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I. Research Notes

A note about the "New dates for recent cultivation of *Triticum monococcum* and *Triticum dicoccum* in Yugoslavia"

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Under the quoted title in WIS No. 3, Elisabeth Schiemann has published the research note on recent cultivation of *T. monococcum* and *T. dicoccum* in Yugoslavia. I found it necessary to make some corrections on this article.

That "Einkorn is still a regular crop in 4 villages in Kroatia, Hercegowina and Macedonia" and that "Emmer is still found in 7 villages in Kroatia, and one in Bosnia, Hercegowina and Montenegro respectively" are not correct and show very little why and to what extent they are actually grown. I have visited many parts of the country and collected these species, but just in how many villages they are cultivated is difficult to say. The fact is that these species are much more widely spread than Schiemann has informed us.

In province Lika (Kroatia) Emmer and Einkorn are not grown only in counties Gospić and Perušić but also in Gračac, Korenica, Otočac, Brinje etc., what includes many villages in each country. The same is true for Bosnia, Hercegowina, Montenegro etc. Recent statistics show that Emmer and Einkorn are cultivated on ca 10,000 to 15,000 hectares (varying largely from year to year), more than 3/4 of that belonging to Emmer.

In the most mountainous regions where the climate is severe and soils are poor or in dry continental regions on Karst, peasants like to have in addition to wheat or barley a field (rarely more than 0.25 hectare per a holding) of Emmer or Einkorn because they withstand coldness, drought and rust infection better than wheat.

Emmer is mostly grown mixed with oats or barley while Einkorn is mostly found in pure culture. Both crops are used as fodder for horses and pigs and very rarely for bread. If so, then they are always mixed with common wheat or barley.

Morphological and other characteristics of the species concerned will not be discussed here.

The occurrence of new color of glumes and awns in the *Triticum vulgare* and *Triticum dicoccum* cross

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Triticum vulgare var. *lutescens* Al. (variety "Graf Törring") and *T. dicoccum* var. *farrum* Körn. (Emmer from Trebinje, Yugoslavia) were crossed, both having white color of glumes and *dicoccum* as a bearded variety with white color of awns as well. In the F₁, red color of glumes has occurred. In the F₂ and later generations the color of glumes and awns was found to be inherited on the basis of at least two factor difference segregating for red and white in 9:7 ratio.

The red color varied from intensive red to light-red. Glumes were completely red whereas palea exterior was red only on the part which is not covered by the glume. This fact warned to check whether the red color depends upon the presence of sunlight or not. Therefore the experiment with bagging of ears has been performed. The ears of some segregates homozygous for red color were bagged just before heading and immediately after heading. The same was done with another *vulgare* variety with red glumes. Unbagged ears were used as control. The red color was not developed at all on the ears bagged before heading while those bagged after heading were light-red. The same was true for *vulgare* variety. Thus, the conclusion was drawn that red color is genetically controlled but it can be developed only in the presence of sun-light.

In principle, the color of awns was the same as that of glumes. Many segregates however, had more intensive color of awns, i.e. dark-red or black. These colors occurred particularly in the F₄ during the hot and dry growing season. Quite a number of segregates which had red color of glumes and awns in early generations, in the F₄ gave progenies with black color of awns and in some cases black glumes as well. Even plants with white color gave progenies with white glumes and black awns or with blue-black glumes and black awns.

In majority of the plants black color disappeared in the F₅ and succeeding generations, especially black color of glumes while that of awns remained in some segregates. The occurrence and disappearance of black color has been explained to be primarily due to the influence of environmental factors, particularly the strength and duration of sunlight, even though its genetic basis can not be neglected.

The red and white color were present in all species-type segregates, black color being linked only to 14-chromosome types. This shows that D genome inhibits the development of black color.

A new strain of *Triticum polonicum*

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As mentioned in WIS No. 3, a species with the name of *Triticum monococcum* var. *eredivianum* was given to the senior authors¹⁾ by the courtesy of Dr. M. Atai, University of Tehran, Iran, revealed $2n=28$, which is the chromosome number of Emmer wheat. (Ref. to Table 1 on page 20).

Accordingly, the morphological characteristics have been studied into detail. The plant is semi-dwarf and has narrow and slender ear, differing strikingly from all other wheats in possessing ears with long and narrow empty glumes, which are typical in *Triticum polonicum*.

Description:

Straw: 60-70 cm, hollow with comparatively thick walls.

Ears: 5-7 cm long, 6-8 mm wide, lax, narrow and slender, tapering towards the apex, fragile in wedge type disarticulation.

Spikelets: 14-17 (including 3-4 abortive lower spikelets), 14-17 mm long, 3-4 mm wide, 1- to 2- grained, with awns 4.5-5 cm long.

Empty glume: Glabrous, light-yellow, 14-16 mm long, with 5-6 nerves, very short with two teeth or the secondary tooth is absent.

Outer glume is slightly longer than inner glume and is as long as empty glume. Outer glume of the 1st floret has many nerves and a short awn, while that of the 2nd floret has a short tooth.

Grains: Long and narrow, red, flinty, smooth, 8 mm long, 3 mm wide, 1.0-1.2 mm thick.

In conclusion, this strain differs from other varieties of *T. polonicum* in having the following characters:

1. Semi-dwarf
2. Hollow straw
3. Ear narrow, slender, small and fragile.
4. Empty glume is not papyraceous.
5. Small grains.

1) Members of the Scientific Expedition to the Karakoram-Hindukush of the Kyoto University, Kyoto, Japan, 1955.

Effect of X-rays on fertility and mutation rate in Einkorn wheat

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Dormant seeds of *Triticum monococcum* were exposed to various kinds of X-rays with different dosages or wave lengths, without a filter. The frequencies of ears with chromosome aberrations in X_1 -plants and of head progenies with gene mutations in X_2 increased with X-ray dosage (5,400-13,500 r). It was also fairly certain that the shorter the wave length of X-rays, the higher not only the frequency of chromosome aberrations, but also that of gene mutations (c.f. WIS No. 2). In all cases the frequencies of both aberrations and mutations were higher in var. *vulgare* than in var. *flavescens*. Thus, var. *flavescens* showed always higher tolerance to X-rays than var. *vulgare* (Tab. 1).

There were some quantitative differences between the effect of various kinds of X-rays upon the fertility of single spike of X_1 -plants. Mean fertility of each spike in untreated plants was 82.67% and 53.22% in var. *flavescens* and var. *vulgare* respectively and that of X-rayed plants decreased generally in a linear relation to the increase of X-ray dosage. This relation is in good accord with the relation between the frequency of chromosome aberrations or gene mutations and X-ray dosage. Also, there is a marked difference between the fertility at 80 and 180 KVP. This relationship of sterility to wave length coincides roughly with the relation of aberration or mutation frequency to wave length (Tab. 1). In all cases the fertility was also markedly lower in var. *vulgare* than in var. *flavescens*. The former variety matures later than the latter. Therefore, the fertility of var. *vulgare* is sometimes low and variable, influenced by higher summer temperatures. Even taking into consideration this unfavorable seasonal factor, the fertility of X-rayed plants is more heavily reduced in var. *vulgare* than in var. *flavescens*. This might be due to the above mentioned difference in tolerance between both varieties.

