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THE STATUS OF THE 1B/1R TRANSLOCATION CHROMOSOME IN SOME RELEASED WHEAT VARIETIES AND THE 1989 CANDIDATE VARIETIES OF PAKISTAN

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Abstract

The homozygous chromosome translocation, 1B/1R 1B/1R, involving the short arm of *Secale cereale* chromosome 1 (1RS) and the long arm of *Triticum aestivum* chromosome 1B (1BL) has been a potent genetic source of disease resistances in wheat varieties released globally. The genes located on 1RS have been associated with leaf-rust (*Lr26*), stem-rust (*Sr31*), stripe-rust (*Yr9*) and powdery mildew (*Pm8*). In the 1988-89 national uniform wheat yield trials (NUWYT) of the 38 entries including three checks; one for each of the normal, short-duration and rainfed categories; there were 25 entries with the 1B/1R translocation. The Pak-81 variety was 1B/1R homozygous. Some of the recent wheat varietal releases in Pakistan after 1980 were also analyzed, and 7 varieties of the 11 checked possessed the 1B/1R homozygous translocation. This paper also discusses the constraints that may be prevalent when large chromosome segments are involved in transfers from a common genetic base.

Introduction

The first wheat-rye substitution was reported by Kattermann (1938) leading to identification of several European wheat varieties specifically with the 1B/1R wheat/rye translocation (Zeller, 1973; Mettin *et al.*, 1973). The translocation involves the short arm of rye chromosome 1 (1RS) and the long arm of wheat chromosome 1B (IBL) (Zeller & Fuchs, 1983; Bennett, 1984; Mettin & Bluthner, 1984; Heun & Fishbeck 1987).

The incorporation of the 1B/1R translocation in CIMMYT spring wheats was a consequence of the crosses between spring and winter wheats with Kavkaz winter wheat being one of the sources of the translocated chromosome. Other sources of the translocation were from the varieties Weique Red Mace and Aurora (Rajaram *et al.*, 1983). The most prominent of the wheat releases from CIMMYT was the group of sister lines "Veery" of which in Mexico sister lines 1, 2, 3 and 5 were released as Glennson-81, Ures-81, Genaro-81 and Seri-82 and from the latter (Seri-82) selected through testing by researchers in Pakistan was the varietal release Pak-81. The 1B/1R translocation in Veery's was simultaneously and independently identified by Merker (1982) and Mujeeb-Kazi (1982). Elite *T. aestivum* germplasm was also analyzed by Mujeeb-Kazi (1982, 1983) leading to identification of several other cultivars with the translocation homozygotes.

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Table 1. Lines or Varieties included in the 1988/89 National Uniform Wheat Yield Trials in Pakistan of Normal Duration Planting.

S. No.	Line/Variety	Parents/Pedigree	1B/1R Homozygous	1B Homozygous
1.	PR-28	ND/VG 9144/KAL BB/3/YACO CM 62661-D-1M-1Y-4M-1Y-CM		X
2.	PR-30	13 WA 8085 MRNG (NAD TDRxVAR PC H/BLT "S"- MES "S") PAT 72195 (2)-ZP "S"xALD "S-EMU "S" CM 57616-A-3Y-1Y-1M-2Y-2M-4M-0M		X
3.	1697-S-1	(LU 31 x LU 60) x SA75		X
4.	M-143	Pavon NaN_3 10-32 hrs.		X
5.	M-179	Sind-81 Gamma rays 150Gy.		X
6.	V-8512	JUP-ZPxCOC/PVN CM 58705-3M-1Y-1M-1Y-1M-0Y	X	
7.	V-5003	VEE "S" - MAD "S" CM 64663-6Y-3M-5Y-1M-0Y	X	
8.	NR-1	TTR "S-JUN "S" CM 59123-3M-1Y-2M-1Y-2M-2Y-0M	X	
9.	NR-7	QLV-AZ67xMUS "S"/DODO "S" CM 74490-BN-BK-SN-BN.		X
10.	V-84021	WL-711-HD 2167 Pb. 19279-2A-0A		X
11.	V-85054	WL-711/3/KAL/BB/ALD Pb 19282-la- la-0a	X	
12.	V-85276-2	CHB-70 (KN 83xCHB 70-ALD) CHB-70 (INIA-CNO/KAL/INIA "S")] Pb. 17528 A-la-6N-2N-0N		X
13.	V-86369	INIA/A.DISTT//INIA/3/GEN 81 W 5898-1	X	
14	V-6751	Veery "S" CM 33027-F-12M-1Y-1M-1Y-1M-0Y	X	
15.	PAK-81	CHECK	X	

