マカロニコムギにおける5B-5D染色体重複置換系統

誌名	The Japanese journal of genetics
ISSN	0021504X
著者	小野, 一 望月, 明 永吉, 照人
巻/号	55巻4号
掲載ページ	p. 251-257
発行年月	1980年8月

JAPAN. J. GENETICS Vol. 55, No. 4: 251-257 (1980)

A DISOMIC SUBSTITUTION LINE OF A COMMON WHEAT CHROMOSOME 5D FOR 5B OF *DURUM* WHEAT

HAJIME ONO, AKIRA MOCHIZUKI AND TERUTO NAGAYOSHI

Laboratory of Genetics, Faculty of Agriculture, Kobe University, Kobe 657

Received October 17, 1979

On the bases of morphological features, two plants having 28 chromosomes were selected in a selfed progeny of 13″+2′ plant that was obtained from recurrent-backcrossing of the offspring of monosomic 5B common wheat (Chinese Spring)×*durum* wheat (Stewart) with Stewart. Those plants were crossed with Stewart *durum* and with ditelosomic 5D of Chinese Spring. Resulted F_1 individuals showed exclusively a meiotic pairing of 13″+2′ in the former cross and 1″hm+13″+7′ in the latter, where one heteromorphic pair belongs to chromosome 5D. Therefore, those two plants could be identified as the disomic substitution of 5D for 5B of Stewart *durum*.

The substitution line was little different from normal Stewart, showing thicker culm, lux ear and somewhat early ear emergency. It is highly fertile and can be easily maintained.

INTRODUCTION

Since the first establishment of the complete set of twenty-one monosomics of a hexaploid wheat, *Triticum aestivum* cv. Chinese Spring, by Sears (1954), successful efforts have been made to produce monosomics of hexaploid wheat other than Chinese Spring with the aid of the monosomic lines of Chinese Spring. Several monosomic series of hexaploid wheat including Chinese Spring have been developed so far and are of great value in studying wheat genetics, especially cytogenetics, and wheat breeding.

In tetraploid wheat, on the other hand, little information with respect to monosomics is available, because of unexpected difficulty of self-perpetuation of the monosomics. Kihara and Tsunewaki (1962) obtained three monosomics of tetraploid wheat, *Triticum dicoccum* cv. Khapli, by treating florets with N_2O. However, no monosomics were recovered from the offspring of all 3 monosomics (Tsunewaki 1964). Mochizuki (1971) has established fourteen possible monosomics of *Triticum durum* cv. Stewart, by means of recurrently backcrossing *durum* to the offspring of hybrids between the fourteen monosomics for chromosomes of the A and B genomes of Chinese Spring and *durum*. Unlike Tsunewaki's observation, all the monosomics obtained were transmissible, however, the transmission rate was only 3.0 per cent even in the highest one which was observed in monosomic 5A.

These facts suggest that monosomics of tetraploid wheat are not suitable for genetic investigation such as monosomic analysis unless this drawback of the monosomics of tetraploid wheat is overcome. Then, we designed an experiment to obtain alien substitution lines in which a single chromosome pair of *durum* wheat is replaced by a homoeologous pair of D genome in *Triticum aestivum* or by a chromosome pair of a related genus.

This paper deals with breeding procedure and morphology of a disomic substitution line of 5D for the 5B chromosome of *durum* wheat. Effects that are induced by the absence of chromosome 5B of *durum* wheat on chromosome pairing, will be presented in a separate paper with some additional data obtained from aneuhaploid *durum* substituting 5D for 5B chromosome.

MATERIALS AND METHODS

The monosomic 5B of a hexaploid wheat, *Triticum aestivum* cv. Chinese Spring, was crossed to a tetraploid wheat, *Triticum durum* cv. Stewart. The cross, one of all of the fourteen cross combinations between monosomic lines for the chromosomes belonging to A or B genome of Chinese Spring and Stewart, was primarily made with the aim of production of a monosomic series of this tetraploid wheat (Mochizuki 1968).

The F_1 plants with 34 chromosomes in root-tip mitosis were selected and crossed as the female plant to Stewart. In order to reduce the genetic heterogeneity resulted from the interspecific cross, eight additional backcrosses were carried out, where the plants having $13''+2'$ in meiosis were always selected as the female parent in each backcross generation. The $13''+2'$ plants in BC_8 generation were used in this experiment for selfing.

Somatic and meiotic chromosomes were observed by means of aceto-carmine squash method of root-tip and pollen mother cell (PMC) after fixation with ethanol and acetic acid (3 : 1 v/v).

