# WHEAT INFORMATION SERVICE

# CONTENTS

# I. Research Notes

## *Triticum zhukovskyi* as a source of male sterile cytoplasm and fertility restorer genes

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Male sterility conditioned by cytoplasm was first reported in wheat by KIHARA (1951, Cytologia 16: 177) who transferred the chromosome complement of common wheat (2n= 42) into the cytoplasm of *Aegilops caudata* (2n=14) by successive backcrossing. FUKASAWA (1953, Cytologia 18: 167) similarly transferred cytoplasmic male sterility from *Aegilops ovata* (2n=28) into emmer and durum wheats (2n=28) and later (1958, W.I.S. 7: 21) observed that a variety of the wild emmer, *Kotschyanum* (2n=28), when used as the pollen parent, restored fertility of the male sterile lines. This source of male sterility was later transferred to some commercial common wheat varieties by workers in Kansas State University, U.S.A. However, the common wheat varieties used thus far as pollinators of these male-sterile types have produced only male-sterile hybrids.

Subsequently, a more promising sterility system was developed (WILSON and ROSS 1962, W.I.S. 14: 29) by obtaining through backcrossing the chromosomes of the common wheat Bison in the cytoplasm of *T. timopheevi* (2n=28). The male sterile Bison strain thus developed was pollinated with a hexaploid wheat having *T. timopheevi* in its ancestry and fertile plants were produced (SCHMIDT, JOHNSON and MAAN 1962, Nebr. Exp. Sta. Qtrly. 9: 1). Thus, *T. timopheevi* turned out to be the source of cytoplasmic male sterility as well as of the nuclear genes restoring pollen fertility. Recently, two additional sources of this system were indicated by MAAN and LUCKEN (1967, W.I.S. 23~24: 6) in crosses involving *T. zhukovskyi* and a *T. boeoticum*-type diploid wheat.

During our study of the phylogenetic relationships among *Triticum* species, we crossed *T. zhukovskyi* (2n=42) with a common wheat variety N.P.876 reciprocally in March,

1963. The plants raised from the seeds borne on the *zhukovskyi* parent were invariably male sterile whereas the plants obtained from the reciprocal cross were fertile. These male sterile lines, being maintained here by hand-pollination, gave progeny segregating for varying degrees of male fertility when pollinated by *T. zhukovskyi*. Two lines selected from this material produced anthers with fertile pollen and a cytological study of microsporogenesis in these plants revealed that they had largely a normal meiosis. The preliminary data on recombination analysis indicated that more than two genes were involved in this system.

The present observations show that *T. zhukovskyi*, like *T. timopheevi*, possesses "sterile" cytoplasm as well as nuclear factors for fertility restoration. *T. zhukovskyi* is morphologically very similar to *T. timopheevi* and was in fact considered as a form of the latter until JAKUBZINER (1959, Proc. First Intern. Wheat Genet. Symp.: 207) raised it to the species level. UPADHYA and SWAMINATHAN (1963, Chromosoma 14: 589) showed that *T. zhukovskyi* probably arose through chromosome doubling in the cross *T. timopheevi × T. monococcum* var. *hornemanni*. WAGENAAR (1961, Canad. J. Genet. Cytol. 3: 47) showed that *T. timopheevi* causes male sterility through a desynaptic mechanism and UPADHYA and SWAMINATHAN (1965, Indian J. Genet. 25: 1) observed a similar desynaptic system in *T. zhukovskyi*. Our observations indicate that *T. zhukovskyi*, being hexaploid like the common wheat, can conveniently replace the tetraploid *T. timopheevi* as a source of both the male sterility-fertility restoration mechanism and the disease resistance normally associated with the latter.

# Male fertility and sterility in the hybrids of crosses of T. zhukovskyi, T. sphaerococcum and T. aestivum with common wheat carrying T. timopheevi cytoplasm

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Cytoplasmic male sterility in wheat was first reported by KIHARA (1951) by transferring the nucleus of hexaploid wheat into the cytoplasm of *Ae. caudata* L. FUKASAWA (1953, 1958) reported male sterility when *T. durum* had the cytoplasm of *Ae. ovata* L. and that *T. dicoccoides* var. *Kotschyanum* restored the pollen fertility of this male sterile *durum*. The possibility of hybrid wheat became apparent only when WILSON and ROSS (1962) discovered another effective source of male sterility in *T. timopheevi × Bison* cross and soon afterwards SCHMIDT, JOHNSON and MAAN (1962) discovered fertility restoration when a *T. timopheevi* derivative wheat was crossed to Nebred. Studies by several workers of this cytoplasmic-

genetic male sterility and fertility restoration system have revealed that two dominant genes and some modifiers are necessary for full fertility restoration of male sterile wheat. Hence, the development of fertility restorer line (R) in different wheat varieties is not as easy and as satisfactory as in *Sorghum* which requires only one gene for fertility restoration. The problem of the perfect fertility restoration in wheat has not been fully overcome.

*T. zhukovskyi*, a hexaploid wheat, appears to have arisen through chromosome doubling of *timopheevi-monococcum* hybrid on the basis of cytological evidence and morphological resemblance of the resynthesized species (KOSTOFF 1937a, BELL, LUPTON and RILEY 1955; UPADHYA and SWAMINATHAN 1965). If this hypothesis is valid then one would also expect *T. zhukovskyi* to be carrying genes for fertility restoration of male sterile wheat with *timopheevi* cytoplasm. Therefore, to test this, in 1965~66 season, we crossed *T. zhukovskyi* as a pollinator with a male sterile plant selected from a population of $F_3$ plants derived from the stock ( *T. timopheevi* × Marquis²) $F_4$ × Pembina³) $F_2$ kindly supplied by Dr. A.B. CAMPBELL, Canada Department of Agriculture, Winnipeg, Manitoba. The resulting two $F_1$ plants, grown in pots were quite fertile and were late in maturity as compared with the original stock carrying the *timopheevi* cytoplasm. From this, 33 $F_2$ plants were grown. One plant was found to be completely sterile and the rest were fertile with varying degrees of fertility. There were 21 plants in the 20 to 41 seeds per ear class and 11 plants were in the 12 to 20 seeds per ear class indicating that perhaps either two dominant genes and some modifiers permit full fertility restoration or a single gene with tetrasomic inheritance and dosage effect and some modifiers are involved in fertility restoration. Further study on inheritance of fertility restoration is in progress to obtain a definite answer.

The possibility of a single gene and tetrasomic inheritance of fertility restoration seems to be remote, since this will involve the presence of the fertility restoring gene in the A genome also. The emmer group having genomic constitution AABB has received its cytoplasm from BB analyzer (KIHARA 1966). Hence the B genome is the likely carrier of the genes for restoring the fertility of its own cytoplasm.

In addition to the cytological evidence (UPADHYA and SWAMINATHAN 1965) on the origin of *T. zhukovskyi*, the presence of fertility restoring factors in this species supports the view that *T. timopheevi* might have been one of its putative parents and that *T. zhukovskyi* might be carrying the cytoplasm of *T. timopheevi*. If this is true, then the fertility restoring system of *T. timopheevi* should be identical to that of *T. zhukovskyi*. Thus, the two gene hypothesis of fertility restoration seems to be more plausible.

It is interesting to note that *T. timopheevi* arose from *T. dicoccoides* (WAGENAAR 1966) which restores the fertility of male sterile *durum* and male sterile *dicoccum* wheats carrying *Ae. ovata* cytoplasm (FUKASAWA 1958) and it is quite likely that *T. dicoccoides* may also restore the fertility of male sterile common wheat with *timopheevi* cytoplasm. And *T. zhukovskyi* arose from *T. timopheevi* (UPADHYA and SWAMINATHAN 1965). *T. zhukovskyi* restores the

fertility of male sterile *T. aestivum* with *timopheevi* cytoplasm.