Notable among these were: Sunbird "S", Lira "S", Kea "S", Alondra "S", Bobwhite "S", Chat "S" with others tabulated in Mujeeb-Kazi (1983), of which Bobwhite "S" figured in the Sarhad-82 release in Pakistan. More recently, Mujeeb-Kazi *et al.*, (1990) have analyzed the 15th, 18th, 21st and 22nd IBWSYN germplasm and have demonstrated the role that 1B/1R wheats are playing in wheat germplasm development in CIMMYT and globally.

In Pakistan's 1988-89 NUWYT nursery, several entries have pedigrees that have one or more 1B/1R wheats involved in their development and it was the purpose of this study to document the contribution of this translocation for wheat varietal improvement and consider its futuristic implications plus research strategies.

Materials and Methods

Germplasm for this study was provided by the National Wheat Co-Ordinator's office in NARC, Pakistan. The material was categorized under (i) Normal duration (ii) Short

duration and (iii) Rainfed, and is listed with their pedigrees in the experimental results of Tables 1, 2 and 3. The varietal data is in Table 4 that cytologically identifies the 1B or 1B/1R wheat releases since 1980.

CYTOLOGY

The following procedure was followed:

(i) Ten seeds of each entry in the NUWYT were germinated in Petri dishes lined with moist filter paper.

(ii) Upon germination, root tips were collected from 6 seedlings per entry and kept individually separated such that they could be related to their respective plants that were grown to maturity for seed increase.

(iii) The root-tips were pre-treated for 3 hours 30 minutes in a 8-hydroxy-quinoline + colchicine + dimethylsulfoxide solution according to the procedure of Mujeeb-Kazi & Miranda (1985).

(iv) One root tip of each of the six plants per entry was fixed and stained simultaneously in 0.2% aceto-orcein and stored in the refrigerator at 4°C until use.

Table 2. Lines or Varieties included in the 1988/89 National Uniform Wheat Yield Trials in Pakistan of Short Duration Planting.

S. No.	Line/Variety	Parents/Pedigree	1B/1R Homozygous	1B Homozygous
1.	V-5002	LIRA "S"	X	
2.	V-5004	BUC "S" (TZPP-IRN46-CNO 67/PRI CM 56744-74-24-1M-14-0M		X
3.	V-84133	SA 75/5 Ti71/4/KAL/SKA//CNO "S" INIA "S"/3/CNO/CHE/6 AU ERECTION Pb. 18260 4a-4a-0a.	X	
4.	V-86299	Pb 76/4/H 6496/71A//HORK "S"/3/JUP/5/ Pb. 76/KLT "S"//Pb. 76/TTR "S" Pb. 19874-2a-la-0a	X	
5.	V-85110	HD 2204-JUN Pb. 18843-7a-6a-0a		X
6.	V-85195	B. Silver/KLT "S" Pb. 18242-la-la-2a-0a	X	
7.	PR-32	KVZ/3/TOB/CTFN//BB/4/BLO "S"/5/VEE "S"/6/ BOW "S"/3/YD "S"//BB-CHA CM75650-C-1M-1Y-3M-3Y-0B	X	
8.	PR-31	AI-FUNG "S"-DOVE SWM 1134-1F-1F-1F-0F	X	
9.	V-6236	Bulk 88		X
10	V-6550	Golden Valley/AZ 67//Musala "S"/3/Bwp-79 Pb. 18615-1B-0B	X	
11.	V-6632	MAYA 74 "S"/MONCHO "S"//B.BIRD BR 186-3B-0B	X	
12	Faisalabad-83	Check		X

Table 3. Lines or Varieties included in the 1988/89 National Uniform Wheat Yield Trials in Pakistan of Rainfed Duration Planting.

