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I. Research Notes

An induced mutant type sphaerococcoid in *T. durum*

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In the last years were obtained experimentally *sphaerococcum* type mutations in *Triticum aestivum* ssp. *vulgare*, which confirms the idea for mutation orgin of this species (now subspecies) from the hexaploid group of the genus *Triticum*—Swaminathan, Jagathesan and Chopra (1963), Makarova and Zoz (1965), Chavdarov and Djelepov (1968).

Mutations type sphaerococcoid were experimentally induced in the tetraploid group, namely in *Triticum durum* by Bozzini (1965) and in *Triticum dicoccum* by Gupta and Swaminathan (1967). In this contribution we like to inform of an induced mutant type sphaerococcoid of durum wheat.

Seeds of the variety Apulicum 233-II were irradiated with X-rays in doses of 10, 15 and 15 kr in 1964. Part of the seeds of M_2 were treated with EMS of 0.2 and 0.4% concentrations at 25°C during 24 hours. Immediately after the treatment and washing in running water, the seeds were sown in the field.

In the progeny of one of the plants from the variant 15 kr X-rays plus 0.2% EMS (in the second year after the treatment—1968) were found four plants simulating morphological features found in the hexaploid *Triticum sphaerococcum*. From the sown and germinated 20 seeds, 14 plants survived the winter of which 10 were normal (type durum) and four type sphaerococcoid. The established plants were considerably shorter than the normal ones which can seen from Table 1. Essential differences were observed in the form and arrangement of the leaves. The changed plants were with shorter, pointed and standing ones. The hairiness of the glumes were more pronounced but ears were shorter and more compact with smaller average number of spikelets. The mutant is characterised by hemispherical glume and strongly suppressed awns which was well de-

Table 1. Characteristics of type sphaerococcoid and type durum

Type	Tillering		Height of culm cm	Length of main ear cm	Number of spikelets in main ear	Number of grains in main ear	Average number of grains per ear	Average number of grains per plant	Weight of 1,000 kernels gr
	general	productive							
sphaerococcoid	2.75	2.75	60.00	6.75	17.75	38.95	35.57	103.75	32
durum (normal)	3.71	3.71	100.71	7.43	21.00	48.10	42.30	151.71	52

veloped in the initial variety. The grain was considerably smaller and spherical, the weight of 1,000 kernels was 32 g, and 52 g for the durum plants. Chromosome number was 28 for sphaerococcoid and normal forms. From Table 1 can also seen that all elements connected with the yield was lower in values for the mutant compared with durum plants. It should be noted that the fertility of the changed form was entirely normal, on the average 35.5 grains per ear, which does not correspond with the results obtained by BOZZINI, and BAGNARA 1965 with some of the mutants type sphaerococcoid.

The above described mutant induced in *Triticum durum* shows that the factor for *sphaerococcum* is not limited only in D genome (3D-XVI chromosome) but probably is found also in A or B genome. It appeared very interesting from both a practical and a theoretical point of view. It is considerably valuable with its spherical grain and with short culms resistant to lodging

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Relative amount of nuclear DNA in tetraploid wheats

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Triticum timopheevi is a species in which much interest of wheat cytogeneticists has arisen. Genome analysis, protein or enzyme analysis and microspectrophotometry of nuclear DNA content has been carried out by many workers, but origin of *T. timopheevi* remains still ambiguous.

TANAKA *et al.* (1968) identified two types of *T. araraticum*, No. 1 and No. 2, based on the morphological characters. According to them, No. 2 is cytogenetically more alike to

T. timopheevi than No. 1; the F_1 of the former with *T. timopheevi* is fertile, while that of the latter sterile.

The relative amount of nuclear DNA in tetraploid wheat measured by means of microspectrophotometry is given in Table 1. Among tetraploid wheat, Emmer (AABB) represented by three species including five varieties had the equal amount of nuclear DNA. While, two strains of *T. timopheevi* (AAGG) had the significantly less DNA than Emmer, that is the same result of REES and WALTERS (1965). Species or varieties with the same genome constitution have been proved to have the equal amount of nuclear DNA in polyploid wheat (REES and WALTERS 1965, NISHIKAWA and FURUTA 1968, 1969). In contrast to these previous findings, *T. araraticum* showed intraspecific difference in nuclear DNA content; namely *T. araraticum* No. 1 had higher amount of DNA than No. 2, the former being equal to Emmer and the latter to *T. timopheevi*. Since DNA values given in Table 1 were obtained from four separate sets of slides, another measurement was made so as to allow the direct comparison of DNA content among *T. durum reichenbachii*, *T. araraticum* No. 1 and No. 2, and *T. timopheevi* No. 1. On each slides of those varieties or strains to be compared were placed side by side in order to subject them to the same Feulgen staining condition. The result supported the original measurement given in Table 1.

The present result in relation to nuclear DNA content agrees with cytogenetical examination of this species by TANAKA *et al.* that *T. araraticum* No. 2 is closer to *T. timopheevi* than No. 1.

Table 1. DNA content per nucleus in tetraploid wheats (arbitrary unit)

Species (variety)	Genome	Mean±S.E.
T. dicoccoides		
spontaneo-nigrum	AABB	536.5±10.0
kotschyanum	〃	533.7± 6.6
T. dicoccum		
Vernal	〃	528.4± 7.7
T. durum		
reichenbachii	〃	525.2± 6.9
LD 222	〃	536.7± 7.3
T. araraticum		
No. 1	AAGG	522.3± 6.9
No. 2	〃	480.4± 8.8
T. timopheevi		
No. 1	〃	477.2± 6.5
No. 2	〃	489.3± 6.0

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Frequency and spectrum of induced chlorophyll mutations in *Triticum dicoccum*

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Dry seeds of eight hybrid varietal selections of *T. dicoccum* having 10~11% moisture content, were exposed to different dosages of gamma rays (10 kr, 15 kr and 20 kr). Seeds of two selections, i.e. H.W. 85 and H.W. 84 were treated with EMS also. The studies were undertaken in order to investigate (a) the relation of radiation effects to dose rate, (b) frequency and spectrum of induced chlorophyll mutations with gamma rays and EMS treatments and (c) cytogenetical implications of lethality of chlorophyll deficient plants. The results obtained indicate that in most of the cases there is linear correlation between

Table 1. M_1 fertility and percentage of chlorophyll mutaions in M_2

Material	Treatment	M_1 fertility per spikelet (mean values)	Total of chlorophyll deficient mutants	Total population	% of chlorophyll mutations
H.W. 85	Control	1.67	Nil	2419	—
	20 krads	1.27	13	1120	1.16
	15 〃	1.46	8	2062	0.38
	10 〃	1.38	16	3269	0.48
	EMS 0.2%	1.71	2	620	0.32
H.W. 84	Control	1.71	Nil	2651	—
	20 krads	0.95	12	375	3.2
	15 〃	1.81	8	785	1.01
	10 〃	1.38	24	2200	1.09
	EMS 0.2%	1.28	2	321	0.62
H.W. 77	Control	1.46	Nil	2310	—
	15 krads	1.00	23	1190	1.92
	10 〃	1.39	7	1898	0.37
H.W. 62	Control	1.60	Nil	2114	—
	20 krads	1.38	71	2548	2.70
	15 〃	1.32	51	2964	1.70
	10 〃	1.38	7	2184	0.32
H.W. 22	Control	1.88	Nil	1978	—
	20 krads	1.67	14	2054	0.67
	15 〃	1.36	10	2394	0.41
	10 〃	1.61	7	1950	0.35

1) Communicated from Biology Department, Brookhaven National Laboratory, Upton, New York 11973, U.S.A.