With the objective of finding possible new sources of fertility restoration, we corssed *T. sphaerococcum* as a pollinator with the same male sterile plant which was used in the cross with *T. zhukovskyi*. Thirty three $F_1$ plants obtained were highly male sterile and the seed setting was poor, with a maximum of 4.3 seeds per ear. Two plants were in less than one seed per ear class, 15 plants in 1~2 seeds class, 12 plants in 2~3 seeds class and three plants were in 3~4 seeds per ear class. This suggests that *T. sphaerococcum* does not carry dominant gene for fertility restoration and that perhaps it contains recessive genes for sterility in homozygous condition.

Sterile plants selected from the stocks (*T. timopheevi* × Marquis[2]) $F_4$ × Pembina[8]) $F_2$ and (*T. timopheevi* × Marquis[2]) $F_4$ × Selkirk[8]) $F_2$ were also crossed with the hexaploid spring wheat varieties e.g. C. 303, S. 310, S 227, C 306, NP 830, NP 875, S 308, Sonora 64, Lerma Rojo and PV 18 as male parents with a view to develop sterile lines in them. The resulting $F_1$ plants, grown from these crosses were found to be highly sterile on the basis of seed set data and hence presumably these varieties carry recessive genes for sterility. Backcross progenies resulting from crossing $F_1$ plants with C 303 and Sonora 64 were also highly sterile because in most of the plants less than two seeds per ear were obtained. These varieties can be made fully sterile after a few backcrosses, when their characters are fully recovered. The sterility noted in some of the intervarietal crosses was not as complete as in Sonora 64, C 303 and in the cross involving *T. sphaerococcum* species.

The progenies of all the aforementioned crosses were grown in pots and the heads were not bagged. Data on sterility and fertility were collected by taking the average seed setting per ear of a plant. The very low seed setting observed on sterile plants might be either due to cross pollination or due to the fact that the sterility was not complete.

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## Inducing mutations type *sphaerococcum* in *Triticum aestivum* ssp. *vulgare* with the aid of X-rays and ethyl methan sulphonate

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Seeds of the varieties Besostaya 1 and Mironovskaya 808 were treated in 1964 with ethyl methan sulphonate with concentrations of 0.1, 0.2, 0.4, and 0.6% using 10 ml solution for 100 seeds at 25°C during 24 hours. In the same year other samples of the two varieties were X-rayed in doses of 10, 15 and 20 kr and part of the seeds of $M_1$ were treated with EMS concentrations of 0.2 and 0.4% applying the above-mentioned method.

During 1966 from Besostaya 1 in $M_2$ were selected 2, and in 1967 3, and from Mironovskaya 808 5 plants type *sphaerococcum*. In all from 93 plants 10 were mutations or in a ratio 9:1. They were characterized by a higher rate of general and productive tillering, were of lower height, short ears, more spikelets with lesser absolute weight of seeds and greater sterility compared with the starting forms.

Two type mutations similar to *T. sphaerococcum* reported by SWAMINATHAN, JAGATHESAN and CHOPRA (8) were established from the varieties studied. The first type is characterized by short culms, stiff and erect flag leaves, with a spatulate ending, compact dense spikes, small, spherical grains and is perfectly similar to the corresponding subspecies of *Triticum aestivum*. We suppose this pertains to a mutation of the dominant gene *Sp* in a recessive direction which was localized by SEARS (6) as hemizygous-ineffective recessive in chromosome 3D (XVI).

The second type differs from the first by longer and incompact spikes and shows considerable sterility. The 40 seeds received from this type of Besostaya 1 gave 36 plants of

which 17 survived the winter. Of these, 13 plants were of the type *sphaerococcum* and 4 of the type *vulgare* which fully conforms with the ratio 3: 1. This shows that this type is an inherited dominant and cannot be identified by the factor localized in 3D (XVI). The high percentage of failure to survive the sterility and the small number of analysed plants do not permit making a full and detailed genetic analysis. Maybe it is not a case of a fully dominant inheritance of this new gene but for a partial one as already reported by SWAMINATHAN, JAGATHESAN and CHOPRA (8), SCHMIDT, WEIBEL and JOHNSON (5) and SWAMINATHAN (7). A full interpretation of the character of inheritance and localization of the gene, which we will attempt to do with the help of monosomic series, should throw light on the second type of *sphaerococcum* effect. It is not impossible for the gene to be identical with the one of tetraploid wheats reported by SCHMIDT and JOHNSON (3, 4), BOZZINI (1), GUPTA and SWAMINATHAN (2).

Receiving several types of *sphaerococcum* increases the possibilities of its practical use in breeding by induction of genes with lesser pleiotropic action. This will help solve the problem of transferring only sphaerical grain in *T. aestivum* ssp. *vulgare* without negative characters of *T. sphaerococcum*. The mutants obtained are of considerable interest for the evolution and taxonomy of the genus *Triticum*.

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# Chromosome variations in some strains of hexaploid *Triticale*[1]

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Chromosome numbers in eight strains of hexaploid *Triticale* were studied, the materials being shown in Table 1. Most of the materials have been grown 7 or 8 generations after the crosses were made between different lines of primary *Triticale* (Table 1). Chromosome numbers were counted in root tip cells.

The results of chromosome counts in bulk population were shown in Table 2. Chromosome numbers varied from 2n=40 to 44 with the exceptions of each one of 2n=21

Table 1. Experimental materials

| Group | Strain (UM No.) | Cross combination |
|---|---|---|
| A | 6211, 6211-2, 6316 | 6A 189 (*T. durum* var. "Ghiza" × *Secale cereale*) × 6A20 (*T. durum* var. "Carlton" × *S. cereale*) |
| B | 6242, 6408 | 6A 20 × 6A 66 (*T. dicococides* × *S. cereale*) |
| C | 6245, 6250, 6250-2 | 6A 69 (*T. persicum* × *S. cereale*) × 6A 67 (*T. persicum* × *S. cereale*) |

Table 2. Chromosome constitution in bulk population of eight strains of hexaploid *Triticale*

| Chromosome constitution (2n) | A | | | B | | C | | | Total No. of plants |
|---|---|---|---|---|---|---|---|---|---|
| | UM 6211 | UM 6211-2 | UM 6316 | UM 6242 | UM 6408 | UM 6245 | UM 6250 | UM 6250-2 | |
| 21 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 40 | 2 | 0 | 0 | 2 | 2 | 0 | 0 | 0 | 6 |
| 41 | 6 | 6 | 7 | 6 | 9 | 7 | 8 | 6 | 55 |
| 41+1 telo | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 42 | 91 | 93 | 91 | 91 | 86 | 93 | 86 | 93 | 724 |
| 42+1 telo | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 43 | 1 | 4 | 3 | 2 | 3 | 3 | 4 | 4 | 24 |
| 43+1 telo | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 2 |
| 44 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 3 |
| 63 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| Total | 101 | 104 | 101 | 101 | 101 | 105 | 101 | 104 | 818 |
| 2n=42 (%) | 90.1 | 89.5 | 90.1 | 90.1 | 85.1 | 88.6 | 85.1 | 89.5 | 88.5 |
| hypoploid (%) | 8.9 | 5.8 | 6.9 | 7.9 | 11.9 | 6.7 | 7.9 | 5.8 | 7.7 |
| hyperploid (%) | 0.9 | 4.8 | 2.9 | 2.0 | 3.0 | 4.7 | 6.9 | 4.8 | 3.8 |

and 63. The frequency of 42-chromosome plants varied from the lowest 85.1 percent to the highest 90.1 percent, the overall average for eight strains was 88.5 percent. The differences of the frequency of euploids between groups, between lines within group, and between any two lines were not statistically significant.

