# TRANSMISSION OF B-CHROMOSOMES IN *MISCANTHUS JAPONICUS* ANDERSS(1)

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## Introduction

B-chromosomes, also called accessory chromosomes or supernumerary chromosomes, were detected in four out of some two hundred clones of *M. japonicus* collected from various localities in Taiwan. The four clones were Wu-lai 1, Wu-lai 13, Ta-wu 23 and Ta-wu 47, the first two being collected from Mt. Wu-lai in northern Taiwan and the others from Mt. Ta-wu in southern Taiwan. The appearance, cytological behavior and numerical variation of such chromosomes were described in detail by the senior writer (Weng, 1962). Some of the background information is hereby presented: This grass species normally has a chromosome complement of 2n=38; but in each of the four clones aforementioned a variable number of B-chromosomes were present in excess of the normal complement. One of the four clones, namely Ta-wu 47, was singled out for detailed study. The number of B-chromosomes per PMC in this clone was found to vary from 0 through 10 with the mean number of B's per PMC for the individual=3.94, and the mean number of B's per PMC for each anther within a spikelet also differed very significantly from one another. It was found, further, that in the root-tips the number of B's per cell also varied from cell to cell, oscillating between 1 and 4. While numerical variation of B-chromosomes in the root-tips was presumably ascribed to somatic elimination during root development, the inter-cellular variation in the number of B's in the floral parts was assumed to be due to somatic non-disjunction at spikelet initiation combined with similar events in pre-meiotic mitosis in the anthers. The original number of B-chromosomes in this clone was inferred to be 4, and the average probability for each B-chromosome in a cell to undergo non-disjunction was estimated to be 3.38. In general, the B-chromosomes were heterochromatic and considerably smaller than the regular ones, and had a median or submedian centromere. At diakinesis and MI the majority of the B-chro-

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mosomes appeared as univalents, while the rest existed as bivalents. Evidently a certain number of the B-univalents had been subjected to meiotic elimination, because 40 out of the 73 PMC's studied were found to have laggards at AI or micronuclei at interphase.

In this paper the writers try to deal with the transmission of the B-chromosomes from a self-pollinated mother plant, namely the clone Ta-wu 47, to the progeny, counting the chromosomes in the progeny and making comparisons both among progeny plants and between mother plant and progeny. The possible effects of B-chromosomes in natural populations will also be touched upon.

## Material and Methods

In the summer of 1960 when the clone Ta-wu 47 came to flower, four panicles were isolated and self-pollinated in paper bags. In the following fall the seeds thus obtained were sown and transplanted into four panicle-rows, each constituting a selfed line. When the seedlings grew up to flower again in the summer of 1961, two or so young panicles were plucked from each individual and fixed with 1:3 acetic-alcohol. Finally, the detailed study was made from 49 plants. Chromosome counting was made exclusively from acetocarmine smears throughout the study.

## Presentation of Data

1. *Occurrence of B-chromosomes in Natural Populations.* The present collection of *Miscanthus* material (see Table 1) was made available by one of the junior authors, H. W. Li, in 1955. The order in which the locations are listed is roughly that of their distribution from north to south in Taiwan. The number of B-chromosomes was not given, because of their inconstancy within an individual. The species, occurring chiefly in the mountainous area of Taiwan, is capable

**Table 1.** *Distribution of plants of* M. japonicus *in Taiwan having B-chromosomes.*

| Locality | No. of clones collected | No. of clones containing B-chromosomes |
|---|---|---|
| Mt. Wu-lai | 75 | 2 |
| Mt. Kuan-tzu | 51 | 0 |
| Hsin-ying | 6 | 0 |
| Mt. Ta-wu | 60 | 2 |
| Heng-chun | 5 | 0 |
| Total | 197 | 4 |

of propagating sexually as well as asexually; sexually because in particular when the woods is deforested numerous young seedlings of the species will usually be found there, and asexually because in the undisturbed habitat the individuals of the species often exist as tremendous clumps. The two localities, Mt. Wu-lai and Mt. Ta-wu, where clones having B-chromosomes were found are situated in the north and the south of Taiwan, respectively. Such clones seemed to occur in small pockets in each of the said localities. It remains to be determined whether or not there is geographical or ecological differentiation among the natural populations.

