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Selection of Hypo- and Hyper-tetraploid Seedlings from Abnormal Cotyledons Seedlings Obtained during Crossing of Tetraploid Grapes (*Vitis* Complexes)

Young Sik Park[1], In Jong Kim[1], and Sung Min Park[2*]

[1]*Gangwon-do Agricultural Research & Extension Services, Chuncheon 200-939, Korea*
[2]*Applied Plant Science, Kangwon National University, Chuncheon 200-701, Korea*

Abstract. We observed abnormal morphology of cotyledons occurring in seedlings derived from open-pollinated and cross-pollinated tetraploid grapes and selected aneuploids, especially hypo- and hyper-tetraploid in seedlings with abnormal morphology of cotyledons. Five types of morphologically abnormal cotyledons were observed. In open-pollination of four tetraploid grapes, the frequency of abnormal cotyledons was 1.6% (49 of 3029 seeds). Percentage of aneuploids in the seedlings of abnormal cotyledons was 20.4% (10 of 49 seedlings). Aneuploids in open-pollination consisted of three (4n = 4x-2), four (4n = 4x-1), and three (4n = 4x+1) seedlings. In cross-pollination of tetraploids, the frequency of abnormal cotyledons was 3.4% (59 of 1729 seeds). Percentage of aneuploids in the seedlings with abnormal cotyledons was 22.0% (13 of 59 seedlings). Aneuploids from cross-pollination of tetraploids consisted of two (4n = 4x-2), nine (4n = 4x-1), one (4n = 4x+1), and one (4n = 4x+3) seedlings. According to the results, although the abnormal cotyledon morphology of seedlings obtained from crossing between tetraploid grapes appeared at low rate (2.3%), aneuploid seedlings occurred at high rate (22.0%); therefore, it indicated that this selection strategy might be very efficient in the initial seedling stage.

***Additional key words*:** aneuploid, chromosome, morphology

Introduction

Seedlessness is one of the important breeding characters in grape (*Vitis* spp.) as well as in most fruit trees. Seedless grape cultivars are classified into four types, i.e., stimulative parthenocarpy, stenospermocarpy, triploid, and aneuploid. Most seedless grape cultivars in the world have been bred using cultivars with the stenospermocarpic character controlled by recessive genes. However, application of this breeding method to the crosses between grape cultivars could be restricted, since at least one of two cultivars used for the crossing must have genes controlling stenospermocarpy.

Therefore, the aneuploid plants such as hypo- and hyper-tetraploids have been considered important breeding materials because aneuploids have potentially produced seedless fruits in grape (Fukushima and Tokumasu, 1957; Khush, 1973; Yamane et al., 1978). It is known that the aneuploids are created by odd cell division and failure of meiosis, which occasionally occurred by mutagenic treatment, descant of tetraploids, and cross between heterogeneities (Edwards et al., 1980; Khush, 1973; Weber, 1983, 1991). In grapes, Yamane et al. (1978) reported one aneuploid cultivar ‘Takao’ (2n = 4x-1 = 75), a chance seedling from open-pollinated tetraploid ‘Kyoho’. In addition, the aneuploid plants were expected to be highly sterile and produce seedless berries with the minimum aid of gibberellin. From self-pollinations of two tetraploid grapes, Park et al. (1999a) reported also 4 aneuploid plants with hypo-tetraploid chromosome numbers 75 (4x-1), 74 (4x-2) and 74 (4x-3). Park et al. (1999a) suggested that aneuploid, especially hypo-tetraploid, in seedlings derived from self-pollinated tetraploid grapes could be selected by the abnormal morphology of cotyledons soon after seed germination.

