

SOMATIC CHROMOSOME VARIATIONS IN BACKCROSS I PROGENIES FROM INTERGENERIC HYBRIDS INVOLVING SOME TRITICEAE

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SUMMARY

Several hybrid combinations of *Agropyron* sp., *Elymus* sp., *Hordeum vulgare*, *Secale cereale*, *Triticum turgidum* and *T. aestivum* have been produced. The cytological information obtained from these hybrids and backcross I (BCI) progenies is presented, including amphiploidy, mitotic variations in BCI progenies, meiotic restitution, somatic doubling, and haploid production. The practical significance of these observations in intergeneric hybridization and *T. aestivum* germplasm improvement is discussed.

INTRODUCTION

The struggle for increased food production is universal, and plant breeders are often stymied by a lack of appropriate germplasm for incorporation into existing food crops. Such genetic resources may either be unknown, do not exist in the cultivated or wild species, or reside in secondary or tertiary gene pools (Harlan & De Wet, 1971), all of which prevent a rapid genetic flow or transfer, and inhibit the operation of expressivity mechanisms. Since the late 1960's, however, researchers have made numerous ingenious attempts to resolve crossability barriers. Their accomplishments in this area have shed light on the future promise and potential as well as the limiting factors of intergeneric hybridization, (Mujeeb-Kazi and Rodriguez 1980, 1981a).

It is fortuitous that a majority of the studies have included the *Triticum* species, with the greatest emphasis placed on improving bread wheat (*T. aestivum* (2n=6x=42), AABBDD). It may be at least another decade before the impact of such a genetically diverse intergeneric hybridization program is felt. We must question whether the wheat plant can be so modified as to express for example (i) high lysine or protein from *H. vulgare*; (ii) salt

and/or drought tolerance from *A. distichum*, *A. elongatum* or *E. giganteus*; (iv) fusarium and helminthosporium resistance from a possible few of the *Agropyron* or *Elymus* species; (v) rust resistance and freedom of leaf spotting complex diseases from *Agropyron* or *Elymus* species; and (vi) powdery mildew resistance from *Haynaldia villosa*. This paper reports the progress to date toward realizing such practical research goals.

MATERIALS AND METHODS

The production of F₁ sterile hybrids was described earlier (Mujeeb-Kazi & Rodríguez 1981b). The BCI progenies were maintained in potted soil under greenhouse conditions of 26.6°C/15.5°C (14h. day/10h night) and approximately 45% to 50% relative humidity. Root tips were sampled to determine the somatic chromosome number of each BCI plant and analyzed according to the procedures of Mujeeb *et al* (1978), except that a 2% acetoorcein stain was used instead of feulgen. A minimum of five metaphase cells were scored from each plant over three root-tips. Bennett *et al*'s (1977) procedure was utilized for C-banding.

RESULTS AND DISCUSSION

Intergeneric hybrids among the Triticeae have been easy to obtain by utilizing the greenhouse environment and a post-pollination treatment of the florets with gibberellic acid, similar to the procedure of Kruse (1973). Somatic variations in the F₁ hybrids are not easily detected, and they generally represent a composition expected by the combining of the male and female gametic number. One exception has been the differentiation into an *A. fibrosum* polyhaploid (n=2x=14), of an embryo extracted from a potential *A. fibrosum* (2n=4x=28) x *T. aestivum* (2n=6x=42) cross. This is not similar

to the *T. aestivum* polyploid generation mechanism (Barclay, 1975), since a hybrid of *A. fibrosum* x *T. aestivum* with $n=5x=35$ has been obtained. The meiotic associations in the *A. fibrosum* polyploid was of 13.592_1 0.204_{11} (rods), which indicates a lack of autosyndetic pairing, and facilitates interpretations for the *A. fibrosum* x *T. aestivum* hybrid and the BCI progenies with *T. aestivum*.