S. No.	Line/Variety	Parents/Pedigree	1B/1R Homozygous	1B Homozygous
1.	V-85078	TTR "S"-JUN "S" CM 57123-3M-1Y-1M-4Y-1Y-1M-0M	X	
2.	V-86175	BAN-70/SNB "S" Pb. 19805-24a-2a-0a	X	
3.	V-85162	CHB 70 [(KN 83XCHB 70 ALD) CHB-70 (INIA-CNOxKAL/INIA "S") Pb. 17528A-2a-0a	X	
4.	V-86371	INIA/AA.DISTT//INIA/3/GEN.81W.8461-3	X	
5.	PR-33	KVZ-CNO-CHRxON.E 375-125-35 FR 2208-7F-1F-0F	X	
6	V-8550/PR-29	NAC-VEE "S" CM 64224-5Y-1M-1Y-2M-0Y	X	
7.	V-8203-S-1	[CNO-8156xTOB-TOB (NO66/12300xLR-8156] TRF "S" CCM 41631-3M-2-1-1M-0R-1R-0R	X	X
8.	V-8557	VEE "S"/FLN-ACCxANA CM 64576-9Y-1M-3Y-2M-0Y	X	
9.	V-8501	JUP/HD 1944xCNO "S"-G110 RP-645-5E-1R-0R	X	
10.	NR-14	BAGULA "S" CM 59123-3M-1Y-2M-1Y-2M-1Y-0M	X	
11.	LYP-73	CHECK		X

(v) Two days prior to squashing 0.2% orcein was replaced with 2.0% aceto-orcein for stain intensification. The squashing process was identical to that of Mujeeb-Kazi & Miranda (1985), as were the subsequent steps upto permanent slide preparation.

(vi) Each squashed preparation was observed for 5 metaphase cells and analyzed for the secondary constrictions of 1B, 1B; 6B, 6B; and the less frequently resolved 5D, 5D secondary constriction site. Absence of the satellites on the 1RS segment of the 1B/1R chromosomes provides an initial index of the presence of this translocation pair.

CHROMOSOME BANDING

C-banding: The two remaining root tips of each of the plants in each entry after pre-treatment were fixed in 0.1% aceto-carmine for 48 hours in the refrigerator (4°C), squashed in 45% acetic acid, with the cover-glass removed by processing in liquid nitrogen or on dry ice. The slides were air-dried for 4 hours, treated in absolute alcohol (ethanol) for 2 hours and air dried overnight. The treatments in barium hydroxide ($Ba(OH)_2.8H_2O$) and SSC (Sodium citrate 0.03M + Sodium chloride 0.3M) were essentially similar to those described by Bennett *et al.*, (1977). The slides were stained for 6-8 minutes with a 2% giemsa stain (Sigma, G-4507) pH 6.8 and checked for the C-banded sites of chromosome 1B or 1B/1R.

Table 4. Some varietal releases during 1980's in Pakistan of *Triticum aestivum* L. and status within them of the 1B/1R chromosome translocation.

