

CHROMOSOMAL BEHAVIOR AND FREQUENCY OF QUADRIVALENTS IN AUTOTETRAPLOID *BRASSICA*

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ABSTRACT:

The present investigation was carried out to induce autotetraploids from two cultivated *Brassica* species, *B. campestris* L. ssp. *rapifera* and *B. oleracea* L. convar. *capitata*. Chromosomal behavior, meiotic pairing and frequency of quadrivalents of produced autotetraploids were analyzed. Autotetraploids of *B. campestris* L. and *B. oleracea* L. revealed marked increase in the size of their cells and nuclei as compared with their respective diploids. The frequency of quadrivalents at metaphase I of autotetraploid *B. campestris* L. was fairly low and was observed only in 5 plants out of 14 autotetraploid plants in Turnip Baladi. Their average number/PMC ranged from 0.10 to 0.36. The major part of chromosomes of autopolyploid *B. campestris* L. were paired in the form of bivalents reaching an average number of 20/PMC. Anaphase I and II proceeded quite regularly but unequal separation of chromosomes has been detected in few cells. In case of *B. oleracea* L., quadrivalents were observed in 6 plants out of 12 autotetraploid plants in Cabbage Baladi. The average number of quadrivalents/PMC ranged from 0.06 to 0.29. Bivalent formations were dominating in the autotetraploids, the highest average number of bivalents reached 17.72 and 17.70 in two of the six autotetraploid plants. Also, the behavior of chromosomes at anaphase I and II was quite regular except for some few cases. The finding that autotetraploids of both *B. campestris* L. and *B. oleracea* L. are forming bivalents point to a probability of the existence of bivalency genes which restrict the pairing to only bivalents, even in the existence of 4 homologous partners of each chromosome. The results could throw some light on the possible-and still incompletely known mechanisms regulating chromosome pairing in autopolyploid of the genus *Brassica*.

INTRODUCTION

Numerous species have been recognized in the genus *Brassica*. Most of these are diploids and only three are polyploids-tetraploids. Since the establishment of the colchicine technique a large number of autopolyploid plants have been raised artificially in various cultivated species. Studies on the character and behavior of those polyploidy plants have hitherto been to some extent accomplished. No species of the crop *Brassica* occurs as a natural autotetraploid. However, there have been several reports of its occurrence through colchicine. Chromosome behavior in autotetraploids has received considerable attention (Morrison & Rajhathy, 1960 and Dagne, 2001). Fertility and reproductive stability in polyploids depend on the precise control of chromosome pairing at meiosis (Jenczewski *et al.*, 2002). The process of meiotic regularization, equal distribution of chromosomes at anaphase I

necessary for improved fertility in autotetraploids, was achieved in different plant species in different ways. Some cytological studies have dealt with the problem of whether improvement in fertility can be achieved by selection on a cytological basis (Hilpert, 1957 and McCollum, 1958). The cytological examination of chromosomes at meiosis in autotetraploid plants is an important part of the study of chromosome behavior. Cytological studies have varied in intensity from easy observations at meiosis to meticulous analyses of all configurations observable, including an estimate of the frequency of quadrivalent formations. Polyploidy has played a major role in the evolution of higher plants. Precise control of chromosome pairing is vital for conferring meiotic regularity, and hence reproductive stability in allopolyploids (Jenczewski & Alix, 2004). Synthetic, newly created or human-made allopolyploid *Brassica*, combination of any two genomes among *B. oleracea*, *B. rapa* and *B. nigra* have been generated de novo in the laboratory (Jeffrey Chen & Zhongfu, 2006).

Extensive basic research and breeding work in addition to modern biotechnological approaches are needed to realize genetic improvement in *Brassica*. Autopolyploid breeding could be one of the target approaches. The application of colchicine as a mean of chromosome doubling agent has opened a large reservoir of possibilities in genetics and plant breeding. It greatly facilitate the production of fertile allopolyploids from sterile primary hybrids as well as the production of autopolyploids from diploid species. Such induced autopolyploids could be used for direct production of allopolyploids or as basic material for further breeding at the autopolyploid level. The newly synthesized AC amphihaploids (*B. campestris* L. x *B. oleracea* L.) which were found to be characterized by high meiotic pairing and multivalent formations tended to show only preferential pairing and bivalent formations after doubling their chromosome number in the amphidiploids AACC (Attia & Röbbelen, 1986). Interpretations and significance of multivalent formations in *Brassica* and possible mechanisms for the regulation of meiotic pairing are certainly of great interest.