Aneuploids, especially hypo- or hyper-tetraploids, have not been frequently reported in progenies of artificially induced tetraploid plants. However, it has been reported that several aneuploids were observed in some plants, including tomato (Oka, 1936, 1938), barley (Karpechenko, 1938; Tsuchiya, 1957),

***Corresponding author:** parksm@kangwon.ac.kr
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sugar beat (Levan, 1942; Mochizuki, 1953), rice (Masema, 1952), artemisia (Suzuka et al., 1955), rye (Morrison, 1956), Japanese radish, and Chinese cabbage (Fukushima and Tokumasu, 1957). In citrus, Bacchi (1940) found two aneuploids among open-pollinated seedlings, one with the chromosome number of 2x+3 = 21 and the other with the chromosome number of 4x−3 = 33. Esen and Soost (1972) reported aneuploidy seedlings in an open-pollinated progeny of tetraploid Lisbon (*C. limon* L.) two of which were 2x+6 = 24 and 4x+1 = 37. Considering the low frequency of aneuploid appearance in breeding materials, development of efficient selection methods from pollinated seedlings is required because screening of aneuploids from seedlings is extremely hard.

The purpose of the present study was to examine the characteristics of abnormal morphology of cotyledons occurring in seedlings derived from open-pollinated tetraploid grapes and crossing between tetatraploid grapes and to determine aneuploidy with those characteristics in seedlings.

Materials and Methods

Plant material

Fifteen tetraploid grapes; 'Benifuji', 'Black Olympia', 'Cannon Holl Muscat', 'Fujiminori', 'Heukgoosul', 'Honey Black', KA9301, 'Kyoho', 'Pione', RB9127, 'Red Pearl', 'Shigyoku', 'Takasumi', 'Tensyu', and 'Yufu' were used in the study. 'Red Pearl' and 'Yufu' were tetraploid sports of diploidy 'Delaware' and 'Muscat Bailey A', respectively. KA9301 was an eight-year-old hybrid seedling obtained from 'Kyoho' (4x) × 'Muscat of Alexandria' (2x). RB9127 was an eight-year-old hybrid seedling obtained from 'Red Pearl' (4x) × 'Muscat Bailey A' (2x). These two tetraploid grapes resulted from the fusion of diploid egg and unreduced male gamete (Park et al., 1999a) (Table 1). Grapes were grown in a greenhouse at Kangwon National University Orchard, Chuncheon, South Korea. The clusters of tetraploid and diploid grapes each were bagged several days before anthesis to prevent outcross. Flowers of the pistillate parents were emasculated 2 days before anthesis, washed with running water, and bagged. Pollination was carried out by placing the fresh pollens directly onto the stigma. The pollinated flower clusters were bagged to exclude random pollination. Fully developed seeds were excised from mature berries about four months after open-pollination and cross-pollination.

Seedling morphology

Seeds collected from open-pollinated tetraploid cultivars were stored in a plastic box containing moistened sand for 4 months and then sowed in 47×34 cm polyethylene boxes filled with desalted sea sand. Morphology of cotyledons was observed just after the seedling expansion and the seedlings were transplanted in 240×300 mm polyethylene pots filled with silt clay loam soil and leaf mold mixture (2:1).

Chromosome observation

The root tips of seedlings with abnormal cotyledons were collected, pre-treated with 2 mM 8-hydroxyquinoline at room temperature for 2 hrs and fixed in the mixture solution of acetic acid and ethyl alcohol (1:3, v/v) at 4℃ for 4hrs. Samples were washed with distilled water and macerated in a solution of enzyme mixture for 30 to 60 minutes at 38℃. The enzyme mixture consisted of 40% cellulase RS

Table 1. Origin of tetraploid cultivars and lines used in this study.