Variety Name	Parent/Pedigree	1B/1R Homozygous	1B Homozygous
Chakwal-86 (V-79388)	FORLANI-ACCxANA SWN 4578-56M-3Y-3M-0Y	X	X
Sutlej-86 (V-6000)	CMT.YR.MON "S" CCM 43405-A-2Y-1M-5Y-5M-1Y-0B	X	
Rawal-87 (V-8305)	MAYA-MON "S" XKVZ-TRM CM 44083-N-2Y-2M-1Y-1M-1Y-2M-0Y	X	
Khyber-87 (PR-12)	LIRA "S" CM 43903-H-4Y-1M-1Y-3M-2Y-0B	X	
Shalimar-88 (V-83152)	Pb.81/HD 2182/Pb.81 Pb. 18618 A-3a-Oa		X
Punjnad-88 (V-6521)	K-4500.2/BJU "S" CM 40480-25Y-2M-1Y-3M-1Y-OB	X	
Hyderabad-88 (V-5001)	VEE 5 "S" CM 33027-F-15M-500Y-0M-87B-0Y	X	
Kohinoor		X	
Pirsabak 85		X	
Punjab 85		X	

N-banding: Root-tips were subsequently collected from the young actively growing individual plants of each entry and processed until the 0.1% aceto-carmine stage as done for C-banding. After squashing, the cover-glasses were removed and slides treated for 10 to 15 minutes in 45% acetic acid at 60°C (Endo & Gill, 1983). The slides were air dried overnight, following which the buffer and stain treatment was essentially similar to that of Gerlach (1977) except that a 2M buffer was used, treatment was at 87°C for 26 to 28 minutes accompanied by giemsa staining for 20 to 30 minutes in a 3% giemsa solution at 6.8 pH (Jewell & Mujeeb-Kazi, 1982). The 1B and 1B/1R N-banded identification was based upon diagnostic banding patterns as elucidated by Gerlach (1977), Mujeeb-Kazi (1982), Jewell & Mujeeb-Kazi (1983).

Results and Discussion

Triticum aestivum L. cultivars (2n=6x=42, AABBDD) when analyzed through conventional somatic cytological techniques show secondary constrictions on chromosomes 1B, 6B and 5D (Mujeeb-Kazi & Miranda, 1985). The resolution of the 5D constriction is