The frequency of hypoploids (7.7% on an average) was higher than hyperploids (3.8% on an average). Four out of 818 plants (0.49%) had telocentric chromosomes.

The 42-chromosome plants from the above bulk populations were grown in the greenhouse and the chromosome numbers were studied in the progeny of those 42-chromosome plants with the results shown in Table 3.

Table 3. Chromosome constitution in the progeny of 42-chromosome plants
in eight strains of hexaploid *Triticale*

| Chromosome constitution (2n) | A | | | B | | C | | | Total No. of plants |
|---|---|---|---|---|---|---|---|---|---|
| | UM 6211 | UM 6211-2 | UM 6316 | UM 6242 | UM 6408 | UM 6245 | UM 6250 | UM 6250-2 | |
| 39 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 |
| 40 | 1 | 1 | 0 | 0 | 1 | 1 | 2 | 0 | 6 |
| 40+1 telo | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 41 | 5 | 11 | 10 | 1 | 2 | 6 | 7 | 4 | 46 |
| 41+1 telo | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 42 | 67 | 63 | 93 | 72 | 82 | 84 | 72 | 76 | 609 |
| 42+1 telo | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 43 | 1 | 1 | 0 | 0 | 0 | 2 | 3 | 2 | 9 |
| Total | 74 | 76 | 105 | 73 | 86 | 93 | 85 | 82 | 674 |
| 2n=42 (%) | 90.5 | 83.0 | 88.5 | 98.5 | 95.3 | 90.3 | 84.8 | 92.7 | 90.4 |
| hypoploid (%) | 8.1 | 15.8 | 10.5 | 1.5 | 4.6 | 7.5 | 11.8 | 4.9 | 8.2 |
| hyperploid (%) | 1.4 | 1.3 | 0.9 | 0 | 0 | 2.2 | 3.5 | 2.4 | 1.5 |

Chromosome numbers varied from 2n=39 to 43. Telocentric chromosome was found in three out of a total 674 plants (0.45%) studied, which is similar to the value in the bulk population (0.49%).

The cytological stability expressed by the frequency of 42-chromosome plants varied from the lowest 83.0 to the highest 98.5 percent, the overall average frequency for eight lines being 90.4 percent which is not significantly different from that of bulk population.

There are no differences in the frequency of 42-chromosome plants between different lines within each group. The difference of the cytological stability between groups A and B, and B and C was statistically significant, group B being shown highest average stability with 96.9 percent of 42-chromosome plants. The difference between the group A and C was not significant. The frequency of hypoploids are higher (8.2%) than that of hyperploids (1.5%). It is noteworthy here that no hyperploid was obtained in either strain of the group B.

# Breeding behaviour of aneuploids in some hexaploid *Triticale*[1]

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Chromosome numbers in the progeny of aneuploids were counted in several strains of hexaploid *Triticale*. The materials are the same as those reported previously: the group A, B, and C correspond to the designation of materials shown in the previous paper (Tsuchiya 1968, WIS 27: 7~8). The results are summarized in Table 1.

In the progeny of 41-chromosome plants the average frequency of 42-chromosome plants was 18.7 percent. About 50 percent progeny were 2n=41 and 26 percent were

Table 1. Chromosome constitution in the progeny of aneuploids of hexaploid *Triticale*

| Chromosome constitution | Progeny of 2n=41 | | | | Progeny of 2n=43 | | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | Total | A | B | C | Total |
| 27 | | | | | | | 1 | 1 |
| 39 | | | 2 | 2 | 1 | | | 1 |
| 39+1 telo | | 2 | | 2 | | | | |
| 40 | 6 | 14 | 11 | 31 | | | 2 | 2 |
| 40+1 telo | | 1 | | 1 | | | | |
| 40+2 telo | | | | | | | 1 | 1 |
| 41 | 8 | 18 | 32 | 58 | 2 | | 17 | 19 |
| 41+1 telo | | | | | | | 1 | 1 |
| 42 | 3 | 5 | 14 | 22 | 10 | 10 | 89 | 109 |
| 42+1 telo | | | | | 2 | 4 | 1 | 7 |
| 42+2f* | | | | | 1 | | | 1 |
| 43 | | | 2 | 2 | 2 | 9 | 15 | 26 |
| 43+1 telo | | | | | | 2 | 1 | 3 |
| 44 | | | | | | 3 | 9 | 12 |
| 44+1 telo | | | | | | | 1 | 1 |
| 45 | | | | | | | 1 | 1 |
| Total | 17 | 40 | 61 | 118 | 18 | 28 | 139 | 185 |
| 2n=42 (%) | 17.7 | 12.5 | 23.0 | 18.7 | 55.6 | 35.7 | 64.0 | 59.0 |
| hypoploid (%) | 82.3 | 87.5 | 73.7 | 79.6 | 16.7 | 0 | 15.8 | 13.5 |
| hyperploid (%) | 0 | 0 | 3.3 | 1.7 | 27.8 | 64.3 | 20.2 | 27.5 |
| 2n=41 (%) | 47.0 | 45.0 | 52.5 | 49.2 | | | | |
| 2n=43 (%) | | | | | 11.1 | 32.1 | 10.8 | 14.1 |

*One telocentric, and another an acrocentric fragment.

2n=40. Telocentric chromosome was found in 3 (2.6%) out of 118 plants in the progeny of 41-chromosome plants. On an average about 80 percent progeny of 41-chromosome plants were hypoploids including 2n=39 and 39+1 telocentric. Only two (1.7%) out of a total 118 plants were hyperploids (2n=43).

The breeding behaviour of 43-chromosome plants is considerably different from plant to plant and from group to group. No tetrasomic plant was obtained in group A, while 10.7 and 6.5 percent plants were 2n=44 in group B and C, respectively. In group A and C the frequency of 43-chromosome plants was only 11.1 and 10.8 percent, respectively, while it was 32.1 percent in group B. Also in group A and C about 16 percent were hypoploids, but none at all in group B. Plants with telocentric chromosome were obtained in 7.6 percent on an average among progenies of 43-chromosome plants.

These results mentioned above are considerably different from those obtained in other hexaploid strains by Krolow (1966).

<p style="text-align:right">(Received March 4, 1968)</p>

## Reciprocal intergeneric hybridizations between wheat and rye

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Since Firbas (1920), several authors have tried to hybridize rye ♀ × wheat ♂. Because of the ambiguous results reported in the literature, the following study was initiated to investigate the difficulties in obtaining this hybrid. The wheat variety "Chinese Spring" (2n=42) and a family of the "Petkuser" spring rye (2n=14) were used for reciprocal crosses. The seed setting in the combination wheat ♀ × rye ♂ (haploid *Triticale*) was 61.0 per cent, but only 1.0 per cent in the reciprocal cross (haploid *Secalotricum*). Part of the difference in seed setting could be attributed to a relatively slow growth of the wheat pollen tubes in the styles of rye; the male gametes, therefore, failed to reach the embryo sac in time for fertilization.

In contrast to the early statement of Tschermak (1933), the reciprocal haploid hybrids being composed of the same genomes (R and W) but different in cytoplasm [r or w] were not completely alike phenotypically. In addition, the haploid *Secalotricum* was not of "maternal" type as Karapetian (1966) reported. Rather were both reciprocal hybrids intermediate. In particular, the haploid *Secalotricum* was about 10 days earlier in ear emergence and its straw was about 5 cm shorter than that of the corresponding *Triticale* plants. These characters clearly demonstrate a cytoplasmic, but not a maternal type of inheritance.

