園学雑. (J. Japan. Soc. Hort. Sci.) 68 (1) : 18–22. 1998.

Transmission Rates of Extra Chromosomes in Alien Monosomic Addition Lines of Japanese Bunching Onion with Extra Chromosomes from Shallot

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Summary

In a series of alien monosomic addition lines (AMALs, FF+nA, $2n$=17) of *Allium fistulosum* L. with extra chromosomes from *A. cepa* L. Aggregatum group, the transmission rates of the extra chromosomes were assessed to examine the possibility of maintaining these lines by seed propagation. Chromosome numbers of the seedlings obtained from reciprocal crossings between the AMALs and *A. fistulosum* ($2n$=16; genomes, FF) were 16 and 17. The percentage of plants with 17 chromosomes in the seedlings obtained from the crossings FF (♀) × FF+nA (♂) and FF+nA (♀) × FF (♂) were used to indicate the male and female transmission rates, respectively. The male transmission rates varied from 0 to 7.6 % (mean 2.6 %) among eight kinds of extra chromosomes, whereas the female transmission rates ranged from 6.1 to 40.4 % (mean 19.8 %). These results revealed the following: 1) Both the male and female transmission rates are generally low. 2) These rates show considerable variations among the extra chromosomes. 3) The female transmission rate is obviously higher than the male transmission rate in all AMALs. Furthermore, both transmission rates of the extra chromosome 8A were relatively high and those of 5A were low. Chromosome numbers of the pollen grains produced by the AMALs were eight and nine. The percentages of pollen grains with nine chromosomes varied from 18.1 to 49.4 % (mean 34.9 %) among the eight types of AMALs and were undoubtedly higher than the male transmission rates in all the AMALs. These phenomena seem to relate to a certation between pollen grains with different chromosome numbers or a chromosome elimination after fertilization. The present results demonstrate that crossings, with the AMALs as seed parents, are useful to maintain the series of AMALs by seed propagation.

Key Words: *Allium*, shallot, Japanese bunching onion, alien monosomic addition line, transmission rate.

Introduction

Alien monosomic addition lines have been useful for studies on genetics and breeding of many plant species. In *Allium*, a series of alien monosomic addition lines (AMALs) of Japanese bunching onion (*A. fistulosum* L.) with extra chromosomes from shallot (*A. cepa* L. Aggregatum group) proved to be reliable to determine the chromosomal locations of several genes and genetic markers of shallot (*A. cepa* L. Aggregatum group) (Shigyo et al., 1996, 1997a, 1997b, 1997c). It is essential to maintain permanently AMALs for further determinations of a large number of genes and genetic markers in this species. We have maintained AMALs since 1991 through vegetative propagation, which, however, involves a high risk of losing these plant materials. It is, therefore, necessary to maintain AMALs through seed propagation. Our previous study revealed that all the eight types of AMALs of *A. fistulosum* with extra chromosomes from *A. cepa* Aggregatum group possessed enough seed and pollen fertility to produce their backcross and/or selfed progenies (Shigyo et al., 1999). Actually, a large number of vigorous seedlings were obtained from reciprocal crossings between AMALs and *A. fistulosum* and from selfings of AMALs. It is necessary to confirm the transmissions of the extra chromosomes to the seedlings for efficient maintenance of AMALs.

The objective of this study is to examine the male and female transmission rates of the extra chromosomes in a series of AMALs of *A. fistulosum* with extra chromosomes from *A. cepa* Aggregatum group.

Materials and Methods

A series of AMALs of *A. fistulosum* with extra chromosomes from *A. cepa* Aggregatum group ($2n$=17, FF+1A – FF+8A) and *A. fistulosum* cv. Kujyo ($2n$=16, FF) were used as plant materials. Each type of AMALs and *A. fistulosum* were reciprocally crossed. The percentages of plants with 17 chromosomes in the seedlings

Received; December 19, 1997. Accepted; March 16, 1998.
A part of this study was presented at the 1997 Autumn Meeting of the Japanese Society for Horticultural Science, Nagoya. The research was supported in part by Grant-in-Aid for Research Fellow of the JSPS (No. 0058) from the Ministry of Education, Science, Sports, and Culture of Japan.