This report deals with the cytological behavior, emphasizing quadrivalent and bivalent frequencies at metaphase I of two induced autotetraploid *Brassica*, *B. campestris* L. and *B. oleracea* L.. These two induced autotetraploid *Brassica* plants have 40 and 36 chromosomes in the two species, respectively. In addition, a limited study was made of meiosis in autotetraploid *B. campestris* L. and *B. oleracea* L. to investigate what proportion of the chromosomes occurred as quadrivalents. In this study we have considered quadrivalent frequency as related to chromosome size. So, this paper reports on an analysis of chromosome pairing in induced autotetraploid plants of *B. campestris* L. and *B. oleracea* L. because *B. napus* could be resynthesized from interspecific cross between them.

MATERIALS AND METHODS

Autotetraploid induction

One genotype of *B. campestris* L. ssp. *rapifera* (local variety, Turnip Baladi), and one genotype of *B. oleracea* L. convar. *capitata* (local variety, Cabbage Baladi) were obtained from the Department of Horticulture, Faculty of Agriculture, Fayoum University and used in this study. Colchicine treatments of the two diploid species has been applied with young seedlings according to the method of Eissa Ahmed, (1992). Before treatment, seeds were usually

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germinated in small pots-nurseries, and young seedlings at 6-8 leaf-stage were removed from pots. Their roots were washed and cut to 4cm length and submerged into 0.05% colchicines+1.5% dimethyl sulphoxide with roots heads up to their shoot apex for 12 hours in the dark. Finally, the treated plants were replanted into soil pots individually and kept in a greenhouse.

Chromosome preparations

Young flower buds were collected between 8 and 10 a.m., killed and fixed in Carnoy's solution composed of 4 parts chloroform: 3 parts ethyl alcohol: 1 part glacial acetic acid. Preparations for meiotic analyses and quadrivalents frequency were made using anthers squashes in acetocarmine. Pollen mother cells (PMCs) at the right stage were analyzed by research microscope with phase contrast and half automatic camera. The counts and behavior of the chromosomes were studied by using oil immersion objective of 100 X and an ocular lens of 10 X. The cytological preparations were temporary smears of PMCs. Chromosomal behavior and frequency of quadrivalents on the induced autotetraploid plants was analyzed from the best obtainable preparations at diakinesis, metaphase I and anaphase I. When possible, anaphase II stage has also been analyzed. Pairing configurations were analyzed on the basis of meiotic pairing and chiasma frequency.

RESULTS

Nuclear volume in autotetraploids

The results indicate that in both induced autotetraploids of *B. campestris* L. and *B. oleracea* L., it was clearly observed that cell size as well as nuclear volume increased in autotetraploids in comparison with their respective diploids. This was probably to accommodate the doubled number of chromosomes and cell constituents. Behavior of chromosomes was studied at metaphase I and anaphase I, II of colchiploid Turnip Baladi and Cabbage Baladi.

Frequency of quadrivalents in autotetraploid *B. campestris* L.

From the 14 autotetraploid plants examined in *B. campestris* L., 9 plants formed only bivalents (Table 1 and Fig. 1b and c). Even in the other five multivalent forming plants, the occurrence of quadrivalents was fairly low (Table 1). The average number of quadrivalents/PMC ranged from 10 to 36%. Usually, only one quadrivalent/cell was detected (Fig. 1d) but also two (Fig. 1g and h) and rarely three quadrivalents/cell were detected in few cells (Fig. 1i and j). The quadrivalent shapes were rings, zigzags and chain quadrivalents. One trivalent was observed in few cells. The major part of colchicine doubled number of chromosomes was paired in form of bivalents and their average number/cell in the five plants (Table 1) exceeded 19 (Fig. 1e and f). The other nine plants showed 20 bivalents/cell in each plant, indicating the predominating tendency of this type for chromosome pairing in autotetraploid plants of *B. campestris* L..