By treatment of seedlings with 0.1 per cent colchicine solution amphidiploids of the *Secalotricum* and *Triticale* hybrids were obtained. The amphidiploid *Secalotricum* turned out to have longer straw and ears than the corresponding *Triticale*. Two backcrosses of the reciprocal $F_1$ haploids to the male parent were made (cf. figure on the cover i and its explanation on the cover iii). The percentage of seed setting was the following:

in the first backcross, [r] RW×WW=4.4% and [w]WR×RR=4.9%,

in the second backcross, [r]WWR×WW=18.3% and [w]RRW×RR=7.2%.

These differences in seed setting reflected the influence of the relative number of univalent chromosomes during the foregoing meiosis.

In addition to the poor seed setting in these crosses many of the seeds obtained were shrivelled. But with the aid of embryo culture it was always possible to raise hybrid plants from such seeds. This showed that only the endosperm was degenerated. There were, however, drastic differences in the percentage of shrivelled seeds among various crosses (Table 1).

Table 1. Seed development in reciprocal combinations of wheat and rye and their backcrosses

| No. | Combination | Fully developed seeds | Shrivelled seeds | |
|---|---|---|---|---|
| | | | absolute | % of total |
| 1 | [w] WW × RR | 273 | 12 | 4.2 |
| 2 | [ r ] RR × WW | 32 | 18 | 36.0 |
| 3 | [w] WR × RR | 19 | 91 | 82.7 |
| 4 | [ r ] RW × WW | 45 | 4 | 8.2 |

According to MÜNTZING (1933), disturbances in endosperm development frequently result from deviations of the normal ratio between chromosome numbers of the maternal tissue, the endosperm and the embryo (2:3:2). This assumption was based on the observation that the parent with a higher chromosome number, used as a female, yielded the better seeds. In Table 2 the ratios of the chromosome numbers in our hybrids are compared with those of the respective species. The deviation of the crosses Nos. 1~4 from the normal chromosome ratio does, however, not correspond to the percentage of shrivelled seeds, as given in Table 1. For example, there were 4.2 per cent of poor seeds in cross No. 1 and 82.7 per cent in cross No. 3, both of which showed almost the same chromosome ratio between endosperm and embryo (1.75 and 1.80, respectively).

This problem can be solved, if the comparison is not based on the chromosome number as such but on the number of the different wheat and rye genomes in the endosperm itself. It can be seen that in the amphidiploid hybrids, both yielding perfect seeds, 9 wheat and 3 rye genomes each with 7 chromosomes are combined in the endosperm. Wherever this ratio decreases, the endosperm developement is inhibited (cf. cross Nos. 2 and 3), but an equal deviation in the opposite direction does not cause similar disturbances (cf. cross Nos.

Table 2. The ratio between chromosome numbers of maternal tissue
endosperm and embryo

| Combination | Maternal tissue | Endosperm | Embryo | Wheat and rye genomes in the endosperm and the ratio |
|---|---|---|---|---|
| Self-pollination | | | | |
| [w] WW | 42* | 63* | 42* | |
| | | 0.66**    1.50** | | |
| [r] RR | 14 | 21 | 14 | |
| | | 0.66    1.50 | | |
| [w] WWRR | 56 | 84 | 56 | $W^{3x}W^{3x}W^{3x}+R^xR^xR^x$ |
| | | 0.66    1.50 | | 9 : 3=3 |
| [r] RRWW | 56 | 84 | 56 | |
| | | 0.66    1.50 | | |
| Interspecific cross | | | | |
| No. 1 [w] WW×RR | 42 | 49 | 28 [w] WR | $W^{3x}W^{3x}+R^x$ |
| | | 0.85    1.75 | | 6 : 1=6 |
| No. 2 [r] RR×WW | 14 | 35 | 28 [r] RW | $W^{3x}+R^xR^x$ |
| | | 0.40    1.25 | | 3 : 2=1.5 |
| No. 3 [w] WR×RR | 28 | 63 | 35 [w] RRW | $W^{3x}W^{3x}+R^xR^xR^x$ |
| | | 0.44    1.80 | | 6 : 3≒2 |
| No. 4 [r] RW×WW | 28 | 77 | 49 [r] WWR | $W^{3x}W^{3x}W^{3x}+R^xR^x$ |
| | | 0.36    1.57 | | 9 : 2=4.5 |

\* Chromosome numbers, ** Chromosome ratios.

1 and 4). This leads to the conclusion that specific interactions between the wheat and rye genomes combined in the hybrid endosperm are responsible for normal endosperm development.

Cytological investigations of the various hybrids were made. In 51.7 per cent of the *Secalotricum* and in 55.7 per cent of the *Triticale* pollen mother cells, no pairing of the 28 chromosomes was observed in metaphase I. On the average of 170 cells of the *Secalotricum* haploids 26.2 univalents and 0.92 bivalents and in 140 cells of the *Triticale* haploids 26.1 univalents and 0.94 bivalents were counted. From these results it can be concluded, that the different cytoplasm does not affect the pairing of the chromosomes in the reciprocal hybrids, [r] RW and [w] WR, resp. The observations of this study are not in favour of a pairing between rye and wheat chromosomes; the observed bivalents appeared to result from autosyndesis of the wheat chromosomes only. A detailed description of the experiments is given by SMUTKUPT (1968).

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# Homoeology of a rye (*Secale cereale* var. DAKOLD) chromosome[1]

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The substitution of alien chromosomes into the wheat complement is now well established. A number of alien substitution lines having 20 pairs of wheat chromosomes and one pair of alien chromosomes are now known. In these substitution lines the alien chromosome came from *Aegilops* (RILEY et al. 1966), *Agropyron* (BAKSHI & SCHLEHUBER 1959, WEINHUES 1960 and KNOTT 1964) and *Secale* (O'MARA 1947, RILEY 1964 and JENKINS 1966).

With the success of these substitutions, now there is increasing interest in the genetic relationship between substituting alien chromosome and the replaced wheat chromosome. Efforts are also being made to extend the homoeologous relationship between three genomes of wheat to the other genera of the sub-tribe *Triticinae* viz. *Aegilops, Agropyron, Haynaldia* and *Secale*. Some of the alien chromosomes have already been designated on the basis of knowledge regarding their homoeology e.g. 6R for a rye chromosome (RILEY 1964) and 2M for an *Aegilops* chromosome (RILEY et al. 1966).

Since rye chromosomes do not pair with wheat chromosomes, one has to depend on indirect evidence in order to find out the homoeologous relationships. Compensation effect of a rye chromosome for the absence of different wheat chromosomes can, for instance, be studied in the same manner in which nullisomic-tetrasomics were studied by SEARS (1966). Compensation can either be studied in the form of morphology, meiotic stabiltiy and fertility of the substitution lines (20"W+1"R) or in the form of transmission of substitution (20'W+1'R) and normal wheat gametes (21'W) in the form of pollens.

In order to study the compensating effect of rye chromosome I (designated after BHAT-TACHARYYA & JENKINS 1960), $F_1$ plants of the constitution 20"W+1' W+1'R were obtained. For this purpose wheat monosomics of the D genome were pollinated by the addition line (21"W+1"R) for rye chromosome I. These $F_1$ lines belonged to 1D to 6D depending upon wheat monosomic from which one was derived. These six $F_1$ lines were then used to pollinate normal wheat plants and the transmission of four types of gametes (20'W, 20'W+1'R, 21'W and 21'W+1'R) was studied in the progeny.

Theoretical ratios were, however, obtained following HACKER (1965) and RILEY et al. (1966). There was cytological and genetical evidence that rye univalent was eliminated in 86.4% of the gametes. Wheat univalent was lost in 75% of the gametes as usual. Therefore, when 20'W and 20'W+1'R gametes did not function due to competition, the transmission of the remaining two types of gametes was expected in 25:4 ratio. Also when there was no competition between 21'W and 20'W-1'R gametes as a result of compensation, 12:25:4 ratio was expected.