Inducing amphiploidy has been difficult in several intergeneric combinations that include *H. vulgare*, *Elymus* sp., and *Triticum* spp., but is relatively easier when *Agropyron* species are in the parentage. The *T. aestivum* x *A. junceum* hybrid ($n=6x=42$) with a mean meiotic relationship of 20.65_1 8.58_{11} (rods) 1.38_{11} (rings) 0.40_{111} 0.10_{1V} produced a partially fertile amphiploid, $2n=12x=84$. The C-2 progeny has from 79 to 82 chromosomes. The BCI plants (*T. aestivum* - *A. junceum*) x *T. aestivum*, range from 59 to 63 chromosomes and include telocentrics or dicentrics.

In all other hybrid combinations, where the BCI progenies resulted from fertilizing an unreduced egg cell of the male sterile F_1 hybrid by the desired backcross male parent, the chromosome variations would be the result of hyper- or hypoploidy in the egg cell composition (see Table 1). These variations are anticipated because all the hybrids expressed very low chiasmata frequencies, and that would provide enough opportunity for misdivision of the univalents to occur. These misdivisions could lead to related cytologically detectable chromosomal effects seen as dicentric, acrocentric, telocentric, and isochromosomes. Hybrids involving *A. trachycaulum*, *A. elongatum* (4x), and *A. fibrosum*, did not indicate any intergenomic or autosyndetic pairing, with chiasmata frequencies ranging from 0.226 to 0.476 per. cell. Similar positive or negative variations in the chromosome composition of the BCI progenies were expressed by (i) (*E. dahuricus* - *T. aestivum*) x *T. aestivum*, and (ii) (*E. canadensis* - *T. aestivum*) x *T. aestivum* (Table 1).

More drastic variations were expressed by three backcross I combinations. The (*A. fibrosum* - *T. turgidum*) x *T. turgidum* produced a BCI plant with 56 chromosomes instead of 42 (Table 1, number 11); the (*T. aestivum* - *A. elongatum*) x *T. aestivum* progenies analyzed so far ranged from 42

to 61 instead of the expected $2n=11x=77$ (Table 1, number 16), and (*A. elongatum* - *S. cereale*) x *S. cereale* (Table 1, number 17) formed a BCI plant with 49 chromosomes. The variations obtained for the former two BCI combinations have yet to be determined. The variations of the latter seem to be a consequence of the fertilization of a spontaneously doubled egg cell ($2n=6x=42$) with *S. cereale* pollen ($n=7$). Giemsa C-banding of this BCI plant confirmed the presence of 21 *S. cereale* chromosomes. It shall be interesting to ascertain whether the backcross I seed was formed as a consequence of fertilization of the unreduced egg cell with an aneuploid condition. This possibility applies to those BCI progenies where the observed BCI somatic counts do not deviate markedly from the expected BCI chromosome numbers. Where the BCI counts deviate significantly (Table 1, numbers 16 and 18); the variations may require special cytological analyses utilizing the N-banding technique, (Gerlach, 1977), as modified for high altitudes (Jewell & Mujeeb-Kazi, 1982). Initial observations of a BCI (*T. aestivum* - *A. elongatum*) x *T. aestivum* plant with 50 chromosomes, instead of $2n=11x=77$, have indicated that the ABD complement from the *T. aestivum* backcross male parent did fertilize the F_1 egg cell, which, though unreduced seemingly did not possess the F_1 chromosome number of $n=8x=56$. This interpretation was facilitated by identifying 15 N-banded chromosomes from the maximum 18 possible i.e. 14 from the B genome and four from 4A and 7A, (Jewell and Mujeeb-Kazi, 1982). More analyses are in progress to elucidate the variation seen in the above BCI and other progenies listed in Table 1.

CONCLUSION

Over the past decade, intergeneric hybridization research has yielded promising results. Our investigations at CIMMYT, and the findings of other workers during the past few years have elucidated the inherent complexities of intergeneric hybridization, which can be of such a magnitude as to prevent practical agricultural gain. Fortunately, the plant system offer enough flexibility to allow the use of cytological manipulative techniques. Such techniques may relate to alien genetic transfer and

Table 1. Some intergeneric F₁ hybrids and backcross (BC) I combinations, with somatic cytological constitutions and variations in BCI.

