍数関係が示された。本報のマタタビは2n=58 の2倍性であったが、これまでに報告された2n=116 の存在を考えると両者の間には、2x と 4x の同質倍数関係があるのかかもしれない。本研究の2n=174 のキウイフルーツの3品種‘マチュア’、‘アポット’、及び‘ブーノ’は体細胞核6仁または小胞子核で3仁を有し、いずれも基本数x=29の6倍性を示している。