(Continued)

H. 201-6	Control	1.80	Nil	2368	—
	20 krads	1.26	23	1170	1.90
	15 〃	1.43	23	1534	1.40
H. 201-4	Control	1.75	Nil	2150	—
	20 krads	*	24	962	2.40
	15 〃	*	22	1508	1.40
	10 〃	1.32	11	1378	0.79
H. 201-3	Control	1.70	Nil	1758	—
	20 krads	*	18	549	3.20
	15 〃	*	13	1482	0.8
	10 〃	1.27	15	2028	0.73

*Mean fertility per spikelet could not be taken.

Table 2. Spectrum of chlorophyll mutations

Material	Treatment	Albina	Viridis	Xantha	Chlorina	Striata
H.W. 85	20 krads	8 (0.71)	—	5 (0.44)	—	—
	15 〃	4 (0.19)	—	2 (0.09)	2 (0.09)	—
	10 〃	7 (0.21)	4 (0.12)	5 (0.15)	—	—
	EMS 0.2%	2 (0.32)	—	—	—	—
H.W. 84	20 krads	12 (3.20)	—	—	—	—
	15 〃	3 (0.38)	2 (0.25)	1 (0.12)	2 (0.25)	—
	10 〃	7 (0.31)	6 (0.27)	11 (0.50)	—	—
	EMS 0.2%	1 (0.31)	1 (0.31)	—	—	—
H.W. 77	15 krads	13 (1.09)	7 (0.58)	3 (0.25)	—	—
	10 〃	4 (0.21)	1 (0.05)	2 (0.10)	—	—
H.W. 62	20 〃	56 (2.19)	—	5 (0.19)	6 (0.23)	4 (0.15)
	15 〃	33 (1.11)	15 (0.50)	3 (0.10)	—	—
	10 〃	4 (0.18)	—	2 (0.09)	—	1 (0.04)
H.W. 22	20 〃	7 (0.34)	—	7 (0.34)	—	—
	15 〃	5 (0.20)	3 (0.12)	1 (0.04)	1 (0.04)	—
	10 〃	1 (0.05)	—	1 (0.05)	4 (0.08)	1 (0.05)
H. 201-6	20 〃	21 (1.79)	1 (0.08)	—	1 (0.08)	—
	15 〃	18 (1.17)	1 (0.06)	4 (0.26)	—	—
	10 〃	2 (0.16)	—	2 (0.16)	2 (0.16)	—
H. 201-4	20 〃	7 (1.76)	3 (0.31)	—	4 (0.41)	—
	15 〃	18 (1.19)	—	2 (0.13)	2 (0.13)	—
	10 〃	10 (0.72)	1 (0.07)	—	—	—
H. 201-3	20 〃	18 (3.27)	—	—	—	—
	15 〃	11 (0.74)	—	2 (0.13)	—	—
	10 〃	9 (0.44)	—	6 (0.29)	—	—

F.N. : Figure in bracket indicates the percentage.

dose rate and chlorophyll mutation percentage (Table 1). Progenies giving higher sterility in M_1 gave maximum number of chlorophyll mutants in M_2 (Table 1). Spectrum of chlorophyll mutation is wide in gamma irradiated progeny and albina type was a predominant class in all the treatments, irrespective of the varietal genotype involved (Table 2). Cytological observations confirm that the albina type (white) owe their origin to gross chromosomal rearrangement.

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Telocentric mapping of a second gene for grass-clump dwarfism

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McMILLAN (1937) explained grass-clump dwarfism on the basis of interaction between four genes, two of which were completely linked in repulsion. HERMSEN (1963) proposed a three gene system which could adequately explain McMILLAN's results. He designated the genes *D1*, *D2* and *D3*. The results of HURD and McGINNIS (1958), and HERMSEN (1963) showed that chromosomes 2D, 2B and 4B, respectively, carry these genes. McINTOSH and BAKER (1968) indicated that *D1* is located 3.2 cross-over units to the right of the *2D* centromere. This report describes a preliminary study involving telocentric mapping of *D2* and indicates the locus order for centromere, *D2* and *Sr9b* on 2B.

Kenya W744 (number refers to the Sydney University Wheat Accession Register), *d1 D2 d3*, produces F_1 dwarfs in crosses with Gabo, *D1 d2 D3*. In a preliminary experiment a (Chinese Spring mono-2B × Kenya^3) monosomic plant was pollinated with Gabo. Somatic counts on ten F_1 plants showed that nine possessed 41 and one, 42 chromosomes. The phenotype of the nine monosomic plants was normal and that of the disomic plant was dwarf.

The Kenya parent was then used to pollinate a Chinese Spring stock (*d1 d2 d3*) ditelosomic for the right arm of chromosome 2B. These F_1s were used as pollen parents in test-crosses to Gabo. Observations were made on the test-cross seedlings to determine their chromosome constitution by root tip counts, the presence of the gene *Sr9b* conditioning stem rust resistance known to be on chromosome 2B and for dwarf versus normal habit. Kenya carries *Sr15* in addition to *Sr9b* and Gabo possesses *Sr11*. Stem rust strain 34–2,4,5 (culture 64231) was used to detect *Sr9b*. This strain is virulent on plants with *Sr11* and glasshouse temperatures at the time of study were sufficiently high to prevent the operation of *Sr15*.

On the basis of test-cross results, which are presented below (Table 1), the most likely gene order is shown in Figure 1.

Table 1. Test-cross results

Chromosome constitution	Phenotype	Type of chromosome	Number of individuals
42-entire	*Sr9b D2**	Parental	9
	*sr9b D2**	D.C.O.-regions I & II	2
	Sr9b d2+	S.C.O.-region II	10
	sr9b d2+	S.C.O.-region I	3
42-1 telo	*Sr9b D2**	S.C.O.-region I	1
	*sr9b D2**	S.C.O.-region II	2
	Sr9b d2+	D.C.O.-regions I & II	—
	sr9b d2+	Parental	6
Total			33

* : grass-clump, + : normal habit.

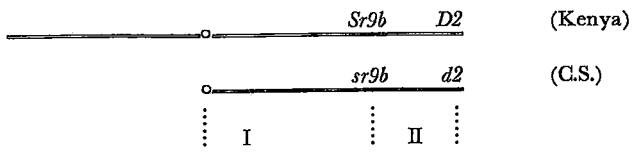

Fig. 1. Representation of gene order in cross C.S. ditelo-2B×Kenya

Recombination estimates from the data are:

Centromere	—	*Sr9b*	18.2%	(6/33)
Centromere	—	*D2*	48.5%	(16/33)
Sr9b	—	*D2*	42.2%	(14/33)

Sears and Loegering (1968) estimated recombination between the centromere and *Sr9a* to be 10.6% which at P=0.05 does not differ from the value of 18.2±6.7% obtained in the current investigations. It appears that *D2* is located on the right arm considerably distal to *Sr9b*. As Sears and Loegering showed that *Sr16* was distal to, and independent of *Sr9a*, linkage between *Sr16* and *D2* is probable.

