M. Feldman

Wheat Information Service
December 79: 28 – 32 (1994)

The ineffectiveness of the *ph1b* gene on chromosome association in the F_1 hybrid, *Triticum aestivum* × *Psathyrostachys huashanica*

Genlou Sun and Chi Yen

Triticeae Research Institute, Sichuan Agricultural University, Dujiangyan City, 611830, China

Summary

An intergeneric cross was made between Chinese Spring *ph1b* mutant and perennial *Psathyrostachys huashanica* Keng. The meiotic chromosome pairing in the hybrid was 27.14 univalents and 0.43 bivalents. The result indicated that the *ph1b* gene did not induce homoeologous chromosome pairing between common wheat and *P. huashanica*, as well as among the common wheat chromosomes. Therefore, the presence of a *Ph1* or *Ph1*-like gene in *P. huashanica* was suggested.

Introduction

The evolutionary success of many polyploid species is largely due to their diploid-like cytological behavior, which is expressed by the virtually exclusive formation of bivalents, rather than multivalents, at the first metaphase of meiosis. Common wheat, *Triticum aestivum* L., contains several unlinked diploidizing gene systems (Sears 1976). The *ph1b* gene mutant was obtained by Sears (1977). This mutant allows homoeologous pairing in common wheat and in its hybrids.

The transfer of alien genetic material to common wheat through homoeologous recombination is an importment step in the efforts to increase the genetic variation. The previous studies indicated that the *ph1b* gene has strong effect on inducing homoeologous pairing in the hybrids between bread wheat and *Aegilops variabilis*, *Ae. triuncialis*, *Ae. turcomenica*, *Ae. triaristata*, *Ae. cylindrica*, *Ae. colmnaris*, and *Ae. ovata* (Kushnir et al. 1982; Sharma et al. 1986; Fan et al. 1992, 1993). However, the effectiveness of the *ph1b* gene inducing chromosome pairing in the hybrid between common wheat and *Psathyrostachys huashanica* has not been demonstrated yet.

This paper reports the first production of an intergeneric hybrid between Chinese Spring *ph1b* mutant and *P. huashanica*, and the meiotic analysis of the hybrid. The possible presence of a *Ph1*-like gene in *P. huashanica* is discussed in connection with the result of the meiotic analysis.

Materials and methods

The *ph1b* mutants of a common wheat cultivar Chinese Spring (abbreviated to CS *ph1b*) was kindly provided by the Cytogenetic Laboratory of Sichuan Agricultural University. Professor Z.L. Ren proved the authenticity of the mutant *ph* by cytogenetic method (personal communciation). The euploid Chinese Spring (CS) was kept at the Triticeae Research Institute, Sichuan Agricultural

University, *Psathyrostachys huashanica* Keng (2n=14, genomes NN) is an endemic species of Huashan mountain, Shaanxi Province, China. All materials were grown in the field at the Triticeae Research Institute.

The euploid Chinese Spring and *ph1b* mutant were used as female parents. Their spikes were emasculated, covered with cellulose bags, and few days later, artificially pollinated with *P. huashanica*. Well-developed 14 to 16 day-old embryos were excised, and cultured on N_6 basic medium. When the hybrid seedings had three leaves, they were transplanted into sand-pot and kept in an airconditioned room to survive the hot summer.

Young spikes of the hybrid were fixed in Carnoy's solution (95% ethanol:glacial acetic acid=3:1) for 24hr, transferred to 70% ethanol, and stored at 4°C in a refrigerator. The 1% aceto-orcein smear method was used for the cytological study.

The F_1 hybrid was backcrossed with the *Ph1b* mutant.

Results

1. Production of intergeneric hybrid: The result of the crosses is shown in Table 1. The cross CS *ph1b* × *P. huashanica* produced 5 embryos out of 286 pollinated florets. One well-developed seedling was obtained by means of embryo culture. No hybrid embryo was obtained from the cross between CS and *P. huashanica*. The previous studies (Chen et al. 1991; Sun et al. 1992) and the present result showed that the crossibility of *P. huashanica* with different common wheat cultivars varies 0 to 2.81% (Table 1).