2. *Transmission of B-chromosomes.* In the progeny of the self-pollinated clone, Ta-wu 47, B-chromosomes were also present in varying numbers both within a plant and among plants. Since it was impossible to assign a definite number of B's as typical of a given plant, only one single spikelet from each plant was used for chromosome counting, the three anthers in each spikelet being mounted together in a slide. This enables us to take a rapid survey of variation in the progeny (see Table 2). The data given in Table 2 are interesting at least in four ways. Firstly, the range of inter-individual variation in the number of B's in the progeny, being 0–13 as indicated in the table, is rather widened as compared with that of intra-individual variation in the mother clone Ta-wu 47, being 0–10 as referred to previously. Apparently there have occurred in the progeny some plants which on the average have a higher number of B-chromosomes than the mother clone. Secondly, the grand mean for the progeny ($=3.60$) is very significantly less than that of the mother clone ($=3.96$), with $t=18.947$ and $P<1\%$. This seems to be due to meiotic elimination of B-chromosomes in the mother clone, as reported previously. Thirdly, the distribution pattern of plant types with respect to number of B-chromosomes is in general comparable to that of PMC types in the mother clone (cf. Weng, 1962); but the mode number has decreased by 2, evidently due also to meiotic elimination of B-chromosomes in the mother clone. Fourthly, there is a striking difference between line means in the progeny. Here the variance ratio F of "Between Lines" and "Within Lines" amounts to 83.751, which is extremely significant statistically. This is quite contrary to expectations, insofar as difference between panicle means in the mother clone was not statistically significant (cf. Weng, 1962). Further studies are needed before this question could be answered.

To look into the variation of B-chromosomes in the progeny in more detail, the five plants 3–6, 4–5, 2–16, 4–11 and 2–5 each having a mean number of 0, 1.57, 4.18, 6.28 and 8.41 B-chromosomes, respectively, in the single-spikelet chromosome counting were picked out as representatives. Tens of spikelets from each representative were used for chromosome counting, with the three anthers