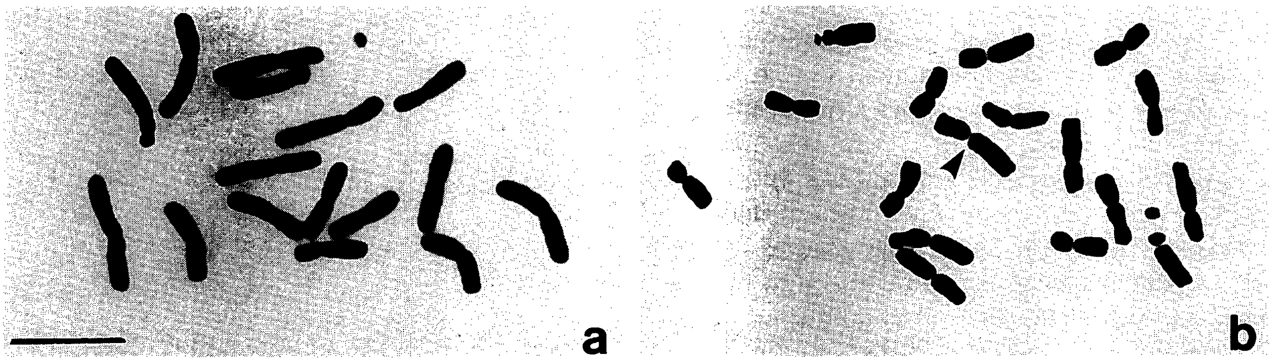

Fig. 1. Somatic chromosomes of seedlings obtained from crosses between alien monosomic addition lines and *A. fistulosum*. a: $2n$=16. b: $2n$=17. Arrowhead points to extra chromosome 4A. Scale bar = 10 μm.