Table 1. Distribution of progenies from (21"W) ♀ × (20"+1'W+1'R) ♂, where rye chromosome I is involved

| Wheat chromosome monosomic | Chromosome number | | | Total | Ratio (P) 25 : 4 | Ratio (P) 12 : 25 : 4 |
|---|---|---|---|---|---|---|
| | 41W-1R | 42W | 42W-1R | | | |
| 1D | 9 | 28 | 4 | 41 | — | 0.90∼0.50 |
| 2D | — | 49 | 4 | 53 | 0.20∼0.10 | — |
| 3D | 13 | 15 | 3 | 31 | — | 0.50∼0.20 |
| 4D | 1 | 49 | 10 | 60 | 0.50∼0.20 | — |
| 5D | — | 51 | 6 | 57 | 0.50∼0.20 | — |
| 6D | — | 27 | 6 | 33 | 0.50∼0.20 | — |
| Total | 23 | 219 | 33 | 275 | | |

As evident from Table 1, when theoretical ratios were compared with observed results, the data in 1D and 3D gave a good fit to 12:25:4 ratio and the remaining lines gave a good fit to 25:4 ratio. In a reciprocal cross where $F_1$ plants were used as female parent, all the four types of gametes were transmitted in the expected proportions. It was therefore concluded that rye chromosome I was genetically related to both 1D and 3D. That such a relationship was possible, is evident from the fact that JENKINS (1966) was able to substitute rye chromosome I for all wheat chromosomes of the homoeologous groups 1 and 3. There is increasing evidence that these substitution lines are fertile and meiotically stable.

If *Secale cereale* was derived from the same diploid ancestor which gave rise to the three diploid progenitors of wheat, normally we would expect homoeologous relationship of a rye chromosome with chromosomes of only one homoeologous group in wheat. But as pointed out by RILEY & KIMBER (1966) *S. cereale* has at least two translocations and this

— 14 —

species was derived from *S. montanum*. Therefore rye chromosome I in the present study is presumably the result of such a translocation, thus having segments from two original chromosomes. It is natural therefore to expect that a more precise relationship can be obtained only by using *S. montanum*. It is unfortunate that in most of the wheat improvement programmes in the past, *S. cereale* has been used. It is only now that *S. montanum* is being used at certain places.

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## A new interpretation of the mechanism regulating chromosome pairing in *Triticum*

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The cytological studies of 27-chromosome hybrids between *Secale cereale* and monosomics of *T. aestivum* variety Chinese Spring, deficient in turn for all the twenty-one chromosomes, had revealed that the absence of chromosome 5B leads to a reduction and the absence of 6A leads to an increase in condensation of chromosomes at the first meiotic division. These observations thus suggested the presence of genes on chromosomes 5B and 6A which control the condensation cycle of meiotic chromosomes. This control of condensation process might have certain bearing on the control of homeologous pairing among the wheat chromosomes has been suggested. The details are being published elsewhere (Biol. Zentral. in press).

However, the recent reports of FELDMAN (Proc. Natl. Acad. Sci. U.S. **55**, 1966) and FELDMAN *et al.* (Proc. Natl. Acad. Sci. U.S. **56**, 1966) have opened a new approach to the

understanding of the mechanism controlling chromosome pairing in polyploid wheats. The data on the control of chromosome condensation by 5B and 6A, when viewed in the light of these reports on the premeiotic associations of homologous chromosomes, lend themselves to an interesting new interpretation of the control of diploid-like meiotic behavior of polyploid wheats.

FELDMAN (Proc. Natl. Acad. Sci. U.S. **55**, 1966) has shown that with the normal two doses of 5B, homologous chromosomes are associated before meiosis begins to give rise to regular bivalent formation in hexaploid wheat. And it has also been shown by FELDMAN *et al.* (Proc. Natl. Acad. Sci. U.S. **56**, 1966) from their studies of the somatic associations of the homologues in the dividing root tip cells of *T. aestivum,* that the homologues tended to lie near each other. Therefore, it would seem that pairing of the homologous chromosomes during meiosis is predetermined by their associations at the last premeiotic mitosis.

MOENS (Chromosome, Berl. **15**, 1964) had observed that in the microsporocytes of tomato (*Lycopersicon esculentum*), the earliest visible chromosomes are fully paired bivalents, and thus has suggested that synapsis may therefore have occurred during or prior to premeiotic interphase. He had further indicated that the observations of McCLINTOCK (Amer. J. Bot. **32**, 1945) and SINGLETON (Amer. J. Bot. **40**, 1953) in *Neurospora crassa* could well be applicable to higher plants. That is after the last premeiotic mitosis the condensed chromosomes pair immediately and undergo decondensation, and that the despiralization of the paired chromosomes facilitates point-by-point pairing. Also, the pairing of condensed chromosomes is, to some extent, supported by the absence of interlocking of bivalents. SMITH (Canad. J. Res Sec. D. **20**, 1942) had also concluded from his studies that the meiotic pairing consumated at pachytene is initiated at the latest by the telophase of the last premeiotic division, and that at the anaphase of the last premeiotic division homologues become associated in pairs and reappear in the following prophase relationally coiled. He had also indicated that telophase pairing considered in relation to the time, phase and degree of relational coiling have an obvious bearing on such diverse phenomenon as "asynapsis" and somatic reduction. These conslusions give an indication that premeiotic association serves as an essential step in regulating meiotic pairing.

Therefore, it would seem plausible to assume that in polyploid wheats the time, degree and the phase of condensation and decondensation at the telophase of the last premeiotic mitosis determine the regular association, in pairs, of homologues instead of homeologues. And that this phasing and degree of condensation, also reflected during meiosis, is controlled by chromosomes 5B and 6A. It may be that the genetic systems of chromosomes 5B and 6A ensure regular pairing among the homologues by controlling the degree and phase of condensation and decondensation at the last premeiotic telophase to bring about a point-by-point pairing of homologues only. This then leads to pairing exclusively among homologues. However, this balanced mechanism of 5B and 6A does not completely prevent

the homeologues from approximating each other leading to secondary associations, as was demonstrated by KEMPANNA and RILEY (Heredity **19,** 1964).

# Genome differentiation, nucleolar organizers and RNA synthesis in wheat

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Four of the 21 pairs of chromosomes in *Triticum aestivum* are known to have a nucleolar organizing locus (CROSBY 1957). The relative contribution of each of these four loci to RNA synthesis has been studied in the root tip cells by observing the incorporation of tritium labelled uridine. The incorporation has been analysed in two types of materials. It has been studied in the first place in the four ditelosomes for the long arm of chromosomes 1A, 1B, 6B and 5D, as well as in the variety Chinese Spring, from which they have been developed by SEARS (1952a and b). The missing short arm of one of the four chromosomes in the above ditelosomes is known to carry the nucleolar organizer.

The incorporation of the tritium labelled uridine has also been observed in root tip cells of four diploid, tetraploid and hexaploid wheat species. The method of incorporation of the labelled precursor and of the preparation of the autoradiographs has been described earlier by one of us for another material (JAIN 1966). A large number of interphase cells were scored (Fig. 1) for grain count in several slides of each of the lines and varieties, following identical incorporation treatments.



Fig. 1. One of the root tip cells showing incorporation of labelled uridine in the form of silver grains.