Table 1. Relation of frequencies (%) of induced chromosome aberrations or gene mutations and fertilities of spikes of X_1 -plants

Dosage (r)	Voltage (KVP)	var. <i>flavescens</i>			var. <i>vulgare</i>		
		Chromosome aberration in X_1	Gene mutation in X_2	Fertility of spike in X_1	Chromosome aberration in X_1	Gene mutation in X_2	Fertility of spike in X_1
Control	—	0.00	0.00	82.67	0.00	0.00	53.22
5,400	180	5.77	6.67	76.50	5.88	11.36	43.28
8,100	180	12.50	12.73	69.57	15.09	19.23	32.67
13,500	180	28.95	37.04	57.90	38.08	40.00	17.70
8,100	130	12.50	3.64	67.82	14.49	9.31	41.47
8,100	80	7.50	5.56	75.23	3.95	8.69	41.06

Effects of fast neutron radiation on Einkorn, Emmer and bread wheats

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Seeds and seedlings of various crop plants are being treated with different chemical and physical mutagens in the course of the Mutation Research Programme in progress at the Indian Agricultural Research Institute.

As a part of this work, dry seeds of *Triticum monococcum* (var. Japanese Early), *T. dicoccum* (var. Khapli) and *T. aestivum* (var. C. 591) were irradiated for 3 hours with fast neutrons of source strength $10^9 N_F/Cm^2/Sec.$ over a 2π solid angle at the cascade generator of the Tata Institute of Fundamental Research, Bombay, using the reaction $d(Be^9B^{10})\alpha$. The seeds were germinated in petridishes; some seedlings were transplanted into pots and some were used for the study of somatic cell division, which was done in Feulgen root tip squashes prepared from material fixed in acetic-alcohol (1:3) 24, 48 and 96 hours after germination.

Among the seedlings grown in pots, plant vigour and survival decreased in the following order: *T. dicoccum*, *T. aestivum* and *T. monococcum*. In material irradiated with thermal neutrons, Konzak and Singleton (1954) have reported a similar superiority in resistance of the tetraploid wheat. We have observed and many other authors have also reported, that for a given dose of X-ray or B radiation, there is an increase in resistance with increasing polyploidy. The results with thermal and fast neutron radiation where the hexaploid shows a higher degree of sensitivity than the tetraploid are therefore different from those observed with the other radiations.

The study of the effects on somatic cell division showed the occurrence of chromosome breaks at metaphase and dicentric bridges and fragments at anaphase in all the three species. The mean number of chromosome breaks per cell in the different species was as below:

	Metaphase	Anaphase
<i>T. monococcum</i>	0.64	0.18
<i>T. dicoccum</i>	2.24	1.04
<i>T. aestivum</i>	12.24	11.84

A striking feature in the hexaploid wheat was the presence of a large number of cells (nearly 40%) with each one of the 42 chromosomes fragmented. Such extensive breakage was rare in the diploid and tetraploid wheats. The frequency of occurrence of breaks in different cells was found to follow a Poisson distribution in the case of the diploid and tetraploid wheats, thus indicating that the formation of the chromosome break is unaffected by the presence or absence of other breaks in the cell. In the case of the hexaploid, however, the distribution of breaks did not fit into the Poisson pattern.

It appears from the data that in the hexaploid wheat, the advantage of ploidy is offset by the occurrence of extensive chromosome breakage in a large number of cells. This may probably account for it being more sensitive to neutron radiation than the tetraploid. It appears likely that threshold of breakage may exist beyond which breakage at any one region may facilitate further breakage among the chromosomes.

In the variety of *T. monococcum* used, there are two pairs of satellited chromosomes, one of which is shorter than the other (designated Sat-chromosomes I and II; relative lengths 12.6μ and 10.4μ respectively). There is a weak super-numerary constriction near the short arm of the Sat-chromosomes. Analysis of the types and points of origin of chromosome breaks at metaphase in material irradiated with fast neutron showed that a break frequently occurred near the super-numerary constriction region of one of the Sat-II chromosomes. The frequency of occurrence of this particular break and the total number of breaks observed in different cells are given below:

Description	No. of cells	No. of localised breaks in Sat-II	Total no. of breaks
Regular	11	0	0
1 chromosome break	20	9	20
2 chromosome breaks	21	12	42
3 " "	5	2	15
4 " "	2	1	8
5 " "	2	1	10
6 " "	1	1	6
20 " "	2	4	40
Total	64	30	141

The total length of the somatic complement in *T. monococcum* was calculated to be 172.2μ of which the length of the Sat-II pair was 20.8μ . If we assume complete random breakage, approximately 1 in every 8.3 breaks could occur in the Sat-chromosomes. The observed figure of 30 out of a total of 141 breaks does not, fit with this expectation ($X^2=11.30$; $P=0.01$). This would suggest that the region near the super-numerary constriction of Sat-II chromosomes is preferentially disposed to breakage by neutron radiation. It is not possible, to determine by microscopic observations whether the breakage occurs only in one chromosome of the Sat-II pair. Only 2 among the 28 cells in the Sat-II breaks showed breakage in both the chromosomes (P between 0.05 and 0.02), thus indicating that breakage occurs in only one chromosome of the pair, and not at random in either of them. The occurrence of single Sat-II break in most of the cells suggest, that some degree of differentiation, with reference to localised neutron sensitivity, may occur in the apparently homologous chromosomes.

There was no evidence for the occurrence of localised chromosome breakage in Sat-II or any other chromosomes of *T. monococcum* in material treated with X-rays or

³²P. The localised break in fast neutron treated seeds, therefore, appears to be a correlated consequence of the interaction between the reactions set in motion by the neutron particles and the concerned chromosome segment. There was no evidence in our *monococcum* material that the concerned segment is heterochromatic. From this practical point of view, the occurrence of localised chromosome breakage is of interest since detectable mutation resulting from such a structural change may be expected to recur. The results of Prof. Gustaffson, in which erectoid mutants in barley occurred most frequently when dry seeds were treated with thermal neutrons, are probably attributable to some such mechanism.

“White scald” mutation in wheat

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Although huge seedling populations of wheat are under observation each year, very rarely are mutants reported. The occurrence of a recessive mutant in an F_2 population from the cross Maguarovar 98 × Thew is of interest in that it has apparently not been recorded previously.

Maguarovar 98 of Hungarian origin was obtained from the U. S. D. A. World Wheat Collection in 1952. Thew is a well known Australian variety. Both are resistant to mildew and the cross was made with a view to establish the identity of the gene for resistance in Maguarovar 98. No mildew susceptible segregates were detected in the F_2 of 207 plants. However 5–6 days after germination a number of plants developed unusual lesions on the first leaves. Ten days after germination there were 153 normal plants and 54 plants bearing lesions. The plants with lesions later grew quite normally and, with the unaffected plants, were grown on to produce F_3 seed.