McIntosh and Baker (1968) located *D2* on chromosome 2D close to the centromere. Since *D2* appears to be independent of the *2B* centromere it appears unlikely that these genes represent mutations at "homoeologous" loci.

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Tom Pouce Blanc and Tom Pouce Barbu Rogue, two *Triticum aestivum* sources of very short straw

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Introduction

Two varieties named Tom Pouce Blanc (TPB) and Tom Pouce Barbu Rouge (TPBR) occur in the I.v.P.-wheat collection. They were received by Dr. J.G.Th. HERMSEN from Dr. P. MARTIN, Vilmorin-Andrieux, Massy-Palaiseau, France in 1960. The main feature of these varieties is their very short straw. This character could be used for breeding short-straw wheat cultivars.

The varieties should not be confused with a Tom Pouce variety mentioned by the N.I.A.B. (1963) and which came from Maison F. Lepeuple in Bersée, France.

General description

A picture of both varieties is given in a figure on the cover, while some of the main characteristics are given in Table 1. Although they are winter wheats they can be grown as transitory wheats. Their big flag leaves are very prominent and this characteristic could also be introduced in modern cultivars.

Table 1. Some main characteristics of two varieties

	Botanical variety	Growth habit	Mean height (cm)	1000-grain weight (g)
TPB	*lutescens*	winter	35.1	23.3
TPBR	*ferrugineum*	〃	40.6	30.4

Average length of Felix=59.7 cm and of Manella=58.7 cm. The plants were space-planted (25 interrow, about 15 cm interplant).

The ears are of normal length. A normal ear of TPB had 24 spikelets and 41 grains. In general these grains are shrivelled. Seed emergence is low.

Some outcrossing occurs but any illegitimate F_1 plant is easily recognized by its length.

The poor seed emergence and the outcrossing may result from the shortness of the plants. The grains developing in the ears can easily be infected by *Septoria* spores in rain splash, while pollen grains may drop from surrounding tall plants into the florets.

Neither variety carries a dominant gene for hybrid necrosis (ZEVEN 1968) so no necrotic F_1's plants will occur.

Pedigree

According to Dr. P. MARTIN (1960) TPB was found in the old English variety Hybrid

Carter G. TPBR probably originated from outcrossing in TPB. The origin of Hybrid Carter G is not known to me.

Inheritance of short-straw character

Crosses were made between these two varieties and the winter wheats Felix, Manella, Sylvia and the spring wheat Orca. The mean length of the F_1-plants appeared to approximate the mid-parent value. The F_2 segregated significantly into 1(short): 2 (intermediate): 1 (tall). From these observations it is concluded that the short-straw character of the Tom Pouce varieties is conditioned by a single semi-dominant gene.

Conclusion

The present trend of wheat breeding shows that many semi-dwarf varieties are produced. Some of these varieties prove quite productive.

Future varieties may be still shorter than the present one. If so, shortness of straw may be obtained from the Tom Pouce varieties. Besides, its big flag leaf may be important for productivity breeding since that part of the plant appears to play an essential part in grain weight (LUPTON 1966).

These varieties may be of importance as A-lines in hybrid wheat breeding. Because of their shortness a higher percentage of seed set may occur than in taller plants. The F_1 plants of avariety carrying the short straw gene of Tom Poucè and a modern variety may give a hybrid variety of a desired length. Its present susceptibility to *Septoria* is a disadvantage.

Summary

Two very short varieties are described. Shortness of straw is conditioned by a single semi-dominant gene. These varieties may prove valuable as a source of shortness of straw and such varieties may be used as parents in the hybrid wheat breeding.

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Identification of the double satellited chromosome of hexaploid wheat variety Pb. C591

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BHADURI and NATARAJAN (1956) worked out the karyotype of the hexaploid wheat variety Pb. C591 and observed that it possessed (1) one long pair of satellited chromosomes, sub-medianly constricted and (2) two pairs of sub-medianly constricted medium sized chromosomes with satellites. The first pair of satellited chromosomes was found to be unique to this variety. This pair had a doubly constricted sat.-segments, i.e. there was a chromatic segment intervening the achromatic sat.-thread of the satellited chromosomes. This note reports the identification of this double constricted satellited chromosome.

Root tip squashes of seeds derived from monosomic lines (2n=41) 1B, 6B and 5D of Pb. C591 were made and the somatic chromosome complement of the monosomic seed was studied. It was observed that in the aneuploid line 1B only one doubly constricted chromosome was present, whereas monosomic seeds of line 6B and 5D contained a pair of this chromosome. This chromosome is thus identified as 1B chromosome of the complement of Pb. C591.

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Pairing between the two arms of the same chromosome in nulli-5b haploid plants of Chinese Spring

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In the earlier report on the meiotic behaviour of nulli-5B haploid plants (UPADHYA and SWAMINATHAN 1967), an interesting observation was left out. It was observed that in 54% of the total 173 miocytes analysed from the two plants, a maximum of three chromosomes showed pairing between their two arms like an isochromosome (Fig. 1).

Since these two plants were isolated from the progeny of the cross between a single plant of mono-5B and rye, the meiotic preparations from 27- and 28-chromosome hybrids should have also shown the presence of up to three isochromosomes if the three chromosomes in nulli-5B haploid plants were to be isochromosomes. However, none of the 27- or 28-chromosome hybrids analysed showed the presence of any isochromosome. Hence, it is certain that the two nulli-5B hyploid plants did not have any isochromosome in their constitution.

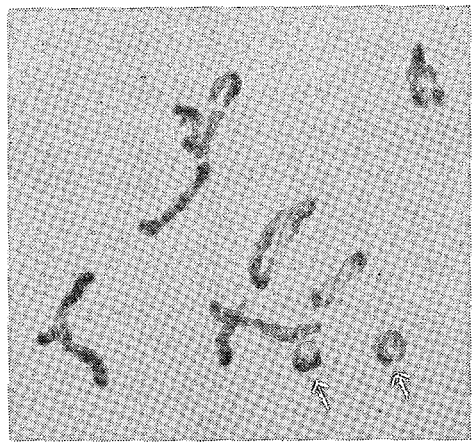

Fig. 1. Metaphase I of meiosis in nulli-5B haploid (2n=20), showing $4_{II}+12_{I}$. Two of the univalents show pairing between the two arms (marked by arrows).

The above observations thus show that in haploid condition, when the critical chromosome 5B is absent, there are at least three chromosomes which show pairing between their two arms. This would indicate a certain degree of homoeology between the two arms of these three chromosomes. However, these three chromosomes do not show similar behaviour in the 5B deficient 27-chromosome wheat-rye hybrids. It is possible that in 5B deficient 27-chromosome plants the presence of rye genome in some way modifies the effect of 5B deficiency realizable in the nulli-5B haploid plants.