Ditelosomic 5D of Chinese Spring was also used to identify the chromosome that was introduced to Stewart from Chinese Spring.

RESULTS

Somatic chromosome number and constitution. If all the four types of gametes derived from the plants with $13''+2'$ were functional, the nine different types of offspring should have been born on selfing as summarized in Table 1, in which the plants symbolized by (AABB)−5B5B, (AABB)−5B, (AABB)−5B5B+d, (AABB), (AABB)−5B+d, (AABB)−5B5B+dd, (AABB)+d, (AABB)−5B+dd, and (AABB)+dd will be referred to as nullisomic 5B, monosomic 5B, nullisomic 5B monosomic d, normal disomic, monosomic 5B monosomic d (monosomic substitution d for 5B), nullisomic 5B disomic d (disomic substitution d for 5B), monosomic d, monosomic 5B disomic d, and disomic d, respectively, where d indicates a given chromosome of D genome. Among them, (AABB)−5B5B+dd is desirous in itself and (AABB)−5B5B+d and (AABB)−5B+dd must be useful

Table 1. Expected chromosome number and constitution of individuals in the selfed progeny of the 13″+2′ plant*

Chromosome number and constitution in gamete		13 (AB)−5B	14 (AB)	14 (AB)−5B+d	15 (AB)+d
13	(AB)−5B	26 (AABB)−5B5B	27 (AABB)−5B	27 (AABB)−5B5B+d	28 (AABB)−5B+d
14	(AB)	27 (AABB)−5B	28 (AABB)	28 (AABB)−5B+d	29 (AABB)+d
14	(AB)−5B+d	27 (AABB)−5B5B+d	28 (AABB)−5B+d	28 (AABB)−5B5B+dd	29 (AABB)−5B+dd
15	(AB)+d	28 (AABB)−5B+d	29 (AABB)+d	29 (AABB)−5B+dd	30 (AABB)+dd

* Of the two univalent chromosomes in the parent, one is the chromosome 5B from Stewart and the other is a given chromosome (d) came from D genome of Chinese Spring.

Table 2. Distribution of somatic chromosome number in selfed progeny of the plant with 13″+2′

Year	No. of seeds obtained	No. of seeds germinated	Chromosome number				
			26	27	28	29	30
1975	133	102	0	1	91	9	1
1976	105	85	0	0	81	4	0
Total	238	187	0	1	172	13	1

Table 3. Chromosome pairing at the first meiotic metaphase of selfed progeny of the plant with 13″+2′

Year	No. of plants examined	Chromosome number and pairing					
		27 13″+1′	14″	28 14″+2′	Others*	29 14″+1′	30 15″
1976	92	1	45	30	4	9	1
1977	82	0	44	33	1	4	0
Total	174	1	89	63	5	13	1

* Pollen mother cells having both 13″+2′ and 14″ are mixed in an anther.

for establishment of disomic substitution.

Of a total of 187 individuals in the selfed progeny, only one plant with 27 chromosomes was obtained (Table 2). However, it was decided to be monosomic 5B, since the cross between the plant and normal disomic Stewart produced the plant with 14″ instead of 13″+2′ at meiosis. As shown in Table 3, the 14″ plants were about one-half of the selfed progeny having 28 chromosomes, among which a desirous disomic substitution, if any, might be expected. All the 14″ plants, however, were nearly normal in appearance and not distinguishable with each other as well as with normal

Table 4. Chromosome pairing of the 28-chromosome plants obtained from self-pollination of an expected (AABB)−5B+dd plant

Chromosome pairing	Number of cells examined			
	Plant No. 1	Plant No. 2	Total	
$14''$	32	14	46	(61.3%)
$13''+2'$	10	6	16	(21.3%)
$12''+4'$	2	6	8	(10.7%)
$1'''+12''+1'$	1	0	1	(6.7%)
$1''''+12''$	1	0	1	
$1''''+11''+2'$	1	1	2	
$1''''+10''+4'$	1	0	1	

Table 5. Chromosome pairing in the F_1 hybrid between Stewart and the selected 28-chromosome plant

Chromosome pairing	Number of PMCs	Frequency (%)
$13''+2'$	106	97.3
$14''$	2	1.8
$1'''+12''+1'$	1	0.9

disomic Stewart on the bases of morphological observation. While, the plants with 29 chromosomes exclusively showing $14''+1'$ arose as many as 13 individuals. One of them was obviously different from the others in some morphological features such as ear length (longer), ear density (lax) and fertility (lower). In order to examine its chromosome constitution, the plant was selfed. Two of 13 offspring raised from the selfed seeds had 28 chromosomes and the remainders were of 29. Chromosome pairing of those 28-chromosome plants was scored and summarized in Table 4. These data show that 6.7 per cent of the total PMCs observed had at least a multivalent (tri- or tetravalent), suggesting that homoeologous pairing might have occurred, because of the missing 5B chromosome. Therefore, those two plants were selected for further examination.