Chromosome behavior at anaphase I and II

The behavior of chromosomes in such autotetraploid plants at anaphase I and II was quite regular with nearly complete tendency for equal separation of 20 chromosomes at each pole (Fig. 1k). This behavior was noted in 305 out of 312 PMCs (Table 2). Unequal separation of chromosomes to the opposite poles at anaphase I was rare, but at anaphase II, a relatively high amount of unequal

distribution in the form of 20-20-21-19 was found (Table 2). Besides the normal distribution of 20-20-20-20 which was observed in 129 cells, cells with lagging chromosomes or bridges were also rarely observed.

Table 1: The mean and range (between parenthesis) of various types of metaphase I chromosome configurations in autotetraploid plants of *B. campestris* L. and *B. oleracea* L..

Autotetraploid	Plant No.	Cells studied	Mean and range of chromosome configurations			
			IV	III	II	I
<i>Brassica campestris</i> L.	1	72	0.35 (0-3)	0.03 (0-1)	19.25	0.04
	2	69	0.33 (0-1)	0	19.32	0
	3	70	0.32 (0-2)	0	19.34	0
	4	63	0.36 (0-2)	0.03 (0-1)	19.22	0.03
	5	50	0.10 (0-2)	0	19.71	0.08
	6	64	0	0	20	0
	7	53	0	0	20	0
	8	48	0	0	20	0
	9	36	0	0	20	0
	10	79	0	0	20	0
	11	55	0	0	20	0
	12	39	0	0	20	0
	13	61	0	0	20	0
	14	57	0	0	20	0
<i>B. oleracea</i> L.	1	38	0.07 (0-2)	0.01(0-1)	17.72	0.03 (0-9)
	2	89	0.29 (0-3)	0	17.50	0.02
	3	102	0.06 (0-2)	0	15.64	5.18
	4	85	0.28 (0-3)	0	17.40	0.01
	5	41	0.07 (0-2)	0.02 (0-1)	17.70	0.02 (0-7)
	6	91	0.08 (0-3)	0	15.62	5.13
	7	88	0	0	18	0
	8	73	0	0	18	0
	9	56	0	0	18	0
	10	63	0	0	18	0
	11	49	0	0	18	0
	12	55	0	0	18	0

Table 2: Chromosomal behavior at anaphase I and II of autotetraploid *B. campestris* L. and *B. oleracea* L..

Autotetraploid	Cells studied	Chromosomal distribution			Cells studied	Chromosomal distribution		%Cells with		
		Anaphase I				Anaphase II		Bridges	Laggards	
		20-20	21-19	Others		20-20-20-20	20-20-21-19			
<i>Brassica campestris</i> L.	312	305	5	2	151	129	22	1.32	1.50	
<i>B. oleracea</i> L.	204	198	2	4	31	18-18-18-18	Others	2	2	3

As shown in Table (1) half of the 12 induced autotetraploid plants of *B. oleracea* L. revealed bivalent formations in all 384 examined PMCs (Fig. 2c and d). While, the other six plants showed multivalents, mainly quadrivalents. As in the case of *B. campestris* L., the formation of quadrivalents was very infrequent. The average number of quadrivalents/PMC ranged from 6 to 29%. The same four autotetraploid plants showed mainly one quadrivalent/cell (Fig. 2e) and in some cells of each, two quadrivalents were detected (Fig. 2f), while up to 3 quadrivalents has been found in few cells of plant No. 6 (Table 1). Average number of bivalents was high reaching 17.70 and 17.72, respectively in plants No.5 and 1. This average was relatively low in plants No. 6 and 3, respectively (15.62 and 15.64) due to the existence of high frequency of univalents (Fig. 2g and h) in these two plants (5.13 and 5.18, Table 1).

Chromosome behavior at anaphase I and II

As far as anaphase I and II is concerned, Table (2) shows clearly the regularity of separation at anaphase I, as 198 out of 204 PMCs had 18 chromosomes at each pole. The other six cells showed an irregular separation of 16-20 and other separations (Fig. 2i). Likewise, the distribution of chromosomes at anaphase II was normal in nearly all the examined cells (Fig. 2j). During anaphase I separation, lagging chromosomes could be detected in only three cells (Table 2 and Fig. 2k). Chromosomal bridges could be observed also, in only two cells (Table 2).