It is, therefore, indicated that in Chinese Spring there are at least three chromosomes which carry certain degree of genetic duplication in their two arms. If this is true, then in future these observations would be of significance in genetic mapping of chromosomes in Chinese Spring, and in the interpretation of data on chromosome pairing utilizing telocentrics, specially in the absence of chromosome 5B.

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Effect on seed viability of wheat varieties at various maturity levels and moisture content

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Wheat production in Rajasthan sometimes becomes very risky due to sudden variation in temperature and other climatic conditions like hail storm and high wind velocity after

flowering. These hazards are very common in Rajasthan due to its geographical position and arid conditions. In order to save the crop or get higher yield or reduce the production cost it may be advantageous to harvest the crop early. No information is available on effect of harvesting the wheat crop at different stages of maturity in relation to the yield and viability of seeds. To acquire this knowledge present studies were taken-up to find out the effect on germination of wheat seeds with reference to different number of days to harvest after certain intervals from full flowering onwards.

An experiment was taken at the State Agriculture Research Farm, Durgapura, Rajasthan, during Rabi 1966~67, with seven recommended wheat varieties having different maturity periods and suitable for different tracts of this State. The varieties studied were C. 281, R.S. 31-1, N.P. 718, Sonora-64, S. 227, C. 591 and Lerma Rojo. C. 281 started earing in 64 days, while the varieties R.S. 31-1, N.P. 718 and Sonora-64 flowered after 68 days of sowing. The variety S. 227 flowered after 77 days from sowing and variety C. 591 and Lerma Rojo started earing after 80 days from the date of sowing.

Harvesting was started after 20 days of flowering and further on 25th, 32nd, 37th, 44th, 51st and finally on 59th days in all cases. In every harvest 50 earheads were collected. Each sample was hand threshed for a moisture-test and soon after the threshing, was divided in two lots - one was taken for an immediate moisture determination and another for drying at room temperature for 30 days. The average maximum and minimum temperatures during this period happened to be 30°C and 17.5°C respectively. In all cases the dried seed samples were tested for moisture content and were germinated between wet blotters in petridishes and in moist sand trays. The temperature was maintained at 20°C. Data on days to flower, days to harvest, moisture content and germination percentage in all the studied varieties were recorded and are given in Table 1.

From the results, it appeared that all the varieties if harvested at higher moisture percentage show a decline in germination percentage. As in wheat variety N.P. 718 at 45% moisture content the germination is 56% while the seed harvested at 27% moisture content, germination improved up to 86%. This type of moisture-germination relationship was observed in all the wheat varieties studied (Table 1).

The period of vegetative phase differed in different varieties. This was manifested in variety C. 281 in which the flowering took place after 64 days while in varieties R.S. 31-1, N.P. 718 and Sonora-64, the flowering took place 68 days from the date of sowing. The ears emerged in variety S. 227 after 77 days, while the varieties C. 591 and Lerma Rojo flowered after 80 days from the date of sowing. The period taken later for reproduction leading to maturity was approximately the same in all the varieties. SPRAGUE (1936) collected corn seeds after 10 and 25 days from pollination and dried for 12 days at room temperature after which the germination was recorded 50% and 90% respectively. ROBERTSON and CURTIS (1967) collected winter wheat seeds after 18, 21, 27, 30 and 36

days from anthesis and air dried them. The germination were found 38%, 56%, 60%, 59% and 78% respectively.

Table 1. Germination percentage in wheat varieties at different stages of maturity and moisture content

Name of wheat variety	Days to harvesting after flowering	Moisture % of freshly harvested seed	Germination % after 1 month long dried seed at room temp.	Germination difference with previous reading of column	% reduction in the germination
1. C. 281	20	43	62	—	35
	25	38	67	5	30
(Flowering in 64 days)	32	33	81	14	16
	37	26	88	7	8
	44	23	92	4	4
	51	18	95	3	1
	59	12	96	1	—
2. R.S. 31-1	20	44	61	—	36
	25	39	69	8	27
(Flowering in 68 days)	32	33	76	7	20
	37	27	85	8	12
	44	23	91	7	4
	51	17	95	4	—
	59	12	95	—	—
3. N.P. 718	20	45	56	—	40
	25	37	69	13	27
(Flowering in 68 days)	32	34	77	8	18
	37	27	86	9	9
	44	23	92	6	2
	51	17	94	2	—
	59	12	94	—	—
4. Somora-64	20	47	59	—	38
	25	39	66	7	30
(Flowering in 68 days)	32	32	76	10	20
	37	28	81	5	15
	44	23	89	8	6
	51	17	93	4	2
	59	14	95	2	—
5. S. 227	20	46	57	—	39
	25	39	66	9	30
(Flowering in 77 days)	32	33	78	12	17
	37	27	87	9	7
	44	22	91	4	3
	51	16	93	2	1
	59	13	94	1	—

(continued)

6. C. 591	20	47	53	—	44
	25	38	62	9	34
(Flowering in 80 days)	32	34	73	11	22
	37	27	85	12	10
	44	22	89	4	5
	51	18	92	3	2
	59	13	94	2	—
7. Lerma Rojo	20	46	57	—	40
	25	39	61	4	36
(Flowering in 80 days)	32	34	73	12	24
	37	27	85	12	11
	44	23	93	8	3
	51	17	95	2	1
	59	13	96	1	—

To permit direct comparison between early and fully matured harvest effects the percentage-reduction in germination was calculated by the Abbot formula $[(x-y)/x] \times 100$, where x represents the percentage emergence of fully matured seed, y represents the percentage emergence of immature seed. According to seed testing rules as prescribed by I.S.T.A. recommendations the minimum germination percentage approved is fixed at 85% in case of wheat crop. While this germination percentage was recorded in above mentioned varieties harvested at 27% moisture. This moisture percentage was found in wheat varieties under reference on 37 days after flowering except variety Sonora-64 where this percentage of moisture is attained on 44th days after flowering (Table 1).

Thus the wheat varieties which are conventionally harvested at full ripe on or after 59 days of flowering may be harvested even earlier without any detriment to the standard germination capacity of the seed. This finding is useful especially in view of the determination of a correct stage of harvesting. Thus saving the growers from the anxiety of waiting for a long time till they become quite sure of the desirable stage of the crop for the purpose of its harvesting. This also suggests that if in the event of a bad weather a variety can be harvested and if so with what consequences.

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Source of fertility-restoring genes for *Ae. ovata* and *T. timopheevi* cytoplasms[1)]

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Hermaphroditic nature of wheat was reduced to unisex by the discovery of male-sterility inducing cytoplasms (KIHARA 1953, FUKASAWA 1959, WILSON and Ross 1962 and MURAMATSU 1965), and later on clarification of mechanism of fertility-restoration as well as availability of some effective fertility restorers made the sublime objective of exploiting heterosis in wheat more distinct. But the problem of restoration even still exists; the restorers at hand are effective for certain varieties only, and there is also high degree of fluctuation in their effectiveness in different climatic zones.

