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IV. Editorial Remarks

Correction

In the article of Dr. J. MAC KEY, "Chemical induction of mutation in common wheat", in page 9 of WIS No. 14, the last sentence beginning by "Since ethyleneimine" the last 4 lines should be changed to the following:

"Since ethyleneimine gives a pH-value in water solution over 10, an adjustment down to pH 7.7 was undertaken by adding salt acid, and since diethyl sulfate is unstable at the low pH-value obtained in pure water, a Tris buffer was here added to keep pH at 7.6-7.7. In addition, a continuous shaking occurred in open flasks to accomplish a certain aeration".

Explanation of the Figure on the cover

Spikes of seven monosomic addition lines and the parental species. From left to right, Stewart *durum*, monosomic addition lines ($e_1 \sim e_7$), and *Ag. elongatum.*

(A. Mochizuki, s, page 50)

Announcement for further issues

WIS Nos. 17 and 18 will be published during the fiscal year from April 1963 to March 1964. Manuscripts for those issues are accepted any time, and they will go to press in sequence as soon as they cover the planned pages of each number. WIS is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics and cytology of *Triticum, Aegilops, Agropyon, Secale* and *Haynaldia.*

The manuscripts should not exceed 3 printed pages. List of stocks is exempted from this page limit. No illustrations are accepted for this publication.

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Nos. 15,16 March 1963

I. RESEARCH NOTES

Radiation - induced striping in einkorn wheat and its inheritance

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Seeds of *Triticum monococcum flavescens* were exposed to X - and γ -rays by ^{60}Co, thermal and fast neutrons (14 MeV) and β -rays by ^{32}P and ^{131}I -solution. In the treated X_1 and later generations white and / or yellow stripes were often observed and their mode of inheritance was studied. The striping was divided into the following types.

1) Most of white - or yellow - striping found in X_1 was maternally or cytoplasmically inherited and was due to plastid mutation. The first appearance of this type occurred in the X_2 generation.

2) In the X_2 head progeny segregating *albina* in a simple Mendelian ratio, white-striped leaves were often observed in a few plants. They might be mostly due to a somatic mutation in a heterozygous plant concerning *albina* (*Aa*).

3) Some white stripes which could be distinguished from others by the fine nature of striping occurring in all leaves of a plant were controlled by a mutated recessive gene.

4) Special variegation was found in three X_1 - plants. Their progeny contained some white seedlings. The *basi - viridis* (or *virido - albina*) seedlings, other than *albinas,* invariably grew up to be variegated; they were controlled by a mutated recessive gene. Evidence indicated that the recessive *basi - viridis* gene for variegation, which was stable, stimulated plastids to mutate (irreversibly) from green to white. Plastid "exomutation", or mutation from green to white was affected by environmental factors, such as temperature. This type of variegation was already reported for "Okina" - barley by Imai (1928).

Boron effects upon gamma-ray and thermal neutron irradiations in Einkorn wheat; RBE of heavy particles from $^{10}B(n, \alpha)^{7}Li$ reaction

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In order to study RBE for chromosome aberrations and gene mutations of (α + ^{7}Li) from the thermal neutron capture reaction $^{10}B(n, \alpha)^{7}Li$, compared with gamma-rays, seeds of *Triticum monococcum flavescens* soaked in water and 0.1, 0.5 and 1.0 % aqueous solutions of borax for 2 days were exposed to ^{60}Co gamma-rays at the doses of 0.5, 1, 2 and 3 kr, and to thermal neutrons in JRR-1, of which the integrated flux ranged from 1.3 to 10.4 × 10^{11} n_{th}/cm^2 for 25 ~ 200 seconds (cf. WIS No. 13 : p 4). Chromosome aberrations in PMC's of the X_1 plants and chlorophyll mutations in the X_2 seedlings were investigated.

The frequency of chromosome aberrations increased markedly with the increase of the dose of gamma-rays and thermal neutrons, and especially with increasing borax concentrations for the neutron treatments. Assuming that the chromosome aberration frequency versus gamma-ray dose curve is linear and independent of dose rate as well as of borax concentrations, the overall effective doses of thermal neutrons of 1.3 × 10^{11} and 5.2 × 10^{11} n_{th}/cm^2 can be converted to equivalent gamma-ray doses for the various borax concentrations.

The frequency of chlorophyll mutations increased roughly in a linear relation to the dose of gamma-rays and thermal neutrons and also markedly with increasing borax concentrations only for thermal neutron treatments, as could have been expected. There was no significant boron effect on the mutation frequency induced by gamma-irradiation. Therefore, the data for gamma-treatments were pooled. They show a linear relationship between the mutation frequency and the dose of gamma-rays. The chlorophyll mutation rate per kr of gamma-rays is 1.5%. Assuming a similar linear relationship, frequency-dose curves were drawn for neutron treatments.

Table 1 lists in line 4 the RBE doses for chromosome aberrations and chlorophyll mutations under various irradiation conditions calculated from dose-response curves mentioned above. Line 5 gives the increases in RBE dose due to the added boron, which were calculated by subtracting the corresponding RBE doses for the treatment at zero borax concentration. Line 6 gives the absorbed doses (rad per 10^{11} n_{th}/cm^2) due to neutron capture by added boron, which have been calculated by the first collision dose. The RBE values of the heavy

Table 1. Estimated RBE values of heavy particles from $^{10}B(n, \alpha)^{7}Li$ and relevant data

	For chromosome aberration						For chlorophyll mutation			
1. Borax concentration %	0		0.1		1.0		0	0.1	0.5	1.0
2. Content of borax aqueous solution (weight % relative to dry seed)	91		85		79		91	85	83	79
3. Integrated thermal neutron flux (10^{11} n_{th} cm^{-2})	1.3	5.2	1.3	5.2	1.3	5.2	1	1	1	1
4. RBE dose* of thermal neutrons relative to ^{137}Cs gamma-rays (krem)	0.24	1.5	0.8_6	2.9	1.9	4.8	0.7_7	1.2	1.9	3.3
5. Increase in RBE dose of thermal neutrons due to added borax (krem)**	-	-	0.62	1.3	1.7	3.3	-	0.4_8	1.15	2.5
6. Absorbed dose due to added borax (krad)***	-	-	0.011	0.044	0.105	0.42	-	0.0086	0.0425	0.0826
7. RBE of (α + ^{7}Li) ((5)÷(6))	-	-	56	30	16	8	-	56	27	30

* That dose of gamma-rays which produces the same amount of effect as the given dose (1, 1.3 and 5.2 × 10^{11} n_{th} cm^{-2}) of neutrons.

** RBE dose with borax minus RBE dose without borax, at the same neutron dose.

*** Calculated physically by the first collision dose.

particles listed in line 7 have been obtained by dividing the RBE dose values given in line 5 with absorbed dose values given in line 6.

The RBE values obtained for chromosome aberrations in PMC's and for chlorophyll mutations were 23 ± 10 and 29 ± 10, respectively. These figures are of the same order as those for fast neutrons previously reported for wheat and barley.

Most of the present results are explicable on the assumption that chromosome breakage in wheat requires many ionizations to occur within a chromosome and that the majority of radiation-induced chlorophyll mutations result not from point mutations but from chromosome breakage events.

On the occurrence of chlorophyll mutations in clusters in einkorn wheat

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Dormant seeds of *Triticum monococcum* were subjected to 10, 20 and 30 kr of gamma-rays. All spikes from all X_1 individuals were harvested and chlorophyll mutations were scored in the X_2-seedlings. Number of spikes with chlorophyll mutants increased with increasing dosage. In some cases, several spikes proved to carry the same kind of mutation from the same X_1 individual. Namely, 8 spikes among 16 from one individual segregated *albina*, while in another case, only one spike among 60 spikes *xantha* was found. Thus distribution of cluster mutations showed a wide variation, and the average number of cluster mutants per X_1 individual was not related to dosage. Frequency distribution of cluster mutants of *albina* type was calculated according to KONDO (cf. KONDO, S. 1961, Jap. Jour. Genet. 36: 6-17), as given in Table 1.

Table 1. Frequency of *albina* clusters

No. of spikes which segregated *albina* seedlings in X_2	No. of X_1 plants	Calculation	
		Observed	According to KONDO
0	151	0.795	0.795
1	24	0.126	0.122
2	8	0.042	0.055
3	4	0.021	0.019
4	3	0.016	0.005
5	0	0	0.002
6	0	0	0.0005
7	0	0	0.0001

According to the results, the minimum number of original cells in embryonic stage was estimated as 35 ± 3, and some of these differentiated cells seem to have furnished the initials for the spikes.

Effects of nitrous acid on germinating seeds of *Triticum monococcum* (negative results)

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Oestergren (1957) and Nygren (1955) obtained polyploids in *Phalaris, Crepis* and *Melandrium* by treatment with nitrous acid. Recently, Kihara and Tsunewaki (1960) obtained tetra- and aneuploids in Emmer wheat in the same way. This method was applied by the present author to germinating seeds of *Triticum monococcum* L. var. *flavescens* Koern. 60 seeds for each lot were soaked in water at room temperature. Germinating seeds were picked up 24 and 48 hours after the start of the experiment and were treated with nitrous acid for 8, 16 and 24 hours, each treatment at the pressure of 3 and 5 atmospheres. (Viable seeds showed a developing embryo after 24 hour treatment which was not observed in dead seeds.)

Details of treatments and growth behaviour are shown in Table 1. Nitrous acid treatment apparently does not affect either germination or survival rates and seedling length or the number of offshoots. Induction of polyploidy was examined by the observation of chromosomes at MI with smear technique. All spikes, except two, had seven bivalents like those of the control lots. Thus tetraploids or any kinds of chromosome irregularities were not obtained. One plant in each of the lots subjected to 6 atm. for 24 hours and 3 atm. for 8 hours was haploid but this was not due to the effect of nitrous acid because sporadical appearance of haploids is known in *T. monococcum.*

According to the results of Kihara and Tsunewaki, nitrous acid treatment is very efficient when it is given 24 hours after pollination, when the first meiotic division is taking place. Treatments for 10 hours or longer produced tetra- and hypotetraploids in about 70 per cent or more of the treated plants. Their number was increased to 98 per cent by treatment at 6 atm. pressure for 15 hours. But on the basis of my cytological observation the upper confidence limit on the proportion of induced polyploids at the 95 per cent level was calculated as 0.8 per cent. Nitrous acid did not produce polyploidy when it was applied to germinating seeds for up to 24 hours at pressures of 3 and 6 atms. But polyploid plants may be produced by subjecting germinating seeds or some other growing stage to more intensive treatment.

Corrections: Instead of "nitrous acid" read "nitrous oxide".

Table 1. Effects of nitrous acid treatments given to soaked seeds of *T. monococcum*.

Pre-soak (hrs.)	Pre-ssure (atm.)	Duration of treatment (hrs.)	No. of treated seeds	Germi-nation (%)	Seedling length (cm)*	No. of surviv-ing plants at heading time	Total number of tillers	Average number of tillers	No. of plants or heads examined for the chromo-some number	No. of plants with 7 bivalents
24	-	-	60	91.7	10.5	55	665	12.3	10	10
48	-	-	57	56.1	10.5	27	392	15.1	10	10
72	-	-	54	63.0	10.7	35	633	18.1	10	10
24	3	8	58	79.3	10.4	42	687	16.4	30	30
”	”	16	56	80.4	10.8	44	800	18.2	34	34
”	”	24	59	83.1	9.9	45	810	18.4	39	39
”	6	8	56	87.5	10.3	49	722	14.7	45	45
”	”	16	56	82.1	9.7	45	624	14.5	26	26
”	”	24	50	88.0	10.0	43	634	14.7	28	28
48	3	8	53	56.6	9.2	26	299	12.0	21**	20
”	”	16	57	66.7	8.8	35	372	10.9	27**	26
”	”	24	54	50.0	9.3	27	285	10.9	17	17
”	6	8	59	79.7	10.5	45	566	12.3	37	37
”	”	16	58	77.6	8.7	45	586	13.0	38	38
”	”	24	56	75.0	7.8	39	567	15.3	34	34

* Seedling length was measured 20 days after sowing.

** One plant in each lot had 7 univalents, *i. e.* was haploid.

Percentage emergence in *Triticum aestivum* as affected by seeding rate, season, and variety

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As a result of poor stands of hard red winter wheat in certain years and locations in the semi-arid sections of the Southwestern U. S. A., farmers frequently resort to higher seeding rates. Not infrequently the increased seeding rates do not produce the expected increased stands. Often the stands are somewhat better, i. e. more seedlings emerge, but the percentage emergence does not appear to be proportionate to the increase in seeding rate.

In a study set up to determine certain yield components (number of spikes per unit of area, number of seeds per spike, and weight of seeds) as affected by variety and seeding rate, seedling emergence was also determined by variety, by rate, and by replication. The 3 varieties in the test - Concho C. I. 12517, Kaw C. I. 12871 and Triumph C. I. 12132 - are all commercially grown in Oklahoma and adjacent states. The varieties were seeded in 10 foot 4-row plots with 12 inches between rows and between plots at rates given in Table 1. Each variety and rate was seeded in 4 replications. Seedling counts were made in all 4 rows of each variety within each seeding rate. The tests were conducted two crop years, 1958 - 1959 and 1959 - 1960. Conditions for seeding as to moisture and seed bed preparation were good to excellent in the fall of 1958, but because of extremely heavy rains in the fall of 1959 seeding had to be delayed beyond optimum time (October 1). Consequently, seeding conditions were only poor to fair in the fall of 1959.

The seeding rates (in pounds per acre), the number of seeds planted and the number of seedlings emerged per square foot, and the percentage emergence are given in Table 1. In the 1958 - 1959 season, the percentage emergence for the 20.8 pound seeding rate was significantly higher than for the other three rates. There was no significant difference in percentage emergence in the three higher rates. However, in the adverse year of 1959 - 1960, the picture was somewhat different. Again the lowest seeding rate produced the highest percentage emergence, although considerably less than in the previous year. However, for each variety save one, as the seeding rate increased, there was a decrease in

Table 1. Seeding rate and per cent emergence of 3 varieties of hard red winter wheat, *Triticum aestivum*.