Progenies have been studied in F_3 , F_4 and F_5 and the evidence indicates that the “white scald” condition is inherited as a simple recessive.

Symptom expression of “white scald” varies considerably. Commonly the first leaves are affected although symptoms may not appear until the four leaf stage.

In severe cases several leaves are scalded but on no occasion have affected plants been killed.

Typically a transverse white scald-like band appears across the middle of the leaf, the distal portion bending over but remaining quite turgid and green. Sometimes two bands may appear on a single leaf and occasionally the lesion develops longitudinally.

Cytological evidence for the S genome in *Aegilops juvenalis*

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Genome studies in the genus *Aegilops* have now progressed to the point where most species have been given a genome formula. One of the few species for which the formula is incomplete is *Ae. juvenalis* (Thell.) Eig=(*Ae. turcomanica* Rosh.). In a recent chart prepared by Tanaka and Kihara (W.I.S. No. 1), *Ae. juvenalis* was given the genome formula D (M?) +?, although no published cytological evidence to support this proposal was presented. Recently, McGinnis (C.J.A.S. 1956) studied a number of interspecific and intergeneric F₁ hybrids involving *Ae. juvenalis* and found that the D and C^u genomes probably constitute two of the three chromosome sets. In an attempt to determine the third genome the authors have crossed *Ae. juvenalis* with four members of the *Sitopsis* group and cytologically analysed the F₁ hybrids. The pairing data from these hybrids are presented in the following table.

Hybrid	Univalents per cell	Closed bivalents per cell	Open bivalents per cell	Trivalents per cell	Quadri-valents per cell	Higher multivalents per cell	Average bivalents per cell*
<i>Ae. juvenalis</i> (n=21)							
× <i>Ae. speltoides</i> (n=7)	10.24	.92	4.60	1.57	.40	.08	8.04
× <i>Ae. Aucheri</i> (n=7)	8.32	.20	3.38	1.89	.84	.62	8.72
× <i>Ae. sharonensis</i> (n=7)	13.14	.42	4.17	1.40	.35	.03	6.75
× <i>Ae. longissima</i> (n=7)	15.86	.08	3.23	1.28	.36	.01	5.30

Data averaged from counts made on 200 PMC's for each hybrid. * Based on one trivalent=1 bivalent; one quadrivalent=2 bivalents; etc.

It can be seen from the table that the hybrids involving *Ae. speltoides* and *Ae. Aucheri* (S genome) gave a much higher pairing frequency than the hybrids involving *Ae. sharnensis* and *Ae. longissima* (Sⁱ genome) indicating that the chromosomes of *Ae. juvenalis* are more homologous to the chromosomes of the S genome than of the Sⁱ. The amount of pairing is indicative of the presence of the S genome in *Ae. juvenalis*. From the evidence available thus far, it seems probable that the genome formula for *Ae. juvenalis* is C^uDS.

The B genome of *Triticum*

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Because of the recent suggestion of Sarkar and Stebbins (1956) that the B genome is derived from one or more species of the *Sitopsis* section of the genus *Aegilops*, it

seems desirable to make available some observations from 1941-43 on certain hybrids involving *Ae. bicornis* (S^b), *Ae. speltoides* var. *ligustica* (S^s), *T. monococcum* (A^m), and *T. dicoccoides* (AB).

Hybrid	No. PMC's	Ave. no. uni-valents	Ave. no. bivalents		Ave. no. tri-valents	Ave. no. quadri-valents	Ave. no. 5-valents	Ave. no. 7-valents
			Closed	Open				
A ^m S ^b	150	8.62	.23	2.28	.11	.01		
A ^m A ^m S ^b S ^b	100	.26	13.66		.06	.06		
AA ^m BS ^b	50	10.34	2.82	5.24	.22	.22		
A ^m S ^s	50	.82	2.44	3.84	.18	.02		
A ^m A ^m S ^s S ^s	25	1.60	10.84		.20	.96		.04
ABS ^s	50	7.44	.60	4.06	1.36	.04		
AA ^m BS ^s	20	6.50	3.10	4.05	1.10	.70	.15	.05

Entries 4, 5, and 6 in the table are from previous publications (Sears 1941 and McFadden and Sears 1947). The S^s genome in A^mA^mS^sS^s and AA^mBS^s is from strain II of *Ae. speltoides*, while the one in A^mS^s and ABS^s is from strain I, but it is doubtful that significant chromosome differences exist between the two strains. Strain II showed relatively little pairing in A^mS^s, but the numerous multivalents in A^mA^mS^sS^s indicate strong homology of A^m with S^s from strain II.

It appears that S^b has considerable pairing affinity with B, for AA^mBS^b averaged almost 9 pairs or its equivalent (a maximum of 12 pairs), whereas AA^mB has only 5 or 6 pairs (maximum 7), according to various workers. Presumably BS^b pairing accounts for about 3 or 4 pairs, which is more than were observed for A^mS^b.

S^s, on the other hand, apparently has more affinity for A than for B. A^mS^s had the equivalent of 6.59 pairs on the average, which is almost full pairing. The large amount of association in AA^mBS^s, equaling almost 11 pairs (maximum 13), would suggest much pairing of B with S^s, except that pairing of S^s with A and A^m, as well as of A with A^m and B with S^s, must have occurred. It is therefore unlikely that S^s has as strong affinity for B as for A. Whether B is closer to S^s or to S^b cannot be decided from these data.

The phenotypes of A^mA^mS^bS^b and A^mA^mS^sS^s are such that McFadden (personal communication; 1941) was led to write, "The gross morphological characters of the hybrid *Ae. bicornis* × *T. monococcum* are the same as those of *T. dicoccum*, which is also true for the hybrids of *Ae. speltoides ligustica* × *T. monococcum*." Of the two amphidiploids, *bicornis-monococcum* (s. figure on the cover) resembles *T. dicoccum* more closely. Neither amphidiploid set selfed seed in its hybrid with *dicoccum*.

In the early 1940's McFadden believed that the B genome of *T. dicoccum* had originated from S^b or S^s, as shown by his reference in 1942 to "my theory that the first

cultivated emmers were amphidiploids of *T. monococcum* with either *Ae. speltoides* or *Ae. bicornis*." However, he also thought that the B genome of *T. polonicum* had come from *Haynaldia villosa* and the B of the progenitor of *T. persicum* from *Agropyron triticeum*. When he became aware that the chromosomes of the different supposed B sources were too diverse to account for the good pairing in hybrids among the various tetraploids, he decided that *A. triticeum* was the most probable single source, since it alone could account for to him extremely important free-threshing character. Recent evidence suggests that the gene for free threshing (Mac Key's Q) may simply have arisen as a mutation.