Cultivar and line	Scientific name	No. of chromosomes	Origin
Benifuji	*V.* complex	76	Golden Muscat × Kuroshio
Black Olympia	*V.* complex	76	Kyoho × Kyokuji
Cannon Holl Muscat	*V.* complex	76	Muscat of Alexandria Bud Mutation
Fujiminori	*V.* complex	76	Ikawa 682 × Pione
Heukgoosul	*V.* complex	76	Golden Muscat × Pione
Honey Black	*V.* complex	76	Kyoho × Concord
KA9301	*V.* complex	76	Kyoho × Muscat of Alexandria
Kyoho	*V.* complex	76	Ishihara Wase × Centennial
Pione	*V.* complex	76	Kyoho × Cannon Holl Muscat
RB9127	*V.* complex	76	Red Pearl × Muscat Bailey A
Red Pearl	*V.* complex	76	Delawere doubling
Shigyoku	*V.* complex	76	Wase takasumi early mutation
Takasumi	*V.* complex	76	Kyoho selection
Tensyu	*V.* complex	76	Pione × Cannon Hall Muscat
Yufu	*V.* complex	76	Muscat Bailey A doubling

(Yakult), 1% pectolyase Y23 (Seishin Pharmaceutical Co., Korea), 70 mM KCl, and 7.5 mM Na_2EDTA, and the pH was adjusted to 4.0 by 1M HCl. After washing with distilled water three times, the macerated root tips were placed on a slide glass with a few drops of acetic alcohol (1:3, v/v) solution. Samples were laid by tapping with fine tweezers and air-dried under room temperature. The air-dried specimens were stained with 4% Giemsa solution diluted with 1/15 M phosphate buffer (pH 6.8) for 5 to 10 minutes and air-dried again. They were mounted in paramount and observed under a microscope of 1000 magnifications. Chromosome number was counted in at least three cells per seedling.

Results

The seedlings obtained from open-pollinated tetraploid cultivars were easily classified by their cotyledons being either normal or abnormal shape (Fig. 1 and Table 1). Morphologically, abnormal cotyledons exhibited five types; (A) One cotyledon positioned on a side, presenting attached shape. (B) Two cotyledons positioned as symmetric shape, yet one cotyledon partially split in the center of mid-margin,

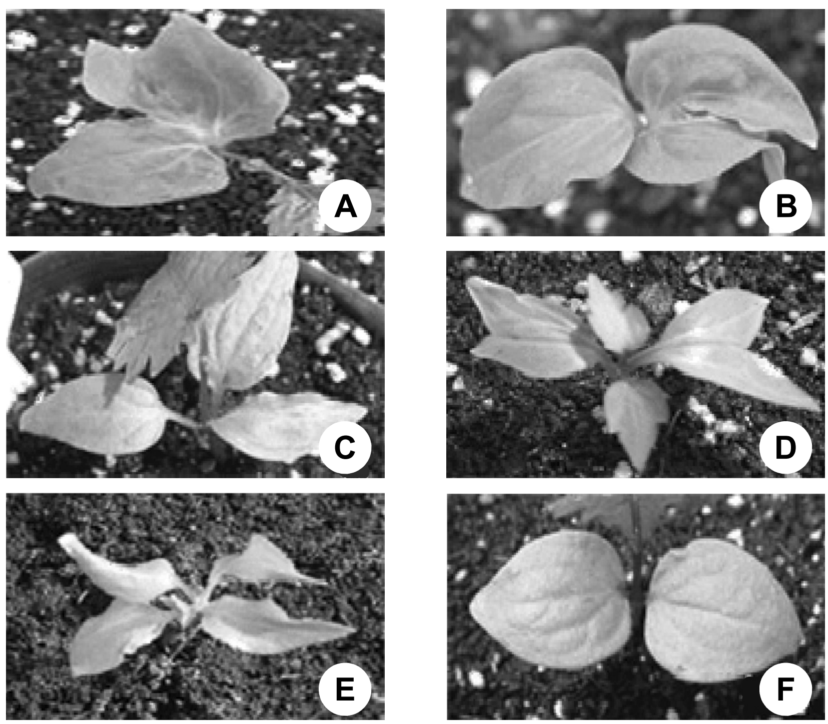

Fig. 1. Morphology of six classified cotyledon types in seedlings derived from open-pollinated tetraploid grapes.
A: Mono-cotyledon was perfectly fused or had various narrow incisions in margin of mono-cotyledon.
B: One of two cotyledons showed asymmetric arrangement of veins and partial split in the edge of mid-leaf, while the other one has normal morphology.
C: Three cotyledons were small and narrow in shape and had symmetric veins, butthe cotyledon was divided into three.
D: Two of the cotyledons were irregular shape, partially split in edgeof mid-leaf.
E: More than four cotyledons, which were small, narrow and asymmetric in shape. The edge of cotyledon was pointed at the end.
F: The edge of cotyledon was smooth and lobing was not observed. Both cotyledons had the symmetric veins.