**Table 2.** *Frequency distributions of B-chromosomes in four selfed lines of clone Ta-wu 47.*

| *Line No. | Plant No. | Spikelet No. | Freq. of PMC's having respective No. of B's | | | | | | | | | | | | | | Total No. of PMC's | **Spikelet mean | Line mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | | | |
| | 1- 1 | 10 | 1 | 2 | 8 | 9 | 14 | 2 | 2 | | | | | | | | 38 | 3.24 | |
| | 1-12 | 29 | | 4 | 11 | 16 | 8 | 1 | | | | | | | | | 40 | 2.78 | |
| | 1- 2 | 2 | | 5 | 18 | 3 | 10 | 5 | 8 | | 1 | | | | | | 50 | 3.63 | |
| | 1-10 | 5 | | 1 | 7 | 2 | 10 | 7 | 5 | 3 | | | | | | | 35 | 4.20 | |
| | 1-16 | 10 | | 1 | 35 | 3 | | | | | | | | | | | 39 | 2.05 | |
| | 1-12 | 13 | | 4 | 3 | 9 | 13 | | 3 | | | | | | | | 32 | 3.34 | |
| | 1-15 | 13 | | 1 | 9 | 4 | 12 | 2 | 7 | | | | | | | | 35 | 3.74 | |
| 1 | 1- 3 | 10 | | 15 | 16 | 6 | | | | | | | | | | | 37 | 1.76 | 2.93 |
| | 1- 6 | 7 | | 3 | 28 | 3 | 3 | 3 | | | | | | | | | 40 | 2.38 | |
| | 1- 7 | 12 | | | 7 | 6 | 13 | 2 | 6 | 1 | | | | | | | 35 | 3.91 | |
| | 1- 5 | 26 | | | 1 | 2 | 11 | 6 | 13 | | 2 | | | | | | 35 | 5.03 | |
| | 1-11 | 6 | | 4 | 17 | 8 | 6 | | | | | | | | | | 35 | 2.46 | |
| | 1- 8 | 10 | | 10 | 15 | 13 | 3 | | | | | | | | | | 41 | 2.22 | |
| | 1- 4 | 3 | 7 | 21 | 17 | | | | | | | | | | | | 45 | 1.22 | |
| | 2- 7 | 5 | | | | | 2 | 8 | 16 | 13 | 8 | 2 | | | 1 | | 50 | 6.58 | |
| | 2-16 | 16 | | | 4 | 5 | 24 | 4 | 7 | 1 | | | | | | | 45 | 4.18 | |
| | 2- 1 | 25 | | 12 | 24 | 15 | 4 | | | | | | | | | | 55 | 2.20 | |
| | 2-13 | 9 | | 1 | 13 | 15 | 4 | 2 | | | | | | | | | 35 | 2.80 | |
| 2 | 2- 5 | 15 | | | | | | 1 | 5 | 11 | 16 | 13 | 11 | 2 | 2 | | 61 | 8.41 | 4.82 |
| | 2-14 | 4 | | | 6 | 6 | 9 | 19 | 5 | 3 | 5 | 1 | 3 | 2 | | 1 | 60 | 5.43 | |
| | 2-12 | 7 | | | | | 9 | 14 | 9 | 12 | 4 | | 2 | | | | 50 | 5.92 | |
| | 2- 6 | 3 | 1 | 2 | 11 | 15 | 7 | 9 | | | | | | | | | 45 | 3.16 | |
| | 2-10 | 12 | | 2 | 14 | 14 | 11 | 2 | | | | | | | | | 45 | 3.07 | |
| | 3- 5 | 2 | | | 4 | 12 | 11 | 10 | 3 | | | | | | | | 40 | 3.90 | |
| | 3- 1 | 16 | | | 11 | 13 | 16 | | | | | | | | | | 40 | 3.13 | |
| | 3- 4 | 5 | | | 8 | 20 | 7 | 5 | | | | | | | | | 40 | 3.23 | |
| | 3- 8 | 4 | | | 1 | 3 | 10 | 10 | 5 | 3 | | 1 | 1 | | | | 34 | 5.03 | |
| | 3-13 | 18 | | | 1 | 11 | 10 | 12 | 9 | 2 | | | | | | | 45 | 4.51 | |
| | 3- 7 | 1 | | | 2 | 15 | 19 | 4 | 5 | | | | | | | | 45 | 3.89 | |
| 3 | 3-10 | 14 | | 2 | 21 | 15 | 7 | | | | | | | | | | 45 | 2.60 | 3.31 |
| | 3- 6 | 12 | 25 | | | | | | | | | | | | | | 25 | 0 | |
| | 3-11 | 1 | | | 15 | 6 | 10 | 3 | 1 | | | | | | | | 35 | 3.11 | |
| | 3- 3 | 7 | | | 1 | 3 | 4 | 2 | | | | | | | | | 10 | 3.70 | |
| | 3- 2 | 16 | | | 9 | 5 | 17 | 4 | | | | | | | | | 35 | 3.46 | |
| | 3- 9 | 8 | | 6 | 24 | 13 | 17 | | | | | | | | | | 60 | 2.68 | |
| | 4-12 | 8 | | | 9 | 10 | 16 | 7 | 11 | | 1 | | 1 | | | | 55 | 4.20 | |
| | 4- 2 | 7 | | | 3 | 7 | 18 | 3 | 8 | 1 | 10 | 1 | | | | 1 | 52 | 5.21 | |
| | 4-11 | 1 | | | | | 4 | 13 | 11 | 4 | 5 | 5 | 1 | | | | 43 | 6.28 | |
| | 4- 5 | 3 | 3 | 16 | 19 | 4 | | | | | | | | | | | 42 | 1.57 | |
| | 4- 3 | 9 | | 10 | 7 | 19 | 15 | 14 | 5 | | | | | | | | 70 | 3.44 | |
| | 4- 4 | 14 | | 5 | 16 | 9 | 14 | 11 | 2 | | | | | | | | 57 | 3.28 | |
| | 4- 6 | 17 | | 4 | 23 | 33 | 5 | | | | | | | | | | 65 | 2.60 | |
| 4 | 4- 1 | 3 | | | 2 | 4 | 10 | 9 | 10 | 15 | 2 | | | | | | 52 | 5.46 | 3.52 |
| | 4- 7 | 8 | | 23 | 37 | 29 | 6 | | | | | | | | | | 95 | 2.19 | |
| | 4- 9 | 15 | | 5 | 14 | 34 | 10 | | | | | | | | | | 63 | 2.78 | |
| | 4- 8 | 23 | 2 | 14 | 29 | | | | | | | | | | | | 43 | 1.60 | |
| | 4-14 | 8 | 2 | 19 | 20 | 9 | | | | | | | | | | | 50 | 1.72 | |
| | 4-10 | 5 | | 4 | 2 | 3 | 7 | 13 | 1 | 1 | | | | | | | 31 | 3.97 | |
| | 4-13 | 19 | | | | | | 8 | 14 | 11 | 14 | | 1 | | | | 48 | 6.73 | |
| Total | | | 41 | 196 | 542 | 431 | 406 | 215 | 173 | 81 | 66 | 25 | 20 | 4 | 3 | 2 | 2,205 | Grand mean: | 3.60 |

* Each line consists of one panicle-row.

** Mean number of B's per PMC per spikelet.

in each spikelet being separated and mounted in different slides. The results are shown in Table 3, a-e. This time the mean number of B-chromosomes per PMC for the said representatives are 0, 2.34, 4.24, 5.03 and 6.60, respectively, the order of these figures being the same as before. Of the five representatives mention should be made of the plant 3-6 which was found to have no B-chro-