Variety	Seeding rate	No. of seeds planted	No. of seedlings emerged	Emergence
	Lbs. per acre	Per square foot		%
		1958 - 1959		
Concho	20.8	7.2	6.0	81.5
C. I. 12517	38.6	14.3	8.6	62.6
	60.8	21.6	13.7	64.1
	76.8	28.6	17.0	63.0
Kaw	20.8	7.0	6.4	90.8
C. I. 12871	38.6	13.9	9.7	74.1
	60.8	20.9	15.6	75.1
	76.8	27.9	19.7	75.4
Triumph	20.8	6.7	5.7	84.9
C. I. 12132	38.6	13.4	8.9	71.0
	60.8	20.2	13.6	68.8
	76.8	26.9	16.4	65.6
		1959 - 1960		
Concho	20	7.2	4.9	67.9
C. I. 12517	40	14.4	7.6	53.3
	60	21.5	9.3	43.3
	80	28.6	11.3	39.6
Kaw	20	6.8	4.3	62.6
C. I. 12871	40	13.6	7.1	51.9
	60	20.4	9.4	45.8
	80	27.1	11.4	42.0
Triumph	20	6.7	4.9	72.3
C. I. 12132	40	13.5	8.2	61.1
	60	20.2	10.8	53.8
	80	26.8	14.5	54.0

All figures are the average from 4 replications.

the percentage emergence. The lone exception was for the variety Triumph at the 80-pound seeding rate, which had a slightly higher percentage emergence than the 60-pound rate. It can be noted that in 1959-1960, the emergence was below 60% in 8 out of 12 cases.

Based on purely physical aspects of the surface soil and of emergence, it would seem logical to expect a higher percentage emergence as the seeding rate is increased within limits. The factors responsible, be they of an inhibitory nature or otherwise, have not been investigated here and the answers are not apparent.

Supernumerary constrictions in the sat-chromosome of *Triticum*

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The occurence of supernumerary constriction in the nucleolar organizing region of the satellited chromosomes (the supernumerary constriction being separated from the secondary constriction by a minute chromosome segment) has been recorded by Bhaduri and Ghosh (Cytologia, 20, 148 - 49, 1956) in *Triticum macha* Dek. et Men and by Upadhya and Swaminathan (WIS. No. 13. p 9 : 1961) in *T. Zhukovskyi* Men. et Er. Both the pairs of Sat - chromosomes exhibit this characteristic supernumerary constriction in the former, while it has been recorded consistently for only one pair, in the latter: Bhaduri and Ghosh have (1. cit.) also stressed the utility of these identifiable pairs of chromosomes in cytological studies as well as in crosses as markers.

During the extensive survey of Karyotypes of different species and varieties of *Triticum*, the supernumerary constriction at the Sat - region has been recorded in several instances sporadically, as well as in some of the established induced mutants (vide Table 1).

Frequent occurrence of such supernumerary constrictions specifically associated with the secondary constriction region, indicates the probable structure of secondary constriction of the chromosomes of *Triticinae* to be of bipartiate nature, but is revealed only occassionally depending on the preparation of the slide and the orientation of the chromosome, a situation very similar to the quadripartiate nature of primary constriction as revealed by pachytene studies of Rye chromosome by Lima de Faria (Chromosoma, 1952: 5: 1-68).

Species	Variety	Location of supernumerary constriction	Remarks
T. aestivum	Hexaploid C. 591	Chromosome 10	In established awnless mutant
T. aestivum	Hexaploid C. 281	Chromosome 10	In some cultures of natural population and established awnless mutants
T. persicum	(Tetraploid) Rubiginosum (Zhuk): K-13810	-	Natural population

Dense-eared mutants derived from X-ray induced lax-eared wheat.

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In the progeny of X-ray induced lax-eared mutants with 41 chromosomes the author newly found two cytogenetic types of dense-eared mutants besides already reported three types of dense-eared mutants of common wheat (Uchikawa, 1960, '61). These newly found two types were called Type IV- and Type V dense-eareds by the author. The arising percentage of the former was 1.23 and that of the latter 0.95.

These two types of dense-eared mutants generally showed condensation of rachis, rounding of glumes, shortening of culms, diminution of germinating percentage and seed fertility, and augmentation of ear density, as shown in Table 1,

Table 1. Measurements of the quantitative characters and seed fertility of dense-eared mutants

Type	Average No. of off-shoot	Average plant height(cm)	Average ear length (cm)	Average No. of spikelets	Average ear density 1)	Average ear breadth	Average seed fertility
Normal (control)	22.4	124.5	12.1	24.5	20.2	1.02	95.6
Lax-eared (mother pl.)	14.2	107.4	13.8	23.4	17.0	0.96	63.3
IV. Het.	15.3	106.6	9.4	24.5	26.1	1.21	70.1
IV. Hom.	11.8	98.7	7.4	23.8	32.0	1.31	45.1
V. Het.	17.2	110.2	8.5	23.6	28.8	1.22	65.3
V. Hom.	14.4	102.4	6.6	23.2	35.2	1.34	40.2

1) Ear density is represented by the number of spikelets per 10 cm in rachis.

Type IV heterozygous dense-eared mutants gave normals, heterozygotes, homozygotes, lax-eareds, and short slender plants with normal ear form in the ratio 1 : 1.1 : 0.1 : 0.6 : 0.1 in the following generation; and the heterozygotes had 42 chromosomes including one iso-chromosome. In meiosis of their PMC's the chromosome associations $20_{\mathrm{II}} + 1_{\mathrm{I}} + 1\mathrm{iso}_{\mathrm{I}}$ (51.7%) and $20_{\mathrm{II}} + 1$ unequal pair (47.2%) were mostly observed, though in rare occasions $19_{\mathrm{II}} + 2_{\mathrm{I}} + 1$ unequal pair (0.7%) and $19_{\mathrm{II}} + 3_{\mathrm{I}} + 1$ iso-chromosome (0.4%) associations were seen. One partner of the unequal pair or one of the two univalents was a middle sized chromosome with submedian attachment, and the other partner was an iso-chromosome which consisted of two long arms of this chromosome. The iso-chromosome usually showed horse-shoe shape or small bivalent form by pairing itself with interstitial chiasmata. Both the unassociated iso-chromosome and its partner frequently lagged in their behaviors and were eliminated forming micronuclei at the outside of the daughter nuclei.

The results of crossing experiments between these heterozygotes and Type I subcompactoids with 42 chromosomes including one iso-chromosome showed that the iso-chromosome of this dense-eareds differed from that of subcompactoids in size and form and that they did not pair each other.

The homozygotes possessed 42 chromosomes, too, but two iso-chromosomes were included in this case. In meiosis of PMC's of them, almost all PMC's had $20_{\mathrm{II}} + 1\,\mathrm{iso}_{\mathrm{II}}$ (53.0%) or $20_{\mathrm{II}} + 2\,\mathrm{iso}_{\mathrm{I}}$ (45.3%) associations.

From these cytogenetic facts, the author assumes that Type IV dense-eared mutants might be originated by duplication of the long arm of a peculiar chromosome (non IX) bearing the dense-eared promoting or lax-eared suppressing gene, and that the iso-chromosome might be produced by misdivisions of one univalent chromosome of a lax-eared mother plant with 41 chromosomes. In fact the phenomena that two long arms went together to the same pole were actually observed occasionally at TI and TII PMC's of lax-eared mother plants. The abnormal segregation ratio of this type may be explained as follows: if the egg cells with 21-, 20 + 1 iso- and 20 chromosomes are produced in the ratio 1 : 1 : 0.5 and fertilizing rates in competition of pollen with 21-, 20 + 1 iso- and 20 chromosomes are 10 : 1 : 1 respectively as was shown in the results of the author's crossing experiments of normals × heterozygotes and its reciprocal cross and in that of observations of pollen tetrads of heterozygotes, there may be produced the zygotes with 42 chromosomes (normal), 41 + 1 iso-chromosome (heterozygote), 40 + 2 iso-chromosomes (Short-normal) and 40 chromosomes (homo. lax-eared) in the ratio 1 : 1.1 : 0.1 : 0.6 : 0.15 : 0.1 by combinations between male and female gametes. This calculated ratio closely coincides with the ratio actually obtained, except in the case of homozygous lax-eared zygotes. Perhaps this kind of zygotes aborted on the way of development.

Type V heterozygous dense-eared mutants gave normal, heterozygote, homozygote and lax-eared decendants in the ratio 1 : 0.93 : 0.14 : 0.14 in the following generation, but short-normal plants did not arise in this case.

In the cytological observations of these four classes of segregates 42- (21_{II}), 43- ($20_{II} + 1_{III}$, 66.4%; or $21_{II} + 1_{I}$, 30.5%), 44- ($20_{II} + 1_{IV}$, 51.5%; or 22_{II}, 44.3%) and 41 chromosomes ($20_{II} + 1_{I}$) were observed. In the case of heterozygotes a few cells showed $20_{II} + 3_{I}$ (2.8%) and $19_{II} + 1_{III} + 2_{I}$ (0.3%) associations, while in homozygotes $20_{II} + 1_{III} + 1_{I}$ (2.0%) and $21_{II} + 2_{I}$ (2.2%) associations were rarely seen, besides above mentioned associations. At TI of PMC's the univalent chromosomes frequently lagged in their behaviors and formed micronuclei at the outside of the daughter nuclei, and then were eliminated.

From these cytogenetic results the author assumes that Type V dense-eared mutants have one excess duplicated chromosome in heterozygotes and two in homozygotes. The origin of Type V dense-eared mutants, therefore, may be the simple duplication of a whole chromosome bearing the dense-eared promoting (or lax-eared suppressing) gene, and the duplication may be caused by non-disjunction of the univalent chromosome in meiosis. In fact, non-disjunctions were frequently observed at TI (2.1%) and TII (9.8%) PMC's in the lax-eared mother plants with 41 chromosomes.

From the above-mentioned chromosome associations, the gametes with 21- and 22 chromosomes may be produced in heterozygotes, besides a small number of 20- and 23 chromosome gametes, but the last ones may not fertilize actually by their weakness of viability due to extreme overdose of chromosomes.

In heterozygotes, if the female gametes with 21-, 22- and 20 chromosomes are produced in the ratio of 10 : 8 : 1 and the male gametes with 21-, 22- and 20 chromosomes fertilize in the ratio 20 : 4 : 1 by competition among them as was shown in the results of normals × heterozygotes and its reciprocal cross and in that of observations of pollen tetrads of heterozygotes, zygotes with 42- (normal), 43- (heterozygote), 44- (homozygote), 41- (het. lax-eared) and 40 chromosomes (homo. lax-eared) may arise in the ratio 1 : 0.94 : 0.15 : 0.15 : 0.005 respectively. This calculated ratio seems to be very near to the actually observed ratio 1 : 0.93 : 0.14 : 0.14 except lax-eared homozygotes. Theoretically expected lax-eared homozygotes with 40 chromosomes did not arise actually. Perhaps these zygotes might have aborted on the way of their development.

Through the cytogenetic results of dense-eared mutants the author assumes that dense-eared mutants arise by partial or whole duplication of a peculiar chromosome (non IX) bearing the dense-eared promoting (or lax-eared suppressing) gene and that lax-eared mutants arise by partial or whole deficiency of the same chromosome. The locus of the dense-eared promoting gene is in one segment of the long arm of this chromosome. This peculiar chromosome perhaps corresponds either to 5B (V) or 5D (XVIII) chromosome, which is homeologous with 5A (IX) chromosome of Chinese-Spring wheat, or to 4D (XV) chromosome having lax-eared suppressing gene.

Differential radio-sensitivity among the different varieties of bread wheats

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From the comparison between the different varieties of bread wheats regarding their response to the evolution of mutations evaluated in terms of yield of the M_2 progenie-s it has been found that different doses of gamma-rays have a positive differential effect on different genomes and varieties. Yield has been considered to be an important factor with regard to the radiation response because its being controlled by many of its components. It thus involves more than a simple gene alteration.

Varieties of hexaploid wheat, Kharchia, RS 31-1, C 591, Jaipur Local and RS 9-11, and one tetraploid wheat, Malvia Ekdania, were included in a study of evolution of useful mutations in these varieties. Seeds were subjected to three doses of gamma-rays viz. 10,000 r, 20,000 r and 30,000 r at the Cobalt-60 facility of the Indian Agricultural Research Institute, New Delhi, India in 1959. Yield of 100 M_2 progenies with equal number of plants of each ear progeny and controls in each of the above mentioned varieties were recorded under field conditions. The treatments were also screened for various mutations. Spontaneous mutations were not observed in any of the large control materials.

The results of the present study indicate that Kharchia is relatively most sensitive than the other varieties when range of yield in various progenies is used as an index of sensitivity. In all cases except in Kharchia 10,000 r and Malvia Ekdania - 10,000 r there is a decline in the yield of the treatments as compared to the controls. Among the treatments themselves the decline in yield is directly proportional to the higher dose of gamma-rays. Different treatments of a variety when collectively are compared in the same way to each other show a different pattern of yield range. Differences of sensitivity as indicated by these studies show that radio-sensitivity depends not only on the kind and number of genomes but also on the kind of alleles present in any particular material.

The lower efficiency of the tetraploid wheat Malvia-Ekdania to produce much less number of mutations due to its lesser mutagenic specificity is also reflected in the studies. Since the tetraploid wheat being more stable is more likely to be less effected by gamma-rays in comparison to the hexaploid it necessarily implies that a lower range of yields be obtained in the treated material of such a variety. Such results showing more stability in the tetraploid wheat have been reported by FUJII (WIS. No. 7 p 11, 1958). The restricted group of mutations observed in our tetraploid material lends support to MACKEY's (Hereditas 40 : 165-180, 1954) contention that the 'diploid sector' of the germ plasm of bread wheat is limited and the polyploidy while imposing a restriction on the morphological frame permits a more varied and subtle differentiation within this frame.

Evidence of gene dosage effects in *Triticum aestivum*

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One of the most striking gene effects in hexaploid wheat, the compactoid-speltoid characteristic, has been shown to be produced by a dosage effect of factor Q on chromosome IX (MAC KEY). Similar cases in wheat, however, are not frequently known as yet. Some new observations on such gene dosage effects therefore will be given, which grew out of cytogenetic investigations on chemically induced drastic mutants of spring variety "Heines Koga II"[1].

To begin with the experimentally induced compactoid mutants, the cytological analysis did not show any change from the original variety; heterozygotes of these mutants segregated in a monohybrid ratio of 214 normal types: 425 intermediate types (subcompactoid) : 201 compactoid mutants ($P>0,05$, $\chi^2 = 0,52$). On the other side each of three speltoid mutants were characterized by a different degree of deficiency in a definite chromosome pair. In reciprocal crossing between these speltoids and compactoids the wellknown dosage effect of the Q factor appeared: The F_1 of the combination of heterozygous subspeltoid ($1Q$) × homozygous compactoid ($4Q$) consisted of heterozygous subspeltoid ($3Q$) and normal phenotypes ($2Q$).

Three other mutants of our sortiment displayed the very same manifestation for the sphaerococcoid factor (sp). All the subsphaerococcoid phenotypes, which were hardly discernible from the original variety, were trisomic. The more distinctive sphaerococcoids were tetrasomic. For the purpose of locating the factor in question the tetrasomic sphaerococcoids were reciprocally crossed to the monosomic XVI of "Chinese Spring". The resulting forms in F_1 and F_2 proved to be disomics when aestivum types, trisomics when subsphaerococcoid types, and tetrasomics when sphaerococcoid types.