In this experiment 92 varieties or strains (73 *T. aestivum*, one *T. compactum*, one *T. spelta*, one *T. vavilovii*, four *T. sphaerococcum* and 12 synthesized 6x wheat strains) were crossed to completely male-sterile lines of common wheat possessing *Ae. ovata* or *T. timopheevi*

Table 1. Seed fertilities of F_1 hybrids between hexaploid wheat varieties (or strains) and cytoplasmically male-sterile lines having *Ae. ovata* or *T. timopheevi* cytoplasm

Species and variety	Strain	F_1 seed fertilities (%)	
		ovata cytoplasm	*timopheevi* cytoplasm
T. aestivum erythrospermum		0.0	0.0
〃	P168	93.3	0.0
〃	P169	0.1	0.0
〃	P170	67.5	0.0
〃	P171	50.0	0.0
〃	P172	0.0	0.0
〃	P173	44.0	0.0
〃	P174	76.0	0.0
〃	Chinese Spring	0.0	0.0
〃 (BMUK collection)	3769	0.0	0.7
〃 〃	3770	0.0	3.4
〃 〃	3801	0.0	12.6
〃 〃	3830	2.2	0.0
〃 〃	3841	0.3	0.0
〃 〃	3845	1.5	0.0
〃 (58 strains of BMUK collections)		0.0	0.0
T. compactum	No. 44	0.0	0.0
T. spelta duhamelianum		0.0	98.5
T. vavilovii vaneum		0.0	0.0
T. sphaerococcum (four strains)		0.0	0.0

1) This work has been supported by a Grant-in-aid from the Ministry of Agriculture, Japan.

Table 2. Seed fertilities of F_1 hybrids between synthesized hexaploid wheat and cytoplasmically male-sterile lines having *Ae. ovata* or *T. timopheevi* cytoplasm

Strain	Origin	F_1s seed fertilities (%)	
		ovata cytoplasm	*timopheevi* cytoplasm
ABD-1	*T. dicoccoides spont.* × *Ae. squarrosa typica* No. 2	53.6	0.0
ABD-9	*T. dicoccoides spont.* × *Ae. squarrosa strangulata*	0.0	0.0
ABD-11	*T. carthlicum* × *Ae. squarrosa strangulata*	0.0	0.0
ABD-13	*T. dicoccum* Vernal × *Ae. squarrosa strangulata*	?	0.0
ABD-14	*T. durum* Gulab × *Ae. squarrosa strangulata*	0.0	0.0
ABD-16	*T. durum* Gulab × *Ae. squarrosa meyeri*	76.8	0.0
ABD-22	*T. carthlicum* × *Ae. squarrosa meyeri*	?	0.0
ABD-23	*T. orientale* × *Ae. squarrosa strangulata*	0.0	0.0
ABD-Vernal	*T. dicoccum* Vernal × *Ae. squarrosa typica*	0.0	0.0
ABD-Golden Ball	*T. durum* Golden Ball × *Ae. squarrosa typica*	9.2	0.0
ABD-Carleton	*T. durum* Carleton × *Ae. squarrosa typica*	0.0	3.0
ABD-Pentad	*T. durum* Pentad × *Ae. squarrosa typica*	0.0	–

? : Seed fertility could not be estimated as all the F_1 plants were dwarf and did not head.
– : Seed fertility unknown.

cytoplasms, estimation of selfed seed fertility (%) in the F_1 gave the account for the presence of fertility-restoring genes.

Fertility-restorers for *Ae. ovata* cytoplasm: Selfed seed fertility of F_1 hybrids between male sterile wheat and various pollen parents is given in Tables 1 and 2. Out of 73 *T. aestivum* varieties or strains tested for *Ae. ovata* cytoplasm, only nine strains, namely, P168 (93.3%), P169 (0.1%), P170 (67.5%), P171 (50.0%), P173 (44.0%), P174 (76.0%), BMUK nos. 3830 (2.2%), 3841 (0.3%), and 3844 (1.5%) restored male fertility in various degrees as shown in parentheses. Out of these, P168, P169, P170, P171, P173 and P174 are 6x derivatives from the cross between *Ae. caudata* and *T. aestivum* var. *erythrospermum*. P168 and P174 are known to carry a pair of a *caudata* chromosome C-sat-2, besides 20 pairs of wheat chromosomes (KIHARA 1959). All these derivative strains except P169 seem to have received restoring gene(s) from *Ae. caudata*, as *T. aestivum* var. *erythrospermum* with *Ae. ovata* cytoplasm is completely male sterile. None of the other species, i.e., *T. compactum*, *T. spelta*, *T. sphaerococcum* and *T. vavilovii* was found to possess dominant restoring genes, since all the F_1 hybrids were completely sterile.

Among the synthesized wheats (rf. Table 2), the seed fertilities of ABD-13 and ABD-22 could not be estimated as all the F_1 plants remained dwarf throughout the growing season and did not head. ABD-1, ABD-16 and ABD-Golden Ball restored fertility up

to 53.6%, 76.8% and 9.2% respectively, in the F_1s. Though ABD-1 and ABD-9 have the same emmer parent, only the former restored fertility. Therefore, the restoring gene (s) of ABD-1 is assumed to have been derived from its *squarrosa* parent (*Ae. squarrosa* var. *typica* strain No. 1). Similarly, ABD-14 and ABD-16 have the same emmer parent, and only the later had restoring gene(s). In this line, too, the gene(s) seems to have been derived from *Ae. squarrosa* parent.

Fertility-restores for *T. timopheevi* cytoplasm: Out of 73 *T. aestivum* varieties or strains tested for *T. timopheevi* cytoplasm, only three, namely, BMUK Nos. 3769 and 3770 of Egyptian origin and BMUK No. 3801 from Turkey were found to possess very weak restoring gene(s), because their F_1 hybrids restored some fertility (0.7, 3.4 and 12.6% respectively), all the rest gave completely male-sterile F_1 hybrids (Table 1). In the other 6x species, only *T. spelta* var. *duhamelianum* was found to carry restoring gene and exhibited very high seed fertility (98.5%) in the F_1.

Among the 12 synthesized wheat strains tested (rf. Table 2), only ABD-Carleton was found to carry some weak restoring gene(s). KIHARA and TSUNEWAKI (1967) reported that *T. dicoccoides* var. *spontaneonigrum*, *T. carthlicum* and many others carry some restoring genes to *T. timopheevi* cytoplasm. On the other hand ABD-1 and other synthesized wheats did not behave as a restorer. MAAN and LUCKEN (1968) showed that *T. aestivum* Chinese Spring with *T. timopheevi* cytoplasm became completely male sterile, while its mono-7D restores some fertility. All these facts indicate that D genome in common wheat as well as in *Ae. squarrosa* carries some inhibitor to fertility restoration.