The observations on mean number of silver grains per cell (estimated by pooling of the observations on different slides of a line) are presented in Tables 1 and 2 for the two types of materials.
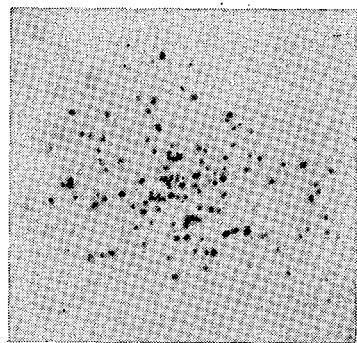
Table 1. Mean number of silver grains per cell in root tips of different lines following uridine incorporation ($3\mu c$/ml-one hour)

| Lines | Ditelosome 1A[1] | Ditelosome 1B[1] | Ditelosome 6B[1] | Ditelosome 5D[1] | Chinese Spring |
|---|---|---|---|---|---|
| Mean grains/cell | 13.48 | 27.29 | 27.09 | 24.91 | 26.64 |
| Ratio | 1 | 2.02 | 2.01 | 1.84 | 1.97 |

Table 2. Mean number of silver grains per cell in root tips of different
species following uridine incorporation (5μc/ml-4 hours)

| Species and varieties | *T. monococcum* (E. 4371) | *T. dicoccum* (E. 4325) | *T. durum* (H. 84) | *T. aestivum* (E. 4642) |
|---|---|---|---|---|
| Mean grains/cell | 161.85 | 343.35 | 366.25 | 375.65 |
| Ratio | 1 | 2.12 | 2.26 | 2.32 |

It will be seen from Table 1 that the absence of the nucleolar organizer present in chromosome 1B, 6B or 5D makes little difference to the turnover of RNA in the root tip cells. In contrast to this, the absence of the organizer present in chromosome 1A reduces the synthesis of RNA very greatly.

A comparision of the grain count in the root tip cells of the four species, representing different ploidy levels, summarised in Table 2 also suggests that the nucleolar organizer of the D genome contributes little to RNA synthesis. However, these observations show that the two organizers contributed by the B genome are active in RNA synthesis, and their combined activity compares with that of the organizer present in the A genome.

It is well known that bulk of the RNA in cells (nearly 80 per cent) is of the ribosomal type; it may, therefore, be inferred that the turnover analysed in the above lines and varieties relates largely to this fraction of the cellular RNA. This inference finds support from the work of several authors, who have shown that the nucleolar organizer is actively involved in the synthesis of ribosomal RNA (BROWN and GURDON 1964; RITOSSA and SPIEGELMAN 1965). The present analysis thus shows that in the evolution of hexaploid wheat, the nucleolar organizer present in the A genome has continued to play a dominant role in the synthesis of ribosomal RNA. It should be interesting to find whether the organizers present in the B and D genomes have an inherently weaker synthetic activity, or alternatively, there has been an interaction between the different nucleolar organising loci in the polyploid species.

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# Development of a monosomic series in an Indian wheat and isolation of nullisomic lines

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The series of twenty one monosomic lines in the wheat variety Chinese Spring, developed by Dr E.R. Sears, has greatly helped in advancing our understanding the genetics of the hexaploid bread wheat. Utilizing the monosomics of Chinese Spring, the Canadian workers have transferred the monosomic condition to other wheat varieties (Unrau and McGinnis 1958). This report deals with the production of a complete series of monosomic lines in an Indian wheat variety Pb. C591 and the isolation of several nullisomic lines in it.

Pb. C591 is a fully bearded variety susceptible to all the three rusts. The purpose of producing chromosome deficient lines in this variety is to utilise them for the study of quantitative traits (Joshi and Kumar 1967, Joshi and Singh 1968) and to locate genes for rust resistance on specific chromosomes. In such studies the susceptible genetic background of Pb. C591 will be helpful in revealing the critical chromosome of the donor variety by the resistant reaction caused by the gene or genes introduced by such a chromosome.

All the 21 monosomic lines of the variety Chinese Spring, obtained from Dr. E.R. Sears, were crossed as female parent with Pb. C591. The monosomic $F_1$'s (2n=41) in each of

Table 1. Salient features of the 14 different nullisomic lines of Pb. C591

| Nullisome | Height (cm) | Tiller number | Spike length (cm) | Spikelet number | Pollen fertility (%) |
|---|---|---|---|---|---|
| 1 B | 96 | 3 | 8.5 | 17 | 73.7 |
| 1 D | 114 | 2 | 10.0 | 17 | 94.9 |
| 2 A | 91 | 2 | 10.5 | 15 | 76.5 |
| 2 B | 101 | 11 | 9.0 | 17 | 19.2 |
| 2 D | 102 | 4 | 8.2 | 17 | 12.6 |
| 3 B | 60 | 3 | 9.1 | 17 | — |
| 4 A | 94 | 13 | 9.5 | 17 | 2.2 |
| 4 D | 104 | 11 | 8.5 | 17 | 89.7 |
| 5 A | 51 | 1 | 3.1 | 13 | — |
| 5 B | 48 | 2 | 3.0 | 11 | 0.0 |
| 5 D | 103 | 3 | 8.0 | 15 | 88.4 |
| 6 B | 91 | 3 | 6.5 | 15 | 85.3 |
| 6 D | 93 | 4 | 6.5 | 19 | 87.8 |
| 7 D | 74 | 1 | 7.1 | 15 | — |
| Disome | 139 | 13 | 11.5 | 21 | 99.9 |

the 21 lines were identified cytologically and again crossed as female with Pb. C591. This backcrossing programme of the monosomic hybrids with Pb. C591 was repeated till the sixth backcross generation, ensuring that all chromosomes in the 21 monosomic series are from Pb. C591. All the chromosome deficient lines of Pb. C591 are morphologically similar to the parent variety.

It is interesting to report that in the sixth backcross generation of mono 5A × Pb. C591, all the 45 plants were monosomics and no disomes were obtained. These plants, in the absence of chromosome 5A on which the speltoid suppressor gene $Q$ is located, were easily identified phenotypically as 'speltoids'.

From among the aneuploid series of Pb. C591, 14 different nullisomic lines (2n = 40) have been isolated. The morphological characteristics of these nullisomics are given in Table 1.

All the 14 nullisomics of Pb. C591, with exception of nulli 1D, are dwarf, weak, thin stemmed and thin leaved and straggling plants. Nulli 1D possesses medium broad leaves and stem. Nulli 5A and 6B have suppressed awning whereas all other nullisomes are fully bearded like the disome. This suggests that factors for awning, in Pb. C591, are located on chromosomes 5A and 6B.

All the nullisomes isolated by us, except nulli 5B, seem to possess good female fertility because in all cases where adequate pollen was available the seed setting was fairly good.

Meiotic metaphase I in nulli 5B of Pb. C591 shows multivalent formation, characteristic of chromosome 5B deficient plants of Chinese Spring (RILEY and CHAPMAN 1958, SEARS and OKAMOTO 1958).

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# A possibility of increasing Turkey's total wheat production by introduction of wheats with high yielding potential

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In 1975, Turkey will probably have a population of 40 million people. In order to feed this population, Turkey requires at least 20 million tons of grain (FAO Mediterranean Development Project 1959). In 1965 Turkey produced 8.5 million tons of wheat and 3.3 million tons of barley, while the average grain production from 1954 to 1958 was 12.5 million tons. If Turkey does not become independent from grain imports by 1975 it probably will face serious difficulties. Since the world wheat supply is already at a low, import wheat may not be available for Turkey at that time.

Possible measures for a quick and drastic improvement of this situation are the following:

1. A shift of the bulk of Turkey's wheat production from the Anatolian Plateau to the coastal areas.

2. Introduction of wheats with high yielding potential.

3. Application of high fertilizer rates.

## 1. A shift in main wheat production areas

Turkey's main wheat supply to date has come from the Anatolian Plateau area which has limited and unstable production potential. More than 2/3 of the total wheat production comes from that area; 1965: 5,830, 337 tons from the Plateau and Eastern Turkey, 2,669,653 tons from the coastal areas (Anonymous 1967).