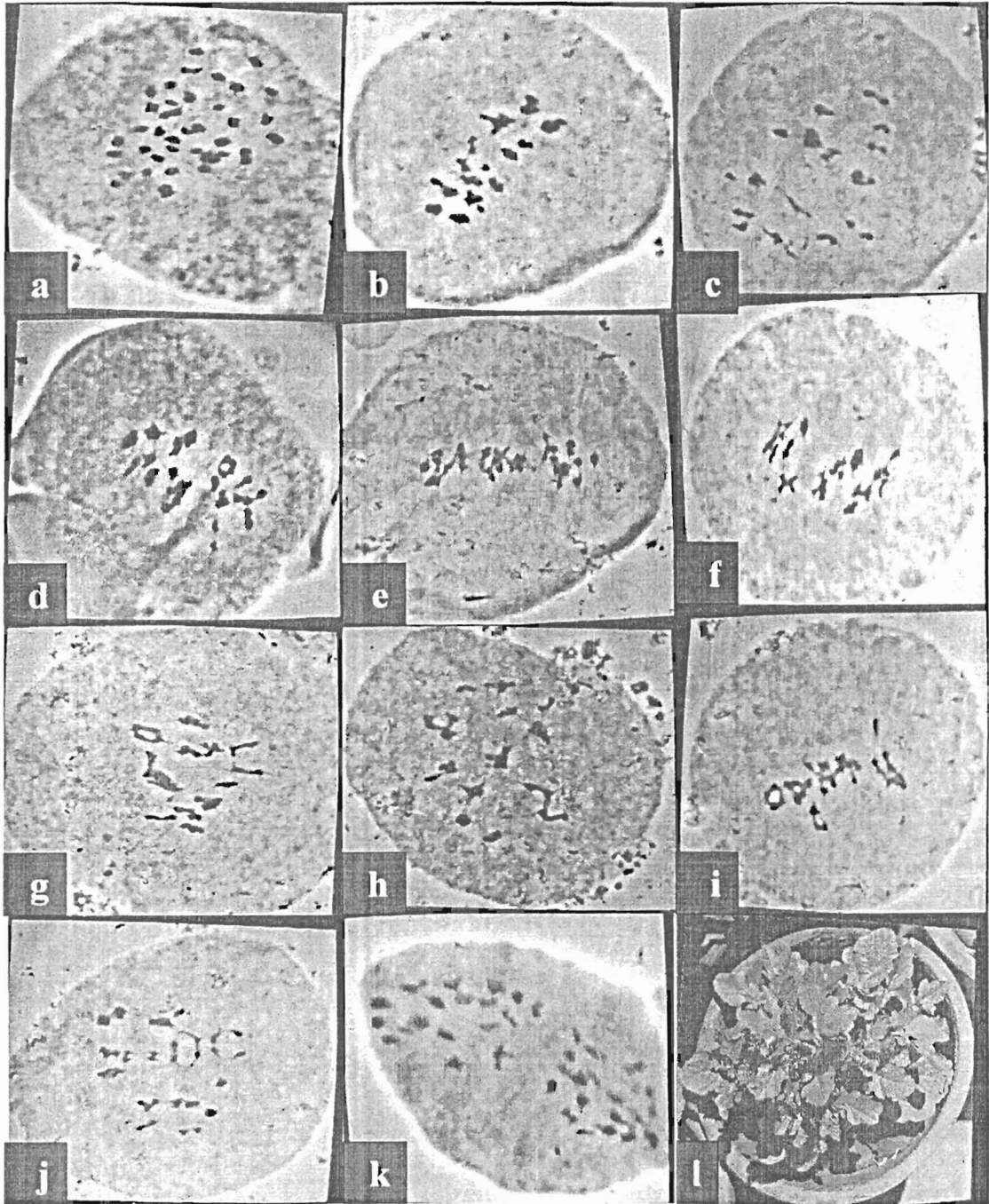


Fig. 1. 4n *B. campestris* (a): cell showing 40 chromosomes, (b and c): MI cells showing 20 II, (d): MI cell showing 1 IV, (e and f): most of chromosomes in two cells showing II only, (g and h): MI cells showing 2 IV, (i and j): MI cells showing 3 IV, (k): AI cell showing normal separation 20 chromosomes at each pole, (l): 4n plant of *B. campestris*.