Table 2. Morphology and frequency of abnormal cotyledons in seedlings derived from open-pollinated tetraploid grapes.

Cultivar[z]	No. of seedlings	No. of seedling in indicated morphology of cotyledons						
		Normal (%)	A	B	C	D	E	Total (%)
Cannon Holl Muscat	52	49 (94.2)[y]	2	1	0	0	0	3 (5.8)
Kyoho	843	832 (98.6)	2	6	1	0	2	11 (1.3)
Red Pearl	2,045	2,015 (98.5)	9	8	4	2	7	30 (1.5)
Yufu	89	84 (94.4)	2	3	0	0	0	5 (5.6)
Total	3,029	2,980 (98.4)	15 (0.5)	18 (0.6)	5 (0.2)	2 (0.1)	9 (0.3)	49 (1.6)

[z]Values in parenthesis mean percentage of abnormal cotyledon types.

while the other was shown normal morphology, (C) Three cotyledons emerged positioning triangularly, (D) Three cotyledons emerged, yet two were irregular shape and the other was partially split in the center of mid-margin, (E) Four abnormal cotyledons emerged (Fig. 1).

Among seedlings classified as abnormal cotyledons, A and B types were the highest frequencies, presenting 0.5 and 0.6%, respectively (Table 2). Seedlings presenting abnormal cotyledons in the four tetraploid cultivars ranged from 1.3 to 5.8%. 'Cannon Hall Muscat' and 'Yufu' showed higher frequency than other cultivars.

Results of chromosome observation in seedlings presenting abnormal cotyledons are shown in Table 3. In an open-pollination of 'Cannon Hall Muscat', two of three seedlings with abnormal cotyledons were aneuploid plants, presenting either hypo-tetraploid or hyper-tetraploid chromosome number, 74 (4x-2) or 77 (4x+1). In an open pollination of 'Kyoho', three of eleven seedlings with abnormal cotyledons were aneuploid plants with 74 (4x-2), 75 (4x-1) and 77 (4x+1) in chromosome number, while eight seedlings were tetraploids. In an open-pollination of 'Red Pearl', four of 30 seedlings with abnormal cotyledons were aneuploid plants presenting either hypo-tetraploid or hyper-tetraploids with chromosome numbers of range from 75 (4x-1) to 77 (4x+1), while 26 seedlings were tetraploids. In an open-pollination of 'Yufu', one of five seedlings with abnormal cotyledons was hypo-tetraploid plants with 74 (4x-2) chromosome number, while four seedlings were tetraploids.

Table 3. The number of chromosomes of seedlings with abnormal cotyledons derived from open-pollinated tetraploid grapes.

Cultivar	No. of seedlings with abnormal cotyledons	Aneuploidy and ploidy of seedling with abnormal cotyledons							No. of aneuploid seedlings
		4x-3	4x-2	4x-1	4x	4x+1	4x+2	4x+3	
Cannon Holl Muscat	3	0	1	0	1	1	0	0	2 (66.7)[y]
Kyoho	11	0	1	1	8 (54.5)	1	0	0	3 (27.3)
Red Pearl	30	0	0	3	26 (87.6)	1	0	0	4 (13.3)
Yufu	5	0	1	0	4 (40.0)	0	0	0	1 (20.0)
Total	49	0 (0.0)	3 (6.1)	4 (8.2)	39 (79.6)	3 (6.1)	0 (0.0)	0 (0.0)	10 (20.4)

[y]Values in parenthesis mean percentage.