**Amphidiploid from the hybrid, *Aegilops umbellulata* 4x ×
Aegilops squarrosa 4x**

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All the possible amphidiploid combinations between five groups of principal analyzers (C, C^u, D, M and S), except C^u × D, have been already obtained (WIS No. 1). M and M^u are included in M group, and S, S^u and S^v in S group. In 1956, I synthesized an amphidiploid C^uC^uDD from the cross of induced 4x parents, *Aegilops umbellulata* 4x × *Ae. squarrosa* 4x. But, in this amphidiploid the chromosome pairing was not regular, and often univalents and polyvalents were seen. The seed-fertility was rather poor (ca. 13%).

From the morphological point of view, this amphidiploid bears the characteristics of Section *Vertebrata*, resembling *Ae. juvenalis*. Consequently, C^uC^uDD × M group (*Ae. comosa*, *Ae. Heldreichii* and *Ae. uniaristata*) must give rise to an amphidiploid which corresponds to *Ae. juvenalis*, as Kihara (1954) indicated.

**Newly synthesized amphidiploids from the hybrids among
diploid species in *Aegilops***

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In WIS No. 1, the possible and successful combinations of amphidiploids among 11 diploid species in *Aegilops* were listed. Newly synthesized amphidiploids are added to the list as follows.

Genome-combination	Chromosome number (<i>n</i>)	Source
C ^a C ^a S ^b S ^b	14	Selection from (<i>Ae. umbellulata</i> No. 2, 4x × <i>Ae. bicornis</i> 4x) in 1955
MMS ^b S ^b	14	Colchicine treatment of (<i>Ae. comosa</i> No. 2 × <i>Ae. bicornis</i>) in 1955
C ^a C ^a DD	14	Selection from (<i>Ae. umbellulata</i> No. 2, 4x × <i>Ae. squarrosa</i> No. 2, 4x) in 1956

Fertility of F₁ hybrids between *Triticum persicum* and *Aegilops squarrosa* No. 1

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In 1947, Kihara and his collaborators produced the hybrids between various Emmer and *Aegilops squarrosa*, from which F₂ plants were obtained in 1948. These plants were the amphidiploids. Out of these, the amphidiploid between *T. persicum* and *Ae. squarrosa* No. 2 was most closely resembling *T. vulgare* in the morphological characteristics, and the fertility was better than the other amphidiploids. The present writer used *Ae. squarrosa* No. 1 as father plant, and crossed to *T. persicum stramineum*. In 1956 two F₁ hybrids were obtained. The growth of these plants was worse than F₁ plants in which *Ae. squarrosa* No. 2 was used as father plant in 1947, and also they were fairly susceptible to rust disease. Table 1 shows the results of the observations of MI at various stages in one F₁ plant.

Table 1. Frequency of chromosome pairing of MI in three different stages in one F₁ plant

Stage of fixation	Chromosome pairing				Total	Percentage of the cells with 2I ₁ to total observed cells
	2I ₁	1II+19I	2II+17I	3II+15I		
10/V	22	14	12	2	50	44 %
17/V	57	33	9	1	100	57 "
24/V	79	15	6	—	100	79 "

Table 2. Pollen fertility at two different flowering times in F₁ hybrids

Individual No.	First heading	Third heading
10-1	2.2 % (anther not bursted)	73.4 % (anther bursted)
11-1	10.0 " (anther not bursted)	63.8 " (anther bursted)

As showed in Table 1, the percentage of 21_1 cells increased as time goes on. Table 2 shows the pollen-fertility of the hybrids in different ear. That is, in the flowers of first heading ear the anthers did not burst and the pollen-fertility was very low, but the anthers of the flowers which headed lately bursted and showed fairly good fertility, but the seed was not obtained.

Adding individual rye chromosomes to wheat

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Experience with interspecific and intergeneric crosses in the *Triticinae* has indicated that some manipulation of the raw amphidiploid will almost certainly be necessary before agriculturally useful forms can be obtained (Bell, Lupton and Riley 1955).

It has been proposed that lines of wheat disomic for the addition of a single pair of chromosomes of a diploid species might incorporate useful features of the diploid with the minimum alteration of the basic phenotype of wheat. Because of their balanced chromosome constitutions such lines might be expected to be true-breeding and of normal fertility.

Six of the seven possible disomic additions of the chromosomes of *Secale cereale*, King II, to *Triticum vulgare*, Holdfast, have been obtained. Each rye chromosome produces a more or less characteristic alteration to the phenotype of Holdfast. The chromosome added may thus be recognised by its phenotypic effect and also, in certain additions, by the morphology of the chromosome itself. Most alterations to the phenotype of wheat are quantitative. The characters which mainly distinguish rye—the narrow single nerved glume, long hairs on the keel of the lemma, exposed grain and the absence of a terminal spikelet—do not appear in the addition series. The only distinguishing character transferred is “hairy neck” controlled in this material, as in that of O'Mara (1951), by a factor on chromosome I, and by a factor of less pronounced effect, and of limited penetrance, on chromosome II (Chapman and Riley 1955).

Certain complementary effects result in expressions shown by neither the rye nor the wheat. Thus three addition lines have red grains although those of Holdfast are white and those of King II grey. One addition line has branched ears. Of more practical potentiality is the resistance to both rye and wheat races of mildew developed by two addition lines. The resistance to wheat mildew introduced by chromosome II is shown to be controlled by a factor on the non-satellited arm, by the behaviour of the telocentrics for each arm.

There is usually a phenotypic expression of the dose difference between monosomic and disomic additions. The characters which distinguish monosomic additions from Holdfast are generally further exaggerated in disomic additions.

Meiotic pairing in the addition lines is rarely so regular as in Holdfast, but regularity differs markedly between different additions. The irregularity, which is usually asynapsis of the alien pair, is perhaps due to the lack of balance between the chromosomes of the donor and the receptor species. Thus the genetical control and synchronisation of meiosis, for which selection has long operated in wheat through the mutual adjustment of the chromosomes, is not effective for the alien pair. Such irregularities are likely to lead to reduced fertility and to the instability of the addition condition, but it may be that balanced and integrated combinations could be produced by selection. However, only one variety of wheat was used in making the present additions so as to preserve an agriculturally tested genotype. Further, by the methods by which the disomic additions were produced the added alien chromosomes are completely homozygous. Heterozygosity must therefore be introduced if selective adjustment is to be made in the addition lines. Crosses are therefore being made between disomic additions and *Triticale* derived from the same wheat variety, Holdfast, but a different rye gametes. In the F_2 of these crosses it should be possible to extract 44 chromosome disomic additions in which some factors of the alien pair are heterozygous, but those of the wheat chromosomes are homozygous. Selection may be practised in subsequent generations for fertility and genetical stability, and so for arrangements of the alien pair which are genetically integrated with the receptor genotype. It is possible that the stability of alien chromosome substitution lines may be improved if the alien pair has been previously adjusted in this way.

F_1 hybrids between three species of *Triticum* and *Agropyron intermedium*

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12, 27 and 3 F_1 hybrids were obtained between *Triticum polonicum* var. *vestitum*, *T. durum* var. *Reichenbachii* and *T. vulgare* var. *erythrospermum*, and *Agropyron intermedium*, respectively.