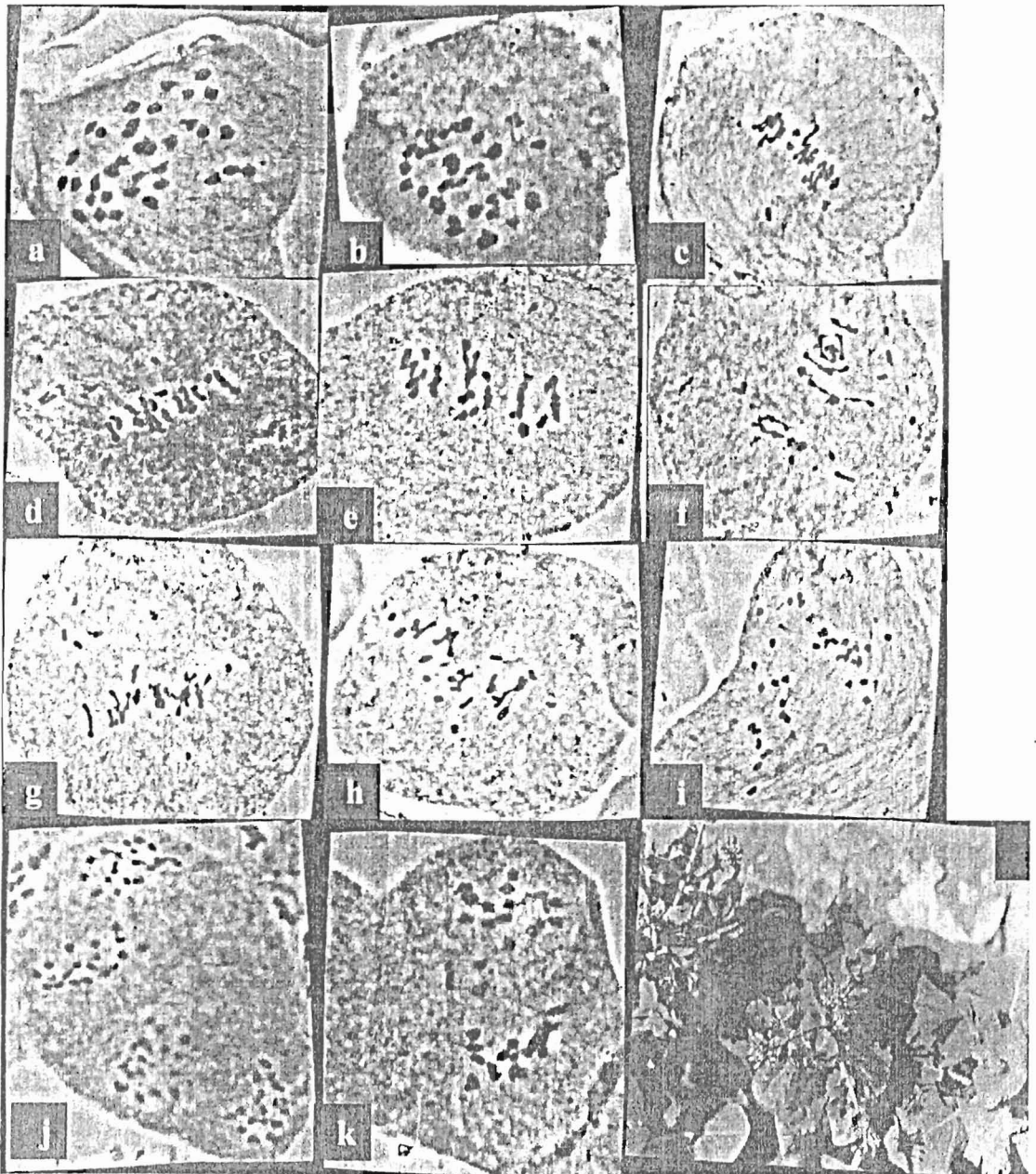


Fig. 2. 4n *B. oleracea* (a and b): cells showing 36 chromosomes, (c and d): MI cells showing 18 II, (e): MII cell showing 1 IV, (f): MII cell showing 2 IV, (g and h): MII cells showing different numbers of I, (i): AI cell showing unequal distribution of chromosomes, (15-20), (j): AI cell showing equal distribution of chromosomes, (k): AII cell showing 2 lagging II, (l): 4n *B. oleracea* plants.