Serial Number	Intergenic hybrid combination (F ₁)			(F ₁) or (C-1)	Backcross I Combination (BCI)	Expected BCI Chromosome Number	Observed BCI Chromosome Number or Range	
				Chromosome Number				
1	<i>T.aestivum</i>	<i>x A.junceaum</i>		42	(F ₁) <i>x T.aestivum</i>	63	42 and 63	
2	<i>T.aestivum</i>	<i>x A.junceaum</i>		84	(C ₁) <i>x T.aestivum</i>	63	59 to 63*+	
3	<i>T.aestivum</i>	<i>x E.giganteus</i>		35	(F ₁) <i>x T.aestivum</i>	56	55 to 56	
4	<i>A.elongatum</i>	<i>x T.aestivum</i>	<i>cv. Jupateco</i>	35	(F ₁) <i>x T.aestivum</i>	56	49 to 56	
5	<i>A.elongatum</i>	<i>x T.aestivum</i>	<i>cv. C.Spring</i>	35	(F ₁) <i>x T.aestivum</i>	56	56	
6	<i>A.trachycaulum</i>	<i>x T.turgidum</i>		28	(F ₁) <i>x T.turgidum</i>	42	41	
7	<i>A.fibrosum</i>	<i>x T.aestivum</i>	<i>cv. Pavon</i>	35	(F ₁) <i>x T.aestivum</i>	56	55 to 56*	
8	<i>A.fibrosum</i>	<i>x T.turgidum</i>		28	(F ₁) <i>x T.turgidum</i>	<i>cv. Cocorit 71</i>	42	39
9	<i>A.fibrosum</i>	<i>x T.turgidum</i>	<i>cv. Mexicall</i>	28	(F ₁) <i>x T.turgidum</i>	<i>cv. Grano Grande</i>	42	43
10	<i>A.fibrosum</i>	<i>x T.turgidum</i>	<i>cv. Mexicall</i>	28	(F ₁) <i>x T.turgidum</i>	<i>cv. Mexicall</i>	42	40 to 42+
11	<i>A.fibrosum</i>	<i>x T.turgidum</i>	<i>cv. Quilafen</i>	28	(F ₁) <i>x T.turgidum</i>	<i>cv. Mexicall</i>	42	56
12	<i>E.dahuricus</i>	<i>x T.aestivum</i>	<i>cv. Pitic</i>	42	(F ₁) <i>x T.aestivum</i>	<i>cv. Pavon</i>	63	42, 61 to 65*+
13	<i>E.canadensis</i>	<i>x T.aestivum</i>	<i>cv. C.Spring</i>	35	(F ₁) <i>x T.aestivum</i>	<i>cv. C.Spring</i>	56	57 to 61*+
14	<i>E.canadensis</i>	<i>x T.aestivum</i>	<i>cv. C.Spring</i>	35	(F ₁) <i>x T.aestivum</i>	<i>cv. Veery</i>	56	54 to 59*+
15	<i>E.canadensis</i>	<i>x T.aestivum</i>	<i>cv. C.Spring</i>	35	(F ₁) <i>x T.aestivum</i>	<i>cv. Zaragoza</i>	56	54 to 59
16	<i>T.aestivum</i>	<i>x A.elongatum</i>		56	(F ₁) <i>x T.aestivum</i>		77	42 to 61*+
17	<i>A.elongatum</i>	<i>x S.cereale</i>		21	(F ₁) <i>x S.cereale</i>		28	49
18	<i>T.timopheevii</i>	<i>x A.elongatum</i>		49	(F ₁) <i>x T.timopheevii</i>		63	38 to 42*

* With telocentrics

+ With dicentrics

genetic expressivity by utilizing the Ph mutant or aneuploids of 5B. In these cases the maternal and alien cytological chromosome relationships are normal in F_1 , BCI and advanced progenies. It is when the variations appear in BCI progeny that intergeneric germplasm utilization complexities develop. Consequently breeders should take care to cytologically evaluate their crossing programs that deal with alien genera, preferably at the BCI progeny stage. Chromosome duplications, triplications, etc., and unaccountable losses do provide novel research information, but simultaneously could thwart the smooth advance in forming alien addition or substitution lines, and accompanying genetic transfers.

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