**Table 3.** *Frequency distributions of B-chromosomes in five plants picked out from the selfed progeny of clone Ta-wu 47.*

| Spikelet No. | Anther No. | Freq. of PMC's having respective No. of B's | | | | | | | | | | | | | Total No. of PMC's | Anther mean | Spikelet mean | * Plant mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | | | | |
| (a) Plant 3-6 | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 31 | | | | | | | | | | | | | 31 | 0 | | |
| | 2 | 18 | | | | | | | | | | | | | 18 | 0 | 0 | |
| | 3 | 23 | | | | | | | | | | | | | 23 | 0 | | |
| 2 | 1 | 39 | | | | | | | | | | | | | 39 | 0 | | |
| | 2 | 19 | | | | | | | | | | | | | 19 | 0 | 0 | 0 |
| | 3 | 31 | | | | | | | | | | | | | 31 | 0 | | |
| 3 | 1 | 24 | | | | | | | | | | | | | 24 | 0 | | |
| | 2 | 12 | | | | | | | | | | | | | 12 | 0 | 0 | |
| | 3 | 21 | | | | | | | | | | | | | 21 | 0 | | |
| Total: | | 218 | | | | | | | | | | | | | 218 | | | |
| (b) Plant 4-5 | | | | | | | | | | | | | | | | | | |
| 1 | 1 | 4 | 6 | 16 | 9 | 8 | | 4 | | | | | | | 47 | 2.57 | | |
| | 2 | 3 | 20 | 20 | 7 | 7 | | 2 | | | | | | | 59 | 2.05 | 2.33 | |
| | 3 | 1 | 3 | 22 | 5 | 9 | | | | | | | | | 40 | 2.45 | | |
| 2 | 1 | 12 | 42 | 33 | 52 | 47 | 20 | 8 | 6 | | | | | | 220 | 2.92 | | |
| | 2 | 6 | 14 | 22 | 42 | 18 | | | | | | | | | 102 | 2.51 | 2.64 | |
| | 3 | 11 | 22 | 28 | 47 | 8 | 1 | 1 | | | | | | | 118 | 2.22 | | |
| 3 | 1 | | 22 | | | | | | | | | | | | 22 | 1.00 | | |
| | 2 | 2 | 4 | 17 | | | | | | | | | | | 23 | 1.65 | 1.44 | |
| | 3 | 7 | 11 | 20 | 4 | 1 | | | | | | | | | 43 | 1.56 | | |
| 4 | 1 | 3 | 4 | 6 | 8 | 2 | 2 | | | | | | | | 25 | 2.32 | | |
| | 2 | 10 | 13 | 25 | 23 | 17 | 8 | 2 | | | | | | | 98 | 2.57 | 2.51 | |
| | 3 | 3 | 12 | 22 | 26 | 12 | 2 | | | | | | | | 77 | 2.49 | | |
| 5 | 1 | 4 | 7 | 19 | 12 | 7 | | | | | | | | | 49 | 2.22 | 2.26 | |
| | 2 | 16 | 35 | 52 | 40 | 20 | 7 | 3 | | | | | | | 173 | 2.27 | | |
| 6 | 1 | 1 | 2 | 24 | 11 | 14 | 22 | | | | | | | | 74 | 3.36 | | |
| | 2 | 3 | 2 | 18 | 5 | 17 | | | | | | | | | 45 | 2.69 | 3.41 | |
| | 3 | | | 5 | | 9 | 17 | 1 | 2 | | | | | | 34 | 4.44 | | 2.34 |
| 7 | 1 | 4 | 4 | 32 | 3 | 2 | | | | | | | | | 45 | 1.89 | 2.33 | |
| | 2 | | 6 | 23 | 5 | 9 | 1 | 4 | | | | | | | 48 | 2.75 | | |
| 8 | 1 | 6 | 5 | 8 | 6 | | | | | | | | | | 25 | 1.56 | | |
| | 2 | 17 | 45 | 65 | 79 | 9 | 1 | | | | | | | | 216 | 2.10 | 2.12 | |
| | 3 | 7 | 28 | 57 | 55 | 11 | 1 | | | | | | | | 159 | 2.24 | | |
| 9 | 1 | 19 | 30 | 77 | 30 | 19 | | | | | | | | | 175 | 2.00 | | |
| | 2 | 25 | 37 | 41 | 3 | | | | | | | | | | 106 | 1.21 | 1.68 | |
| | 3 | 1 | 7 | 2 | 1 | | | | | | | | | | 11 | 1.27 | | |
| 10 | 1 | 6 | 22 | 53 | 79 | 30 | 31 | 2 | | | | | | | 223 | 2.92 | | |
| | 2 | 8 | 30 | 54 | 41 | 7 | 1 | | | | | | | | 141 | 2.09 | 2.48 | |
| | 3 | 6 | 22 | 20 | 20 | 1 | | | | | | | | | 69 | 1.83 | | |
| 11 | 1 | 13 | 55 | 59 | 13 | 6 | 2 | | | | | | | | 148 | 1.66 | 1.87 | |
| | 2 | 4 | 6 | 17 | 10 | 8 | 3 | 1 | | | | | | | 49 | 2.51 | | |
| 12 | 1 | | 2 | 5 | 8 | 5 | 2 | | | | | | | | 22 | 3.00 | 3.17 | |
| | 2 | | 7 | 14 | 25 | 19 | 3 | 2 | 2 | 1 | | | | | 73 | 3.22 | | |
| Total | | 202 | 525 | 876 | 669 | 322 | 124 | 30 | 10 | 1 | | | | | 2,759 | | | |