Numerous squarehead mutants were obtained in the mutation experiments cited above. Ten different forms could be distinguished cytologically: Two of those mutants were found to be tetrasomic for the squarehead chromosome. In a third progeny a deficiency-duplication (21_{II} + 2 fragments of the squarehead chromosomes) was detected. In a fourth not segregating squarehead form 42 chromosomes were counted. In this case one quadrivalent had occasionally been formed in metaphase cells, while trivalents were found in the corresponding subsquarehead forms. The 4 or 3 chromosomes of these multivalents had equivalent lenght, and there is every reason to believe that this mutant originated from chromosome substitution. Consequently those squareheads are nulli-tetrasomic, and the subsquareheads mono-trisomic. No cytological difference from the original variety could be detected among the remaining 6 squarehead mutants investigated. In all the cases studied the squarehead character segregated with a monohybrid ratio dependent on the environment, however, there was a different amount of mutant deficiency. These observations are in contrast to all results on the inheritance of the squarehead characteristic known so far in the literature.

Another dosage effect with regard to the length factors (L) of the ear was found in the progeny of the two lax-eared mutants. These mutants were tetrasomic, and the corresponding intermediate heterozygotes were trisomic. Crossings to the monosomic sortiment of "Chinese Spring" did not yield phenotypes similar to the hybrid progeny of normal "Koga II" × normal "Chinese" except for the disomic F_1 plants in the combination of the lax-eared mutant and mono-XXI. The latter types gave 21_{II} in metaphase I, while the trisomics in the same F_1 had $21_{II} + 1_{I}$.

The last three mutants to be described here were produced by changes in the dosage of factors, influencing the strawlenght. Within a segregating progeny the normal phenotypes with 42 chromosomes had the longest culms, but the internodes remained shorter in trisomic intermediate forms and were extremely reduced in the tetrasomic mutants.

When summarized these results demonstrate gene dosage effects to be relatively frequent in hexaploid wheat. This is so much the more we favour the conception of micro-duplications in the chromosomes of all those mutants, that did not show aberrations in the microscop. With respect to the origin of the first squarehead mutant in the fields of the wellknown English farmer Taylor, it might be more reasonable to assume such a small duplication having no negative influence on the fertility than to trust in the polyfactorial hypotheses of squarehead inheritance postulated for so long time. Similarly our cytogenetic observations are thought to give the following clue to the evolutionary difference between *Triticum aestivum* subsp. *vulgare* and *T. aestivum* subsp. *sphaerococcum*. It is wellknown that Sears was the first to locate the sphaerococcum factor of *T. sphaerococcum* on chromosome XVI by crossing different nullisomics of *T. vulgare* ("Chinese Spring") to *T. sphaerococcum*. Monosomic plants of the critical F_1 with 1 chromosome XVI of *T. sphaerococcum* were of vulgare phenotype, but the corresponding disomics in F_2 with 2 chromosomes XVI of *T. sphae-*

rococcum were of the sphaerococcum phenotype. Therefore SEARS argued the recessive sphaerococcum factor to be hemizygous-ineffective. Considering however, the same result in relation to the cytogenetical findings on our mutants, the following conclusions may be drawn: Just as sphaerococcoid mutants arose by indusing a duplication in the normal "Koga II", *T. aestivum* subsp. *vulgare* may have a sphaerococcum factor on chromosome XVI, which phenotypically is ineffective in its normal diploid dose. In similar way *T. sphaerococcum* might be produced by a small duplication on chromosome XVI, i. e. in consequence of a dosage effect of the sphaerococcoid factor. Obviously this conception is confirmed by some crossing results of ELLERTON (1939): In the F_2 of *T. vulgare* × *T. sphaerococcum* segregation was unifactorially in relation to the sphaerococcum characteristic. The heterozygous F_1 plants having 1 vulgare chromosome XVI (1 sp) + 1 sphaerococcum chromosome XVI (2 sp) were subsphaerococcoids comparable to our trisomic mutants.

1) ZSCHEGE, C.: Mutationsausloesung durch Chemikalien bei Weizen. (Cytogenetische Untersuchungen an Mutanten). Diss. Landw. Fak., Univ. Goettingen (1963).

Genetics of field resistance of wheat varieties to the races of stem, leaf and stripe rusts prevalent in India

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In the major wheat growing regions of north India all the three rusts namely black or stem rust (*Puccinia graminis tritici* (Pers.) Erikss. & Henn.), brown or leaf rust (*P. recondita* Rob. Ex-Desm.) (*P. triticina* Erikss.) and yellow or stripe rust (*P. glumarum* (Schmidt) Erikss. & Henn.) attack the crop leading to considerable losses in yield. The data available till today indicate that there are 13 races and 5 biotypes in the stem rust (14, 15, 17, 21, 24, 34, 40, 42, 72, 75, 117, 122, 194; 15-C, 21-A, 21-A-1, 34-A and 42-B), 13 races in leaf rust (10, 11, 17, 20, 26, 63, 70, 77, 106, 107, 108, 131 and 162) and 10 races in stripe rust (13, 19, 20, 31, A, D, E, F, G, and H). In addition some colour mutants in 15C and 192 of stem rust have also been isolated.

All the indigenous wheats, with the exception of Khapli emmer which also shows only partial resistance to stem rust, are susceptible to one or the other of the three rusts. Among the wheats obtained from outside the country Thatcher, Hope, Kenya C 10854, Yalta, Ridley, Charter, (Gabo × Dundee) and Kenya 58-F (L. 1) were at one time resistant to stem rust but these have become susceptible to the races subsequently isolated. Same was the fate with the leaf rust resistant wheats Mediterranean and Democrat. Spalding's Prolific and Carsten's V have however, maintained their resistance to stripe rust all these years in the field. It is interesting that Thatcher in spite of its susceptibility to some of the stem rust races of India gave highly resistant segregates like N. P. 789 and N. P. 790 in cross with another susceptible wheat N. P. 165 (N. P. or Pusa 4 × Australian Federation).

Efforts are being made to build up an extensive collection of Indian and foreign wheats at the Division of Botany of the Indian Agricultural Research Institute, New Delhi and this number already stands at 8000 at present. Out of this collection, the most promising at present from the view point of resistance to one or the other of the three rusts are:

Stem rust	Leaf rust	Stripe rust
Kenya 184 P.2. A.I.F.	Frontiera	Carsten's V
Yaqui 53	La Prevision	Spalding's Prolific
Gaza	Frondoso	La Prevision
N. P. 789	Rionegro	Rionegro
N. P. 790	Gabo	Frondoso
(Kenya-Gular-Pilot) × K58-New Thatch	Kenya 338 A. C. 2.	Ceres Klein
	E. 2 I 49 - 89	
Arabian durum E 2025	Gaza	Cometa Klein
		Klein 33
	Yaqui 53	Klein 66
	Timstein × Sel. 2086	N. P. 785
	Arabian durum E 2025	N. P. 786
	Trigocentiera	Supremo × Mentana
	Trigofrontiera	St. 464 (*T. durum*)
	Triticum timopheevi	Cometo semiduro
	Bowie	Arabian dicoccum E 740

A number of dicoccums received recently from Ethiopia showed resistance to all the existing Indian races of leaf and stripe rusts. So also one monococcum received from Japan, showed resistance to all the Indian races of stem rust and leaf rust. More sources of resistance to the Indian races of the rusts are expected to be available from the International Rust Nurseries material which is now under critical study here. Crosses between some of the susceptible wheats of *T. aestivum, T. durum* and *T. dicoccum* have recently yielded strains which are resistant to all the existing Indian races of stem and leaf rusts.

Studies were undertaken to find out the mode of inheritance of field and seedling resistance of some of these rust resistant wheats to the Indian races of the three rusts. The following is the summary of results so far obtained with regard to field resistance (data on seedling resistance would be published later) to a mixture of races of the rusts prevalent in India.

Table 1. Summary of studies on the genetics of field resistance to the Indian races of the three wheat rusts.

Rust	Resistant stock	Susceptible variety/s	Mode of inheritance	Authority
Stem rust	Kenya C 10854	Pb. C. 591	3S : 1R	Sen and Joshi (1955)
	Gabo	N. P. 761	3S : 1R	Sen and Joshi (1955)
	N. P. 789	Ridley	27S : 37R	Murty and Das (unpubl. 54)
	„	Frondoso	„	Pal, Sikka and Rao (1956)
	N. P. 790	Pb. C. 591, Pb. C. 281,	61S : 3R	Sikka and Rao (1958)
		Pb. C. 273, Pb. C. 518	„	Prasad and Rao (1960)
	„	N. P. 775	13S : 3R	Suva, Sikka and Rao (1958)
	„	N. P. 718	3R : 1S	Sikka and Rao (1958)
	„	N. P. 710 & N. P. 781	„	Murty and Mallanna (unpublished, 1955)
	Kenya 184	N. P. 710, Pb. C. 281	15S : 1R	Sikka, Rao & Ahluwalia (1960)
	P. 2. A. I. F.			
	Gaza	N. P. 710, N. P. 718	15S : 1R	Murty and Lakhani (1958)
	Yaqui 53	N. P. 824	45S : 19R	Pokhryal and Kohli (unpublished 1962)
	-	P. I. 94616 × N. P. 200 (both dicoccums)	9R : 7S	Srinivasan (unpubl. 1959)

Leaf rust	Frondoso	N. P. 789	9R : 7S	Pal, Sikka and Rao (1956)
	Frontiera	Pb. C. 591	3S : 1R	Suva, Sikka and Rao (1958)
	„	N. P. 710	„	Sikka, Rao & Ahluwalia (1960)
	La Prevision	N. P. 710	3S : 1R	Sikka, Rao & Ahluwalia (1960)
	Gaza	N.P. 710, N.P. 718	15S : 1R	Murty and Lakhani (1958)
	Timstein × Sel. 2086	N.P. 165, N.P. 718 and Pb. C. 281	15S : 1R	Rao and Prasad (unpub. 1958)
	Rionegro	N. P. 718	9R : 7S	Jain, Joshi and Rao (1962)
	Rionegro	N. P. 710, Pb. C. 281 and Pb. C. 518	9R : 7S	Rao, Somayajulu and Ahire (1962)
	Gabo	N. P. 710, N. P. 798 and Pb. C. 281	15S : 1R	Rao, Somayajulu and Ahire (1962)
	Kenya 338 AC. 2. E. 2. I 49-89.	N. P. 710, N. P. 790 and N. P. 798	3S : 1R	Rao, Somayajulu and Ahire (1962)
	Yaqui 53	N. P. 718	9R : 7S	Jain, Joshi and Rao (1962)
	„	N. P. 824	13S : 3R	Pokhriyal (unpubl. 1962)
	H 167 (derivative of the cross Rionegro × N.P. 760)	Ridley N. P. 770	9R : 7S	Pokhriyal (unpubl. 1962)
		I. C. 1131 × Local (Both dicoccums)	9R : 7S	Srinivasan (unpubl. 1962)
Stripe rust	Frondoso	N. P. 789	57R : 7S	Pal, Sikka and Rao (1956)
	Cometa Klein	N. P. 710, Pb. C. 281	3R : 1S	Suva, Sikka and Rao (1958)
	La Prevision	N. P. 710	13R : 3S	Sikka, Rao and Ahluwalia (1960)
	N. P. 785	N. P. 710, N. P. 718	13R : 3S	Sikka, Rao and Ahluwalia (1960)
	St. 464	Ekdania 69, Ujjain Prog. 7, HI-7-75, AM24	3R : S	Rao, Mathur, Ahire and Narula (unpublished, 1962)

These genetical studies were further extended to identifying sources carrying diverse factors for field resistance to the rust races prevalent in India.

Changes in rust susceptibility due to partial irradiation of wheat seedlings and its dose dependence

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The stems and leaves of seedlings at leaf stage of *Triticum vulgare* (Norin No. 16) were irradiated by X-rays at 5 kr. The seedlings were inoculated 10 days after irradiation by spraying with an aqueous uredospore suspension of *Puccinia triticina*. The first leaves of the seedlings were removed 10 days after inoculation and the size of uredosori was measured. They were on plants whose whole bodies or stems were irradiated about 1.7 times larger than on the control and plants whose leaves only were irradiated.

Seedlings at 2 leaf stage of *T. vulgare* (Norin No. 50) were irradiated by gamma-rays, at 0.1, 0.25, 0.5, 1, 2.5, 5 and 10 kr. The seedlings were inoculated 6 days after irradiation by spraying with the spore suspension. Seedling length was measured 7 days after irradiation, and then the size of the sori was measured 12 days after inoculation. Inhibition of seedling growth increased with the increase of dosage and the seedling length at dosage above 1 kr remained unchanged. Also, the size of the sori increased with the increase of the dosage, however it did not further increase of dosages above 5 kr.

Karyotype analysis of seven D-nullisomic wheat lines and their gigas plants

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Seven D-nullisomic lines have been among the offspring of the pentaploid wheat hybrid between *Triticum spelta* and *T. polonicum* (MATSUMURA 1952). They are very dwarf, weak and are called a ~ g - dwarfs. In the progeny of the selfed dwarfs, so-called gigas plants having normal hight and vigor appeared unexpectedly. It was assumed that the appearance of the gigas plants was due to an increase in the number of chromosomes of A or B genome, which are homoeologous to the lacking D chromosomes.

Among 21 chromosomes of the Dinkel wheat, two are Sat-chromosomes. According to KIHARA (1958), they are called Sat-1 and Sat-2 and are distinguishable by their shape and size. According to MORRISON (1953), chromosome I and X have satellites. Among MI chromosomes of a ~ g - gigas plants which are nulli-trisomic having 41 somatic chromosomes, the additional chromosome, homoeologous to the lacking a~g-chromosome respectively, is often a univalent. In the case of b- and c-gigas, the univalent is often, but not always, observed as satellited. However, the univalents of a-, d-, e-, f- and g-gigas have no satellite.

Somatic chromosomes of seven nullisomic lines and their gigas plants have been examined with special reference to the Sat-chromosomes. Four chromosomes with a large satellite were observed in all nullisomic and gigas lines except the b- and c-gigas in which the number of Sat-chromosomes was increased. The b- and c-gigas, both of which are nulli-trisomic having 41 somatic chromosomes, have five chromosomes with large satellites. It is believed that SEARS' chromosome I or KIHARA's Sat-1 is supernumerary in b-gigas and chromosome X or Sat-2 in c-gigas.