Table 1. Results of crosses between common wheat and *P. huashanica*

Combination	Florets pollinated	Seed set		Reference
		No.	%	
CS × *P. huashanica*	560	0	0	Present study
Cs *ph1b* × *P. huashanica*	286	5	1.75	Present study
J-11 × *P. huashanica*	450	9	2.81	Sun et al. (1992)
CS × *P. huashanica*	320	0	0	Sun et al. (1992)
7182-0-11-1 × *P. huashanica*	166	2	1.20	Chen et al. (1991)
Common wheat × *P. huashanica*	1576	3	0.19	Chen et al. (1991)

2. Cytology: The chromosome pairing at metaphase I of the pollen mother cells (PMCs) of the hybrid CS *ph1b* × *P. huashanica* is shown in Table 2. The hybrid (2n=28) had 22 to 28 univalents, 27.14 on an average. Of 58 PMCs examined, 38 PMCs had 28 univalents (Fig. 1-1). Twenty PMCs contained 1 to 3 rod bivalents (Fig. 1-2). No ring bivalents and multivalents were observed. The average number of bivalents was 0.43 per cell. The chiasma frequency was 0.43 per cell. There were lagging chromosomes at anaphase I and II and micronuclei were found at the tetrad stage.

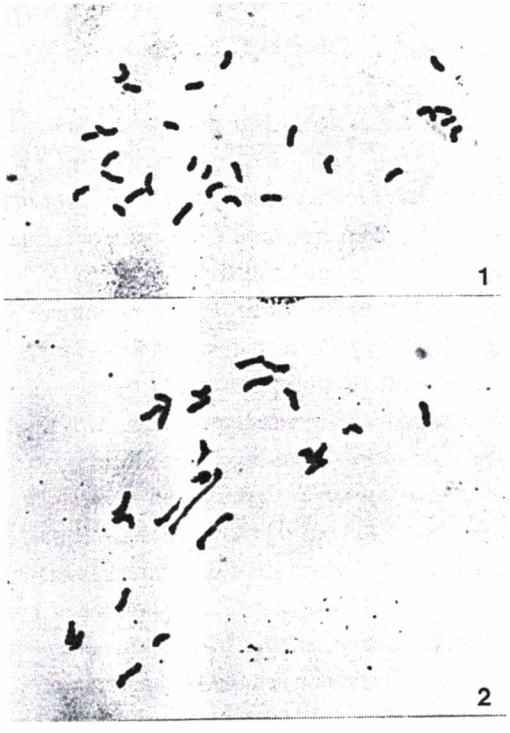

Fig. 1. Chromosome pairing of the CS *ph1b* × *P. huashanica* at meiotic metaphase-I
1. 28 univalents; 2. 22 univalents and 3 rod bivalents.

Table 2. Chromosome configurations of F_1 hybrids wheat × *P. huashanica*

Combinations	No. of cells examined	I	II			III	Chiasma frequency	Reference
			Total	rod	ring			
CS *ph1b* ×	58	27.14	0.43	0.43	0	0	0.43	Present study
P. huashanica		(22-28)	(0-3)	(0-3)				
J-11 ×	173	26.72	0.62	0.62	0	0.01	0.64	Sun et al. (1992)
P. huashanica		(17-28)	(0-4)	(0-4)		(0-1)		
H881	495	26.01	0.99	0.99	0	0	0.99	Chen et al. (1991)
		(22-28)	(0-3)					

3. Fertility of F_1 hybrid: The hybrid had yellowish white anthers, which did not dehisce. Staining of the pollen grains with Iodine-KI solution showed that the hybrid plant was completely male sterile. The F_1 hybrid plant was back crossed with CS *ph1b*, and three well-developed embryos were obtained from 210 pollinated florets.