**Table 3.** (*Continued*)

| Spikelet No. | Anther No. | Freq. of PMC's having respective No. of B's: 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total No. of PMC's | Anther mean | Spikelet mean | *Plant mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (c) Plant 2-16 | | | | | | | | | | | | | | | | | | |
| 1 | 1 | | 1 | 1 | 1 | 19 | 5 | 1 | | | | | | | 28 | 4.04 | 3.98 | |
| | 2 | | | 2 | 2 | 16 | 4 | | | | | | | | 24 | 3.92 | | |
| 2 | 1 | | | 1 | 2 | 11 | 13 | 1 | | | | | | | 28 | 4.75 | 4.39 | |
| | 2 | | | 3 | 2 | 7 | 18 | 1 | | | | | | | 31 | 4.26 | | |
| 3 | 1 | | 5 | 3 | 15 | 9 | 4 | | 1 | | | | | | 37 | 3.22 | | |
| | 2 | | 1 | 7 | 15 | 29 | 25 | 8 | 5 | | | | | | 90 | 4.27 | 3.86 | |
| | 3 | | 1 | 4 | 4 | 3 | | | | | | | | | 12 | 2.75 | | |
| 4 | 1 | | 2 | 1 | 5 | 9 | 2 | 3 | 4 | | | | | | 26 | 4.27 | 4.24 | |
| | 2 | | 3 | 5 | 8 | 21 | 17 | 8 | 3 | | | | | | 65 | 4.23 | | |
| 5 | 1 | | 1 | 2 | 7 | 9 | 6 | 1 | 1 | | | | | | 27 | 3.89 | 4.05 | |
| | 2 | | 1 | 3 | 17 | 28 | 20 | 7 | | | | | | | 76 | 4.11 | | |
| 6 | 1 | | | 1 | | 19 | 3 | 13 | 1 | 2 | 1 | | | | 40 | 5.08 | 4.95 | |
| | 2 | | | | | 13 | 1 | 5 | 1 | | | | | | 20 | 4.70 | | |
| 7 | 1 | | | 1 | 6 | 7 | 9 | 1 | | | | | | | 24 | 4.13 | 4.00 | 4.24 |
| | 2 | | 1 | 8 | 8 | 19 | 11 | 5 | 1 | | | | | | 53 | 3.94 | | |
| 8 | 1 | | 2 | 5 | 22 | 33 | 15 | 6 | 5 | 1 | | | | | 89 | 4.09 | 4.10 | |
| | 2 | | 1 | 3 | 5 | 2 | 3 | 5 | | 1 | | | | | 20 | 4.15 | | |
| 9 | 1 | | | 2 | 2 | 19 | 18 | 3 | | | | | | | 44 | 4.41 | 4.38 | |
| | 2 | | | 1 | 2 | 14 | 10 | 2 | | | | | | | 29 | 4.34 | | |
| 10 | 1 | | | 1 | .1 | 13 | 1 | 10 | | | | | | | 26 | 4.69 | 5.11 | |
| | 2 | | | 1 | | 13 | 5 | 26 | 3 | | | | | | 48 | 5.33 | | |
| 11 | 1 | | | 7 | 11 | 29 | 10 | 7 | 2 | | | | | | 66 | 4.08 | 4.26 | |
| | 2 | | 2 | 3 | 12 | 11 | 22 | 5 | 7 | | | | | | 67 | 4.43 | | |
| 12 | 1 | | 1 | 3 | 4 | 6 | 8 | 3 | | 1 | | | | | 26 | 4.19 | | |
| | 2 | | 2 | 1 | 6 | 9 | 10 | 3 | 2 | | | | | | 33 | 4.24 | 4.14 | |
| | 3 | | | 2 | 2 | 4 | 1 | 1 | | | | | | | 10 | 3.70 | | |
| Total | | | 24 | 71 | 159 | 377 | 241 | 125 | 36 | 5 | 1 | | | | 1,039 | | | |