Development analysis of the rachis disarticulation in *Triticum*

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Two types of rachis disarticulation are known in *Triticum*, i. e. wedge type (W-type, rachis breaking at the upper side of the spikelet base) and barrel type (B-type, rachis breaking at the lower side of the spikelet base). W- and B-types have abscission zones or layers at different locations of rachis joint, i. e. W- and B-type layers being located at the upper and the lower parts of the rachis joint, respectively. Moreover, various degrees of fragility of rachis are present among the species belonging to each type. Morphological observations of the rachis disarticulation in several species of *Triticum* and *Aegilops* were reported by Zimmermann (1934). The present study was concerned with the developmental analysis of the rachis disarticulation in *Triticum*.

The authors analyzed the development of disarticulation at five stages (I-V) in two *Triticum* species belonging to the W- and B-types. And seven species of *Triticum*, four strains of synthesized 6x wheat (by Kihara et alii, 1948) and one of their parental species, *Aegilops squarrosa*, were also studied comparatively at stage V. Longitudinal hand sections of rachis joint were microscopically examined, and also tested for lignification and suberization with hydrochloric acidphloroglucine and sudan III.

The results obtained are presented in Table 1 and 2, which indicate that the degree of fragility of each type was determined by the following main factors.

(1) Constriction of rachis exterior.

In both W- and B-types, a constriction is formed at the exterior part of each abscisson layer, and the deeper the constriction is the more fragile the rachis becomes. In the W-type, the constriction in the rachis side develops more remarkably than in the rachilla side in rachis joint, while it is vice versa in the B-type.

(2) Cell growth in rachis cortex.

In the W- and B-types, localized cortical cells of rachis joint do not elongate, in the longitudinal direction, remaining as linearly arranged short type cells to form an abscission layer, while the outside cortical cells of each ab-

Table 1. Analysis of rachis disarticulation at stage I-V in two *Triticum* species belonging to W-and B-types.

Charcteristics	Stage	I. (Meiosis)	II. (First earing)	III. (First flowering)	VI. (10 days after first flowering)	V. (20 days after first flowering)
W-type layer of *T. monococcum* var. *flavescens*						
Constriction	(in rachis side)	2	2	3	3	4
Elongation of cortical cells	(a) localized cells	2	2	2	3	3
	(b) outside cells	2	3	4	5	5
Lignification of cortical cells	(a) localized cells	1	2	3	4	5
	(b) outside cells	1	1	2	2	3
Fragility of rachis		-	1	2	3	4
B-type layer of *T. Spelta* var. *Duhamelianum*						
Constriction	(in rachilla side)	1	1	2	2	3
Elongation of cortical cells	(a) localized cells	1-2	1-2	1-3	1-3	1-3
	(b) outside cells	1-2	1-3	2-4	3-5	3-5
Lignification of cortical cells	(a) localized cells	1	1	1-2	1-3	1-3
	(b) outside cells	1	1	1-3	2-4	3-5
Fragility of rachis		-	1	2	3	4

Note: The numbers in this Table indicate the grade in the characteristics of each item. Thus the largest number (5) indicates the most developed characteristics in each item.

Table 2. Analysis of rachis disarticulation in seven *Triticum* species, four synthesized wheats and *Aegilops squarrosa* at stage V.

Characteristics	Species and Strain	*T. aegilopoides* var. *boeoticum*	*T. monococcum* var. *flavescens*	*T. dicoccoides* var. *Kotschyanum*	*T. dicoccum* var. *liguliforme*	*T. Timopheevi* No. 1	*T. Spelta* var. *Duhamelianum*	*T. vulgare* var. *erythrospermum*	Synthesized 6 x -wheat ABD No. 1	ABD No. 2	ABD No. 4	ABD No. 5	One of the parental species *A. squarrosa* No. 2
Type of rachis disarticulation		W	W	W	(W)	W	B	(B)	W	(W,B)	(B)	(W,B)	B
Fragility of rachis		5	4	5	2	3	4	2	4	2	2-3	2	5
W-type layer													
Constriction	(in rachis side)	5	4	5	2	3	2	2	3	2	2	2	2
Elongation of cortical cells	(a) localized cells	2	3	2	5	4	2	2	3	2	2	2	2
	(b) outside cells	5	5	5	5	5	5	5	5	5	5	5	5
Lignification of cortical cells	(a) localized cells	5	5	5	5	5	5	5	5	5	5	5	5
	(b) outside cells	2	3	2	5	4	5	5	3	5	4	5	5
B-type layer													
Constriction	(in rachilla side)	1	1	1	1	1	3	2	2	2	3	2	4
Elongation of cortical cells	(a) localized cells	3-5	3-5	3-5	3-5	3-5	1-3	1-3	1-3	1-3	1-3	1-3	1-3
	(b) outside cells	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5
Lignification of cortical cells	(a) localized cells	3-5	3-5	3-5	3-5	3-5	1-3	3-5	3-5	3-5	2-4	3-5	1-3
	(b) outside cells	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5	3-5

Note: As to the number in this Table, refer to the note of the Table 1.

scission layer become elongated, in the longitudinal direction, or enlarged as irregularly arranged long type cells resulting in tough tissues. It is observed that rachis actually breaks at the crevice formed in the intercellular spaces of linear short cells in the layer. Therefore, the degree of fragility of each rachis is partly determined by the difference in cell growth between the localized and outside cortical cells in the W - and B - types.

(3) Cell differentiation in rachis cortex.

In the W - type, rachis becomes more fragile as lignification increases in the localized cortial cells but not in the outside cortial cells. In the B - type, however, lignification in the outside cells but neither lignification nor suberization in the localized cells causes the fragility of rachis. This result indicates that the fragility of each rachis is also determined by the degree of cell differentiation between the localized and outside cortical cells in the W - and B - types.

Hybridization of *Triticum* with 3 *Agropyron* species

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In a system of grassland - wheat farming there is a reluctance to plow established grass stands and to establish new stands of grass. Easily established grasses would remove some of the hazards involved and provide greater flexibility in shifting from small grain to grass. The small seed of present dryland grasses may limit the coditions under which satisfactory stands can be obtained.

A program was initiated in an effort to improve tall, intermediate, and pubescent wheatgrass by intergeneric crossing with wheat. The objectives are to develop wheatgrass strains with large, free-threshing seeds with reduced tendency for sod binding. An initial phase of this program was to establish hybrids between *Triticum* and *Agropyron* species, During the summer of 1961 plants of 8 wheat species were crossed with plants of 2 *Agropyron intermedium* strains, one *A. trichophorum* strain, and 3 *A. elongatum* strains. The seed sources of these wheat and wheatgrass strains are listed alphabetically in Table 1. The crossing results are recorded in Table 2. The percentage of crossability is based on the appearance of the F_1 plants in the greenhouse. Only grass-like plants are considered to be true hybrids. Plants with typical annual characteristics and wheat-like morphology are considered to have originated from selfed seed. It is realized that this procedure may not account for some of the resulting hybrids. The hybrids are listed in this table according to their percentage of crossability. The most successful crosses were *T. persicum* × *A. trichophorum* and *T. timopheevi* × *A. elongatum.*

For the evaluation of crossing results in intergeneric hybridisation it is extremely important to consider the conditions and techniques used. For hand emasculation and pollination of the 1961 Bozeman crosses untrained labor (high school girls) was used. The crosses were accomplished during the 18 day period of July 7 to July 24, 1961. The range of maximum daily temperatures was 75 to 90°F with a mean maximum of 83.8°F. Minimum relative humidity was down to 25% with a range of minimum relative humidity of 25-40%. The low humidity may account in part for the low crossability. ZENNYOZI 1959 (WIS 9-10) and others reported higher percentages of crossability in similar intergeneric crosses.

Table 1. Sources of parent material used for intergeneric crossing during the summer of 1961 at Bozeman, Montana, U. S. A.

Species	Accession numbers	Seed source
Agropyron elongatum (Host) Beauv.	P. I. 179,162	Collected by Jack R. Harlan, 10 miles west of Bor, Nigde, Turkey September 23, 1948, growing on flat Nigde plain on gray soil in low rainfall area.
A. elongatum (Host) Beauv.	P. I. 205,279	Collected by R. K. Godfrey 53 km southeast of Ankara along Route 60, Turkey, August 28, 1952.
A. elongatum (Host) Beauv.	P. I. 206,622	Collected by R. K. Godfrey, near Sivrihisar Eskisehir, Turkey, October 9, 1952.
A. elongatum (Host) Beauv.	P. I. 206,624	Collected by R. K. Godfrey, between Istanbul and Corlu, Turkey, October 25, 1952.

Table 1 Continued

Species	Accession numbers	Seed source
A. intermedium (Host) Beauv.	P. I. 173,627	Collected by Jack R. Harlan at Dere Ici, Kars, Turkey, at an altitude of 1,750 feet on August 10, 1948.
A. intermedium (Host) Beauv.	P. I. 204,386	Collected by R. K. Godfrey, base of Tosik Mountain, Erzurum, Turkey, September 13, 1952.
A. trichophorum (Link) Richt.	P. I. 206,625	Collected by R. K. Godfrey near Mezraa, Kars, September 19, 1952.
Triticum dicoccum Schrank.	P. I. 193,880	Collected by W. A. Archer at the market of Addis Ababa, Ethiopia, 1950
T. durum Desf. var. *hordeiforme* (Host) Koern.	B-65 [2]	Seed received from Hirayoshi in 1938. Inner Mongolia Expedition.
T. orientale Persiv.	B-66	Seed collection of the Department of Plant and Soil Science, Montana State College, Bozeman, Montana, U. S. A.
T. persicum Vavilov var. *fuliginosum* Zhuk.	P. I. 78,812	Presented by director of Botanic Garden, Tiflis, Caucasus, Russia, on February 4, 1929.
T. persicum Vavilov	P. I. 94,749	Obtained from J. G. Dickson, November 20, 1939. Collected in Georgia, Russia.
T. polonicum L.	B-69	Seed collection of the Department of Plant and Soil Science, Montana State College, Bozeman, Montana, U. S. A.
T. pyramidale Persiv.	B-70	Same as B-69
T. spelta L.	B-71	Same as B-69
T. timopheevi Zhuk.	P. I. 190,974	Presented by Estacion Experimental de Aula Dei, Zaragoza, Spain, September 28, 1950.

[2] Seed of B accessions available from the Department of Plant and Soil Science, Montana State College, Bozeman, Montana, U. S. A.

Table 2. Percentage of crossability determined from hybridization of 8 wheat species with 3 wheatgrass species during the summer of 1961 at Bozeman, Montana, U. S. A.

Cross combination	No. of florets pollinated	No. of grass-like F_1 plants	% crossability
1. *T. persicum* (2n=28) × *A. trichophorum* (2n=42)	180	11	6.11
2. *T. timopheevi* (2n=28) × *A. elongatum* (2n=70)	169	10	5.92
3. *T. spelta* (2n=42) × *A. elongatum* (2n=70)	753	32	4.25
4. *T. pyramidale* (2n=28) × *A. intermedium* (2n=42)	531	17	3.20
5. *T. orientale* (2n=28) × *A. intermedium* (2n=42)	370	5	1.35
6. *T. persicum* (2n=28) × *A. intermedium* (2n=42)	489	6	1.23
7. *T. dicoccum* (2n=28) × *A. intermedium* (2n=42)	176	2	1.14
8. *T. orientale* (2n=28) × *A. elongatum* (2n=70)	682	3	0.44
9. *T. durum* var. *hordeiforme* (2n=56) × *A. elongatum* (2n=70)	883	3	0.34
10. *T. polonicum* (2n=28) × *A. intermedium* (2n=42)	445	1	0.23
Totals	4678	90	2.42

F_1 hybrids between four species of *Secale* and *Agropyron intermedium*

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Four species of *Secale,* i. e. *cereale, africanum, montanum* and *kuprijanovii* were crossed with *A. intermedium,* and the following results were obtained.

S. cereale × *A. intermedium:* In 1958, 429 florets of *S. cereale* were pollinated with the pollen of *A. intermedium,* and obtained three F_1 hybrids. The F_1 plants grew slowly and were weak. As F_1 hybrids of all the three plants were lacking alike the anther in all the florets, it was not possible to carry out any observation of PMC's.

S. africanum × *A. intermedium*: The hybridization was made out in 1960. 582 florets of *S. africanum* were crossed with *A. intermedium,* obtaining 118 grains. 25 of those grains were sown and six F_1 hybrids were obtained. External features of the F_1 plants were intermediate of both parents, but in several characteristics they resembled the *Agropyron.* Individual variations in some characteristics were also observed.

At IM, various kinds of chromosome conjugation from $6_{II} + 16_{I}$ to $1_{III} + 9_{II} + 7_{I}$ were observed. $0 \sim 3$ trivalents and $0 \sim 1$ tetravalent were also found frequently. It was in $1_{III} + 6_{II} + 13_{I}$ that the conjugation pattern was most frequently observed. The average of the chromosome conjugation was $0.03_{IV} + 0.84_{III} + 6.48_{II} + 12.40_{I}$. Most of the bivalents observed were of open type and $1 \sim 5$ bivalents of ringshaped type were also observed (average being 1.99 per cell). Further, a heteromorphic bivalent was found in only one of 100 PMC's observed.

S. montanum × *A. intermedium:* The hybridization was carried out in 1960, pollinating 206 florets of *S. montanum* by *A. intermedium* pollen and 63 grains were obtained. And 14 F_1 hybrids were produced by sowing 30 of those grains. The results regarding external characteristics of the F_1 plants were such as that of *S. africanum* × *A. intermedium* F_1 plants mentioned above, i. e. being approximately intermediate of the parents, showing their individual differences among the F_1 plants. Further, as *S. cereale* × *A. intermedium* F_1 plants this F_1 hybrids were very weak, and there were some individuals that stopped the growth before the earing stage. Althongh eared in some plants, there were those F_1 plants that were lacking the anther in the florets.

At IM, the chromosome conjugation patterns from $6_{\mathrm{II}} + 16_{\mathrm{I}}$ to $10_{\mathrm{II}} + 8_{\mathrm{I}}$ were found. In addition to the bivalents $0 \sim 4$ trivalents and $0 \sim 1$ tetravalent were observed. The modal configuration was found to be $1_{\mathrm{III}} + 6_{\mathrm{II}} + 13_{\mathrm{I}}$, and the average being $0.04_{\mathrm{IV}} + 0.81_{\mathrm{III}} + 6.52_{\mathrm{II}} + 12.37_{\mathrm{I}}$. Most of the bivalents were open type, though often $1 \sim 6$ closed ones were observed (average being 3.03 per cell). The case having a heteromorphic bivalent was observed twice out of 100 PMC's.