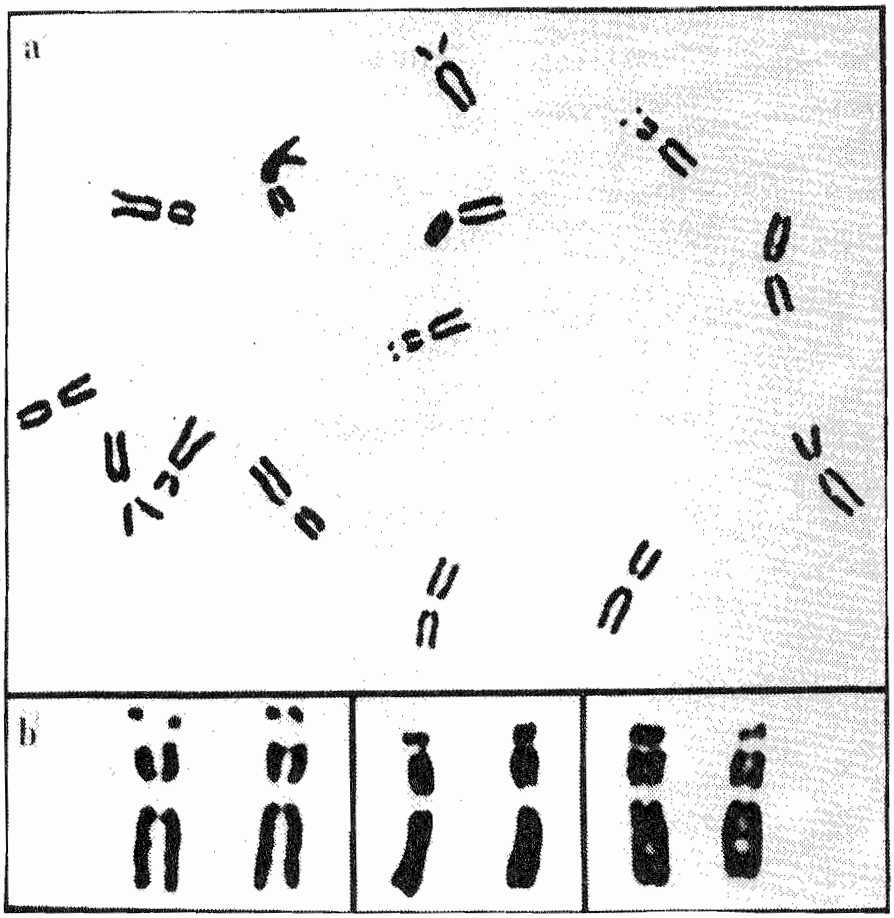

Fig. 1 (a) A somatic root-tip metaphase chromosome count of 2n=2x=14 for *Secale cereale* L. cv. Snoopy with the secondary constriction resolution of 1RS (b) Chromosome 1R pairs showing the secondary constriction site magnified in rye cultivars (left to right) Snoopy, Centeno Brazil and Blanco.

rather inconsistent. In the 1B/1R translocated wheat cultivars, almost always the secondary constriction of the 1RS segment does not get resolved (Merker, 1982); does so in invariably all euploid *secale cereale* (Fig. 1); hence these translocated wheat cultivars express only four satellites – a pair each for chromosomes 6B and 5D respectively (Merker, 1982; Mujeeb-Kazi & Miranda 1985; Rayburn & Mornhinweg, 1988).

The above generalized observations have remained consistent over the present varieties studied following somatic analysis by the 2 percent aceto-orcein staining technique as well as for a cytological standard check Chinese Spring and Pak-81 which are 1B and 1B/1R homozygous respectively. The 1B and 6B satellites were very frequently resolved in each somatic preparation from a root-tip, 5D satellites occasionally in some metaphases from several root-tips but in all cultivars (Fig. 2), and the 1RS secondary constriction site on the 1B/1R translocated chromosome never apparent in any of the metaphases viewed. Superior somatic preparations coupled with satellite resolution is not a consistent feature in every cytological laboratory. Thus chromosome banding applications add more precision to analytical accuracy.

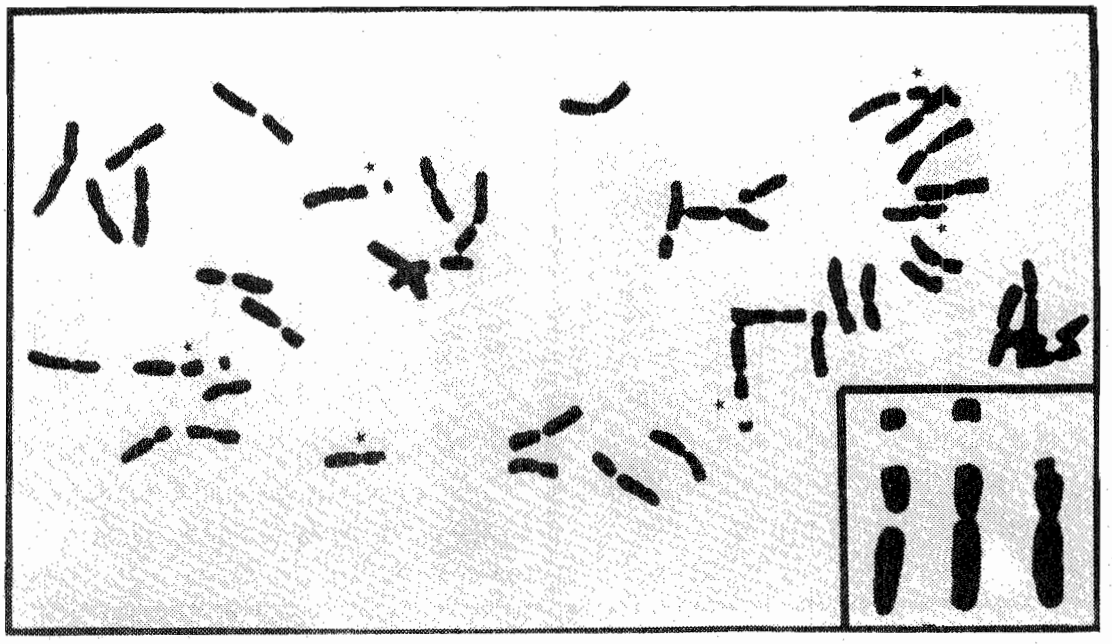

Fig. 2. *Triticum aestivum* (2n=6x=42) showing 6 satellited chromosomes (*) 1B, 6B and 5D. These are magnified and cropped as insert.