| (d) Plant 4-11 | | | | | | | | | | | | | | | | | | |
| 1 | 1 | | | | 6 | 12 | 22 | 9 | 4 | | | | | | 53 | 4.87 | | |
| | 2 | | 1 | | 10 | 21 | 20 | 19 | 1 | 3 | | | | | 75 | 4.80 | 4.20 | |
| | 3 | | 5 | 17 | 34 | 17 | 16 | 2 | | | | | | | 91 | 3.31 | | |
| 2 | 1 | | | 1 | 1 | 3 | 2 | | | | | | | | 7 | 3.86 | | |
| | 2 | | | | 3 | 7 | 20 | 21 | 17 | 6 | 2 | | | | 76 | 5.89 | 5.81 | |
| | 3 | | | | 4 | 5 | 20 | 29 | 11 | 10 | 1 | | | | 80 | 5.90 | | |
| 3 | 1 | | | | 1 | 2 | 5 | 8 | | | | | | | 17 | 5.41 | | |
| | 2 | | | | | 1 | 2 | 13 | 5 | 6 | 3 | | | | 30 | 6.73 | 5.90 | |
| | 3 | | | | 1 | 7 | 2 | 5 | 1 | | | | | | 16 | 4.88 | | |
| 4 | 1 | | | 1 | 2 | 11 | 20 | 34 | 17 | 8 | 6 | 1 | | | 100 | 6.03 | | |
| | 2 | | | | 1 | 3 | 4 | 5 | 5 | 2 | 1 | | | | 21 | 5.95 | 5.81 | |
| | 3 | | | 2 | 7 | 11 | 12 | 12 | 12 | 5 | | 1 | | | 62 | 5.40 | | |
| 5 | 1 | | 1 | 1 | 7 | 6 | 11 | 7 | 4 | | | | | | 37 | 4.68 | | |
| | 2 | | | 2 | 2 | 14 | 11 | 9 | 8 | 1 | | | | | 47 | 5.09 | 4.87 | |
| | 3 | | | 1 | 7 | 26 | 33 | 13 | 8 | | | | | | 88 | 4.84 | | |
| 6 | 1 | | | 3 | 2 | 9 | 11 | 22 | | | | | | | 47 | 5.00 | | |
| | 2 | | | | | 6 | 1 | 12 | | | | | | | 19 | 5.32 | 5.01 | |
| | 3 | | | | 1 | 15 | 6 | 12 | | | | | | | 34 | 4.85 | | 5.03 |
| 7 | 1 | | | 2 | 1 | 7 | 1 | 6 | 1 | | | | | | 18 | 4.61 | | |
| | 2 | | | 2 | 3 | 11 | 4 | 12 | | | | | | | 32 | 4.66 | 4.80 | |
| | 3 | | | 1 | 2 | 26 | 6 | 23 | 3 | | | | | | 61 | 4.93 | | |
| 8 | 1 | | 1 | 10 | 22 | 54 | 29 | 10 | 1 | | | | | | 127 | 4.06 | 4.48 | |
| | 2 | | | | 7 | 15 | 14 | 11 | 10 | 5 | 1 | | | | 63 | 5.33 | | |
| 9 | 1 | | | 2 | 5 | 21 | 21 | 33 | 19 | 6 | | | | | 107 | 5.49 | | |
| | 2 | | | 1 | 1 | 7 | 9 | 11 | 9 | 2 | | | | | 40 | 5.58 | 5.41 | |
| | 3 | | | 4 | 4 | 18 | 21 | 28 | 11 | 3 | | | | | 89 | 5.24 | | |
| 10 | 1 | | | 2 | 1 | 26 | 1 | 35 | 2 | | | | | | 67 | 5.07 | | |
| | 2 | | | | | 13 | | 11 | | | | | | | 24 | 4.92 | 5.01 | |
| | 3 | | | 3 | | 17 | 3 | 22 | 1 | | | | | | 46 | 5.39 | | |
| 11 | 1 | | | 4 | 13 | 15 | 27 | 16 | 5 | | | | | | 80 | 4.66 | | |
| | 2 | | | 3 | 4 | 15 | 14 | 13 | 7 | 1 | | | | | 57 | 4.96 | 4.81 | |
| | 3 | | | | 1 | 2 | 2 | 5 | | | | | | | 10 | 5.10 | | |