Table 4. Morphology and frequency of cotyledons in seedlings derived from crosses of 4x × 4x.

Cross[z]	No. of seedlings	No. of seedling in indicated morphology of cotyledons						
		Normal	A	B	C	D	E	Total
BN×FI	109	106 (97.8)[y]	0	0	2	1	0	3 (2.8)
BN×HB	301	289 (96.0)	0	4	4	3	1	12 (4.0)
BN×KH	110	108 (98.2)	0	0	2	0	0	2 (1.8)
FI×KH	54	53 (98.2)	0	0	1	0	0	1 (1.9)
HB×BN	400	382 (95.5)	2	5	7	3	1	18 (4.5)
HB×KH	145	143 (98.7)	2	0	0	0	0	2 (1.4)
KH×HG	23	22 (95.7)	0	1	0	0	0	1 (4.3)
KH×PN	45	44 (97.8)	0	0	1	0	0	1 (2.2)
RB×CN	18	16 (88.8)	1	0	0	0	1	2 (11.1)
RB×KA	34	32 (94.1)	1	1	0	0	0	2 (5.0)
RB×KH	26	25 (96.2)	0	0	0	0	1	1 (3.8)
RB×RP	55	52 (94.5)	0	0	0	0	3	3 (5.5)
SG×KH	26	25 (96.2)	0	1	0	0	0	1 (3.8)
SG×TS	5	4 (80.0)	0	0	1	0	0	1 (20.0)
TS×BN	263	257 (97.8)	3	3	0	0	0	6 (2.3)
TS×BO	116	113 (97.5)	3	0	0	0	0	3 (2.6)
Total	1,730	1,671 (96.6)	12 (0.7)	15 (0.9)	18 (1.0)	7 (0.4)	7 (0.4)	59 (3.4)

[z]BN: Benifuji; BO: Black Olympia; CN: Cannon Holl Muscat; FI: Fujiminori; HB: Honey Black; HG: Heukguosul;KA: KA9301; KH: Kyoho; PN: Pione; RP: Red Pearl; RB: RB9127; SG: Shigyoku; TS: Tensyu

[y]Values in parenthesis mean percentage.

From 16 crosses with 13 tetraploid cultivars, seedlings with abnormal cotyledons were also obtained (Table 4). Among seedlings classified as abnormal cotyledons, most of them were A, B, and C types at 0.7, 0.9%, and 1.0%, respectively. Percentage of aneuploid in abnormal cotyledon seedlings from 16 cross with 13 tetraploid cultivars was 1.8 to 20.0%. Seedlings of 'Shigyoku' × 'Tensyu' showed higher frequency of aneuploid than those of the other tetraploid cultivars. Results of chromosome observation in abnormal cotyledon seedlings are presented in Table 5. In a 'Benifuji' × 'Fujiminori', one

Table 5. The number of chromosomes in seedlings with abnormal cotyledons derived from crosses of 4x × 4x.

Cross[z]	No. of seedlings with abnormal cotyledons	Aneuploidy and ploidy of seedlings with abnormal cotyledons						
		4x-3	4x-2	4x-1	4x	4x+1	4x+2	4x+3
BN×FI	3	0	0	1 (33.3)[y]	2 (66.7)	0	0	0
BN×HB	12	0	0	1 (8.3)	11 (90.9)	0	0	0
BN×KH	2	0	0	1 (50.0)	1 (50.0)	0	0	0
FI×KH	1	0	0	0	1 (100.0)	0	0	0
HB×BN	18	0	2 (11.1)	4 (22.2)	12 (66.7)	0	0	0
HB×KH	2	0	0	0	2 (100)	0	0	0
KH×HG	1	0	0	0	1 (100.0)	0	0	0
KY×PN	1	0	0	0	1 (100.0)	0	0	0
RB×CN	2	0	0	0	2 (100.0)	0	0	0
RB×KA	2	0	0	0	2 (100.0)	0	0	0
RB×KH	1	0	0	0	0 (0.0)	1 (100.0)	0	0
RB×RP	3	0	0	0	2 (66.6)	0	0	1 (33.3)
SG×KH	1	0	0	0	1 (100.0)	0	0	0
SG×TS	1	0	0	0	1 (100.0)	0	0	0
TS×BN	6	0	0	2 (33.3)	4 (66.7)	0	0	0
TS×BO	3	0	0	0	3 (100.0)	0	0	0
Total	59	0 (0.0)	2 (3.4)	9 (15.3)	46 (78.0)	1 (1.7)	0(0.0)	1 (1.7)