T. polonicum \times *A. intermedium*: Most characteristics of all F_1 plants ($2n=35$) were intermediate but in several others they resembled the *Agropyron* parent. Individual variation in some characters such as waxy—somewhat waxy, wide leaf—narrow leaf and slender stem—thick stem etc. were observed. The plants grew vigorously. Pollen sterility was complete but several seeds were obtained from open-pollination and from pollination with pollen of the *Agropyron* parent.

At MI varying conjugation pattern from $5_{II}+25_I$ to $10_{II}+15_I$ was observed. and the average chromosome conjugation was $0.03_{IV}+0.2_{III}+6.8_{II}+20.8_I$. Most of the bivalents

were of open type and only (1-2)_{II} were ring-shaped.

T. durum × *A. intermedium*: All F₁ plants (2n=35) were waxy and had short awns but some variation occurred as to the growth habit.

At MI different kinds of chromosome conjugation from 3_{II}+29_I to 12_{II}+11_I were observed. The average was 0.04_{IV}+0.3_{III}+7.7_{II}+19.5_I and 3-4 ring-shaped bivalents were found.

T. vulgare × *A. intermedium*: F₁ plants (2n=42) were waxy and had short awns. Most of other characters were intermediate. Pollen- and seed-sterility was complete.

Considerable pairing from 8_{II}+26_I to 13_{II}+16_I was observed at MI, and the average was 0.03_{IV}+0.6_{III}+10.1_{II}+19.8_I with ring-shaped (2-3)_{II}.

Judging from the occurrence of 7-10 bivalents in the F₁ hybrids between three species of *Triticum* and *Agropyron intermedium*, homologies among the genomes of *A. intermedium* may be assumed, and moreover, the possibility of autosyndesis of a few chromosomes among the genomes of *Triticum* or allosyndesis of a few chromosomes between the genomes of *Triticum* and those of *Agropyron* is indicated.

F₁ hybrids between three species of *Aegilops* and *Agropyron intermedium*

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Three species of *Aegilops*, i.e. *Ae. longissima*, *cylindrica* and *variabilis* were crossed with *Agropyron intermedium* with the following results.

Ae. longissima × *A. intermedium*: In 1954 one F₁ hybrid was obtained whose somatic chromosome number, examined in root tip cells, was 2n=28 as expected. The ears of this plant resembled those of the *Agropyron* parent but other characters were intermediate. Pollen- and seed-sterility was complete and the development of the anthers stopped before flowering. Various kinds of chromosome conjugation were observed at MI from 1_{III}+5_{II}+15_I to 10_{II}+8_I, and the average chromosome conjugation was 0.07_{IV}+1.1_{III}+6.7_{II}+10.9_I. 3-4 ring-shaped bivalents were found in each cell.

Ae. cylindrica × *A. intermedium*: One hybrid plant (2n=35) grew slowly and was very weak. Tillering and heading were abnormal.

At MI various configurations of chromosomes were found, from 2_{III}+4_{II}+21_I to 1_{III}+9_{II}+14_I. The average conjugation was 0.1_{IV}+0.9_{III}+6.9_{II}+18_I.

Ae. variabilis × *A. intermedium*: Two F₁ plants (2n=35) were obtained but one died. Its tillering was good and the bushy growth was like that of the *Aegilops* parent but the shape of the ears was intermediate. Pollen- and seed-sterility was complete. Various chromosome conjugations from 5_{II}+25_I to 10_{II}+15_I were observed and the average was

0.5_{III}+6.5_{II}+20.9_I. One chromosome fragment was found in every plate.

It is noteworthy that in all above mentioned hybrids the average chromosome conjugation amounted to 6-7 bivalents. Hence, autosyndesis between the genomes of *A. intermedium* may be inferred. The wide fluctuation of the number of bivalents indicates the occurrence of some allosyndesis between the genomes of the employed *Aegilops* species and *A. intermedium*.

II. SUPPLEMENT

Wheat and its Relatives¹⁾

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Classification of *Triticum*

In 1913 Schulz divided wheat species into three main groups, Einkorn, Emmer and Dinkel, from the morphological view point. In 1918, Sakamura and Sax found the right chromosome number for each group as $n=7$, 14 and 21, respectively. Following this finding, Kihara accomplished the genome constitution for each group as AA, AABB and AABBDD, respectively. *Timopheevi* ($n=14$) was afterwards separated from Emmer group by the genome constitution AAGG.

"Genome which is represented by a chromosome set is a fundamental genetical and physiological system, whose completeness as to the basic gene content is indispensable for the normal development of genes in haplo- and zygotes in diplophase."

Pentaploid Hybrids

The investigation of pentaploid hybrids (Kihara 1919, 1924) gave an early start to Kihara's genome-analysis. The pentaploid hybrids were won from crosses between Emmer and Dinkel wheats. Consequently, their genome constitution is represented by the formula AABBDD.

Kihara (1924) found the pentaploid hybrids to follow definite rules which he derived from the chromosome combinations in F_2 . On their basis he divided the F_2 offspring into two groups: 1) "fertile" and 2) "sterile" chromosome combinations. The first group was further subdivided into a) the chromosome number decreasing group and b) the chromosome number increasing group. The first has 28-34 somatic chromosomes and at metaphase the configuration $14II(7AA+7BB)+(0I-6I$ from genome D). The 29-34 chromosome plants revert soon in the course of further generations to the Emmer type with $14II$, i.e. AABB, when all the univalents of the incomplete genome D have dropped out. The increasing group, with 36-42 somatic chromosomes, consists of plants which possess all elements of D, double or single. This group, when bred further, reverts slowly to the 42 chromosome type, AABBDD, by acquiring in the process of fertilization the missing partner of the D complement. Thus, in further generations of the pentaploid hybrids and, in general, all hybrids of the genome pattern AAB return parental genome types, where cytological and eventually, genetical constancy is established. The "sterile" chromosome combinations can never revert to the parental types and, with a few exceptions, die out.

Results of the "Aequationskreuzungen," i.e. $F_1 \times$ parents, and "Zertationskreuzungen," i.e. parents $\times F_1$: The purpose of the first series was to explore the distribution of the various chromosome combinations in the macrosporocytes of the hybrid and to ascertain the fitness of the corresponding gametes. The object of the second series was to examine these conditions for the microsporocytes. The obtained ratios were not in good accord with the theoretical figures, calculated on the basis of a random distribution of univalents. The search began for the causes of the disagreement. The first clue gave the fast development of the decreasing group back to AABB from which an elimination of univalents could be inferred, and calculations have been worked out to determine the degree of elimination. The followings should be mentioned.

1) Excerpton with necessary revisions and corrections from EXHIBITS, International Genetics Symposia, 1956, 6-12 September, Tokyo and Kyoto, Science Council of Japan, 1956

1) Elimination of univalents plays an important role. 2) Moreover, the univalents are distributed not separately but in bunches. 3) Strong competition between the pollen grains; those with 14 and 21 chromosomes being the fittest. 4) Selective fertilization does not occur, provided that enough pollen is furnished. If not, the embryosacs with intermediate chromosome numbers fail to be fertilized which may become a disturbing factor. 5) Poor seed germination was observed when Emmer was the mother, caused by a greater disproportion in the endosperm between the quantities of the genomes AB and D in this direction of the cross than reciprocally, namely 3AB: 1D and 3AB: 2D, respectively. 6) Zygotic elimination of the "sterile" combinations occurs, and so forth.