**Table 3.** (*Continued*)

| Spikelet No. | Anther No. | Freq. of PMC's having respective No. of B's: 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | Total No. of PMC's | Anther mean | Spikelet mean | Plant mean* |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 12 | 1 | | 1 | 1 | 9 | 10 | 5 | 2 | 5 | 1 | 1 | | | | 35 | 4.54 | | |
| | 2 | | | | 2 | 7 | 6 | 3 | 3 | 1 | | | | | 22 | 5.05 | 4.70 | |
| | 3 | | | 1 | 4 | 11 | 10 | 6 | 2 | | | | | | 34 | 4.65 | | |
| Total | | | 9 | 64 | 168 | 451 | 391 | 479 | 172 | 61 | 15 | 2 | | | 1,812 | | | |
| (e) Plant 2-5 | | | | | | | | | | | | | | | | | | |
| 1 | 1 | | | 2 | 17 | 13 | 23 | 15 | 14 | 14 | 4 | 3 | | | 105 | 5.60 | | |
| | 2 | | | | 6 | 16 | 18 | 21 | 12 | 4 | | 1 | | | 78 | 5.43 | 6.01 | |
| | 3 | | | | 1 | 8 | 10 | 19 | 34 | 33 | 4 | | 1 | | 110 | 6.80 | | |
| 2 | 1 | | | 1 | 7 | 18 | 27 | 25 | 30 | 25 | 16 | 6 | 2 | | 157 | 6.47 | 6.72 | |
| | 2 | | | | 2 | 2 | 10 | 11 | 13 | 28 | 9 | 5 | | | 80 | 7.20 | | |
| 3 | 1 | | | 1 | | 1 | 3 | 4 | 5 | 6 | | | | | 20 | 6.40 | 6.68 | |
| | 2 | | | | | | 4 | 9 | 2 | 11 | | 1 | | | 27 | 6.89 | | |
| 4 | 1 | | | | 1 | 2 | 4 | 4 | 7 | 13 | 1 | 1 | 1 | | 34 | 7.00 | 6.85 | |
| | 2 | | | | | 2 | 11 | 15 | 27 | 17 | 3 | 1 | | | 76 | 6.78 | | |
| 5 | 1 | | | | 2 | 7 | 10 | 16 | 17 | 7 | | 1 | | | 60 | 6.08 | | |
| | 2 | | | | | | 2 | 13 | 21 | 15 | 7 | 5 | 3 | 1 | 67 | 7.65 | 6.93 | |
| | 3 | | | | | | | 3 | 1 | 5 | | | | | 9 | 7.22 | | 6.60 |
| 6 | 1 | | | | 5 | 6 | 8 | 9 | | | | | | | 28 | 4.75 | | |
| | 2 | | | | | 8 | | 30 | 2 | 1 | | | | | 41 | 5.71 | 5.30 | |
| | 3 | | | | | 5 | | 7 | | | | | | | 12 | 5.17 | | |
| 7 | 1 | | | | 2 | 18 | 39 | 60 | 47 | 23 | 6 | 1 | | | 196 | 6.17 | 6.61 | |
| | 2 | | | | | | 1 | 5 | 12 | 23 | 12 | 6 | 1 | | 60 | 8.03 | | |
| 8 | 1 | | | | | 4 | | 24 | 1 | 18 | | | | | 47 | 6.62 | 6.60 | |
| | 2 | | | | | | 1 | 22 | 3 | 9 | | | | | 35 | 6.57 | | |
| 9 | 1 | | | | | 2 | 11 | 16 | 20 | 30 | 20 | 11 | 6 | | 116 | 7.72 | 7.38 | |
| | 2 | | | | 2 | | 10 | 13 | 13 | 15 | 4 | | | | 57 | 6.68 | | |
| 10 | 1 | | | | 1 | | 2 | 6 | 11 | 6 | 3 | | | | 29 | 6.93 | 7.02 | |
| | 2 | | | | | | 2 | 16 | 15 | 17 | 2 | 1 | | | 53 | 7.08 | | |
| Total | | | | 4 | 46 | 112 | 196 | 363 | 307 | 320 | 91 | 43 | 14 | 1 | 1,497 | | | |

* Mean no. of B-chromosomes per PMC per plant.

mosomes in the single-spikelet chromosome counting. Evidently this plant was derived from union of two B-free gametes, since B-chromosomes were not detected any more in other spikelets of the plant. As to the other plants having B-chromosomes, they may be regarded as resulting from two uniting gametes either or both of which contained a certain number of B's.

All in all, it may be inferred that inter-individual variation in the progeny might have followed directly from intra-individual variation and meiotic elimination in the mother clone.

## Discussion

Like in the mother plant Ta-wu 47, there was in the progeny an intra-individual variation in the number of B-chromosomes, which may be explained *a posteriori* by the assumption of somatic non-disjunction of B-chromosomes (Müntzing, 1948; Grun, 1959; Evans, 1961; Weng, 1962). Since (1) the B-chromosomes present in mother plant were subjected to a certain degree of meiotic elimination, (2) the original number of B-chromosomes, namely that present in the zygote, of each plant could not be readily and correctly determined, and (3) the size of progeny was not large enough, the exact mode of the transmission of B-chromosomes can hardly be formulated. What can be said about it is merely (1) that the B-chromosomes are transmissible, but they have to suffer a certain loss while being transmitted; (2) that, comparing with the distribution pattern of PMC's in mother plant, the frequencies of various plant types in the progeny are distributed over a rather wider range, with the mode number being considerably decreased and plants having a moderate number of B-chromosomes, say 2, 3 or so, being the most common; and (3) that the mean number of B-chromosomes per PMC for the whole progeny is lowered somewhat than that of the mother plant.

It should be noticed that the number of plant or animal species found to have B-chromosomes is steadily increasing. Darlington and Wylie (1955) have stated that hundreds of species are now known to have B-chromosomes, and it may be expected that many more examples will be added in the future. Müntzing (1954) after reviewing the cytogenetics of B-chromosomes in several plant species belonging to the five genera *Secale, Festuca, Centaurea, Poa* and *Anthoxanthum,* has summarized the effects of B-chromosomes in these words:

> "Thus, the different kinds of material supervised, indicate that in some cases clearly and exclusively negative effects are balanced by strong mechanisms of numerical increase and that there are rather continuous transitions from such cases to material without any mechanism of accumulation, where the B-chromosomes may have a slightly positive selective value."