In addition to other factors such as soil erosion and extensive farm practices, rainfall is one of the main limiting factors on the Anatolian Plateau. In the Konya nad Eskisehir Provinces, for instance, the 9 year average from 1928 to 1936 was little over 300 mm (Erinc 1950). While this average rainfall is in itself insufficient, during some years there is an extremely low moisture supply (Konya Province: 143 mm in 1932). In a dendroclimatic investigation of Gassner and Christiansen-Weniger (1942) it was found that in Central Anatolia during the last 600 years disastrous drought years or a series of such drought years occurred in almost every decade. This situation is undoubtedly the main reason for the fact that Turkey's wheat production is unstable at the present time and that she is forced to import wheat in critical years.

However, the coastal areas have sufficient and more dependable rainfall. For instance,

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according to averages for periods of 10 or more years, Bergama, Izmir, Torbali and Aydin areas have from 600 to 800 mm, Adana from 800 to 1,000 mm, Antalya from 1,000 to 1,200 mm and Rize area 2,000 mm and more annual precipitation (HARITA UMUM MÜDÜRLÜGÜ 1960). Since most of this precipitation is winter rainfall it can be utilized completely by fall-planted wheat. If wheat cultivation in the coastal areas could be expanded and intensified, Turkey could become independent from wheat imports. From 1958 to 1964 an average of about 500,000 tons of wheat had to be imported every year. The expansion of the wheat acreage in the coastal areas would be possible by using wheat in rotation with cotton and tobacco which are presently mainly grown in monoculture. This expansion would increase the potential wheat acreage in the coastal areas by more than 30%; 1965: 2,160,007 ha of wheat, 654,564 ha of cotton and 200,511 ha of tobacco in the coastal areas (ANONYMOUS 1967).

From 1950 to 1965 Turkey's national average wheat yield has increased only slightly from 0.860 to 1.076 tons/ha. This yield level amounted to only 1/3 of that for Europe. The overall use of fertilizer in Turkey has been minimal in the past and has increased only recently. For instance, during the 1953∼1957 period, France used 105 kg of fertilizer per tillable hectare, Greece 27, and Turkey 0.8 kg (EREN 1963.) However, from 1960 to 1967 the fertilizer usage in Turkey has increased from 107,332 tons to 1,535,278 tons with a target of 2,500,000 tons for 1968 of which 1,200,000 tons are to be allotted for wheat (Türkiye Cumhuriyeti, Tarim Bakanligi, Bitki Besleme Subesi 1968).

It is essential that the available fertilizer be applied in those areas where it will produce the highest possible yields. Such places are the coastal areas (Black Sea, Marmara, Aegaeis and Mediterranean) and those areas with proper irrigation. Irrigated farm land in Turkey amounts to less than 10% of the cultivated land. But even these sparse facilities have not been fully utilized (EREN 1963). If fertilizer is going to be used effectively in the areas mentioned, lodging resistant varieties with high yielding potential should replace those presently in use.

## 2. Introduction of wheats with high yielding potential

A project of this nature has encouraging examples in the Mexican Wheat Breeding Program of BORLAUG (1958) and in a similar program started for Pakistan by NARVAEZ and BORLAUG (1966). By developing short straw rust-resistant wheats with high yielding potentials, given high fertilization, and by doubling the area sown to wheat, Mexico's average yield per unit area was more than doubled and, consequently, the total production of wheat was nearly quadrupled during the period from 1945 to 1962 (PETERSON 1965).

In West Pakistan during 1966 the use of these short straw wheats in combination with a fertilizer application of 80 kg N and 60 kg $P_2O_5$/ha raised the average yield from 1 to 3.42 tons/ha. This average was reached in 1966 on 2,100 ha of land. Top yields exceeded 7 tons/ha (QURESHI and NARVAEZ 1966).

Data of preliminary work at the Agricultural Research and Introduction Centre at Izmir, Turkey, during the 1965~66 and 1966~67 growing seasons also were very encouraging. They are first results of an otherwise very extensive breeding program which cannot be described here in detail. During these two growing seasons 2 Italian *Triticum durum* varieties and 9 physically and chemically induced mutant lines were tested on alluvial, fine sandy loam soil and compared with the 2 Turkish standards 'Akpusana' and 'Akbasak'.

The induced mutants were derived from some of the best Italian *T. durum* varieties, 'Grifoni', 'Garigliano', 'Aziziah', 'Russello' and 'Capelli', and are considerably shortened in straw length if compared with their mother lines. They are presently tested in several countries as part of the Near East Project for Wheat and Barley Improvement under the auspices of FAO and IAEA. Capelli, derived from the North African variety 'Jean Rhetifah', is now grown on 50% of the acreage sown to *T. durum* in Italy (SCARASCIA-MUGNOZZA 1965). Most of the mutants showed very good lodging resistance at medium doses of fertilization (60 kg N and 50 kg $P_2O_5$/ha). The local strains Akbasak and Akpusana showed from 94 to 100% lodging. The yields of these varieties and strains during the 1965~66 and 1966~67 growing seasons are shown in Table 1. Two and 4 strains, respectively, are significantly higher yielding than the standard Akpusana. Yields higher than 5 and 6 tons/ha are very promising if compared to the present average of Turkish wheat yields. Of course, one has to consider that these yields probably cannot be reached as future average yields, but that the average yields can be at least tripled by using this promising materi-

Table 1. 1966 and 1967 yields of 11 Italian *Triticum durum*
varieties and mutant lines and 2 Turkish standards

| Material | 1966 yield tons/ha | 1967 yield tons/ha |
|---|---|---|
| 1. GR-A-145 | — | 6.458 |
| 2. GA-B-125 | 4.448 | 5.511 |
| 3. Capeiti | 4.808 | 5.436 |
| 4. AZ-B-155 | 3.512 | 5.306 |
| 5. CP-C-48 | 3.280 | 5.059 |
| 6. GA-A-7 | 4.355 | 4.932 |
| 7. RS-A-1 | 3.813 | 4.786 |
| 8. CP-B-144 | 3.688 | 4.262 |
| 9. Akpusana* | 3.435 | 3.941 |
| 10. CP-B-132-A | 2.945 | 3.891 |
| 11. Akbasak* | — | 3.745 |
| 12. Capelli | 2.353 | 2.792 |
| 13. CP-A-26 | 2.983 | — |
| LSD : | 1.025 | 1.201 P=0.05 |

\* : Standard

al and adequate fertilization.

The use of *T. durum* wheat is still very prominent in Turkey. It can be estimated that nearly 50% of the total acreage is planted to this kind of wheat. Naturally, much of this wheat is used for bread making, however, it is a generally accepted fact that *T.durum* has inferior baking qualities. It probably would be advisable to convert much of the *T. durum* acreage to *T. aestivum*. These *T. aestivum* yield tests have been carried out only for one growing season. The results of at least two more years of testing are needed to confirm these data. Results of the first year are shown in Table 2. Fertilizer application consisted of 120 kg N, 100 kg $P_2O_5$ and 60 kg $K_2O$. This experiment also was conducted on alluvial, fine sandy loam soil. Results indicate that the Mexican wheats 'Penjamo', Sm-t, 'Nainari 60', Fr×KAD and 'Lerma Rojo 64a' were the highest yielders in this test. Eight varieties and strains yielded significantly higher than the standards. Penjamo yielded almost twice as much, and Nainari and Lerma Rojo 64a each produced almost 2 tons more than the standards. Penjamo and Lerma Rojo 64 constitute more than half the shipment of more than 20,000 tons of seed wheat which were imported from Mexico by the Turkish Government in cooperation with the USAID and of which 80% were planted in the coastal regions during fall of 1967.