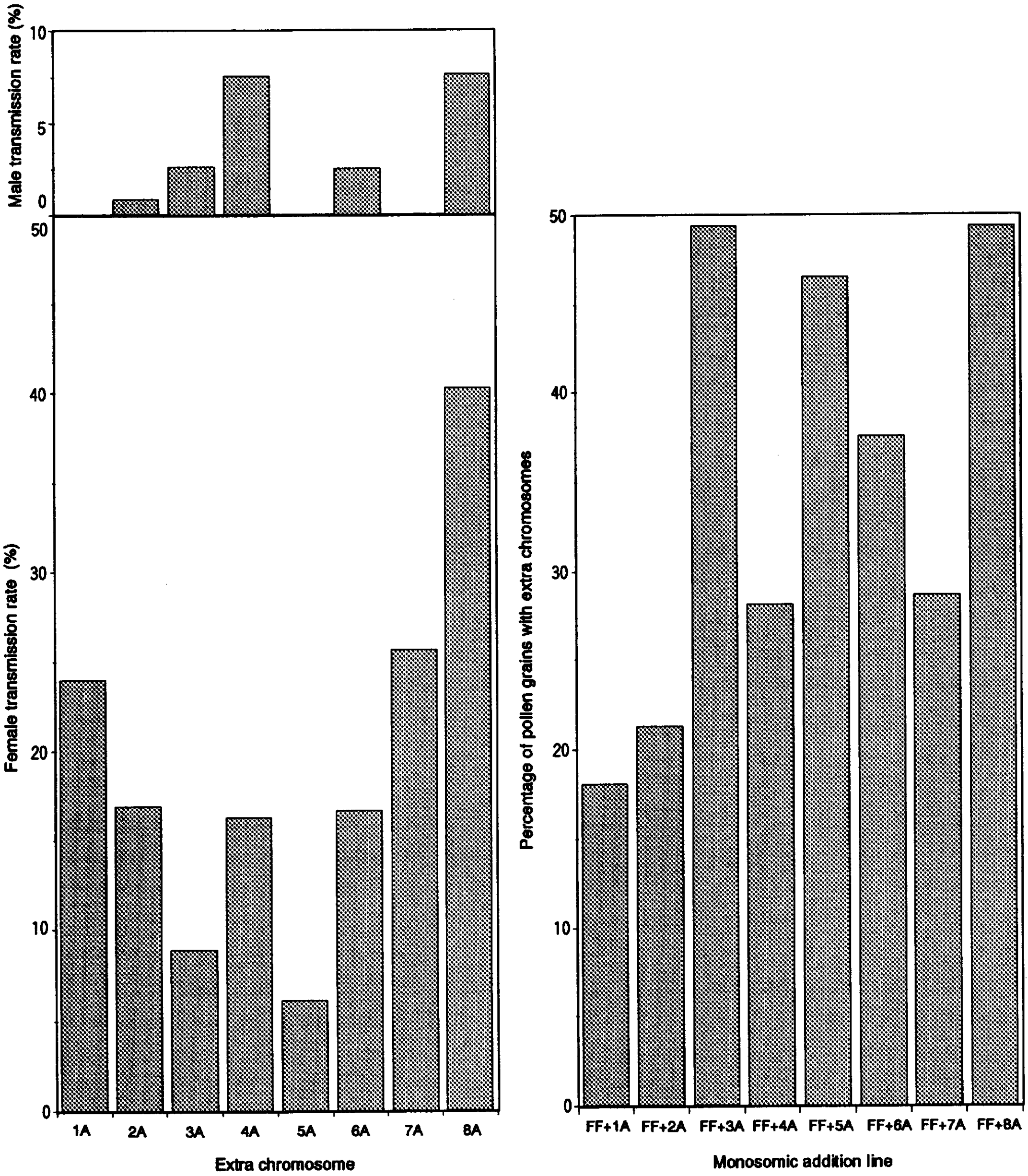

Fig. 2. Male and female transmission rates of extra chromosomes and percentage of pollen grains with extra chromosomes.

obtained from crossings FF (♀) × FF+nA (♂) and FF+nA (♀) × FF (♂) were used to indicate male and female transmission rates, respectively. Somatic chromosomes of root tip cells of the seedlings were observed by Feulgen nuclear staining, followed by the squash method. Eighty-two to 187 seedlings were examined in each cross combination. Furthermore, chromosome numbers in pollen grain mitosis of AMALs were investigated to examine the transmission rates of the extra chromosomes from AMALs to male gametes. Aceto-carmine smears of pollen grains were used to observe chromosomes at mitosis. More than 200 pollen grains were examined in each type of AMALs.

Results and Discussion

Chromosome numbers of seedlings obtained from the reciprocal crossings were 16 or 17 with an extra chromosome (Fig. 1). In the crossing FF (♀) × FF+nA (♂), five out of eight cross combinations produced seedlings with 16 or 17 chromosomes, whereas the other three produced seedlings with only 16 chromosomes. The male transmission rates of the extra chromosomes were very low, ranging from 0 to 7.6 % (mean 2.6 %) among eight kinds of the extra chromosomes (Fig. 2). All cross combinations of FF+nA (♀) × FF (♂) produced seedlings with 16 or 17 chromosomes. The female transmission rates ranged from 6.1 to 40.4 % among eight kinds of the extra chromosomes. The female transmission rates (mean 19.8 %) were obviously higher than the male transmission rates (mean 2.6 %). Among the eight kinds of extra chromosomes, chromosome 8A was transmitted at the highest rate on both male and female sides and 5A at the lowest rate.

Chromosome numbers in pollen grains of eight different AMALs were eight or nine with the extra chromosome (Figs. 3 and 4; also refer to Fig. 13 in Shigyo, 1997). The percentage of pollen grains with nine chromosomes ranged from 18.1 to 49.4 among eight types of AMALs (Fig. 2). The percentages in FF+3A, FF+5A, and FF+8A were relatively high (approx. 50 %) and those in FF+1A and FF+2A were low (< 25 %). These percentages (mean 34.9 %) were remarkably higher than the male transmission rates. These results seem to relate to a certation between pollen grains with different chromosome numbers (eight and nine) or a chromosome elimination after fertilization.