If the pedigree of the tester line is known, C-banding is seemingly more rapidly utilized (Fig. 3a). The C-banded 1B/1R chromosome is characterized by prominent banding sites on the long arm terminal end, at the centromeric region, terminal and sub-terminal sites on the short arm, with a fainter interstitial banded site on the long arm. The 1R chromosome of *S. cereale* cv. Imperial also has an identical C-banding positive pattern, thus in unknown pedigree situations 1R substitutions versus 1B/1R translocations have to be contended with. Utilizing N-banding provides unequivocal diagnosis of the 1B/1R translocation chromosome (Fig. 3b). Chromosome 1B has characteristic band positive sites on both the short and long arms whereas in the translocated chromosome the 1B long arm (1BL) maintains this band distribution with the short arm (1RS) contributed by rye being virtually clear of bands. Thus, in progenies that have unidentified pedigrees, N-banding would be a more appropriate diagnostic to exploit as it would eliminate misclassifications of 1R substitution or a 1B/1R translocation that may arise by the exclusive application of C-banding. The analytical strength of N-banding has also been reported by Rayburn & Mornhinweg (1988). By using C-banding on known pedigree material Cai & Liu (1989) were able to identify the wheat selection "79-4045" as being a 1B/1R translocation line. This was further substantiated by a test-cross with 'Chinese Spring' double-ditelosomic of chromosome 1B where at meiotic metaphase I the diagnostic configurations were a heteromorphic bivalent and a 1BS-telosomic univalent. C-banding analysis as above also led to identifying 1B/1R homozygotes in *T. turgidum* derivatives from *T. aestivum* cv. Veery "S" (1B/1R homozygous) /*T. turgidum* cv. Cando (1B homozygous) Friebe *et al.*, (1989).