### 3. Application of high ferlilizer rates

As already pointed out the above mentioned *T. aestivum* and *T. durum* varieties and

Table 2. 1967 yields of 21 introduced varieties and strains compared with
2 Turkish standards

| Accessions | tons/ha | Accessions | tons/ha |
|---|---|---|---|
| Penjamo | 5.286 | Mara | 3.362 |
| Mexican Hybrid[1] | 4.734 | Gabo 54 | 3.270 |
| Nainari 60 | 4.692 | Floran | 3.262 |
| Columbian hybrid[2] | 4.598 | San Marino | 3.226 |
| Lerma Rojo 64a | 4.588 | 2288 Lucero | 3.197 |
| 908 Frontana II-9 | 4.455 | Bredsol | 3.140 |
| Mexican hybrid[3] | 4.359 | Gabo 55 | 2.825 |
| Yektana 54A | 3.882 | 908 Frontana II-8 | 2.763 |
| M.V.O. Dirk 48 | 3.525 | Floransa* | 2.697 |
| Akova | 3.489 | Mentana* | 2.674 |
| Triple Dirk | 3.460 | Frontana strain[4] | 2.658 |
| Kentana 48 | 3.385 | | |

LSD=0.877
P=0.05

\* : Local standard
1) S-m-t-c-b × Th-o-k-mt × c-b×p
2) Fr×KAD-CBII.5140-4B-2T-IB-IT
3) (My 54-N10-B)--P4160-8715-7Y-40-3Y-2C
4) 908 Frontana C. 14-120-70-50-30-2R

strains are only high yielding under medium and high fertilizer regimes. As a matter of fact, Turkish varieties and standards have produced higher yields than introduced material with a high yielding potential when given none or insufficient amounts of fertilizer because of their better natural adaptability. The dwarf varieties from Mexico can withstand high application of fertilizer without lodging. In newly planted Uniform Regional Wheat Yield Trials 150 kg N and 60 kg $P_2O_5$/ha are being applied. The phosphorus was applied as super phosphate in fall prior to planting by mixing with the soil, or it was applied together with the seed through the grain drill when conditions were favorable. The nitrogen is being given in 3 applications in order to reduce leaching during the season of heavy rainfall. For instance during the 1966∼67 growing season, winter precipitation at Izmir (Menemen) amounted to 110.9 mm in November, 265.8 mm in December, and 121.3 mm in January. The 3 applications consist of 50 kg N/ha before planting as ammonium sulfate, 50 kg N/ha applied at the beginning of tillering in the form of ammonium nitrate as top dressing and 50 kg N/ha 20∼25 days later as second top dressing.

## 4. Experiments in progress

Fall plantings for 1967 at the Izmir Centre included Uniform Regional *T. durum* Yield Trials of the 7 best Italian *T. durum* varieties and mutant lines (Table 1) at 11 locations, and Uniform Regional *T. aestivum* Yield Trials of 14 Mexican, 3 Italian, 3 Australian, 5 Turkish varieties and 3 Turkish standards at 15 locations in the Aegean Region. Proceeding from the North to the South the areas in which these trials are located are Bergama, Akhisar, Izmir (Menemen-2 locations, and Bornove), Manisa, Salihli, Alasehir, Torbali, Oedemis, Söke, Kocarli, Nazilli, Sarayköy and Ortaca. These trials are being conducted on a larger scale of soils and over a wider area than was possible during the two preceeding seasons, and should provide the first comprehensive results for these promising *T. durum* and *T. aestivum* materials.

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# II. Genetic Symbols and Nomenclature

## A report of the Nomenclature Commission of the Genetics Section, I.U.B.S., at the XIIth International Congress of Genetics, Tokyo, August 28, 1968

Meeting of the Nomenclature Commission were held on August 21 and 26, 1968 and an open meeting was called on August 24 which was attended by 22 members of the XIIth International Congress of Genetics who represented a variety of field. At these meetings the following topics were discussed and recommendations were approved as indicated below.

1. The rules for symbolization contained in the Report of the International Committee on Genetic Symbols and Nomenclature (See I.U.B.S. Series B, **30**: 6, 1957) were reviewed. The amendment proposed by Professor Y. TANAKA, that the italicized + in articles 5 and 11 be written without italics, was sympathetically received but no action was taken because most publishers do not have this symbol in italics. Professor K. YAMASHITA explained that in reprinting the report on rules mentioned above in Wheat Information Service 8: 24~27, 1959, no spaces were shown between the gene symbols in the table part of rule 11, although, they are present in the original. Other rules were discussed but no formal action was taken on them.

2. Our attention was drawn to the use of the symbol ♀ for female in the publication "Standard nomenclature for imbred strains of mice" (Cancer Res. **24**: 147~151,

1964). This usage was not regarded favourably.

3. It was agreed, as recommended by Professor Y. TANAKA, that when parents of a cross are written, the female parent should be listed first. When this is not done the system of listing should be specified.

4. There was general support for Professor Y. TANAKA's proposal that a newly studied gene of a mutant should be named and symbolized with words or letters suggestive of its characteristics and that person's names or nonsence names should be avoided.

5. There was also support of Professor Y. TANAKA's suggestion that the rules adopted during this meeting and approved by the Congress should be published in genetic periodicals which have extensive circulation.

6. Professor T. YAMAMOTO was asked to contact other fish geneticists in an attempt to work out a uniform system of symbols for sex and sex chromosomes in fish.

7. The suggestion of Professor E. HADORN, that any cytoplasmic designation should be given in square brackets and should precede the nuclear symbols, was favourably received.

8. Professor J. W. BOYES requested additions to the list of publications regarding genetic nomenclature, symbolization and terminology that he is preparing for distribution.

9. There was general agreement that a publication containing reprints of reports, or excerpts from reports etc., on the practice regarding nomenclature, symbolization and terminology in different fields of genetics, as proposed by Professor J. W. BOYES, would be useful. Some funds are available for this purpose and an effort will be made to obtain further funds if necessary.

10. It was unanimously agreed that the Nomenclature Commission cannot undertake to legislate on general rules at this time and that our approval is no more than an expression of support of the recommendations brought to us.

11. Members of the Nomenclature Commission:
J.R.A. FINCHAM, S.J. GEERTS, E. HADORN, C. STERN, K. YAMASHITA and J.W. BOYES (Chairman).

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# III. Editorial Remarks

## Announcement for future issues

WIS No. 28 will be published during the fiscal year from April, 1968 to March, 1969. Manuscripts for these issues are accepted any time, and go to press in sequence as soon as they cover planned pages of each issue.

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. Contributions should be typewritten in English. The manuscripts should not exceed three printed pages. Lists of stocks are exempted from this page limit. One text-figure (smaller than $7 \times 7$ cm$^2$) will be accepted for each article, if indispensable. Communications regarding editorial matters should be addressed to:

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Yoshida College, Kyoto University
Kyoto, Japan

## Membership

The yearly membership fee is US $ 1.00 or the equivalent paid by Demand Draft, payable at the Dai-Ichi Bank Ltd., Kyoto, Japan or the Sumitomo Bank Ltd., Kyoto, Japan, or by Postal Money Order.

*Explanation of the Figure on the Cover*

A new example of a cytoplasmic but not maternal type of inheritance resulted from reciprocal wheat×rye hybrids. The Figure shows ears of rye, haploid *Secalotricum*, haploid *Triticale*, and wheat (from left to right). The ears of the reciprocal hybrids differ in length corresponding to the male parent. For other characters of these hybrids cf. ROBBELEN and SMUTKUPT, pp. 10~13 in this issue.