In the present instance, B-chromosomes are subjected in some degree of meiotic and/or mitotic elimination, and the mean number of B's per PMC plant tends to decrease in successive generations when selfed. However, there seems to be no effective mechanism of numerical increase to counter balance the loss. Although somatic non-disjunction has been proposed to explain the intra-individual variation in the number of B-chromosomes, yet it still cannot be regarded as an effective mechanism of numerical increase. For, as the senior author of this paper (Weng, 1962) has already pointed out, somatic non-disjunction may cause the number of B's per PMC to vary within an individual not only in the positive direction but in the negative direction as well, and therefore it will not increase the number of B's per PMC within an individual. There is also no indication that the B-chromosomes in this grass species should have a positive selective value. Since the species can propagate sexually as well as asexually, should the B-chromosomes have a positive selective value, plants having B-chromosomes would spread over a wide area. In fact, however, such plants seem to occur only in small pockets in the natural populations, thus it may be speculated that they propagate chiefly by asexual means and consequently the expansion of the individuals is strictly restricted and localized. In short, the B-chromosomes in *M. japonicus* are not necessarily of positive selective value; nevertheless, the plants having B-chromosomes would tend to propagate by asexual means thereby maintaining the B-chromosomes.

**Summary**

1. Four panicles of Ta-wu 47 were selfed and the seeds obtained were sown separately to form 4 different self-lines.

2. In natural population, the B-chromosomes did occur only in a few plants found in only two localities on the island of Taiwan.

3. The range of inter-individual (plant) variation in the number of B's in the progeny ranged from 0–13 (0–10 for the mother plant Ta-wu 47). The grand mean for all the plants in the progeny (49) was 3.60 and it was 3.96 for the mother plant.

4. There was a striking difference between the line means in the progeny, and the variance ratio F of "between lines" and "within lines" amounted to 83.751 which was extremely significant statistically.

5. Five plant were chosen for detailed studies. The mean number of B's in these plants were 0, 1.57, 4.18, 6.28 and 8.41. When more counts involving many separate individual anthers in many spikelets were studied, the final means were 0, 2.34, 4.24, 5.03 and 6.60 respectively. The plant free of B-chromosome would breed true to type. The other four plants had the same pattern of variation as their mother plant, but no attempts were being made for any detailed calculation.

6. It seemed that B-chromosomes in this case were subjected in some degree of chromosomal elimination.

7. It was also possible that B-chromosomes were not transmitted sexually, but they were maintained only asexually however.

## *Miscanthus japonicus* 額外染色體的傳續

翁登山 周 涓 呂嘉琳 李先聞

1. 大武 47（在臺灣各處所採集的 *M. japonicus* 之一株）的四個穗套袋後使之自交，每穗的種子分別種植，成爲四個自交系。

2. 在自然界中，從將近兩百的植株中，我們只發現四株有 B-chromosome, 兩株在臺北，另兩株在大武（南部）。

3. 這四十九株後代的 B-chromosome 數的變異是從 0–13 個，而大武 47 本身的變異是 0–10 個，後代 B-chromosome 的總平均數爲 3.60, 大武 47 本身爲 3.96。

4. 自交系間的差異甚大，在統計的立場看來，這個差異是重要的。

5. 在後代中，選擇五株做仔細的分析，其個別最初的 B-chromosome 之平均數爲：0, 1.57, 4.18, 6.28, 及 8.41, 最後在許多小穗中的花葯分別觀察其 B-chromosome 後，這五株最後的平均數是： 0, 2.34, 4.24, 5.03, 及 6.60, 沒有 B-chromosome 的植株仍然沒有，其他四株所含 B-chromosome 變異的情形大致與其母株大武 47 相同，但未詳細加以統計分析。

6. B-chromosome 的數目，經分析結果爲經過自交後有逐漸減少的趨勢。

7. 因此， B-chromosome 傳佈的情形，似乎是不靠有性的繁殖，但他們依無性繁殖而得保持。（摘要）

## Literature Cited

DARLINGTON, C. D., and A. P. WYLIE. Chromosome atlas of flowering plants. George Allen & Unwin, London. 519 pp. 1955.

EVANS, H. J. Suprenumerary chromosomes in wild populations of the snail *Helix pomatia* L. Heredity **15**: 129-137, 1961.

GRUN, P. Variability of accessory chromosomes in native populations of *Allium cernuum.* Amer. Jour. Bot. **46**: 218-224, 1959.

MÜNTZING, A. Accessory chromosomes in *Poa alpina.* Hereditas **2**: 49-61, 1948.

MÜNTZING, A. Cyto-genetics of accessory chromosomes. Caryologia, Suppl. to Vol. VI. 282-301, 1954.

WENG, T. S. Intra-individual variation in number of B-chromosomes in *Miscanthus japonicus* Anderss. Bot Bull. Academia Sinica **3**: 19-34, 1962.