[z]BN: Benifuji; BO: Black Olympia; CN: Cannon Holl Muscat; FI: Fujiminori; HB: Honey Black; HG: Heukguosul; KA: KA9301; KH: Kyoho; PN: Pione; RP: Red Pearl; RB: RB9127; SG: Shigyoku; TS: Tensyu.
[y]Values in parenthesis mean percentage.

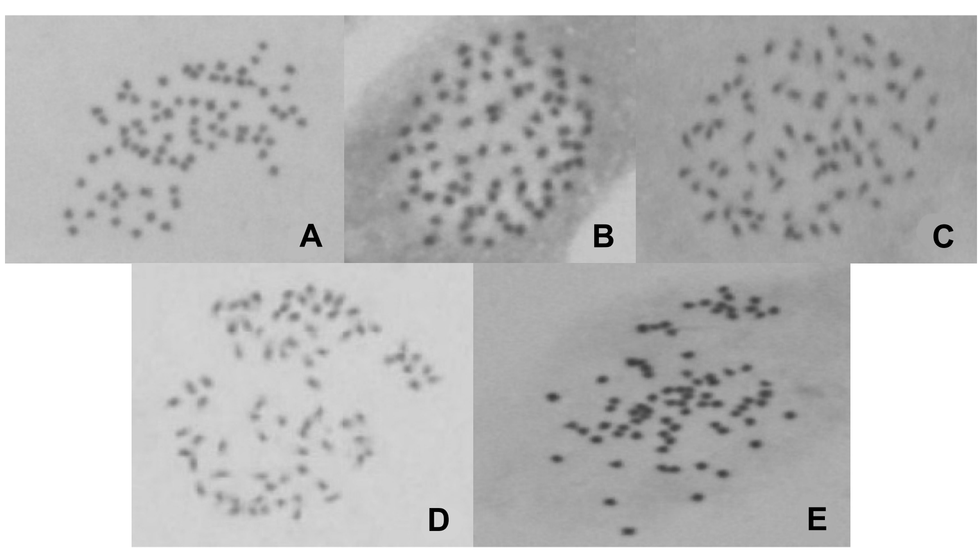

Fig. 2. Metaphase figures in root tip cells of aneuploidy seedlings derived from crosses of 4x×4x and selfing of tetraploid cultivar.
A: Seedling of 'Honey Black' × 'Benifuji', 2n = 4x–2 = 74
B: Seedling of 'Tensyu' × 'Benifuji', 2n = 4x–1 = 75
C: Seedling of 'Cannnon Hall Muscat', 2n = 4x = 76
D: Seedling of 'Yufu', 2n = 4x+1 = 77
E: Seedling of RB9127 × 'Red Pearl', 2n = 4x+3 = 79