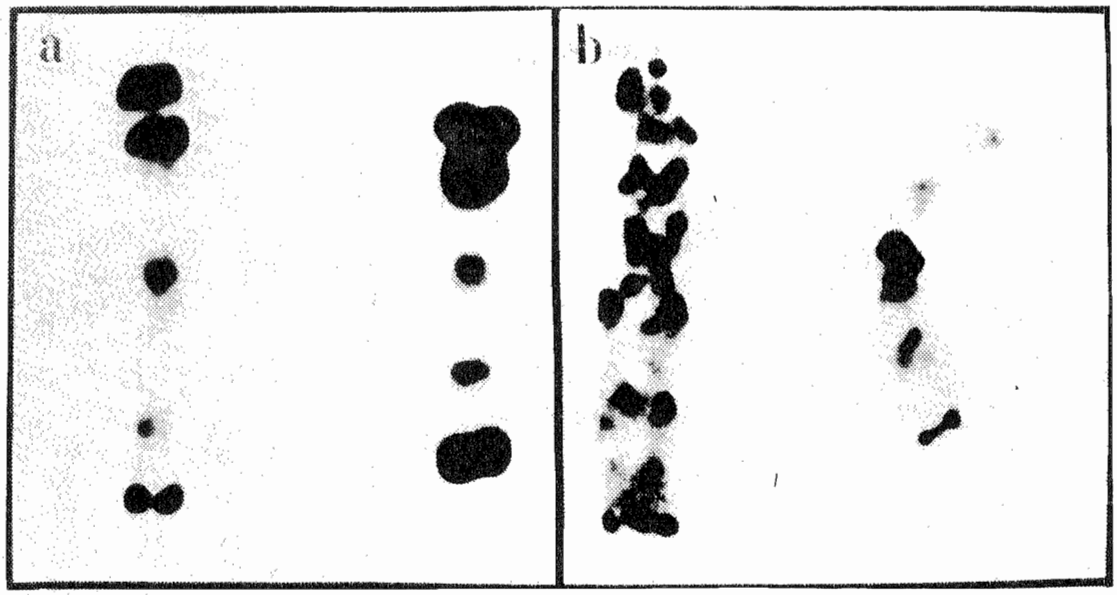

Fig. 3(a). *Triticum aestivum* 1B/1R chromosome C-banded (left) and the 1R C-banded chromosome of *Secale cereale* cv. Imperial on the right; (b) *T. aestivum* 1B chromosome N-banded (left) and the 1B/1R chromosome on the right N-banded. Note the 1RS arm devoid of banding sites. The 1B/1R chromosome is from Veery 3 or Genaro 81.

In the NUWYT trial analyzed by us the normal duration planting group of 14 entries plus a check, 42.8% of the lines (excluding the Pak-81, 1B/1R check) possessed the 1B/1R translocation homozygosity (Table 1). The 1B/1R percentage in the 11 test lines included in the short duration planting (Table 2) increased to 72.7% and upto at least 90% (Table 3) for the rainfed category, where 9 of the 10 test lines were uniform for 1B/1R. One entry had both 1B/1R or 1B homozygous plants (V-8203-S-1) that need to be seed purified further. Of the 10 varietal releases analyzed, 1B/1R types were at least 80%, Shalimar 88 was 1B homozygous with Chakwal 86 needing another analysis after a new seed stock is obtained, since it had a presence of both 1B/1R and 1B homozygous types (Table 4).

The influence of 1B/1R translocation is substantial (Tables 1 to 4). The 1RS segment has been contributed by Petkus rye and also that the resistant genes on this arm (McIntosh, 1983) have not held up their initial resistance reaction in many countries. It is then, in essence, a narrow genetic base that has become so widely distributed as evident from the germplasm analyzed here and in germplasm analyzed elsewhere (Mujeeb-Kazi *et al.*, 1990), that future research strategies need to diversify this variability. There apparently is tremendous merit of the translocated lines in that they have wide adaptability and stability of yield (Rajaram *et al.*, 1983). Whether there are specific genes giving a yield advantage needs critical documentation that shall require chromosome 1B isogenics to be produced for a 1B/1R translocated wheat. Such a genetic stock shall facilitate valid comparisons for the attributes that have been associated with the translocation chromosome. In general 1B/1R wheats tend to be slightly late in maturity, have advantageous biomass that presumably manifests itself into a high yield potential. These aspects are apparently re-

flected in the entries of the NUWYT trial; though the predominance of 1B/1R types in the short duration category does shift from the generalized normality of slight lateness, a shift of demonstrable practical advantage. Again, as a generality, the 1B/1R translocation wheat varieties express inferior bread baking quality, mainly dough stickiness and poor mixing tolerance (Dhaliwal *et al.*, 1987, 1988; Martin & Stewart, 1986; Moonen & Zeven 1984). Research efforts have attempted to reduce the IRS segment via homoeologous recombination (Koebner & Shepherd, 1985, 1986) whereas other researchers have provided data suggesting that presence of 1RS may not be so positively associated with dough stickiness and that the translocation wheats have capabilities of producing acceptable quality bread (Graybosh & Peterson, 1989; Pena *et al.*, 1990).

While these varied findings presented in this paper are encouraging, we must recognize the fact that the fortuitous success of 1A/1R and 1B/1R wheats is not the ideal mode of incorporating genetic diversity. Undoubtedly the most effective transfers would be subtle exchanges introduced via homoeologous chromosome pairing. The genetic potential that *S. cereale* alone may have to offer for wheat improvement is phenomenal and apparently should be exploited extensively by the breeders. We view the 1B/1R wheats as a motivation source for focussing upon incorporation of other rye characteristic into wheat.

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