A very laborious investigation of the distribution of chromosome combinations in a large F_2 was carried out by Kihara and Matsumura (1940). When all the disturbing factors were taken into consideration, the frequency of the chromosome combinations obtained from the F_2 investigation could be brought into agreement with the results of the other experiments and with the theoretical expectations. Also, the differences between the reciprocal crosses could be explained.

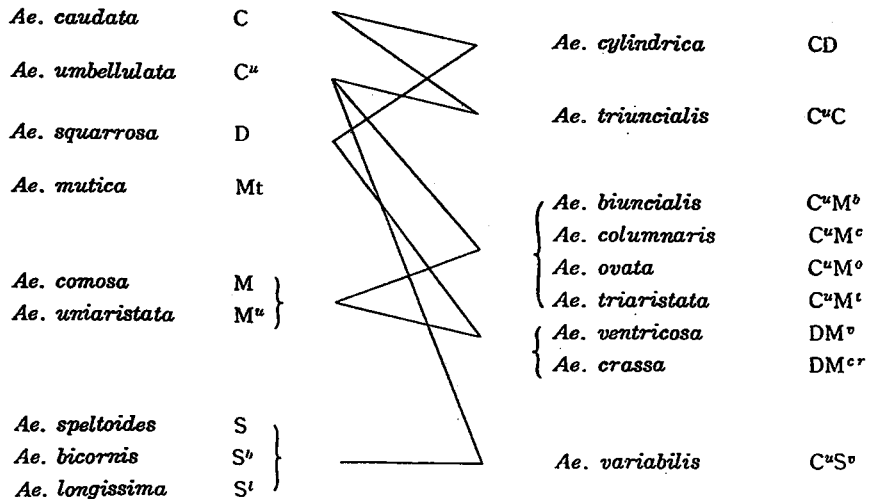
The "sterile" combinations were represented by weak, sterile plants, with the exception of healthy dwarf-like individuals with 20 bivalents and fairly good fertility. At first four different dwarfs were found; in each of them another chromosome pair of the D genome was lacking. Much later Kihara's collaborator, Matsumura (1947), found the three remaining dwarfs. These plants were the first ever produced nullisomics which became so important as instruments in investigations of the gene content of the *vulgare* chromosomes.

Classification of *Aegilops*

The genus *Aegilops* is believed to be originated in Mediterranean districts, namely Asia Minor, Syria and Palestine (Zhukovsky 1928 and Eig 1929), and various species are found naturally in those districts at the present time.

From the morphological standpoint, Eig classified them into six sections and 22 species, while Zhukovsky into nine sections and 20 species. Considering the results of karyotype analysis by Senianinova-Korczagina (1932), Kihara (1949) has set up six sections, *Polyeides*, *Cylindropyrum*, *Comopyrum*, *Amblyopyrum*, *Sitopsis* and *Vertebrata*. *Gastropyrum* by Senianinova-Korczagina was included in section *Vertebrata* by Kihara.

In *Aegilops*, polyploidy relation with the basic number of seven is found. From the results of genome analyses, 9 different genomes, C, C^u , D, M, M^u , Mt, S, S^b and S^l , have been distinguished among 12 diploid *Aegilops* species. Their genome relationships in the *Aegilops* group, are as follows:



According to genome analyses *Ae. Aucheri* is related to *Ae. speltoides*, so *Ae. Heldreichii* is to *Ae. comosa*, and so *Ae. sharonensis* is to *Ae. longissima*. *Ae. Aucheri* is different from *Ae. speltoides* only by one gene for awn. In the hybrids *Ae. comosa* × *Ae. Heldreichii* and *Ae. longissima* × *Ae. sharonensis*, a ring of 4 chromosomes due to reciprocal translocation is found in addition to 5 pairs. Similarly 2 rings of 4 chromosomes are found in the hybrid, *Ae. kotschyi* × *Ae. variabilis*.

In *Ae. triaristata* and *Ae. crassa*, tetraploid and hexaploid plants are known. There are 300 possible hybrid combinations in *Aegilops*, among which 123 combinations have been already raised and cytologically studied.

Autopolyploids and Amphidiploids

Artificial autopolyploids of *Triticum* and amphidiploids of the hybrids between *Triticum* and *Aegilops* are as follows.

Autopolyploids:

T. aegilopoides var. *boeoticum* 4x, *T. durum* var. *hordeiforme* 8x and var. *Reichenbachii* 8x

Amphidiploids (*Aegilotricum*):

S'S'AA (*Ae. longissima* 4x × *T. aegilopoides* var. *boeoticum* 4x)

" (*Ae. sharonensis* 4x × ")

AABBSS (" × *T. durum* var. *hordeiforme* 8x)

AAGGC^uC^u (*T. Timopheevi* × *Ae. umbellulata*)

Synthesized 6x amphidiploids are described elsewhere.

Among these amphidiploids, it will be necessary here to mention briefly about the amphidiploids-S'S'AA. From the morphological point of view, the S group in *Aegilops* has certain characteristics of the B-genome commonly involved in Emmer and Dinkel wheats. However, the hybrids between the amphidiploid S'S'AA and *T. durum* (AABB), revealed only 7 bivalents, and were entirely sterile. This indicates that the A-genomes of the parents are homologous each other, but the S'-genome cannot be homologous to the B-genome.

Induced autopolyploids and synthesized amphidiploids in *Aegilops* are as follows.

Autopolyploids:

Ae. longissima 4x, *Ae. ovata* 8x, *Ae. uniaristata* 4x, *Ae. squarrosa* 4x, *Ae. bicornis* 4x, *Ae. sharonensis* 4x, *Ae. umbellulata* 4x.

Amphidiploids:

S^bS^bDD (*Ae. bicornis* × *Ae. squarrosa*)

CCC^uC^u (*Ae. caudata* × *Ae. umbellulata*)

S'S'C^uC^u (*Ae. sharonensis* × *Ae. umbellulata*)

S^bS^bC^uC^u (*Ae. bicornis* × *Ae. umbellulata*)

M^uM^uC^uC^u (*Ae. uniaristata* × *Ae. umbellulata*)

C^uC^uM^uM^u (*Ae. umbellulata* × *Ae. uniaristata*)

C^uC^uS^bS^b (*Ae. umbellulata* × *Ae. bicornis*)

M^uM^uDD (*Ae. uniaristata* × *Ae. squarrosa*)

C^uC^uDD (*Ae. umbellulata* × *Ae. squarrosa*)

All the polyploid *Aegilops* species are made up from the combinations of different genomes of the 9 analyzers. 14 amphidiploids have been synthesized by Kihara and his collaborators, and 13 by Sears. Some of them are comparable to the spontaneous polyploid species. Namely, CD corresponds to *Ae. cylindrica*, DM to *Ae. ventricosa*, CC^u to *Ae. triuncialis*, C^uS to *Ae. Kotschy* or *Ae. variabilis*, and C^uM to tetraploid species, *Ae. ovata*, *triaristata*, *columnaris* and *biuncialis*. These synthesized amphidiploids resemble the corresponding species in nature. Furthermore, genomes of synthesized CCC^uC^u are completely homologous to those of *Ae. triuncialis*, and C^uC^uS'S' to *Ae. variabilis* or *Kotschy*.