S. kuprijanovii × *A. intermedium*: In 1960, 550 florets of *S. kuprijanovii* were crossed with *A. intermedium* pollen and obtaining 96 grains. 25 out of them were sown and six F_1 hybrids were obtained. In their external features the same cases were observed as that of the two hybrids mentioned above.

At IM, the patterns of the chromosome conjugation were observed from $5_{\mathrm{II}} + 18_{\mathrm{I}}$ to $9_{\mathrm{II}} + 10_{\mathrm{I}}$. Simultaneously, $0 \sim 4$ trivalents and $0 \sim 1$ tetravalent were observed. The conjugation pattern of $1_{\mathrm{III}} + 6_{\mathrm{II}} + 13_{\mathrm{I}}$ was found to be the mode such as the above two hybrids and the average being $0.06_{\mathrm{IV}} + 0.82_{\mathrm{III}} + 6.35_{\mathrm{II}} + 12.60_{\mathrm{I}}$. The ring-shaped bivalents were observed $1 \sim 5$, average being 2.46 per cell. In one out of 100 PMC's was found a heteromorphic bivalent.

In the F_1 hybrids between three species of *Secale* and *A. intermedium* of the cytological studies of PMC's, most of the conjugated chromosomes may have been occurred due to the autosyndesis on the basis of homologies of the chromosomes among three genomes of *A. intermedium.* However, as a larger bivalent than the other ones was found in every F_1 hybrid, it may be assumed to be the autosyndesis of the chromosomes of *Secale.* Further, according to the observations of the heteromorphic pair in these F_1 hybrids, a bivalent is considered to indicate the occurrence of the allosyndesis between the chromosome of the *Secale* and that of the *A. intermedium.*

No pollen- and seed-fertility showed completely in the all F_1 hybrids. The three F_1 hybrids, except for *S. cereale* × *A. intermedium* F_1, were perennial.

Increased occurrence of haploids and twin seedlings due to an alien cytoplasm

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In order to investigate the effects of an alien cytoplasm on the manifestation of various genotypes the authors have been placing by successive backcrosses nuclei of various wheats, including synthesized wheat and Triticale, in the cytoplasm of *Aegilops caudata*. During these experiments the authors have noticed that the alien cytoplasm increased the frequency of haploids and twin seedlings and are reporting their observations.

For convenience's sake wheat strains with their own cytoplasm are termed in this report "autoplasmic" and those with *Aegilops* cytoplasm "alloplasmic".

Haploids: Records on the occurrence of haploids are at present available for two varieties, *Triticum aestivum* ssp. *vulgare* var. *erythrospermum* (*T. vulgare erythr.*) and Taylor's Triticale. The occurrence of haploids in auto- and alloplasmic lines of these varieties is summarized in Table 1.

Table 1. Occurrence of haploids in auto- and alloplasmic lines of *T. vulgare* var. *erythrospermum* and Taylor's Triticale

	Lines			
Nucleus	*T. vulgare erythr.*		Taylor's Triticale	
Cytoplasm	its own	*caudata*'s	its own	*caudata*'s
No. of plants grown (N)	1,633	1,649	19	17
No. of plants checked (n)	312	402	19	17
No. of haploids (M)	0	11	0	9
Haploid frequency $(\frac{M}{N}\ ;\ \%)$	0.0	0.7	0.0	52.9
" $(\frac{M}{n}\ ;\ \%)$	0.0	2.7	0.0	52.9

Haploid frequency of the alloplasmic line of *T. vulgare erythr.* is estimated to be somewhat between 0.7 and 2.7%, while that of the autoplasmic line was 0.0%; the difference is significant. The alloplasmic line of Taylor's Triticale produced haploids at a much higher rate than alloplasmic *T. vulgare erythr.*, namely about 53%. Apparently the nucleus of Taylor's Triticale is more influenced by *caudata* cytoplasm than the pure line nucleus of *T. vulgare erythr.* in regard to parthenogenetic development of haploid embryos.

Twin seedlings: The occurrence of twin seedlings in auto- and alloplasmic lines of wheat (including Taylor's Triticale) was studied in detail in 1962. The results are summarized in Table 2.

Table 2. Occurrence of twin seedlings in auto- and alloplasmic lines of wheat

Materials	No. of seedlings		Freq. of twin (0/00)
	Total	Twin	
Autoplasmic			
F_1 hybrids	6,046	6	0.99
Other hybrids (F_2, B_1, *etc.*)	5,173	3	0.58
Pure lines	2,425	1	0.41
Total	13,644	10	0.73
Alloplasmic			
Taylor's Triticale	98	7*	71.43
Other wheats (hybrids and pure lines)	580	5	8.62
Total	678	12	17.70

* One of the seedlings was a triplet.

In autoplasmic wheat there is some tendency to increase the frequency of twin seedlings in hybrids between lines which produced more twins than pure lines. The average total frequency was about 0.7 per 1,000. It was increased about tenfold in the alloplasmic lines of wheat and about one-hundredfold in alloplasmic Taylor's Triticale. In this regard, too, the nucleus of the latter was more sensitive to *caudata* cytoplasm than those of wheats (including *T. vulgare erythr.*).

Discussion: The observed difference in the frequency of haploids is primarily determined by that of parthenogenetic egg cells, as haploid embryos of wheat are known to be well viable, when the polar nuclei are fertilized to form the endosperm (KIHARA and KISHIMOTO 1942). The frequency of haploid parthenogenesis is symptom of abnormal embryogenesis, since in this case the egg cell develop contrary to rule into an embryo without fertilization. No detail mechanism has been studied on the occurrence of twin seedlings. However, their frequency can be considered as another indication of abnormal embryogenesis.

The present results clearly indicate that the occurrence of both haploid and twin seedlings in various wheat varieties was increased by the alien cytoplasm introduced from *Ae. caudata*. The increase is striking in Taylor's Triticale. Thus, the alien cytoplasm was the cause of abnormal development, though the extent of the response varied with the genotype.

The behavior of Taylor's Triticale is peculiar, because of the extremely high frequency of haploids and twins in the alloplasmic line. This Triticale is a fixed descedant of a hybrid between two Triticale strains, Mains 56 ($2n=56$, AABBDDRR) and Bledsoe 56 ($2n=56$, AABBDDRR), both produced and crossed by Mr. J. Taylor of USDA. The fixed line from his cross used in our experiment, however, has only 42 (21_{II}) chromosomes. An investigation will show in the future which chromosomes have been lost in the process of fixing the employed line.

Abstracts from the
PROCEEDINGS OF THE SECOND WHEAT GENETICS SYMPOSIUM, JAPAN (Seiken Ziho, No. 13, 1962)

Commemorating its 20th Anniversary, the Kihara Institute for Biological Research has sponsored the 2nd Wheat Genetics Symposium (Japan) on April 8-9, 1962, under the auspices of the National Institute of Genetics. 54 wheat specialists from 24 different institutions attended the symposium. Dr. H. KIHARA, the general chairman, pointed out the following accomplishments, as epoc-making events in wheat genetics; (1) discovery of the right chromosome numbers, (2) completion of the genome analysis, (3) discovery of D-genome species and the synthesis of 6x wheat, (4) establishment of the aneuploid series, and (5) discovery of the most probable progenitor of B-genome species. He asked all attendants to make use of this occasion for exchanging and creating new ideas in order to promote wheat genetics and, especially, to prepare for the 2nd International Wheat Genetics Symposium held in 1963.

Biochemical mechanism of pollen abortion and other alterations in cytoplasmic male-sterile wheat

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In the male-sterile strain, already described, plants with 14 bivalents from *Triticum durum* and one extra-chromosome from *ovata* genome (abbreviation, $14_{II} + 1_{I}$-plant) produce good pollen grains, showing nearly normal pollen-fertility, like that of normal fertile *durum* plants. Accordingly, all 14- or 15-chromosome pollen grains are functional, irrespective of the presence or absence of an extra-chromosome. Therefore, it may be said that the extra-chromosome exerts its effect only in the sporophyte - not in the male-gametophyte. Further, male-sterile *durum* plants grown in a glass-house in winter give much smaller anthers than in the field in a normal season. From these findings, it is considered that the cytoplasmic effect on pollen degeneration exists also in the sporophyte including the tapetum, in the first place, -- not in the gametophyte, although GABELMAN (1949) described in his study of cytoplasmic partial male-sterility in maize that a cytoplasmic particle exerts its effect only in the developing gametophyte. Thus, it is assumed in male-sterile wheat that some nutritive substances of microspores fail to be produced in the vegetative tissue or that no transmission from the tapetum to microspores takes place in the anthers (FUKASAWA 1959).

1. Free amino acids in the sterile anthers and leaves: A paper-chromatographic survey of free amino acids in sterile anthers revealed the disappearance of proline and a remarkable accumulation of asparagine during the course of pollen degeneration (FUKASAWA 1954). This notable phenomenon was also found in the anthers of cytoplasmic male-sterile maize (FUKASAWA 1954; KHOO and STINSON 1957). Further, a similar difference in proline and asparagine content has been observed between mature leaves of normal and male-sterile plants. However, artificial sterile anthers and etiolated leaves obtained from dark-grown *durum* plants showed almost the same relationships between asparagine and proline as the male-sterile plants (FUKASAWA and MITO 1956).

2. Sucrose and starch in sterile anthers: Anthers of normal and aborted-pollen-plants may be distinguished by tde difference in sugar content as shown by paper chromatography. Sucrose is virtually absent in sterile anthers, but fructose and glucose contents are remarkably different from those in normal fertile anthers. When the young spikes of male-sterile plants were cultured in sucrose solution, they grew better than those grown in the medium without sucrose. No good pollen was produced, though the addition of sucrose to the medium was found to be efficacious to some extent in improving the microspore development (FUKASAWA, MITO and FUJIWARA 1957). In male-sterile barley, a decrease of carbohydrate content has been observed in young spikes (MOCHIZUKI and ONO 1962). A cytochemical examination of polysaccharide particles (starch grains) in anther tissues revealed that the parietal cells of sterile anthers have small and decreased particles in comparison with those of normal fertile anthers.

3. Succinic dehydrogenase activity and respiration: Succinic dehydrogenase activity of anthers and germinating embryos has been measured by means of reduction of triphenyl tetrazolium chloride (TTC) to its red formazan. Sterile anthers showed fairly lower activity of the enzyme than the normal ones, not only in the pollen-degenerating period, but also at the meiotic stage. In experiments with germinating embryos, no difference was observed between the enzyme activities in normal and male sterile strains (FUKASAWA 1961). Further,

the respiratory capacity was measured manometrically in the homogenate of germinating embryos, resulting in no different amount of O_2-uptake between normal and male-sterile strains. Inhibitory experiments by application of acridine, however, have indicated a higher sensitivity in the sterile strain than in the normal plants.

4. Nucleic acids and nucleotides: Amount of RNA and DNA was measured by the method of Ogur and Rosen (1950) in the sterile anthers during the pollen degeneration period. Mature anthers containing abortive pollen grains showed less content of RNA and DNA than normal fertile anthers. Even in pollen-tetrad stage, the sterile anthers exhibit a fairly lower value of RNA content, but no different DNA content in comparison with normal fertile anthers. Mononucleotide composition of RNA from anthers was determined by column chromatography (Fukasawa 1961). No difference in molar ratios of mononucleotides was found between RNA's from sterile and normal anthers. At degenerating stage, however, RNA from sterile anthers indicated the presence of an unknown characteristic substance. Further, it is noticeable that each content of four nucleotides per fresh weight was lower in sterile anthers at the pollen-tetrad and -degenerating stages than in normal anthers.

5. Nitrogen content: Nitrogen content in anthers, spikes, germinating embryos, seedlings and leaves was measured by Kjeldahl method, comparing both strains. Soluble protein extracted in dilute phosphate buffer was precipitated by ethanol (made up to 70% concentration). A much larger amount of precipitate was obtained from the normal fertile strain with higher nitrogen content in the precipitate than from the male-sterile plants. On the contrary, the soluble part in ethanol exhibits more amount of nitrogen in sterile plants than the normal plants, especially a larger amount of amide-nitrogen. In total nitrogen content of young leaves, no great difference was observed. But, the particles precipitated by centrifugation at 2,000g for 20 minutes showed a fairly lower value of nitrogen content in sterile plants than in the normal ones.

6. Acid-soluble phosphate substances: Acid-soluble substances were extracted from anthers, spikes, germinating embryos, seedlings and young leaves, and then the phosphorous compounds were separated by barium-precipitation method. Phosphorous content in barium-insoluble fraction from male-sterile strain was higher than that from the normal strain, except that from the anthers containing binucleated microspores. Further, chromatographic survey in young leaves showed a different amount of several fractions in both strains. Especially ade-

nosine triphosphate (ATP) content in the sterile strain was higher in comparison with the normal strain. This result agrees with the higher phosphorous content in the barium-insoluble fraction from male-sterile plants.

Functional differentiation among the homoeologous chromosomes of common wheat¹⁾

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Duplication of genetic materials, followed by functional differentiation of the duplicates due to mutation; is an important genetic process from the viewpoint of evolution. Therefore, it is important to investigate the functional similarity and dissimilarity between homoeologous chromosomes, which have become differentiated from homologues.

Four methods are available for this investigation in common wheat, *i.e.*, nullisomic analysis, monosomic analysis, chromosome substitution method and irradiation of monosomics. The author's results on the functional differentiation of homoeologous chromosomes, hitherto obtained mainly by the second and fourth methods, are summarized and discussed together with those obtained by other researchers.

1. Radiosensitivity of monosomics: There is a differential radiosensitivity between the disomic and the monosomics, the former being more resistant than any line of the latter. A differential radiosensitivity also exists among the monosomics. In homoeologous group 1, mono-I behaved differently from the others, being more resistant to high dosages. All three monosomics of group 2, which is rather sensitive as a group, showed a very similar pattern of radiosensitivity. In group 3, mono-III was much more sensitive than the other two lines, which were both equally resistant. In group 4, mono-IV was distinctly more sensitive than the other two, mono-VIII being slightly more resistant than mono-XV. In group 5, all three monosomics behaved differently, namely, radioresistance was significantly increased in the order of mono-V, XVIII and IX,

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the last one being the most resistant among all monosomics. Three monsomics of group 6 showed more or less different patterns but the differences were not significant. All three monosomics of group 7 reacted very similarly to irradiation, all being resistant. These results indicate that all three homoeologous chromosomes belonging to group 2, 6 or 7 have retained almost the same function relating to radiosensitivity, while, in this respect, one chromosome in each of groups 1, 3 and 4 has become differentiated from its two homoeologues, and in group 5 all three homoeologues behave differently from each other.

2. Transmission of monosomic condition: Since 1955 data on transmission of monosomic condition through female gametes have been accumulated for the variety Chinese Spring.