of three seedlings with abnormal cotyledons was an aneuploid plant, presenting hypo-tetraploid chromosome numbers 75 (4x-1), while two seedlings were tetraploids. In a 'Benifuji' × 'Honey Black', one of 12 seedlings with abnormal cotyledons was an aneuploid plant, presenting hypo-tetraploid chromosome numbers 75 (4x-1), while 11 seedlings were tetraploids. In a 'Benifuji' × 'Kyoho', one of two seedlings with abnormal cotyledons was an aneuploid plant, presenting hypo-tetraploid chromosome numbers 75 (4x-1), while one seedling was a tetraploid. In a 'Honey Black'×'Benifuji', six of 18 seedlings with abnormal cotyledons were aneuploid plants, presenting hypo-tetraploid chromosome numbers 75 (4x-1), 74 (4x-2), while 12 seedlings were tetraploids. In the RB9127 × 'Kyoho', one seedling with abnormal cotyledons was an aneuploid plant, presenting hyper-tetraploid chromosome numbers 77 (4x+1). In the RB9127 × 'Red Pearl', one of three seedlings with abnormal cotyledons was an aneuploid plant, presenting hyper-tetraploid chromosome numbers 79 (4x+3), while two seedlings were tetraploids. In the 'Tensyu' × 'Benifuji', two of six seedlings with abnormal cotyledons were aneuploid plants, presenting hypo-tetraploid chromosome numbers 75 (4x-1), while two seedlings were tetraploids. In the 'Fujiminori' × 'Kyoho', 'Honey Black' × 'Kyoho', 'Kyoho' × 'Heukguosul', 'Kyoho' × 'Pione', RB9127 × 'Cannon Holl Muscat', 'Shigyoku' × 'Kyoho', 'Shigyoku' × 'Tensyu', and 'Tensyu' × 'Black Olympia', all of the seedlings with abnormal cotyledons were tetraploids (Fig. 2).

Discussion

Cotyledon is a reserved organ to support nutrition for germination and seedling growth against uncompleted environmental stress conditions such as insufficient light condition (Brookes et al., 1980; Dallings et al., 1999; Grime and Jeffery, 1965). It is routinely known that plants are broadly divided as either monocotyledon or dicotyledon species. However, a few species of dicotyledon, such as Loranthaceae (*Psiticanthus*) were observed to have three to nine in its cotyledon numbers (Juguet, 1992). Number of cotyledons may be determined by size of embryo, genesis of genes, and variation of gene expression (Aida et al., 2002; Bowman and Eshed, 2000; Buchholz, 1919; Butts and Buchholz 1940; Conway and Poethig, 1997; Juguet, 1992; Kaplan and Cooke 1997; Lehman et al., 1996; Torres-Ruiz and Jurgens, 1994). Several investigations reported that the bigger embryos produce the more cotyledons in some species, including Abies procera, Cola-acuminata, and Larch (*Larix* × *leptoeuropaea*) (Harrios and Aderkas, 2004; Oladokun, 1982; Sorensen and Franklin, 1977). Also, certain plant hormones such as cytokinin and auxin can affect to cotyledon mutagenesis, inducing abnormal morphology (Aida et al., 2002; Briand et al., 1998; Chaudhury et al., 1993). Our results showed that a few grape seedlings from pollination of tetraploid grapes contained five types of abnormal cotyledons, exhibiting one to four cotyledon numbers and morphological changes (Fig. 1). In this research, we found that abnormal cotyledons appeared in cross-pollination at 3.4% of frequency, a little higher than 1.6% in open-pollination.

Pierce and Wehner (1990) reported that selection of abnormal cotyledons in seedling stage potentially contributes to selection of cucumber cultivars, whereas selection methods in conventional breeding are time and labor consuming as well as high costing. Abnormal cotyledons were morphologically characterized to revolution, stunted, long hypocotyl, and wavy rimed cotyledons, presenting genetic changes (Lida and Amano, 1990; Robinson et al., 1982; Shanmugasundarun and Williams, 1971; Shanmugasundarun et al., 1972; Whelan et al., 1975). Those morphological differences of abnormal cotyledons may result from single recessive genotype (Pierce and Wehner, 1990). To utilize abnormal cotyledon plants in breeding, survival rate of seedlings and growth to mature plants may be important. According Kyung's study (2001), survival rate of abnormal cotyledon seedlings of a rose of Sharon (*Hibiscus syriacus*) was from 54.5 to 98.6%, depending on cross combinations between cultivars. Our results also showed that grape seedlings with abnormal cotyledons successfully grew with a high survival rate of more than 90% (unpublished data). The survival rate suggested that abnormal cotyledon seedlings may be useful sources for application of breeding methods to select genotypically verified plants, such as aneuploids.