DISCUSSION

As mentioned early, tetraploid PMCs were distinctly identified by their larger size with large sized nuclei (Behera & Patnaik, 1975 and Singh & Roy, 1975). It is very well known that the distribution of the different kinds of chromosome configurations, multivalents, bivalents and univalents at metaphase I in autotetraploids depends upon the frequency and location of chiasmata between homologous chromosomes. During meiosis of an autotetraploid where four homologous chromosomes are present, it is expected that associations of four chromosomes (quadrivalents) should prevail. In many plant species, the theoretical expectation of pairing model of an autotetraploid has been actually realized, where a high percentage of the chromosomes form quadrivalents (Ghosh *et al.*, 1974; Singh & Roy, 1975 and Mercy-Kutty & Kumar, 1983). On the other hand, in the present investigation quadrivalent formations has been found to be very low in both autotetraploid plants of *B. campestris* L. ($4x = 40$) and *B. oleracea* L. ($4x = 36$) (Table 1). Similar results has been reported by Fukushima & Tokumasu (1957) in *B. campestris* convar. *pekinensis* ($2n = 4x = 40$) produced by colchicine, but differ for *B. oleracea* L. than that of Howard (1939 a and b) who found an average number of 3 quadrivalents/PMC in an autotetraploid kale. Using different varieties of the same species could lead to significant differences in chromosome associations especially at the tetraploid level (Sen & Chheda, 1958).

The observed low ability of quadrivalent formations and the dominating bivalency pairing of the autotetraploid *Brassica* genotypes used in the present work, emphasized that the existence in a PMC of more than two homologous chromosomes is not the only prerequisite for multivalent formations. Pairing preferences are not responsible for the cytological diploidization of autotetraploid kales (Jenczewski *et al.*, 2002). The results of Dagne (2001) indicated that quadrivalents occurred in low frequency and were predominantly of the ring type. Meiotic pairing depends not only on homology but also on the degree of association of pairing partners in premeiotic cells (Avivi, 1976). In addition, frequency and position of chiasmata between paired homologous chromosomes are essential for the formation and frequencies of the various pairing configurations at metaphase I. Wu *et al.* (2004) concluded that meiotic configurations in polyploids undergo a complex biological process including either bivalent or multivalent formations, or both.

Estimation of predicted frequency of each pairing configuration is based on the assumption that association of homologous chromosomes is random and involves all the four chromosomes of each homologous set in an autotetraploid individual (Durrant, 1960). In the autotetraploid of the present work, it seemed that pairing associations at prophase I did not involve all the four chromosomes in each set. It may be exclusively restricted to be only between pairs of chromosomes leading to the observed high frequency of bivalents at the cost of quadrivalents. This tendency for excess of bivalent pairing has also been detected by Sen & Chheda (1958) in autotetraploids of *Phaseolus mungo*, Roy-Tapadar (1963) in autotetraploids of *Rauwolfia serpentina* and has been attributed to the existence of a large number of short chromosomes in the genome. Small size of chromosomes has been suspected earlier as a reason for the reduced quadrivalent frequency and the excess of bivalency (Biswas & Bhattacharyya, 1972) in soybean and probably also clarify the results of Murty *et al.* (1978) in grain sorghum. The results of Dagne (2001) indicated

also, that bivalents were the most frequent type of association present in autopolyploid of *Guizotia abyssinica* (L.f.) Cass. The assumption of positive correlation between the size of chromosomes of an autotetraploid and the frequency of formed quadrivalents in its meiotic division could not be fully excluded in some other investigations (Singh & Roy, 1971 and 1975). Accordingly, the study of pairing control genes is still an important task for understanding the stabilization and establishment of allopolyploid species (Jenczewski & Alix, 2004).