Discussion

Fan et al. (1992) reported that PMCs of the hybrids between *ph1b* and *Aegilops ovata*, and between CS and *Ae. ovata* had 12.88 and 0.94 chiasmata at metaphase I, respectively. A similar result was reported with the hybrids of *Ae. umbellulata* with CS and *ph1b* (Fan et al. 1993). These show that the *ph1b* gene has a strong effect on inducing homoeologous pairing in the hybrids of *Ae. ovata*, *Ae. umbellulata* with common wheat (Fan et al. 1992, 1993). In the present study, only the F_1 hybrid between *ph1b* and *P. huashanica* was obtained. However, Chen et al. (1991) and Sun et al. (1992) reported successful hybridizations of common wheat cultivars 7182-09-11-1 and J-11 with *P. huashanica*, respectively (Table 2). The scarce chromosome pairings in the hybrids confirmed the non-homology between the genomes of *T. aestivun* (ABD) and *P. huashanica* (N). Miller and Chapman (1976), and McGuire and Dvorak (1982) reported 0.24 and 0.27 chiasmata per cell in CS haploid plants, respectively. The low chiasma frequency of the hybrid between *ph1b* and *P. huashanica* (0.43), which was lower than those of the hybrids of common wheat cultivars with *P. huashanica* (Table 2), indicated that *ph1b* gene did not induce homoeologous chromosome pairing in the hybrid.

Wang and Hsiao (1984) suggested that the existence of a diploidizing genetic system in *Leymus* (JN genomes), which is similar to the *Ph* gene system found in *T. aestivum*. Dovrak (1981) demonstrated that some species of *Thinopyron* (J genome) promoted heterogenetic pairing in hybrids involving *T. aestivum*. Our data implied that the N genome of *P. huashanica* had a *Ph*-like gene. If so, the high level of auto-alloploidy of *Leymus angustus* (2n=84, containing several N and J genomes), which forms bivalents, would be explained.

Acknowledgements

The authors thank Mrs. B.H. Wu for her technical assistance. This work was supported by the Sciences and Technology Council of Sichuan Province.

References

Chen SY, Zhang AJ and Fu J (1991) The hybridization between *Triticum aestivum* and *Psathyrostachys huashanica*. Acta Genetica Sinica 18(6): 512-518.

Dvorak J (1981) Chromosome differentiation in polyploid species of *Elytrigia* with special reference to the evolution of diploid-like chromosome pairing in ploypoid species. Can J Genet 23: 287-303.

Fan L, Han JH, Yie XG, Cao WG and Pan ST (1992) Effectiveness of *ph1b* in hybrid between bread wheat and *Ae. ovata*. Acta Agronomica Sinica 18 (2): 107-110.

Fan L, Yie XG, Han JH and Pan ST (1993) Effectiveness of *ph1b* gene in hybrid between common wheat and *Ae. umbellulata*. Scientia Agricultura Sinica 26(1): 32-36.

Kushnir U and Halloran GM (1982) Regulation of homoeologous pairing in pentaploid wheat hybrids. Genetica 19: 585-593.

McGuire PE and Dvorak J (1982) Genetic regulation of heterogenetic chromosome pairing in polyploid species of the genus *Triticum sensu lato*. Can J Genet Cytol 24: 57-82.

Miller TE and Chapman V (1976) Aneuhaploids in bread wheat. Genet Res 28: 37-45.

Sears ER (1976) Genetic control of chromosomal pairing in wheat. Annu Rev Genet 10: 31-35.

Sears ER (1977) An induced mutant with homoeologous pairing in common wheat. Can J Genet Cytol 19: 585-593.

Sharma HC and Gill BS (1986) The use of *ph1* gene in direct genetic transfer and search of *Ph*-like in polyploid *Aegilops* species. Z Pflanzenzuchtg 96: 1-7.

Sun GL, Yan J and Yang JL (1992) Production and cytogenetic study of intergeneric hybrid between *Triticum aestivum* and *Psathyrostachys species*. Chinese J Genet 19(3): 205-210.

Wang RRC and Hsaio C (1984) Morphology and cytology of interspecific hybrids of *Leymus mollis*. J Hered 75: 488-492.