Identification. The ultimate test of the validity of the substitution can only be made by crossing the selected plants with Stewart and obtaining a progeny that is exclusively made up of the plant having $13''+2'$ at meiosis. Then, the selected plants were crossed to Stewart. As shown in Table 5 and Fig. 1a, meiotic pairing of the F_1 plants indicated that a pair of chromosomes in the selected plants was not homologous to any chromosome of Stewart. Furthermore, the F_1's between the selected plant and ditelosomic 5D of Chinese Spring produced the PMCs with a heteromorphic pair as shown in Table 6 and Fig. 1b. Therefore, we have concluded the selected plants to be a disomic substitution of 5D for 5B (nullisomic 5B disomic 5D) of Stewart.

Some characteristics of the substitution line. Two plants of the substitution line and four of Stewart grown at nearly the same time in the greenhouse were investigated

Table 6. Chromosome pairing in the F_1 hybrid between the selected 28-chromosome plant and ditelosomic 5D of Chinese Spring

Chromosome pairing*	Number of PMCs	Frequency (%)
$1''hm+13''+7'$	80	79.2
$1''hm+12''+9'$	14	13.8
$1''hm+14''+5'$	3	3.0
$1'''+1''hm+12''+6'$	2	2.0
$1'''+1''hm+11''+7'$	2	2.0

* $1''hm$: hetromorphic pair.

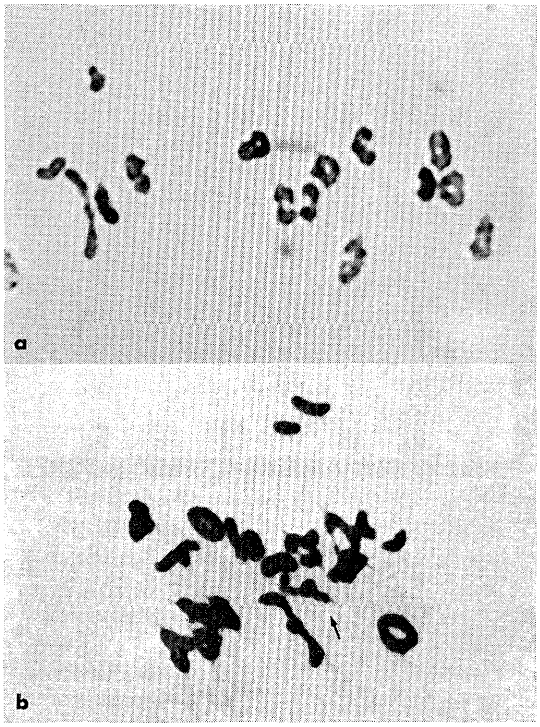

Fig. 1. Chromosome pairing of the F_1 hybrids between the substitution line and two testers.
a: F_1 (substitution line×normal Stewart) shows two univalents.
b: F_1 (substitution line×ditelosomic 5D Chinese Spring) shows a heteromorphic pair (arrow).

for several characteristics (Table 7). Two individuals of the substitution line had approximately normal height and tillers and were vigorous in growth. They were little different from normal Stewart, showing somewhat thicker culm and lux ear with long, sharpened apical tooth on empty glume (Fig. 2). They also tended to be several days earlier in ear emergency than normal. Fertility was fairly good.