It is interesting to note that none of the 92 varieties or strains of 6x wheats tested for *Ae. ovata* and *T. timopheevi* cytoplasms was found to carry restoring genes in common for these cytoplasms. The restorers, which induced partial or complete fertility in *Ae. ovata* cytoplasm, did not function in *T. timopheevi* cytoplasms and, similarly, the strains, which induced complete or partial fertility in *T. timopheevi* cytoplasm, did not show any sign of fertility-restoration in *Ae. ovata* cytoplasm. The interaction between restorer and male-sterile cytoplasm is undoubtedly very specific.

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Chromosome pairing and fertility in some interspecific hybrids of synthesized hexaploid wheats

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In the past, interspecific hybrids among synthesized hexaploid wheats have not yet been studied, except ABD-2×ABD-3(TABUSHI 1965) and ABD-1×ABD-4 (TABUSHI 1968).

Table 1. Frequency of chromosome pairing in F_1 hybrids between ABD-1 and other synthesized hexaploid wheats or *T.v.e.*, a common wheat

Chromosome pairing	ABD-1	ABD-1♀ × ABD-4♂	ABD-4♀ × ABD-1♂	ABD-1♀ × ABD-5♂	ABD-1♀ × ABD-11♂	ABD-1♀ × *T.v.e.* ♂
21_{II}	188		1			5
$20_{II}+2_{I}$	82	2	4		2	$13\binom{(1)}{(2)}$*
$19_{II}+4_{I}$	47	8	$9\binom{(1)}{(1)}$*	2	6	$8\binom{(2)}{(2)}$*
$18_{II}+6_{I}$	12	15(1)	7		2	9(1)
$17_{II}+8_{I}$	1	14	24(1)	9	6	7
$16_{II}+10_{I}$		21	17(1)	8	3(1)	5
$15_{II}+12_{I}$		26	20	7	9	2
$14_{II}+14_{I}$		26(1)	26(2)	9	6	2
$13_{II}+16_{I}$		31(3)	24(2)	10	5	1
$12_{II}+18_{I}$		30	13	8(1)	3	
$11_{II}+20_{I}$		22	11	8(1)	3	
$10_{II}+22_{I}$		12	6	4	3	
$9_{II}+24_{I}$		9	1	2	2	
$8_{II}+26_{I}$		3	1	1	1	
$7_{II}+28_{I}$		4	2		1	
$6_{II}+30_{I}$		1		1		
Total	330	224(5)	$165\binom{(7)}{(1)}$*	69(2)	52(1)	$52\binom{(4)}{(4)}$*

F.N. : Numeral in ( ) or ( )* indicates number of PMC which contains trivalent or tetravalent.

In this paper the results of chromosome pairing and fertility of F_1 hybrids between ABD-1 or ABD-4 and various other synthesized hexaploid wheats or a common wheat species are described.

Chromosome pairing in F_1 hybrid between ABD-1 and ABD-4, ABD-5, ABD-11 or *T. vulgare erythrospermum* (*T.v.e.*) was poor as compared with that in ABD-1. Namely, the range of chromosome pairing was wide, and many univalents was found often in each PMC as shown in Table 1, e.g. $20_{II}+2_{I}$~$6_{II}+30_{I}$. On the other hand, chromosome pairing in F_1 between ABD-4 and ABD-9, ABD-10, ABD-12 or ABD-13 was somewhat poor, but F_1 between ABD-4 and ABD-11, ABD-16a, ABD-16b, ABD-21 or ABD-23 showed good chromosome pairing roughly similar as ABD-4 (Table 2). ABD-1, ABD-9, ABD-10 and ABD-12 are the progeny of the same cross combination of *T. dicoccoides spontaneonigrum* × *Ae. squarrosa*, though varieties or strains of *Ae. squarrosa* used in the crosses were different.

As given in Tables 1 and 2, F_1 hybrids between above mentioned synthesized hexaploid wheats (ABD-1, ABD-9, ABD-10 and ABD-12) and other synthesized hexaploid wheats showed almost always poor or somewhat poor chromosome pairing.

Table 2. Frequency of chromosome pairing in F_1 hybrids between ABD-4 and other synthesized hexaploid wheats (except ABD-1)

Chromosome pairing	ABD 4	ABD4♀ × ♂ABD9	ABD9♀ × ♂ABD4	ABD4♀ × ♂ABD10	ABD4♀ × ♂ABD11	ABD4♀ × ♂ABD12	ABD4♀ × ♂ABD13	ABD4♀ × ♂ABD16a	ABD4♀ × ♂ABD16b	ABD4♀ × ♂ABD21	ABD4♀ × ♂ABD23
21_{II}	275	9	1	65	50	8	43	72	137	118	54
$20_{II}+2_{I}$	103	43 (4) (1)*	6	49(1)	9	15	17	22	34	25	38
$19_{II}+4_{I}$	18	41 (1) (2)*	9	35	2	13(1)	15	7	7	8	21
$18_{II}+6_{I}$	2	26(1)	4	16		10(2)	15	1	3	1	13
$17_{II}+8_{I}$		18	7	5		4	9		1		4
$16_{II}+10_{I}$		5	4	2		6(3)	6				
$15_{II}+12_{I}$		6	1				5				
$14_{II}+14_{I}$		1					1				
$13_{II}+16_{I}$			1								
$12_{II}+18_{I}$											
$11_{II}+20_{I}$											
$10_{II}+22_{I}$											
$9_{II}+24_{I}$											
$8_{II}+26_{I}$											
$7_{II}+28_{I}$											
$6_{II}+30_{I}$											
Total	398	149 (5) (3)*	33	127(1)	61	56(6)	111	102	182	152	130

F.N. : Numeral in ( ) or ( )* indicates number of PMC which contains trivalent or tetravalent.

Table 3. Pollen fertility in F_1 hybrids between ABD-1 and other synthesized hexaploid wheats or *T.v.e.*, a common wheat

Combination	No. of plants	Pollen fertility (%)		Combination	No. of plants	Seed fertility (%)	
		range	mean			range	mean
ABD-1	8	66.2～89.2	79.8	ABD-1♀ × ABD-11♂	5	27.6～74.4	51.0
ABD-1♀ × ABD-4♂	10	1.8～31.0	12.8	ABD-1♀ × *T.v.e.*♂	5	21.6～44.4	38.4
ABD-4♀ × ABD-1♂	20	1.8～35.2	16.7	*T.v.e.*♀ × ABD-1♂	2	7.6～19.6	8.6
ABD-1♀ × ABD-5♂	8	1.6～25.0	11.1				

Table 4. Pollen fertility in F_1 hybrids between ABD-4 and other synthesized hexaploid wheats

Combination	No. of plants	Pollen fertility (%)		Combination	No. of plants	Pollen fertility (%)	
		range	mean			range	mean
ABD-4	11	55.6～91.4	77.3	ABD-4♀ × ABD-13♂	5	62.8～77.7	71.2
ABD-4♀ × ABD-9♂	4	10.8～57.4	43.4	ABD-4♀ × ABD-16a♂	4	45.2～70.0	58.7
ABD-9♀ × ABD-4♂	2	56.4～59.4	57.9	ABD-4♀ × ABD-16b♂	7	50.0～82.4	72.9
ABD-4♀ × ABD-10♂	4	52.2～88.0	68.5	ABD-4♀ × ABD-21♂	8	85.2～95.0	90.7
ABD-4♀ × ABD-11♂	7	80.1～91.6	86.5	ABD-4♀ × ABD-23♂	5	75.8～83.8	79.4
ABD-4♀ × ABD-12♂	7	4.4～70.0	44.1				