Monosomic condition was more readily transmitted in homoeologous group 3 than in groups 2, 7, 6 and 4, while the transmission rate of group 2 was significantly lower than those of groups 1, 5 and 3. In order to test the differences among the three homoeologous chromosomes of a group, χ^2-values for intragroup heterogeneity were calculated. Homoeologous chromosomes of groups 2, 3, 4, 5 and 7 behaved similarly, while differential transmission was found for groups 1 and 6. The transmission rates for chromosome I of group 1 and for chromosome X of group 6 were significantly lower than those found for their homoeologues. This fact indicates that chromosomes I and X have been differentiated from their homoeologues in respect to the transmission rate of monosomic condition.

3. Heading date: Spring-type alleles of major growth-habit genes are almost completely dominant over their winter-type alleles under a long day condition. Based on this fact, the effect of a chromosome of a winter variety on its heading can be quantitatively estimated from the difference between the heading dates of disomic and monosomic F_1's which are obtained from crosses, Chinese Spring monosomics (♀) × winter variety. Four winter varieties, Malakov, Hussar, Mediterranean and Democrat were crossed with 21 monosomic lines of Chinese Spring and the heading dates of the respective disomic and monosomic F_1's were investigated.

In both cases chromosomes IX and XVIII of winter varieties had a great effect on delaying heading, the latter's effect being about three times as much as the former's, The effect of chromosome V in Malakov and other varieties was almost the same as that of their chromosome IX in Misima, while no effect of the former was found in Winnipeg for Elgin and other varieties. This discrepancy between the two data is not explainable at the present. However, it is noteworthy that the three chromosomes, V, IX and XVIII belong to the same homoeologous group and retain the same function in delaying heading, though their effects are quantitatively different.

4. Review of other results: So far as awn development is concerned, three homoeologous chromosomes of groups 2 and 3 have a similar function, namely, promotion and modification of awn development, respectively. No homoeology exists among four epistatic awn-inhibitors. There is also no homoeology among genes which control hairiness, spike morphology or necrosis, while a partial homoeology is found among genes which control red pigmentation of different plant organs. A gene, *v* on chromosome III controls seedling virescence, causing semi-lethality of plants. Its homoeologous chromosomes, XII and XVI are known to carry genes, which interact with *v*, causing seed lethality. This fact indicates that these three chromosomes have a similar function. As to disease resistance, no homoeology in function seems to exist among homoeologous chromosomes, because an apparent similarity between some homoeologous chromosomes can be reasonably explained by coincidence due to chance.

Trisomics in common rye, *Secala cereale* L.

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The winter rye variety Petkus, *Secale cereale*, was utilized in this study. The primary simple trisomics were obtained in the progeny of autotriploids which were derived from the cross between autotetraploids and diploids. Primary simple trisomics appeared in the highest frequency (39.7%), which was higher than that of disomics.

The primary in rye show distinctive characteristics in their external morphology due to the extra chromosome as do trisomics reported for many other plants. In order to distinguish the trisomics cytologically, a karyotype analysis was made for each type. It has been observed that Petkus rye has a somewhat different karyotype from that of Dakold analyzed by BHATTACHARYYA and JENKINS (1960). Morphology and karyotypes of the 7 primary trisomics are as follows:

Slender The plants is slender with thin, erect stems. The leaf is the shortest among all trisomics. The spike is nearly the same as that of the disomics but is more compact. Few tillers are produced. This type has an extra chromosome I which is the longest one with nearly median primary constriction and with a very small satellite at the end of the short arm.

Feeble Plants of this type are very weak in appearance. Various organs. in general, are thin and small, and leaves are extremely narrow. Seedlings of this type are characterized by very narrow thread-like purple leaves and thus are very easily recognized at an early stage. The plant has an extra chomosome II which is slightly shorter than chromosome I; its primary constriction is submedian.

Stout This type has thick culms, the longest and widest leaves, and the longest culms of all types. It is particularly notable that it is susceptible to mildew. The plants have a tendency to forming branched spikes, especially the later ones, and in the greenhouse they are about a half month later in heading than the disomics. The extra chromosome in this type is chromosome III with a median constriction; it is shorter than chromosome II and has no satellite.

Pseudonormal The trisomics of this type are in appearance very much like the disomics but are somewhat smaller. The characteristic hairy neck is usually absent. Spikes are nearly of the same size as those of disomics but spike density is considerably less. In appearance and growth habit the seedlings are quite similar to those of disomics, and distinguishing them from the latter is difficult but they seem to be somewhat weaker. Chromosome IV, which is triplicated, possesses a secondary constriction in the long arm, and the short arm carries a very small terminal satellite.

Semi-stout Trisomics of this type are very similar to *Stout* having a waxy stem and wide leaves, especially in general appearance and growth habit, but the plants are smaller. They do not show susceptibility to mildew which is one of the most characteristic traits of *Stout*. The base of the young leaf is purplish making it not too diffcult to distinguish them from *Stout* in early seedling stages. The extra chromosome V has been observed in root tips. It is very similar to chromosome IV but differs from it in being somewhat shorter. Chromosome V has a longer short arm than chromosome IV.

Dwarf The plant is smaller than any other primary trisomic and has longer, wider leaves. They are more waxy than those of disomics. Hairiness of the neck in this trisomic is expressed to an exceptionally high degree. This type is also characterized by its extra empty glume. The seedlings have rather thick, wide and deep green leaves. The extra chromosome is VI with submedian primary constriction and a very small terminal satellite on the short arm. This chromosome has been described as the "hairy neck" chromosome because it has been associated with the gene for this character (O'MARA 1951; RILEY and CHAPMAN 1958; EVANS and JENKINS 1960).

Bush Plants of this type are like *Slender* in appearance at maturity but slightly smaller. They have comparatively long and narrow leaves. The spike shape is similar to that of *Slender* but the density is obviously less. In the seedling stage the plants tiller profusely and have pale green leaves. Thus *Bush* is easily recognized around the middle seedling stage. This trisomic has extra chromosome VII which is the shortest of the rye chromosomes and is characterized by a very pronounced satellite at the end of the short arm.

Trisomics and disomics grown in a growth cabinet in 1959 were utilized for checking their pollen and seed fertility. In general the pollen fertility of the trisomics is fairly good and is not much different from that of the disomics except for *Stout* which showed 63.4% in pollen fertility. Pollen fertility varied from 63.4% (*Stout*) to 92.8% (*Pseudonormal*), and the average was 79.3%. The seed fertility obtained from trisomics × disomics varied from 38.7% (*Feeble*) to 70.5% (*Dwarf*), and the average was 48.4%. Nearly the same results were obtained from crosses between disomics and trisomics. The seed fertility varied from 37.2% (*Semi-stout*) to 79.9% (*Dwarf*), the average being 52.6%. In all types but *Stout* and *Semi-stout*, the seed fertility from disomics × trisomics is slightly higher than in the reciprocal cross. Seed fertility in open pollination was not precisely examined but was fairly high.

In *Bush* whose extra chromosome VII has the largest satellite, almot all pollen mother cells showed a trivalent attached to a nucleolus. In the other six trisomics no cells with a trivalent attached to a nucleolus have been observed. Consequently, chromosome VII is obviously the nucleolus organizing chromosome. All possible types of trivalents, that is, chain, frying-pan, Y shape and triple-arc, were observed at diakinesis. The first type was most frequently observed, its average frequency in the seven trisomics being 46.5% (31.8~74.6%), it was followed by the second type with the frequency of 33.3% (4.2~56.3%). The frequencies of the last two types were 8.2% (0.9~40.3%) and 4.8% (0.9~16.6%), respectively. At first metaphase the frequency of $1_{III} + 6_{II}$ conjugation was decreased and the configuration $7_{II}+1_{I}$ was correspondingly increased (Tab. 4). The types of trivalents at this stage were mostly chain (84.3%), followed by frying-pan (11.7%) and Y shape (4.0%). In all trisomics no pollen mother cells with a triple-arc trivalent were observed.

Mutation of a gene (or genes) for asynapsis and its use in plant breeding[1]

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Compared with the presence of polyvalents at meiosis and consequent low fertility in artificial *Aegilops triuncialis* (CCC^aC^a), natural *Ae. triuncialis* is characteristic of regular bivalent formation and high fertility. This regularly bivalent forming characteristics in natural *Ae. triuncialis* may have been brought about by mutation, chromosome rearrangements, harmony between chromosomes and cytoplasm, and others, (KIHARA and KONDO 1943).

In spite of the very close genetic relationships between homoeologous chromosomes in hexaploid wheats, no chromosome pairing takes place between them. This lack of chromosome pairing was explained by postulating gene mutation which suppresses homoeologous chromosome pairing and by occurrences of repeated inversions (SEARS and OKAMOTO 1956).

The mutational aspects of the above two hypotheses have been very well supported by the finding that a gene (or genes) for asynapsis is located on chromosome V (=5B) of two varieties of common wheat, Chinese Spring and Holdfast (OKAMOTO 1957; SEARS and OKAMOTO 1958; RILEY 1958; RILEY, UNRAU and CHAPMAN 1960).

If the above gene (or genes) for asynapsis has really been due to mutation of a certain gene (or genes) to asynapsis, and not by deficiencies of genes for synapsis, the back mutation of the asynaptic gene (or genes) to synapsis or to the original gene could be expected.

The present experiment was planned in order to estimate the back mutation rate and at the same time in order to obtain the plants free from asynaptic effect in common wheat.

The chromosome pairing in the F_1 of Chinese Spring wheat × Imperial rye (n=7) is very poor. The mutation of a gene (or genes) for asynapsis in hexaploid wheats would presumably result in very much increased pairing in the Chinese Spring wheat × Imperial rye F_1.

A dosage of 500 r of X-ray was irradiated on emasculated spikes of Chinese Spring wheat one to three days prior to pollination by rye pollen.

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[1] This work was done while the writer was supported by a grant from National Science Foundation of U.S.A. to Dr. E. R. Sears at the University of Missouri, U.S.A.

The anthers were fixed in 3:1 CARNOY's fluid. Chromosome pairing in the pollen mother cells was studied by ordinary acetocarmine smear technique.

As is listed in Table 1, the mutation rate of the gene (or genes) for asynapsis to synapsis was 3.43%.

This supports very strongly the gene mutation aspects of the hypotheses of KIHARA and KONDO (1943) and SEARS and OKAMOTO (1956).

Since the above mutation rate is fairly high, it is highly hopeful that common wheat free from the asynaptic effect could be obtained in the not very distant future. As introduction of desirable characteristics of wild relatives of wheats into common wheat was made almost impossible due to lack of chromosome pairing between common wheat chromosomes and those from wild relatives, the loss of asynaptic effect and the consequent good pairing would make it possible to transfer the characteristics of wild relatives into wheat by ordinary crossing over between wheat chromosomes and those from wild relatives.

Table 1. Frequency of mutation of a gene (or genes) for asynapsis to synapsis

Chromosome number	Number of plants obtained	Plants with good chromosome pairing	Plants with poor chromosome pairing
25	1	0	1
26	6	0	6
27	30	1	29
28	195	8	187
29	1	0	1

Frequency of mutation 3.43%

Meiotic abnormalities observed in some varieties of common wheat and occurrence of aneuploids

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When the "Meiotic Indices" were examined with over 200 varieties grown on our Experimental Farm for the purpose of contributing data to the wheat breeding program of the future, five types of anomalies were distinguished in the course of meiosis of some varieties which showed a low meiotic index of less than 95%. "Meiotic Index", so designated by LOVE (1949), is the percentage of normal pollen tetrads used as an index of the regularity of meiotic chromosome behavior.

The first type of these anomalies is characterized by the occurrence of univalents, the second type by the occurrence of multivalents, the third type by chromosome fragmentation-fusion, the fourth type chromosome-mosaics, and the last type by the formation of microcytes.

From a population of 50 plants of Shirahada, 5 plants were selected on the basis of seed-fertility and morphological characters as follows:

One plant with the highest and 2 with low fertility, and 2 with pubescent glumes.

From the self-pollinated progenies of these 5 plants, 5 plants from each one, *i.e.*, 25 plants altogether were studied cytologically. The fertility of the parental 5 plants and the 2n chromosome number in their self-pollinated progenies are shown in Table 1.

During the course of a series of studies dealing with "Meiotic Index", several aneuploids were found among natural populations of Akasabi-Shirazu No. 1, Hitsumi-Komugi, Shirahada, Yūshōki, Tōhoku No. 98, Nōrin No. 10, Nōrin No. 33 and Nōrin No. 42. Most of them were monosomics, but trisomics were also found in Akasabi-Shirazu No. 1 and Nōrin No. 10. Out of these varieties showing aneuploids, Nōrin No. 42 attracted the author's attention especially on account of monosomics occurring in comparatively high frequency. Therefore, of a population consisting of 35 plants, 2n chromosome number of every plant was examined. As shown in Table 3, nullisomics as well as monosomics were found. Since disomic plants of this variety produce 2 to 6 univalents in 10 to 26% of the cells observed, there is no doubt that aneuploids occur in their progenies as a result of the formation of aneuploid gametes. However, in other varieties

Table 1. Relation between seed-fertility of parents and 2n chromosome number of their progenies

Parents			Progenies	
Plant No.	Hairiness on glumes	Seed fetility (%)	Plant No.	2n
S - I	glabrous	88.33	1 2 3 4 5	42 42 42 42 42
S - II	, ,	26.32	1 2 3 4 5	42 39 40 41 40
S - III	, ,	28.57	1 2 3 4 5	41 42 41 41 41
S - IV	Pubescent	54.76	1 2 3 4 5	42 41 42 42 42
S - V	, ,	47.83	1 2 3 4 5	41 41 42 41 42

forming as many univalents as Nōrin No 42, the occurrence of monosomics is not so frequent as in Nōrin No. 42, and the occurrence of nullisomics is much less. Therefore, the cause of the frequent occurrence of aneuploids in this variety seems to be due to repeated careless sampling of seeds for the preservation of genes from a monosomic plant which occurred spontaneously in this variety one or several generations before. In common wheat, it is difficult to distinguish monosomics or trisomics from disomics by simple observing the morphological characters, though nullisomics can be easily distinguished because of their characteristic dwarfishness. Accordingly, most of monosomics or trisomics that spontaneously occurred in the fields are apt to be overlooked.

As described above failure of chromosome pairing, formation of multivalent chromosomes, or other types of anomalies have been often observed in common wheat. This is because common wheat is an allopolyploid, exhibiting semi-homologous relationships between its three different genomes and moreover, showing sometimes structural differentiation among the chromosomes. If a gene or genes controlling meiotic abnormalities happen to occur on these chromosomes by mutation, the meiotic chromosome behavior will be further disturbed. Thus, in the progenies, aneuploids will necessarily occur.