Synthesis and Origin of Hexaploid Wheats

In 1944, Kihara found that *Aegilops squarrosa* carries the D genome of the hexaploid wheats. In the same year McFadden and Sears drew the similar conclusion from the synthesis of hexaploid amphidiploids of the hybrid between *T. dicoccoides spontaneo-villosum* and *Ae. squarrosa* by the use of the colchicine method. While, in 1946, Kihara and Lilienfeld produced also the amphidiploid of *T. dicoccoides spontaneo-nigrum* × *Ae. squarrosa* through the union of unreduced gametes. In these amphidiploids the seed fertility were fairly good. And the F₁ hybrids from the cross between the amphidiploid and hexaploid wheat (Dinkel wheat) had good fertility.

In 1948, Kihara and his collaborators obtained the amphidiploids of various combinations, among which two combinations are worth while to describe; they are hybrids between two varieties of *T. persicum* and *Ae. squarrosa* No. 2. These two hybrids produced abundant normal pollen grains (up to 85%) and were fairly fertile. The tetraploid *T. persicum* is a species which has very distinct *vulgare* characters. As to morphology, the F₁, *T. persicum* × *Aegilops squarrosa*, was identical with a hexaploid species, which was given to us as "*T. persicum rubiginosum*" by a Russian colleague. However, the ear in the F₁ is fragile and the type of disarticulation is that of *Ae. squarrosa*, viz. barreltype.

Then, where did our cultivated 6x wheats originate? If the progenitors of cultivated 6x wheats were wild plants, the two parent species must have been wild. The place where they grew together must be the place of origin. From the knowledge available to us at present, Armenia and the western part of Iran are the region where the hybridization had a chance to take place. However, there is no decisive evidence that wild hexaploid wheats such as our amphidiploids grew there. If the cultivated 4x wheats, as *T. dicoccum*, *T. durum*, *T. persicum*, etc. contributed one of the parents, the hexaploid probably arose under cultivation. Then the place of origin could have been the whole area where *Ae. squarrosa* grew wild. The Asiatic hexaploid species, such as *T. Macha* and others, which were recently described, may have originated in this way. The geographical distribution of these species is restricted to the regions where *Ae. squarrosa* grows wild most probably in Transcaucasia.

Collections of the Kyoto University Scientific Expedition to the Karakoram and Hindukush, 1955

In the summer of 1955, the Kyoto University, Kyoto, Japan, organized the Scientific Expedition to the Karakoram and Hindukush. Kihara was the leader and eleven specialists in their respective fields, botany, anthropology and geology, two cameramen and a reporter joined the party.

Aegilops squarrosa, one of the ancestors of our common wheat, was found around Quetta, Pakistan, in the beginning of the expedition by Kihara and Yamashita, which is probably the south-easternmost limit of the distribution of this genus. This species was found mostly in association with cultivated wheat everywhere, while in the northern district of Afghanistan, a large natural population of this species was found.

The tour from Quetta, through Afghanistan, to Azerbaijan, Iran, was made from late May to early August. Along a distance of over 5,000 km *Aegilops squarrosa* var. *typica* was seen widely distributed, and its specimens were collected in over 100 different localities. *Aegilops squarrosa* var. *strangulata* was, however, found only in a restricted area in Gorgan, Iran. Number of strains and habitats collected of *Triticum* and *Aegilops* are given in the Tabs. 1 and 2. (A change was made in the arrangement of materials from that given in the tables reported in WIS No. 2.)

Table 1. Number of strains and habitats collected of *Triticum*

Region	Einkorn		Emmer		Dinkel	
	Strains	Habitats	Strains	Habitats	Strains	Habitats
Pakistan:						
Quetta	0	0	0	0	59	10
Afghanistan:						
Kabul	0	0	0	0	61	35
Pulikumuri	0	0	0	0	2	2
Maimana	0	0	0	0	12	5
Iran:						
Meshed	0	0	0	0	24	11
Tehran	0	0	2	2	46	8
Gorgan	0	0	8	3	21	17
Pahlavi	0	0	1	1	44	21
Tabriz	0	0	0	0	31	15
Isfahan	0	0	6	3	46	20
Unknown	3 ¹⁾	2	3	2	8	2
Total	3	2	20	11	354	146

1) A species given by the courtesy of Dr. M. Atai, University of Tehran, Iran, revealed $2n=28$, which is the chromosome number of Emmer wheat. (Ref. to "A new strain of *Triticum polonicum* by Kihara, Yamashita and Tanaka" on page 3.)

Table 2. Number of strains and habitats collected of *Aegilops*

Regions	<i>squarrosa</i>		<i>crassa</i>		<i>cylindrica</i>		<i>triuncialis</i>	
	Strains	Habitats	Strains	Habitats	Strains	Habitats	Strains	Habitats
Pakistan:								
Quetta	15	13	0	0	0	0	0	0
Afghanistan:								
Kabul	35	22	9	2	0	0	0	0
Pulikumuri	31	15	12	8	0	0	12	10
Maimana	24	15	11	7	0	0	24	13
Iran:								
Meshed	0	0	1	1	0	0	1	1
Tehran	14	6	4	1	16	3	50	8
Gorgan	23 ¹⁾	15	0	0	0	0	1	1
Pahlavi	25	13	0	0	3	2	0	0
Tabriz	9	6	10	7	29	16	32	15
Isfahan	0	0	0	0	0	0	0	0
Unknown ²⁾	3	1	11	1	9	4	32	1
Total	179	106	58	27	57	25	152	49

1) Mostly *Aegilops squarrosa* var. *strangulata*.

2) Given by the courtesy of Dr. M. Atai, University of Tehran, Iran, and Mr. M. Mojtabehi, Department of Agriculture, Tehran, Iran. This involves 2 strains of *Ae. umbellulata*.

Himalayan Wheats

Many Himalayan wheats were introduced from Nepal by Nakao, a member of The Japanese Himalayan Expedition to Nepal, 1952-53. The introduced wheats are classified into 17 different botanical varieties, all of which belong to *Triticum vulgare*. Most of them belong to Indian wheat group and some belong to Tibetan wheat group. The grain quality of most of the Nepalese wheats, is hard flinty. The low Himalayan hills are considered to be the home of the flinty bread wheats in the world. Namely three stocks from there such as Hard Red Culcutta, Genun and Etwah furnished very important materials for the breeding of the world famous leading wheat varieties as Marquis, Ruby, Prelude, Garnet and Reward in Canada and U.S.A. and Federation and Aurora in Australia.