Table 5. Seed fertility in F_1 hybrids between ABD-1 and other synthesized hexaploid wheats or *T.v.e.*, a common wheat

Combination	No. of plants	Seed fertility			
		self (%)		free (%)	
		range	mean	range	mean
ABD-1	7	31.9～91.7	73.5	40.9～95.0	67.4
ABD-1♀ × ABD-4♂	10	0.0～17.8	4.6	3.2～23.3	11.8
ABD-4♀ × ABD-1♂	18	0.0～34.6	4.7	0.0～63.3	24.0
ABD-1♀ × ABD-5♂	8	0.0～ 6.3	1.6	0.0～21.9	13.6
ABD-1♀ × ABD-11♂	3	31.3～71.4	46.1	42.9～76.7	62.8
ABD-1♀ × *T.v.e.*♂	5	0.0～15.4	10.6	3.6～41.5	17.4
T.v.e.♀ × ABD-1♂	2	6.1～10.7	8.4	3.1～22.8	13.0

In all the F_1 hybrids involving ABD-1 except ABD-1(♀)×ABD-11(♂), namely ABD-1(♀)×ABD-4(♂) and its reciprocal, ABD-1(♀)×ABD-5(♂) and ABD-1(♀)× *T.v.e.*(♂), showed poor pollen fertility (Tables 3 and 4) and seed fertility (Tables 5 and 6). F_1 hybrids ABD-4(♀)×ABD-11(♂), ABD-4(♀)×ABD-16b(♂), ABD-4(♀)×ABD-21(♂) and ABD-4(♀)×ABD-23(♂) showed good fertility, but ABD-4(♀)×ABD-9(♂) and its reciprocal, ABD-4(♀)×ABD-10(♂), ABD-4(♀)×ABD-12(♂), ABD-4(♀)×ABD-13(♂) and ABD-4(♀)×ABD-16a (♂) showed poor or somewhat poor fertility.

Table 6. Seed fertility in F_1 hybrids between ABD-4 and other synthesized hexaploid wheats

Combination	No. of plants	Seed fertility			
		self (%)		free (%)	
		range	mean	range	mean
ABD-4	11	25.0～94.7	65.8	11.5～100.0	64.3
ABD-4♀ × ABD-9♂	4	9.8～30.0	20.6	57.1～71.4	63.0
ABD-9♀ × ABD-4♂	3	44.1～63.9	54.8	40.6～67.9	55.2
ABD-4♀ × ABD-10♂	4	46.9～75.0	61.3	50.0～99.9	80.2
ABD-4♀ × ABD-11♂	7	47.1～75.0	62.5	82.5～97.2	89.6
ABD-4♀ × ABD-12♂	5	22.7～91.2	55.2	50.0～94.1	77.8
ABD-4♀ × ABD-13♂	5	31.6～91.7	57.8	58.8～97.4	76.6
ABD-4♀ × ABD-16a♂	4	65.6～86.1	77.1	88.2～97.1	93.6
ABD-4♀ × ABD-16b♂	7	31.3～88.2	73.4	71.1～97.2	85.7
ABD-4♀ × ABD-21♂	9	55.9～94.4	74.4	79.4～90.0	83.0
ABD-4♀ × ABD-23♂	3	60.0～91.7	79.0	92.1～97.2	94.8

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Microsporogenesis in alloplasmic rye

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LEIN (1948～49) named alloplasmic rye those plants whose cells have "wheat" cytoplasm and "rye" nucleus (chromosomes). Later SASAKI (1956) obtained alloplasmic rye too.

In 1967, the author (LACADENA 1969) obtained two plants of alloplasmic rye (namely, CAL-1 and CAL-2) of the type *Triticum durum—Secale cereale* whose pedigree was [F_3 Amph. (*T. durum* × *S. cereale*)] × *S. cereale*[6]. Observations on microsporogenesis were made in both plants. Meiosis of pollen mother cells appeared to be quite normal until the formation of tetrads. Nevertheless, in the young pollen cells of the CAL-1 plant asynchronous cycles of condensation and replication of the chromatids were observed. The young microsporocytes showed a gradual chromatid condensation cycle which, like an unaccomplished mitotic process (interphase-prophase-metaphase), brought about young pollen cells with 7 single metaphase-like chromatids (see figure). Sometimes nuclei belonging to the same tetrad showed different "mitotic" stages: interphase, prophase or prometaphase. It was remarkable the high degree of uncoiling of the centromere region observed in the metaphase-like young microsporocytes: the two fully condensed arms of the chromatids were connected by an apparently single chromatic thread. It seems reasonable to attribute the asynchrony

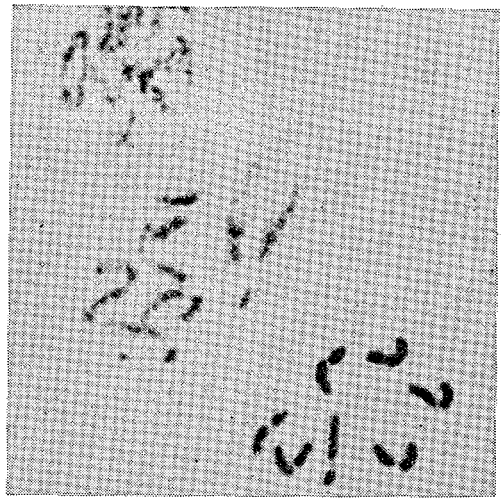

Fig. 1. Microphotograph showing the asynchrony between the condensation and replication cycles of chromatids in alloplasmic rye (plant CAL-1).

of the condensation and replication cycles of chromatids to the peculiar cell constitution of this plant, namely, alloplasmy.

However, in spite of the anomaly indicated, the metaphases and anaphases of the first pollen mitosis appeared to be quite normal, the metaphasic chromosomes having a duoble-chromatid constitution.

The plant CAL-1, which is being referred to, had both female and male gametes fertile. The following results were obtained when it was reciprocally crossed to the rye commercial variety *Elbon*:

Crossing	Florets pollinated	Seeds obtained	Fertility
♀ CAL-1 × ♂ *S. cereale* var. *Elbon*	833	395	47.4%
♀ *S. cereale* var. *Elbon* × ♂ CAL-1	40	9	22.5

It was not possible to observe any young pollen cells of the CAL-2 plant. Pistillody phenomena were not found either in CAL-1 or CAL-2 plant.

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Observations on restoration of pollen fertility and outcrossing of cytoplasmic sterile wheat

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Pollen fertility restoration in the Texas restorer composite (TRC)

In 1967, workers at the Texas Agricultural Experiment Station released a germplasm source, herein called TRC, which resulted from pollination by a composite of the World Collection at Bushland, Texas. The female was cytoplasmic male sterile Bison *Triticum aestivum* L. with *T. timopheevi* cytoplasm. Fertile or partially fertile F_1 plants were harvested and the composite was made of 30 F_2 and 11 F_3 progenies.