In addition to the results mentioned above, all the cross combinations of FF+nA (♀) × FF (♂) reproduced several vigorous plants of AMALs. Therefore, the present study demonstrates that crossings, using AMALs as seed parents, are useful to maintain the series of AMALs by seed propagation. However, it is necessary to devise a plan for increasing the transmission rates of extra chromosomes since there are some chromosomes (*e.g.* 5A) which combine at very low male and female transmission rates. Namai et al. (1991) reported a significant increase in the male transmission rate of a cabbage

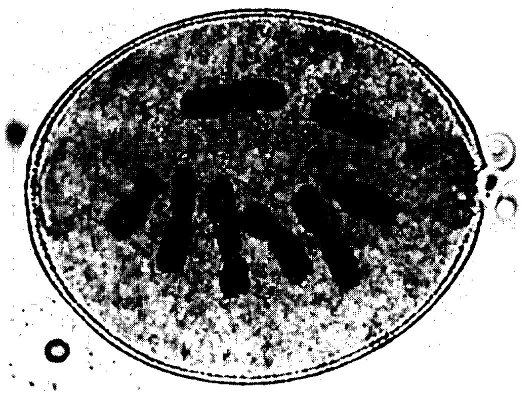

Fig. 3. Microspore with eight chromosomes at pollen mitosis in an alien monosomic addition line.

chromosome by limited pollination in alien chromosome addition lines of Chinese cabbage with a single cabbage chromosome. Such a method may also be useful for increasing the transmission rates of our AMALs.

Tashiro et al. (1982) reported the following: 1) Shallot was crossed readily with common onion (*A. cepa* L. Common onion group). 2) The karyotype of shallot was very similar to that of common onion. 3) Meiosis in pollen mother cells of the F_1 plant appeared to be fairly normal, and chromosome behaviors in meiosis were very similar to those of the parents. 4) The F_1 plant was fully fertile, and there was no evidence of weakness in the F_2 generation. Therefore, it is no exaggeration to say that the chromosomes of shallot, 1A - 8A, are homologous to those of common onion, 1C - 8C, respectively. From the results of examinations on transmission rates of extra chromosomes in selfing of four kinds of AMALs of *A. fistulosum* with extra chromosomes from common onion (FF+3C, FF+4C, FF+7C, and FF+8C), De Vries et al. (1992) reported that the chromosome 8C showed the highest transmission rate (39 %) in the four extra chromosomes as we confirmed in our present study.

Jena and Khush (1989) reported considerable variations on female and male transmission rates of 12 kinds of extra chromosomes in AMALs of rice. Such variations were also observed in our AMALs. In *A. cepa* Aggregatum group, no chromosome of the same shape and size was recognized in its basikaryotype (Shigyo et al., 1996; Sulistyaningsih et al., 1997). It was, therefore, possible to investigate the effect of the shape and size on the transmission rate. However, it seems that there is no correlation between the shape and transmission rate and between the size and transmission rate. Further studies are necessary to discover the factors related to transmission rates.

Acknowledgement

Masayoshi Shigyo acknowledges the support of JSPS Research Fellowships for Young Scientists.