Aneuploidy and wheat-rye breeding

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At the Second Wheat Genetics Symposium (Japan), the present author presented some experimental results of the analysis of various chromosome substitution types obtained from wheat-rye hybrids. He also reported on crosses between those substitution types and wheat monosomic lines. In addition, some new procedures, that might be used in wheat-rye breeding, were formulated.

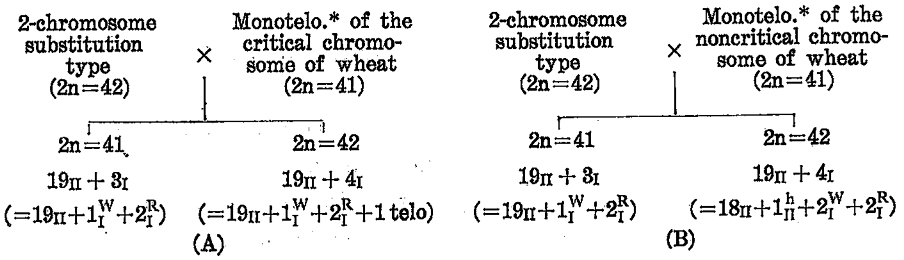
There are three types of wheat-rye hybrids, namely, amphidiploids, heteroploids (including addition types) and substitution types. From the practical viewpoint, however, the substitution type is the most promising material for breeding especially for transferring a useful gene or genes from rye to wheat.

The substitution lines can be classified for convenience's sake into the following four types;

1. Gene substitution type
2. Chromosome substitution type
    a. Single chromosome substitution type
    b. Multiple chromosome substitution type
        2-chromosome substitution type
        3-chromosome substitution type
        ⋮
        n-chromosome substitution type
3. Genome substitution type
4. Nucleus substitution type

Table 1. Number of univalents expected in F_1 hybrids between various chromosome substitution types and wheat monosomics

No. of substituted chromosomes	Wheat monosomics			
	Critical lines		Noncritical lines	
	Monosomic F_1 (2n=41)	Disomic F_1 (2n=42)	Monosomic F_1 (2n=41)	Disomic F_1 (2n=42)
0	0	0	0	0
1	1	2	3	2
2	3	4	5	4
3	5	6	7	6
:	:	:	:	:
n	2n - 1	2n	2n+1	2n



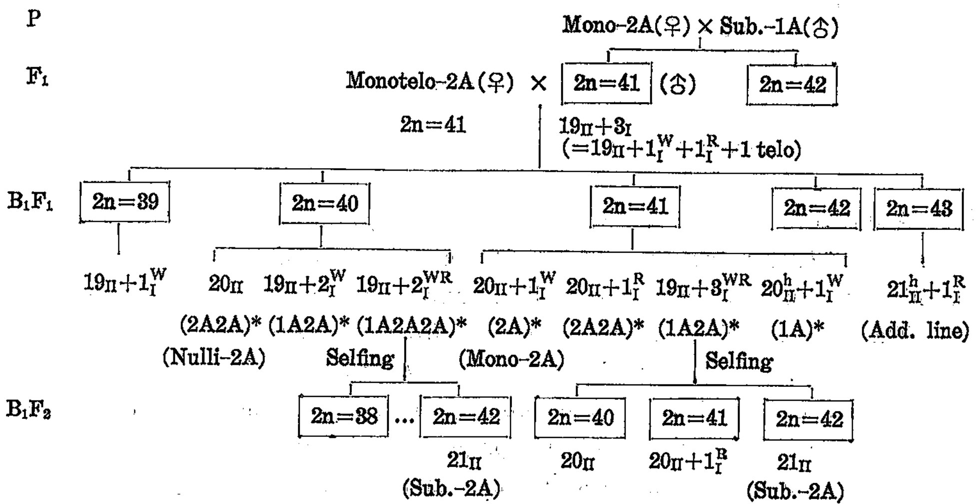
Identification of substituted wheat chromosomes in a 2-choromosome substitution type.

* Monoisochromosome can be used here instead of monotelo.

Superscripts W, R and h indicate wheat chromosomes, rye chromosomes and a heteromorphic bivalent, respectively.

For systematic production of all the theoretically possible 147 lines of single chromosome substitution lines, the procedure described by Jenkins (1956) is recommended. If, however, a series of wheat-rye substitution lines is already available, a new series of substitution lines can be established after a procedure indicated below.

As an example of using wheat aneuploids in the study of wheat-rye hybrids, a method of monosomic analysis, that is now under way for a gene (or genes) controlling the crossability between wheat and rye, is shown in Table 2. This method is based on the assumption that crossability is controlled by a single or a few major genes.



A Procedure for producing a new substitution type (Sub.-2A) by means of crosses between an already established substitution type (Sub.-1A) and monosomic wheat line (Mono-2A).

* Letters in the parentheses indicate the lacking chromosomes in the respective plants.

Table 2. Monosomic analysis of crossability between wheat and rye

Wheat variety	Cross ability with rye	Wheat monosomic line	When controlled by promoter, *A*					When controlled by inhibitor, *i*				
			Genotypes*			Crossability**		Genotypes*			Crossability**	
			a	b	c	A	B	a	b	c	A	B
Chinese Spring	High (H)	Noncritical	*AA*	*A*	*AA*	H	H	*ii*	*i*	*ii*	H	H
		Critical	*A*	-	-	H?	L	*i*	-	-	H	H
Kharkov	Low (L)	Noncritical	*aa*	*a*	*aa*	L	L	*II*	*I*	*II*	L	L
		Critical	*a*	-	-	L	L	*I*	-	-	L?	L

* a, b and c indicate maternal tissues, egg cell and polar nuclei, respectively.

** A and B indicate crossability controlled by the genotype of maternal tissue or egg cell (and polar nuclei), respectively.

Agropyron addition lines of *durum* wheat

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Addition of individual chromosomes of *Agropyron elongatum* (2n=14, EE) to *Triticum durum* var. Stewart (2n=28, AABB) has been attempted. Seven monosomic and six disomic addition lines have successfully been established.

The monosomic lines were produced from the pentaploid hybrid between the amphidiploid *T. durum* var. Stewart × *Ag. elongatum* (AABBEE) and *T. durum*. The chromosome numbers in the progeny of the pentaploid hybrid varied from 28 to 42. About 22 per cent of the progeny were 29-chromosome plants, which had 14 pairs of wheat chromosomes and in addition one *Agropyron* chromosome.

The phenotypes of the seven monosomic addition lines were different from *T. durum* due to the effect of the alien chromosome. The 29-chromosome plants were classified into seven groups ($e_1 \sim e_7$) by their phenotypes. Four monosomic addition lines ($e_1 \sim e_4$) were frequently identified in the populations raised every year (1958~'60), but $e_5 \sim e_7$ lines rarely occurred. The transmission rates of the alien chromosomes of the pentaploid hybrids were not the same. The e_1, e_2, e_3 and e_4 chromosomes were more frequently transmitted to the next generations than the others.

Disomic addition lines were produced in the selfed progeny of monosomic addition lines. Monosomic addition plants yielded three types of progeny, namely, disomic- and monosomic-addition lines and *durum* wheat (2n = 28).

The e_6e_6 disomic addition line has not yet been obtained, although 1055 progeny plants raised from the e_6 monosomic addition line were examined. The frequency of e_6 monosomic addition plants amounted to about 6 per cent of the above progeny. They might be obtained by transmission of e_6 chromosome through the female side. In order to obtain the e_6e_6 disomic addition line, the e_6 monosomics were crossed with the original *T. durum* × *Ag. elongatum* amphidiploid, and 36-chromosome plants were selected. As some of these plants are expected to have the e_6 chromosome pair in addition to 14 wheat chromosome pairs and 6 univalents from *Agropyron* ($e_1 \sim e_5$, e_7), the e_6e_6 disomic addition line may be found in their progeny.

Cytology of the addition lines:

The monosomic addition lines have 29 chromosomes, i.e., 28 wheat chromosomes and one from *Agropyron*. If the *Agropyron* chromosome had homologous segments with wheat chromosomes the monosomic addition line should have a trivalent and 13 bivalents, while no chromosome pairing between wheat and *Agropyron* chromosomes would be found and the *Agropyron* chromosome would remain as a univalent if it had no homology with any of the wheat chromo-

Table 1. Phenotypes of the disomic addition lines

Character \ Lines	e_1e_1	e_2e_2	e_8e_8	e_4e_4	e_5e_5	e_6*	e_7e_7
Leaf		somewhat narrow, light green	broad, stiff	narrow, long	some-what narrow		very broad, stiff, dark green
Flag leaf sheath				very tight	loose		
Ear density	dense	lax	dense		slightltly dense	lax	squarehead
Culm			thick	thin, lank	thin		thick
Waxy or not	waxy	waxy	waxy	waxless	waxy	waxy	waxy
Tillerng			poor		poor		poor
Vigor	slightly weak		vigorous	weak			vigorous

* Monosomic addition line. e_6e_6 disomic addition line has recently been obtained.

Table 2. Chromosome pairing in the PMC's of the monosomic addition lines

Lines	No. plants examined	No. PMC's examined	Chromosome associations			
			$41_{II}+1_I$	$1_{III}+13_{II}$	%	$(1_V, 1_{VI})$
e_1	4	458	449(11)*	12	2.62	
e_2	4	400	185(4)	215	53.75	
e_8	3	400	185(6)	215	53.75	
e_4	3	300	300(16)	0	0.00	
e_5	3	317	87(3)	152	47.95	78 (24.60%)/72.55%**
e_6	4	900	898(10)	2	0.22	
e_7	2	350	349(92)	1	0.29	

* The figures within parentheses indicate the number of PMC's with $13_{II}+3_I$, $12_{II}+5_I$.

** Total percentage of PMC's with tri-, penta- and hexavalent.

somes. As indicated in Table 2, six of the seven *Agropyron* chromosomes have homologous segments in ***durum*** wheat chromosomes. Wheat-*Agropyron* chromosome pairing in e_2, e_3 and e_5 monosomics was more frequent than in e_1, e_6 and e_7 lines, while no pairing was found in the e_4 line.

Such chromosome pairing may indicate the relationships between wheat and *Agropyron* chromosomes, namely the E genome of *Agropyron elongatum* (2n=14) may be semi-homologous to one of the genomes of ***durum*** wheat. Thus in the monosomics with added single alien chromosomes, the homology of the alien chromosome to host chromosomes can be analyzed more precisely than in the F_1 or pentaploid hybrids.

In general, the univalent chromosome divides at first anaphase of meiotic division. At the second anaphase and telophase the morphology of the univalent alien chromosome can be identified clearly and the morphology two different alien chromosomes can be compared at the same time in double monosomic addition lines. The morphological analysis of seven *Agropyron* chromosomes has been nearly completed.

Pentavalent chromosome association shown in the e_5 monosomic addition line suggests that both arms of e_5 chromosome are partially homologous to two different wheat chromosomes.

The disomic addition lines should have 15 pairs in their PMC's, however, 5~30 per cent of PMC's had univalents. The frequencies of such PMC's differ in different addition lines. Presumably the irregularity resulted from asynapsis of the alien pair, due to the unbalance between the alien chromosomes and the

Table 3. Stability of the alien chromosomes and fertility in the disomic addition lines

Lines	No. of plants examined	No. of plants with chromosome numbers of				Years	Fertility %
		2n=30	%	2n=29	2n=28		
e_1e_1	79	74	93.6	5	0	1959-1961	57.9
e_2e_2	138	137	99.2	1	0	”	55.6
e_3e_3	124	96	77.4	28	0	”	47.5
e_4e_4	29	27	93.1	2	0	”	0.96
e_5e_5	91	48	52.7	41	2	1960-1961	31.7
e_7e_7	45	24	53.3	20	1	1961	14.7

complement of the host. As a result, reduced fertility and instability of alien chromosomes were found in the addition lines.

As indicated in the Table 3, e_1e_1, e_2e_2 and e_4e_4 lines are fairly stable, producing only a small portion of progeny with deviating chromosome numbers, but in e_8e_8 e_5e_5 and e_7e_7 lines, 23 to 48 per cent of the progeny had deviating chromosome numbers.

In the double monosomic addition plants obtained from the cross between disomic addition lines, a decrease in chromosome pairing between the host and alien chromosomes was observed. This may be due to an interference effect of the two alien chromosomes on host-alien chromosome pairing.

Radiobiological studies in plants, VII

Chromosome aberrations induced by gamma-irradiation in a Japanese wheat variety[1],[2]

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In the fourth paper of this series the authors reported the effects of gamma-irradiations on oats and wheat, especially in regard to the occurrences of chlorophyll mutations in the progenies of irradiated oats. No chlorophyll mutant was observed in wheat, *T. vulgare* Vill. var. Shinchunaga, so far examined (Nishiyama and Ichikawa 1961a). However many morphological and physiological mutants were often found in the X_2 and the later generations of the same irradiated wheat. From the genetic behaviors of the mutant characters it was assumed that most of them had been induced through chromosome aberrations (Nishiyama and Ichikawa 1961b). A part of results from cytological and genetic observations on these mutants will be briefly reported in this paper.

Results and discussion: Many of the X_2-plants derived from 118 X_1-spikes and of their progenies (X_3-X_5) showed aberrant change in theirs morphological or physiological characters. These plants were cytologically investigated in the meiosis of the pollen mother cells. Out of 44 X_2-lines investigated cytologically, 34 showed abnormal meiotic configurations, such as multivalents, univalents, heteromorphic bivalents, aneuploidy, partial asynapsis, or mixoploidy in their progenies. Total number of plants examined cytologically amounted to 546, of which 342 (63%) showed chromosome aberrations. It is noteworthy that the plants with 38-45 somatic chromosomes were found in the progenies of the irradiated wheat. Excluding the plants which showed partial asynapsis or mixoploidy, about 50% of plants has 42 chromosomes, 21% had 41 chromosomes, 9% 40 chromosomes, 9% 43 chromosomes, 7% 44 chromosomes, and the remainder 38, 39 or 45 chromosomes.

Some different types of meiotic configurations were sometimes found in the plants with the same chromosome number. From this fact it was assumed that these plants had different chromosome constitutions although they had the same number of chromosomes. For instance, the plants with 41 chromosomes could be classified into monosomics ($20_{II}+1_{I}$ in most cases), nulli-trisomics ($1_{III}+19_{II}$ in most cases), and monosomics with one or two complex pairings of chromosomes ($1_{IV}+18_{II}+1_{I}$, $2_{IV}+16_{II}+1_{I}$, *etc.*).