A sample of this composites was space-planted in the field at Davis, California in December 1967. At flowering time it was evident that the population was homogeneous for winter type. Plants with apparent good fertility were selected and crossed with a spring-type Ramona 50 cytoplasmic male sterile (*T. timopheevi* cytoplasm). Anther development in these TRC plants was not entirely normal, however. Hybrid seeds were pro-

Table 1. Fertility of F_1, TRC-derived materials, and fertile varieties at Davis, California in 1969

Cross or parent	No. plants	No. spikes per plant	Mean fertility %	Range %
F_1 plants				
cms Ramona 50×TRC-1	12	4	23.2±13.4	5.2～41.1
cms Ramona 50×TRC-2	12	4	18.3± 9.2	3.2～35.1
cms Ramona 50×TRC-6	14	4	46.6±18.0	11.7～65.5
TRC material				
TRC-1	5	4	73.3± 5.2	65.5～77.5
TRC-2	5	4	63.5± 8.8	50.3～72.4
TRC-6	5	4	74.1± 5.7	67.1～79.5
Random TRC plants	13	4	61.8±11.6	32.1～78.8
TRC selections*	5	1	67.4± 9.5	39.6～79.5
Fertile varieties				
Ramona 50	5	1	56.1	
Nainari 60	5	1	82.3	
Lerma Rojo 64	5	1	77.4	
Siete Cerros 66	5	1	88.7	
Minn. II-54-30	5	1	72.1	
Tascosa	5	1	77.2	

*Mean of 41 lines and the range of the 41 line means presented.

duced on three of the crosses and these were planted in December 1968 along with the parent lines, a random bulk of TRC, and 41 TRC selections. The 41 selections were made on a single head basis in 1968 and resulted from a larger collection that was subjected to selection for seed type and fertility. Fertility estimates were made for each of these three groups of materials. Because this material was winter-type it came to anthesis late in the season during periods of high temperature and low humidity. These could be considered stress conditions for pollen fertility restoration genes.

Fertility data for the TRC hybrids and selections are given in Table 1. Similar data for fertile varieties are also given for comparison. Fertility was scored as the percentage seed set estimated by counting all florets, except the most rudimentary one in each spikelet, in spikelets on one side of the spike. This value was doubled to get whole spike data. All data were from unbagged heads. The TRC-1 parent had quite high fertility (73.3%) but the F_1 had low fertility. Six of the 12 plants had low fertility (5.2～17.8%) in the range expected for unbagged cytoplasmic male sterile plants. A similar fertility level was found for TRC-6 (74.1%), but in this case only one of 14 plants appeared sterile and the F_1 was considerably more fertile. TRC-2, with 63.5% fertility, gave very poor restoration; none of the F_1 plants had more than 35.1% seed set.

It appears that segregation in the TRC-1 cross was due to heterozygosity of the original plant. TRC-2 was apparently homozygous, but not for a full complement of restoration genes. TRC-6 was the most promising selection of this material; however the fertility of the F_1 was not at a level acceptable for a hybrid wheat.

Selection for fertility in the original TRC population might have been effective (Table 1) since the random population had slightly lower fertility than the 41 selections (61.8 vs. 67.4%), slightly higher variance in fertility, and smaller range. Further selection for fertility will be made at Davis while maintaining the winter-type background. At present the TRC lines have lower fertility than most standard varieties. If high fertility lines can be selected under Davis conditions, it is likely that their fertility levels would be high in areas where winter types are adapted. TRC will also be maintained as a bulk population to allow further recombination to occur. Intercrossing among fertile lines may be required to obtain maximum restoration. Small quantities of seed of the bulk or selected lines are available on request.

Restoration of *Triticum zhukovskyi* and Primépi

Primépi was crossed to cms Ramona and the F_1 plants had 50.4% fertility (based on three plants with four spikes each). Primépi itself is very late at Davis and to be useful, pollen fertility restoration from this variety should be introduced into a photoperiod insensitive background.

A Justin-type restorer line, obtained from K. LUCKEN, North Dakota State University, with pollen fertility restoration genes from *T. zhukovskyi* showed quite high fertility at

Table 2. Seed Set on cytoplasmic male sterile wheat at Davis, California in the breeding nursery in 1969

Cytoplasmic male sterile line*	No. of spikes	Fertility %
cms Ramona 50	10	21.8
cms Ram. 50×Lerma Rojo 64[2]	10	15.8
cms Ram. 50×Siete Cerros 66[2]	10	17.6
cms Ram. 50×Nadadores 63[2]	10	19.4
cms Ram. 50×Bajio 66[2]	10	16.7
cms Ram. 50×Onas 53[2]	10	8.2
cms Minn. II-54-30	10	22.8
cms Scout	5	13.3
cms Kaw 61	5	27.3
cms Tascosa	5	14.8
cms Aztec	5	8.8
cms Shawnee	5	10.4
cms Concho	5	34.2

*cms Minn. II-54-30 obtained from K. LUCKEN and the last six varieties are winter types developed by R.W. LIVERS, Kansas State University.

Davis. In a cross with cms Ramona 50 the F_1 fertility was 70.0% (based on three plants with four spikes each). Additional observations will be made on restoration in this material.

Seed set on cytoplasmic male sterile plants

Conversion of varieties to cytoplasmic male sterile forms is in progress using the *T. timopheevi* cytoplasm at Davis. Early generation materials from this program and lines received from other workers were used to judge the general level of outcrossing under nursery conditions. Random open pollinated spikes were taken from cytoplasmic male sterile rows which had at least one male fertile border row. The plants were spaced 30 cm within rows which were 30 or 60 cm apart. The sample included a range of heading time: early and late spring wheats and winter wheats. No seed set has been obtained from bagged cms plants at Davis. From the data of Table 2 it is apparent that outcrossing did not differ greatly depending on time of anthesis. The late flowering winter types had 18% mean seed set and the spring types were similar with a mean of 17% seed set. These results indicate that considerable care will be required to develop pollination blocks with high crossing rates at Davis.

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II. Editorial Remarks

Announcement for Future Issues

WIS No. 30 will be planned for publication with double number of pages in March, 1970. Manuscripts for this issue are accepted any time, not later than February 1, 1970.

WIS is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics and cytology of *Triticum, Aegilops, Agropyron, Secale, Haynaldia* and related genera. Manuscripts should be typewritten in English, and submitted with duplicates. One article should not exceed five printed pages, including one text-figure (smaller than 7×7 cm^2). Lists of stocks are exempted from this page limit. Authors receive 50 reprints free of charge. Extra copies are printed by order at cost price. Communications regarding editorial matters should be addressed to:

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The Managing Editor

Explanation of the Figure on the Cover

A photograph showing dried specimens of the Tom Pouce varieties. The indicated measures are in decimeters (10 cm). (Cf. A.C. ZEVEN, pp. 8~9 in the present issue.)