Frequency of aneuploidy seems to have positive correlation with chromosome polyploidy and is apparently 1-3% (Ising, 1969; Khush, 1973). We identified that hypo- and hyper-tetraploids were 10 of 3029 seedlings in open-pollination of tetraploids and 13 of 1729 seedlings in cross-pollination of tetraploids (Tables 3 and 5).

The abnormal cotyledon morphology attributes to the disturbance of morphogenesis during embrogenesis. In tetraploid embryos with balanced genome, expression of genes controlling morphogenesis might be normal; however, in hypo- and hyper-tetraploids embryos lacking and adding one or more chromosomes, it might be abnormal. Therefore, the degree of abnormal morphology in cotyledons of hypo-tetraploid and hyper-tetraploid may be highly dependent on the types and number of chromosome lacking or adding, at least one of which has genes controlling embryo and cotyledon development (Park et al., 1999a). It may be considered that in hypo- and hyper-tetraploid seeds the function of endosperm during their development is also different from that in tetraploid seeds. On the other hand occurrence of abnormal cotyledons in tetraploid seedlings suggests that in tetraploid seeds disturbance of normal morphogenesis of cotyledons also occurs during their development depending on some factors intrinsic to the embryos, the environment and so on. Also, it is possible that certain aneuploids may still exist in normal cotyledon seedlings, which was not determined in this study. Park et al. (1999a) reported an aneuploid seedling with normal cotyledon from self-pollinated tetraploid grape.

Our results here clearly indicate that initial screen of abnormal cotyledons might be a very efficient and relatively easy way to select aneuploids from grape seedlings compared to classical selection of breeding methods. Also, aneuploids such as hypo- and hyper-tetraploids in abnormal cotyledon seedlings varied from 4n = 4x-2 to 4n = 4x+3, while their survival rate did not differ much from compared to normal cotyledon seedlings. Unlike other fruit tree species in which aneuploids were associated with poor quality of fruits and poor growth (Crane and Lawrence, 1930), use of aneuploidy of grapes may have potential benefit improving fruit quality, such as breeding of seedless grapes (Park et al., 1998).

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4배체 포도간 교배된 이상자엽실생으로부터 저·고4배체 식물의 선발

박영식[1] · 김인종[1] · 박성민[2*]

[1]강원도농업기술원, [2]강원대학교 식물응용과학부
(*교신저자)

초　록. 본 실험은 4배체 포도의 방임수분과 인공수분으로부터 획득된 실생으로부터 이상자엽의 형태적 특성을 조사하였고, 특히 이들 이상자엽 실생으로부터 저·고4배 식물을 선발하였다. 이상자엽은 크게 5 형태로 구분되었다. 4배체 4품종의 방임수분 실생에서 이상자엽의 발생빈도는 1.6%로 조사되었고, 이상자엽실생 중 이수체 발생율은 20.4%이었다. 4배체 품종의 방임수분에서 얻어진 이수체 식물은 3개체(4n = 4x-2 = 74), 4개체(4n = 4x-1 = 75), 3개체(4n = 4x+1 = 77)로 총 10개체이었다. 4배체 16품종간 교배실생에서 이상자엽의 발생빈도는 3.4%이었다. 이상자엽실생 중 이수체 발생율은 22.0%이었다. 4배체 품종간 교배에서 얻어진 이수체 식물은 2개체(2n = 4x-2 = 74), 9개체(2n = 4x-1 = 75), 1개체(2n = 4x+1 = 77), 1개(2n = 4x+3 =79)로 총 13개체이었다. 본 실험결과 4배체 포도품종간 인공교배를 통해서 얻어진 이상자엽실생들은 대부분 이수체식물로 육묘단계에서 효율적인 선발이 가능성한 것으로 나타냈다.

추가 주요어 : 이수체, 염색체, 형태학