Total 204 $X_3 \sim X_5$-segregates from 31 X_2-lines had the same number of chromosomes as the original variety, showing 21 normal bivalents (42 somatic chromosomes). However, aberrant configurations of chromosomes such as one or two complex pairings of four or sometimes more chromosomes were occasionally found in the progenies of many X_2-lines. Further observations showed the occurrences of mono-trisomics ($1_{III}+19_{II}+1_{I}$) and nulli-trisomics ($1_{III}+19_{II}$) in a few cases. Besides, there were observed mixoploid segregates and partially asynaptic plants, the details of which will be mentioned later.

In the $X_2 \sim X_5$-progenies were often found various abnormal characters, *e.g.*, dwarfness, short spike, lax spike, speltoid, compactoid, square head, thick culm, slender culm, bent culm, narrow leaf, sterility, *etc.* Most of these abnormalities appeared to be associated with various chromosome aberrations. For instance, speltoid plants had always 42 or less chromosomes while compactoid plants had always 42 or more. On the other hand there were some mutants showing only normal 21 bivalents. They were probably induced through gene mutations.

It was generally observed that the plants with 42 chromosomes had high fertilities but those with chromosome numbers deviating from 42 showed decreased fertilities. Moreover, it should be noted that wide variations in the fertility were often observed in the plants with the same chromosome number, probably due to the presence of multivalent pairings of chromosomes or other chromosome aberrations (Tab. 2).

Many monosomic plants were found in the progenies of 15 different X_2-lines. They were expected to segregate nulli-, mono- and disomic (normal) plants in the following generations, and nullisomic plants were actually obtained in the progenies of seven X_2-lines. All nullisomic plants in these lines were dwarf and feeble, and had 40~100% sterility. Mono- and disomic (normal) segregates were usually vigorous and highly fertile. Nullisomic segregates could easliy be distinguished from the related mono- and disomic ones by the differences in their morphological characteristics. Seven nullisomic types were also distinguished from each other by their different morphological characters. Nullisomic plants bred

Table 2. Seed fertilities of the plants with or without chromosome aberrations

No. of chromosomes	Characteristics of meiotic configurations	No. of X_2-lines examined	Seed fertility (%)	
			Range	Average
45	multivalent	2	25 - 33	29
44	21_{II}	5	18 - 79	54
	multivalent*	6	0 - 79	47
43	$21_{II}+1_{I}$	7	62 - 91	79
	multivalent**	10	14 - 89	63
42	21_{II}^{+}	3	77 - 92	86
	multivalent	15	20 - 97	82
41	$20_{II}+1_{I}$	15	46 - 96	77
	$20_{II}+1_{I}^{+}$	1	96	96
	multivalent	7	28 - 89	64
40	20_{II}	7	0 - 60	25
	$19_{II}+2_{I}$	5	5 - 78	62
	multivalent	1	68	68
39	$19_{II}+1_{I}$	1	37	37
	$18_{II}+3_{I}$	2	80 - 83	82
	multivalent	1	7	7
38	multivalent	1	0	0
42	21_{II}	31	31 - 100	84
Control 42	21_{II}	3	96 - 99	97

* Including a part of tetrasomic plants which showed $1_{IV}+20_{II}$ or $1_{III}+20_{II}+1_{I}$ in more than 25% of pollen mother cells.

** Including a part of trisomic plants which showed $1_{III}+20_{II}$ in more than 25% of pollen mother cells.

$^{+}$ Having a heteromorphic bivalent.

true usually in the following generation if they were fertile. However three giant plants were found in the progeny of a nullisomic strain (N4). They had 41 somatic chromosomes and showed a specific meiotic configuration of $1_{III}+19_{II}$ in most of the pollen mother cells. The formation of a trivalent could be due to a substitutional increase of a homoeologous chromosome in place of the chromosome which was lost in the nullisomics. Their seed fertilities and plant growth recovered as in usual monosomics, but their major characteristics were rather similar to those of the original nullisomic plants.

In the progenies of three different X_2-lines were found some segregates which showed partial asynapsis of chromosomes at MI of PMC's.
That is, only one and three asynaptic plants were found in two strains, PA1 and PA2 respectively. In the remaining strain (PA3), however, three partially asynaptic X_3-plants were found and all of their $X_4 \sim X_5$ plants were partially asynaptic. The chromosome numbers of these segregates ranged from 40 to 43. The number of univalents in the plants with 40 chromosomes varied from 0 to 20 per cell, 5.63 being the average. A range from 1 to 19 univalants and an average of 5.55 univalents were counted in the plants possessing 41 chromosomes. Considering the meiotic abnormalities, the low fertilities in the asynaptic plants could easily be explained. However, the partially asynaptic plants with 41～43 chromosomes usually showed higher seed fertilities than those with 40 chromosomes most of which were completely sterile. And it was further noted that asynaptic plants with 40 chromosomes were generally accompanied with dwarfness with a few exceptions. The high sterility and dwarfness might mainly be caused by the nullisomic nature of chromosome constitution. An experiment is now under way to know the genetic behavior of the partial asynapsis in relation to the asynaptic effect of chromosome V of Chinese Spring wheat (Okamoto 1957).

SECOND ANNOUCEMENT

2nd INTERNATIONAL WHEAT GENETICS SYMPOSIUM

in Lund - Svalöf, Sweden.

August 19-24, 1963

PROGRAM The 2nd International Wheat Genetics Symposium will be held in August 19-24, 1963. The meetings are planned to be in the Genetics Institute, Sölvegatan 23, Lund, Sweden, but the great interest in the Symposium provisionally registered may make it necessary to use a larger lecture hall in Lund. The program is planned around seven special and one miscellaneous session and two excursions. It is now almost settled to all its details and a PRESENT PROGRAM VERSION is enclosed.

REGISTRATION A first announcement letter about the Symposium was sent out in the end of last year. All who have reacted positively by sending in the preliminary application form are now reached by this second announcement.

Irrespective of your earlier indication of a definite or tentative participation, you are here asked to send the enclosed DEFINITE REGISTRATION FORM to the Secretariat, if you wish to be registered for attendance at the 2nd International Wheat Genetics Symposium. You are asked to fill the form as completely as possible, and the form has to be sent in **before April 1, 1963.** If the form is received after this date, accommodation and participation in the social events cannot be guaranteed.

Full membership is open to all interested persons for a registration fee of 50 Swedish crowns. Each full member is entitled to participate in all scientific and social gatherings and to receive one copy of the Proceedings.

Associate membership is open only to wives, husbands and older children (over 15 years of age). Each associate member has to pay a registration fee of 20 Sw. crowns and is entitled to participate in the social events and in a special Associate Members' Program. The extremely low number of children and husbands not interested to attend the scientific sessions revealed by the preliminary inventory implies that this special program will mainly be arranged for accompanying wives.

ACCOMMODATION The preliminary inventory indicates that three different accommodation facilities in Lund will suffice. Grand Hotel is an ordinary, first class hotel with single and double rooms with or without bath. Student House implies accommodation in modern student dormitories (built in 1961) with high comfort, individual rest rooms and floor bathroom, kitchen and social room. Uarda Summer Hotel is also a student dormitory but more regularly arranged as summer hotel. Restroom and washroom at each floor and outside a very attractive garden.

When you book room on the Definite Registration Form please give the exact length of your stay. Only the time indicated will be guaranteed.

ARRIVAL It is highly appreciated, if you can give your exact time and station of arrival (Bulltofta Airport -- Lund Railway Station) already now on the Definite Registration Form or in due time before the Symposium. Plans are to meet you, if possible, and bring you to the Registration Desk at the Genetics Institute and to your room.

CLOTHING AND WEATHER No formal dress will be required on any occasion during the congress. The weather in South Sweden is at the time of the Symposium likely to be mild with an average day temperature of 17 degrees C. You will certainly need a raincoat.

SECRETARIAT The Symposium Secretariat will be Swedish Seed Association, Svalöf, Sweden until August 17, 1963. In August 18-24, the Symposium Bureau will be installed in the Genetics Institute, Sölvegatan 23, Lund, Sweden. The secretariat will supply additional Registration Forms on request.

Present Program Version.

August 19, Monday.

Morning

8.30 Opening remarks and address of welcome.
SESSION I. **Wheat Quality.**
9.00 Announcement of the Chairman.
9.10 F. J. R. Hird (Australia): Wheat quality in relation to chemical bonds.

9.50 O. Hall and R. Olered (Sweden): Electrophoretic and physical properties of wheat protein.

10.30 Recess.

10.50 A. Avila and E.A. Favret (Argentina): Inheritance of gluten quality in wheat.

11.10 General Discussion.

11.30 NOON LUNCH.

Afternoon

1.00 Conducted tour agricultural areas and historical sites near Lund and a visite to Weibullsholm Plant Breeding Institute, Landskrona.

7.00 Dinner at Strandpaviljongen, Landskrona. Address by Dr. F. Eajersson (Sweden): Methods and achievements in Swedish wheat breeding.

August 20. Tuesday

Morning

SESSION II. **Plant Breeding Methods in Wheat.**

8.30 Announcement of the Chairman.

8.40 A. Vincent (France): Quantitative inheritance in respect to early selection in crosses.

9.20 S. Borojevic (Yugoslavia): Combining ability in wheat crosses.

10.00 Recess.

10.20 C. F. Konzak (USA): Physical and chemical mutagenesis in wheat breeding.

11.00 R. E. Scossiroli (Italy): Wheat mutagenesis in quantitative traits.

11.40 General Discussion.

12.00 NOON LUNCH.

Afternoon

SESSION III. **Disease Resistance in Wheat.**

1.30 Announcement of the Chairman.

1.40 P. Zhukovsky (USSR): Natural immunity regularities and world wheat breeding resources.

2.20 A. T. Pugsley (Australia): The genetics and exploitation of resistance to mildew.

3.00 Recess.

3.20 E.E. Sebesta (USA): Wheat viruses and their genetic control.

4.00 W. Q. Loegering (USA): The relationship between host and pathogen in wheat rust.

4.40 General Discussion.

5.00 Intermission for dinner and rest.

7.00 R. C. F. Macer (Great Britain): The formal and aneuploid genetic analysis of stripe rust resistance.

7.40 R.G. Anderson (Canada): The inheritance of leaf rust resistance in wheat.

8.20 D.R. Knott (Canada): The inheritance of stem rust resistance in wheat.

9.00 General Discussion.

August 21. Wednesday

Morning

SESSION IV. **Wheat Taxonomy and Phylogeny.**

8.30 Announcement of the Chairman.

8.40 D. Zohary (Israel): The evolution of genomes in ***Aegilops*** and ***Triticum.***

9.20 Y. Cauderon (France): The genome constitution of ***Agropyron.***

10.00 Recess.

10.20 M. M. Jakubziner (USSR): . Modern Russian aspects on the systematics of wheat.

11.00 J. Mac Key (Sweden): Species relationship in ***Triticum.***

11.40 General Discussion.

12.00 NOON LUNCH.

Afternoon

1.30 Tour of the Swedish Seed Association, Svalöf.

7.00 Dinner at Svalöf Hotel. Svalöf. Address illustrated with motion pictures by K. Yamashita (Japan): Collection of wheat and wheat relatives in the near East.

August 22, Thursday

Morning

SESSION V. **Amphiploids and Addition to Wheat of Characters from Related Genera.**

8.30 Announcement of the Chairman.

8.40 V. Pissarev (USSR): ***Triticale*** amphidiploids.

9.20 B.C. Jenkins (Canada): ***Secale*** substitutions and additions to common wheat.

10.00 Recess.

10.20 H. Kihara (Japan): Chromosome and nuclear substitutions involving wheat and ***Aegilops.***

11.00 A. Wienhues (Germany): Transfer of resistance from ***Agropyron*** to wheat by addition, substitution and translocation.

11.40 General Discussion.

12.00 NOON LUNCH.

Afternoon

SESSION VI. **Aneuploidy in Wheat Genetics.**

1.30 Announcement of the Chairman.

1.40 R. I. Larson (Canada): Aneuploid analysis of quantitative characters in wheat.

2.20 J. Kuspira (Canada): Chromosome substitution lines in wheat.

3.00 Recess.

3.20 E.R. Sears (USA): Chromosome mapping with the aid of telocentrics.

4.00 M. Norohna-Wagner and T. Mello-Sampayo (Portugal): Aneuploids in durum wheat.

4.40 General Discussion.

August 23, Friday

Morning

SESSION VII. **Cytogenetic Structure of Wheat.**

8.30 Announcement of the Chairman.

8.40 R. Riley (Great Britain): The regulation of chromosome behaviour in wheat and its relatives.

9.20 M. Okamoto (Japan): Studies on the chromosome 5B effects in wheat.

10.00 Recess.

10.20 M.S. Swaminathan (India): Mutational analysis of the hexaploid wheat complex.

11.00 J.G.T. Hermsen (Netherlands): Hybrid necrosis and red hybrid chlorosis in wheat.

11.40 General Discussion.

12.00 NOON LUNCH.

Afternoon

SESSION VIII. **Presentation of Short Papers of Various Topics.**

1.30 Announcement of the Chairman.

1.40 K. W. Finlay (Australia): Genotype-environment interaction in wheat.

2.00 J. W. Schmidt and V. A. Johnson (USA): Sterility-fertility interaction in wheat.

2.20 N. E. Borlaugh (Mexico): Genetics and transfer of semi - dwarfness in wheat.

2.40 M. J. Pinthus (Israel): A contribution to the genetics of heading date of spring wheat.

3.00 Recess.

3.20 R. M. Caldwell (USA): The genetic and expression of resistance to hessian fly, ***Phtophaga destructor*** (Say.).

3.40 E. B. Wagenaar (Canada): Cytogenetic relationship between ***Triticum timopheevi*** and ***T. araraticum***.

4.00 A. Müntzing (Sweden): Cytogenetic and breeding studies in ***Triticale***.

4.20 C. J. Driscoll (Australia): A genetic method for detecting induced inter-generic translocations.

4.40 S. Rajki (Hungary): The conversion process by autumnisation of wheat.

5.00 Intermission for rest and redressing.

7.00 Closing banquet at Akademiska Föreningen, Lund.
Address by Dr. D. U. Gerstel (USA): Evolution of polyploid crops.

August 24, Saturday

Morning

BUSINESS SESSION.

9.00 Transaction and election.
This session will include a brief report from the Sock Preservation Committee given by E.C. Heyne (USA).

12.00 End of Symposium.

Two types of lectures will be given at the Symposium. The majority of lectures are presented by invited specialists who will give their contribution in 30 minutes papers each followed immediately by a 10 minutes discussion. An additional, general discussion in 20 minutes is further reserved at the end of each session. The second type of lecture includes a restricted number of voluntary papers. The time available for the presentation of such a paper is 15 minutes directly followed by a 5 minutes discussion.
The language of the Symposium will be English. Provision is made to present lectures and contributions to discussion in other languages, if summary in English is provided.

Coordinating Committee

Editorial Board

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The Managing Editor

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