Although the genus *Brassica* is known by its small sized chromosomes, this seemed not to affect their abilities to pair and to form multivalents even in haploids of *B. campestris* L. and *B. oleracea* L. (Armstrong & Keller, 1981 and 1982), due to the existence of genetic similarities in certain chromosomes of haploid genomes (Venkateswarlu & Kamala, 1971). Pairing abilities of small *Brassica* chromosomes extended to multivalent associations either in diploid genotypes (Attia, 1987) or in hybrids between *B. campestris* L. and *B. oleracea* L. (Attia & Röbbelen, 1986). On this basis, it was necessary to search for other reason-for the prevailing bivalent pairing in autotetraploids of *Brassica*. The other alternative, the existence of genes favoring bivalent formations, bivalency genes. The existence of genetic control of chromosome pairing has been emphasized frequently in many polyploidy plant species. It could be concluded that induced autotetraploids may carry gene or genes which either permit full pairing between all chromosomes in each homologous group, allowing the highest possible potentiality of quadrivalent formations as found by Ghosh *et al.* (1974), Singh & Roy (1975), Mercy-Kutty & Kumar (1983) Santos *et al.* (2003). Or restrict such pairing to be only bivalents as was suggested in the present investigation and in accordance with Gupta & Gupta (1975), Harberd (1975) and Armstrong & Keller (1982). The possible controlling mechanism by which pairing in a group of four homologous chromosomes could be restricted only to bivalents is still unknown and certainly deserve extensive research.

It is confirmed in this study that unbalanced gametes and infertility of autotetraploids is limited because of quadrivalents as it is due to trivalents and univalents. A variable number of quadrivalents is formed (Table 1). Univalents were also seen in few cells. In most metaphase I of *B. campestris* L. ssp. *rapifera* nuclei there appeared quadrivalent and bivalent chromosomes, and the exceptional occurrence of a few univalent and trivalent chromosomes was noticed in 3 plants. It is very likely that univalents are the main cause of the production of aneuploid gametes. Thus, any future efforts on using autotetraploids for breeding purposes will have to focus on minimization of the occurrence of the univalents. Lagging chromosomes at anaphase I were observed. Chromosomal bridges were noticed rarely in 2 plants. It is possible to recognize quadrivalents and also secondary association bivalents at metaphase I. Some types of quadrivalent are very obvious at metaphase I and other types would be difficult to distinguish from secondarily associated bivalents. It must also be stated, however, that it would be one of the types confused with secondarily associated bivalents.

Occasional lagging chromosomes were seen at anaphase I in autotetraploid of *B. oleracea* L. convar. *capitata*. The frequency of plates with the regular chromosome number of 18 and the irregular number of 19 and 17 etc. is due to irregular disjunctions at first anaphase. Reduction divisions of the PMCs in autotetraploid plants of *B. oleracea* L. proceeded quite regularly,

forming exclusively quadrivalents and bivalents at metaphase I. Any other multivalent chromosomes were not encountered, but the trivalent and univalent chromosomes were noticed in some rare cases (Table 1).

The results could throw some light on the possible-and still incompletely known mechanisms regulating chromosome pairing in polyploidy of the genus *Brassica*. The main problem facing breeding by polyploidization is the reduced fertility of the resulting tetraploids which limits the importance and application of this approach. Specially if propagation of the concerned plant is not by vegetative means. The amphidiploids may be artificially synthesized by crosses between the parents on the diploid as well as on the tetraploid level. Disregarding complications, caused by irregularities at meiosis of the tetraploids, the amphidiploids may be obtained directly by crossing the tetraploids. To overcome the difficulty of low fertility due to abnormal meiosis, genotypes characterized by diploid-like meiotic behavior should be selected or induced. Practically, autopolyploid breeding has resulted into the release of new varieties of *B. oleracea* convar. *Acephala*. Likewise, a tetraploid variety of *B. campestris* ssp. *rapifera* has been also released. Furthermore, hybridizations between induced autotetraploids of variable varieties and selection in the resulting hybrids raise the opportunity to get a considerable improvement in plant characters and especially stable high yielding genotypes.

In conclusion, the present study has shown positive and negative features regarding induced autopolyploid *B. campestris* L. and *B. oleracea* L. plants. The positive side includes the high frequency of bivalent formation on diploidization. The main negative features are the prevalence of univalents and the subsequent reduction of fertility. Induced autotetraploid *B. campestris* L. and *B. oleracea* L. has the potential for possible future breeding. Before such a conclusion is made, it would be necessary to study more plants that comprise autotetraploids of these two species.