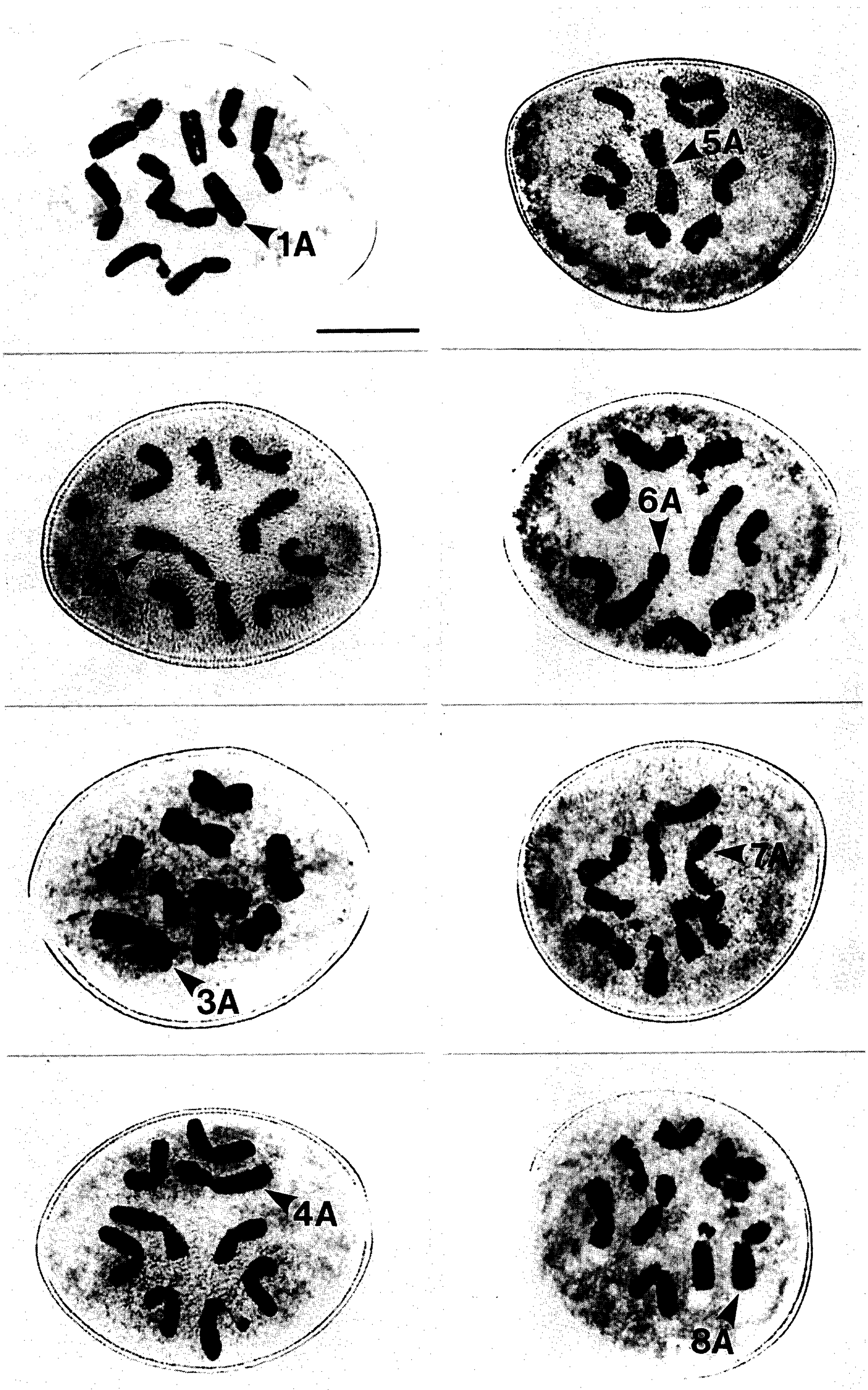

Fig. 4. Microspores with nine chromosomes at pollen mitosis in alien monosomic addition lines. Arrowheads point to extra chromosomes 1A to 8A. Scale bar = 10 μm.

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シャロット由来単一異種染色体を添加したネギ系統における添加染色体の伝達率

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摘　要

シャロット由来単一異種染色体を添加したネギ系統シリーズ (2*n*=17, 第 1 添加型-第 8 添加型) の種子繁殖による系統維持を検討するために，添加染色体の後代への伝達率を調査した．添加系統とネギの正逆交雑から得た実生の染色体数は 16 および 17 であった．そこで，添加染色体の雄性伝達率はネギを種子親，添加系統を花粉親に用いた交雑から，また，雌性伝達率はその逆交雑から，それぞれ得られた染色体数 17 の実生の百分率で表した．8 種類の添加染色体間で，雄性伝達率は 0 から 7.6 % (平均 2.6 %) の，また，雌性伝達率は 6.1 から 40.4 % (平均 19.8 %) の変異を示した．従って，雄性および雌性伝達率ともに低く，添加染色体間で差があり，雌性伝達率は雄性伝達率より明らかに高いことが分かった．なお，雄性および雌性伝達率はともに第 8 染色体で高く，第 5 染色体で低かった．さらに，添加系統シリーズの花粉粒の染色体数を調査した結果，8 および 9 であった．染色体数 9 の花粉粒の割合は 8 種類の添加系統間で 18.1 から 49.4 % (平均 34.9 %) の変異を示し，明らかに雄性伝達率よりも高かった．従って，添加染色体は配偶子へ伝達された後でも淘汰されることが分かった．以上の結果から，本添加系統シリーズの種子繁殖による系統維持は添加系統を種子親として用いれば可能であることが明らかになった．