Table 7. Some characteristics of the substitution line in comparison with those of normal Stewart

	No. Plants examined	Plant height (cm)	No. of tillers	Culm diameter (mm)	Ear length (cm)	Ear density	Awn length (cm)	Seed fertility (%)
Stewart	4	145.2	9.5	1.98	9.3	22.9	15.2	86.7
Substitution	2	149.3	8.5	2.35	10.6	21.3	13.5	79.5

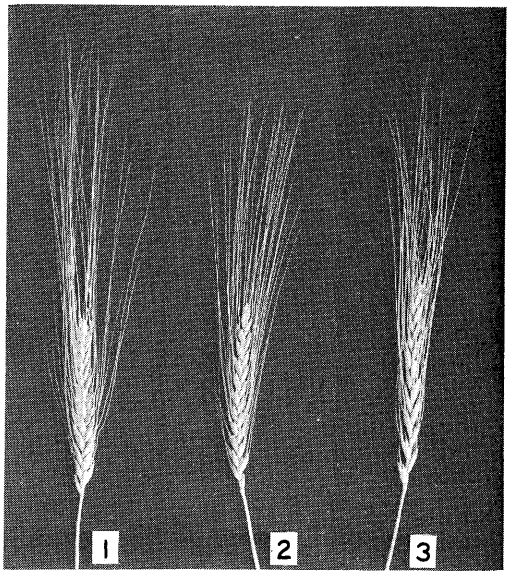

Fig. 2. Spikes of normal Stewart (1), disomic substitution of 5D for 5B, 2n=28 (2) and monosomic 5B disomic 5D, 2n=29 (3).

DISCUSSION

Almost all the monosomic lines in tetraploid wheat obtained so far are less fertile and seldom transmissible for monosomic condition (Tsunewaki 1964, Mochizuki 1968, 1971). Therefore, such aneuploids are not very usable for genetical research of tetraploid wheat. As Longwell and Sears (1963) have pointed out, the substitution, in which the missing chromosome is replaced by the corresponding homoeologous one, would be advantageous in order to avoid this drawback brought by monosomic condition. In fact, those workers have discovered that monosomic trisomic condition such as monosomic 2A trisomic 2B, monosomic 3A trisomic 3B and monosomic 6A trisomic 6B gives fairly good vigor and fertility. The other combinations such as monosomic 1A trisomic 1B and monosomic 5B trisomic 5A, however, are not well compensated, the plants being extremely infertile.

Noronha-Wagner and Mello-Sampayo (1963) have also indicated that the compensation between A or B genome chromosome and D genome chromosome is better than that observed between A and B genome chromosomes, because D genome is probably less differentiated from A and B genomes than between the latter two. Nullisomic 1A disomic 1D plants produced by them had almost normal vigor and high fertility, while monosomic 1A trisomic 1B was considerably weak and showed sterility. The present experiment showed that substituting 5B to 5D (nullisomic 5B disomic 5D) caused conspicuous increase in fertility up to 78 per cent from 8.0 per cent of monosomic 5B plant.

Along the same procedure as that used in this experiment, Mochizuki and Nagayoshi (1977) have obtained another substitution line, nullisomic 2B disomic 2D, which has also normal vigor and high fertility. At least, these disomic substitution lines of *durum* wheat with the D genome chromosomes of Chinese Spring are easy to maintain.

ACKNOWLEDGMENTS

We wish to thank Miss A. Yasuhara, Faculty of Agriculture, Kobe University, for her help during the course of these experiments.

LITERATURE CITED

Kihara, H., and K. Tsunewaki, 1962 Polyploids and aneuploids of *Triticum dicoccum* var. Khapli produced by N_2O-treatment. Wheat Inf. Serv. **14**: 1-3.

Longwell, J. H., and E. R. Sears, 1963 Nullisomics in tetraploid wheat. Amer. Natur. **97**: 401-403.

Mochizuki, A., 1968a Production of monosomics in *durum* wheat. Wheat inf. Serv. **26**: 8-10.

Mochizuki, A., 1968b The monosomics of *durum* wheat. Proc. 3rd Int. Wheat Genetics Symp. Canberra 1968: 310-315.

Mochizuki, A., 1971 Production of three monosomic series in Emmer and common wheat. Seiken Ziho **22**: 39-49.

Mochizuki, A., and T. Nagayoshi, 1977 Genetical studies on a chromosome substitution line of *durum* wheat, 2D(CH) for 2B (in Japanese). Sci. Rept. Fac. Agr. Kobe Univ. **12**: 217-221.

Noronha-Wagner, M., and T. Mello-Sampayo, 1963 Aneuploids in *durum* wheat. Proc. 2nd Int. Wheat Genetics Symp. (Hereditas Supp. Vol. **2**): 382-392.

Sears, E. R., 1954 The aneuploids of common wheat. Mo. Agr. Exp. Sta. Res. Bull. **572**: 1-58.

Tsunewaki, K., 1964 Transmission of monosomes and trisomes in an Emmer wheat. Wheat Inf. Serv. **17**, **18**: 34-35.