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السلوك الكروموسومى و معدل تكوين الوحدات رباعية الكروموسوم فى البراسيكا بعد استحداث التضاعف المجموعى الكروموسومى الرباعى
توفيق محمد ثابت وعيسى احمد عيسى
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التضاعف المجموعى الكروموسومى الرباعى يلعب دورا هاما كأداة تربية فى العائلة الصليبية- وقد تم إنجاز هذا البحث فى نوعين تابعين لجنس البراسيكا هما الكامبسترس والاوليراسيا- اللفت والكرب بعد استحداث التضاعف الرباعى فيهما- وتم تحليل ودراسة سلوك الكروموسومات ومعدل تكوين الوحدات رباعية الكروموسوم خلال الانقسام الميوزى فى النباتات الرباعية المستحدثة. وقد ألفت النتائج الضوء على ميكانيكيات تنظيم تزاوج الكروموسومات المحتمل حدوثه والتي كانت غير معروفة بالكامل. ويمكن تلخيص النتائج المتحصل عليها كما يلي: تميزت النباتات فى كلا الطرازين المتضاعفين من الكامبسترس والاوليراسيا بزيادة حجم خلاياها وأنويتها مقارنة بالأنواع الثنائية المستحدثة منها. ميكانيكيات تنظيم تزاوج الكروموسومات كانت متمثلة فى تقليل كلا من معدل تكوين الوحدات ثلاثية وأحادية الكروموسوم كما يمكنها أن تعمل أيضا من خلال زيادة معدل تكوين الوحدات الثنائية حتى فى وجود الوحدات متعددة الكروموسومات المتروجة الأخرى. كان معدل تكوين الوحدات الرباعية فى الطرازين الأول فى الطراز الرباعى من اللفت منخفض بدرجة ملحوظة وتم مشاهدتها فى 5 نباتات فقط من 14 نبات متضاعف وتراوح بين 0.10 - 0.36 فقط. كان عدد الوحدات الرباعية وحده واحده فى كل خلية بصفة عامة فى الكامبسترس المتضاعف وكان الجزء الأكبر من الكروموسومات متزاوجا فى صورة وحدات ثنائية فقط ووصل عددها إلى 20 وحدة ثنائية لكل خلية فى 9 نباتات متضاعفة منه. الطور الانفصالى الأول والثانى كان منتظم تماما فى توزيع الكروموسومات ولكن عدم التساوي فى توزيعها تم ملاحظة فى عدد قليل من الخلايا فى طراز الكامبسترس المتضاعف. فى حالة الأوليراسيا المتضاعفة رباعيا فان الوحدات الرباعية قد تم مشاهدتها فى 6 نباتات فقط من 12 نبات متضاعف من الكرب وتراوح معدل تكوينها بين 0.06 - 0.29 فقط ولكن معدل تكوين الوحدات الثنائية كان سائدا حيث بلغ متوسط عددها 17.70 و 17.72 فى نباتين من النباتات الست المتضاعفة و 18 وحدة ثنائية فى الستة نباتات الأخرى وكان سلوك الكروموسومات منتظما تماما خلال الطور الانفصالى الأول والثانى أيضا فيما عدا بعض الحالات القليلة التى تم فحصها منه. النتائج المتحصل عليها من هذا البحث فى كلا الطرازين المتضاعفين رباعيا من الكامبسترس و الأوليراسيا كانت ممثلة فى تكوين الوحدات ثنائية الكروموسوم فى النباتات المتضاعفة التى أدت إلى أن هناك احتمال وجود جينات تتحكم فى معدل تكوين الوحدات الثنائية التى تحدد عملية التزاوج الكروموسومى فى شكل وحدات ثنائية فقط حتى فى وجود أربعة نسخ متماثلة من كل كروموسوم - وهناك علاقة بين السلوك الكروموسومى خلال الانقسام الميوزى و درجة خصوبة النباتات المتضاعفة رباعيا المستحدثة فى كلا الطرازين المتضاعفين من الكامبسترس و الأوليراسيا. أحد الأهداف الرئيسية من تربية النبات فى الوقت الحاضر تتمثل فى البحث عن استحداث طرز متضاعفة مجموعيا من البراسيكا وذلك لتراكيب وراثية قادرة على تنظيم عملية تزاوج الكروموسومات أثناء الانقسام الميوزى فى شكل وحدات ثنائية الكروموسوم فقط وانتخاب التراكيب الوراثية ذات درجة الخصوبة العالية منها وقد تم الوصول إلى المؤشر الأول للنجاح المتوقع بواسطة بعض نتائج هذا البحث.