X-Ray Induced Mutations in Einkorn Wheats

Many characters of common wheats, including some of economic importance, have been genetically studied, but very few linkages have been found. The difficulties are due mainly to their polyploid constitution. However, Einkorn wheats which are diploid with seven pairs of chromosomes are fairly well adapted to genetic and cytological studies. By means of induced mutations and induced chromosomal rearrangements, including reciprocal translocations, the genetic and cytological analyses have been largely developed.

Various types of induced reciprocal translocations in *Triticum aegilopoides* and *T. monococcum* were analyzed, and a series of 6 types involving 7 chromosomes of Einkorn wheat from a to g were established. They are a-b, b-c, c-d, d-e, e-f and e-g. Subsequently, by the successive crosses, plants with all the possible combinations of rings and pairs have been obtained.

These materials were also used for locating genes in respective chromosomes. Accordingly, the seven linkage groups have been established.

d-chromosome with lethal-1 and f-chromosome with lethal-2 have been combined in a ring of six chromosomes, as $\frac{\mathbf{d} \ \mathbf{e-f}}{\mathbf{d-e} \ \mathbf{f}} = \textcircled{6}$, where chromosomes with lethal genes are given with bold face.

The permanent heterozygosity should be maintained by this plant due to the balanced lethal mechanism known in *Oenothera*.

Right- and Left-handedness

Right- and left-handed leaves are defined according to the way of folding; i.e. when the overlapping edge of a leaf is on the right hand of the observer, it is called right-handed and if on the left hand, left-handed. The right- and left-handedness of a spikelet has been defined from the position of its first floret, namely, when the first floret is on the right, seen from dorsal side, a spikelet is right-handed, and when it is on the left, left-handed. Generally, the right-handed and left-handed leaves are regularly arranged in alternative sequence from the base up to the flag leaf. This regularity is continuously found in the spikes.

The data of observations on the right- and left-handedness of the leaves and spikelets from the first foliage leaf to the apical spikelet, indicated that the degree of the intensity of the regularity changes throughout the developmental stage. Namely the regularity appears from the 3rd or 4th leaf's position and is maintained up to around the 10th spikelet, but it disappears again around 20th spikelet.

Concordance proportion: Two kinds of the measure of the intensity of the regularity are used. One is the concordance proportion (C_k), which represents the intensity of regularity at the k th position on the stem, and the other is the mean concordance proportion (\bar{C}) which expresses the intensity of the polarity of investigated shoots or plants. They can be obtained by the following

formulas: $C_k = X/n$ C_k : The intensity of regularity at the k th position.
 X : The number of concordant spikelets at the k th position.
 n : The number of investigated shoots.
 $\bar{C} = \frac{\sum_{k=1}^m C_k}{m}$ m : The number of investigated spikelet positions.

The \bar{C} -value among species *Triticum* and *Aegilops*:

Each species of *Triticum* and *Aegilops* has its own specific value of \bar{C} . Throughout *Triticum* and *Aegilops* only two genomes, A and D, have \bar{C} -values significantly higher than fifty per cent. Namely, genome A shows the highest value of \bar{C} (80% or more), and D about 65%, whereas C, M, C^u, and S^t give no indication of regularity in spikelets. Emmer (AABB) and *T. Timopheevi* (AAGG) have \bar{C} -values of about 50 per cent, which means the absence of the regularity. This suggests that genomes B and G suppress the effect of the genome A. Dinkel wheats (AABBDD) have about the same \bar{C} -value as *Ae. squarrosa* (DD), indicating the dominance of the D genome over AABB.

Polygenic analysis: In 1951, a crossing experiment was carried out between two species of Einkorn wheats, *T. monococcum flavescens* ($\bar{C}=78.2\%$) and *T. aegilopoides boeoticum* ($\bar{C}=88.2\%$). In 1954, besides the two parental species, F₁, F₂, F₃ and backcrossed generations (B₁, B₂) and back-cross selfed generations (B_{1s}, B_{2s}) were analyzed; their \bar{C} -values were as follows: F₁=93.1, F₂=87.2, F₃=84.9, B₁=86.7, B₂=90.5, B_{1s}=82.9 and B_{2s}=89.8 in percent, respectively.

The \bar{C} -value which satisfied the Mather's criteria (1942) was used to measure the expression of right- and left-handedness in spikelets.

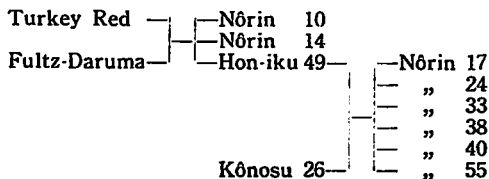
Variation measured can be partitioned into three components. The estimates of the contributions made by nonheritable (E_1 , E_2), fixable heritable (D) and unfixable heritable variations (H) are $D=35.4 \pm 17.7$, $H=46.4 \pm 37.7$, $E_1=36.8 \pm 4.9$ and $E_2=16.2 \pm 4.7$ in percent, respectively. Since H is pretty larger than D , it seems that there is a marked degree of dominance, but the high value of its standard error makes this conclusion somewhat unreliable.

The genetic portion in variances in various generations was found to be significant. The heritability of F₂-generation was about 44.3%. The large portion of the nonheritable in variances may have been caused both by environmental fluctuations and the experimental systematic errors.

The numbers of effective factors concerning the intensity of the right- and left-handedness were estimated by several methods. The greatest estimate was 2.3 and the smallest 0.6.

Japanese Varieties of Wheat

The wheat varieties of standard productivity recommended by the government to the farmers are registered by the Nôrin numbers. Nôrin is the abbreviation of the Department of Agriculture and Forestry. From 1926 up to the present, 90 Nôrin varieties have already been established. Through the studies on various hybrid progenies it became clear that high productivity together with early maturing habit and disease resistance can be secured only by crossing of selected parents. Therefore, the parents of the Nôrin varieties are few in number. For example, Nôrin winter wheats for the snowy parts of Japan have been raised as follows:



Nôrin 3 which was registered in 1930 is a selection from the hybrid progeny of *Triticum vulgare* × *T. durum*. In 1939, this variety covered about 10,000 acres.

The Japanese indigenous wheats are characterized by the short stature, early maturation, short and flat ear, mealy and red grain.

Quality of *Triticum* and *Aegilops*

With the interest in the quality, *T. monococcum*, *T. dicoccum*, *T. vulgare*, *T. Spelta*, synthesized 6x wheat and *Aegilops* species with D-genome were submitted to the analyses.

The appearance of the loaf of *Ae. squarrosa* was poorer than *T. vulgare*, but when mixed with *T. vulgare* as to contain 11% protein, the loaf was soft as *T. vulgare*. The taste of the bread of *Ae. squarrosa* was good.

Nuclear Substitution

Kihara's method (Kihara 1951) of nuclear substitution and restoration by successive backcrosses can be understood as follows:

	α CC	<i>Ae. caudata</i>		β VV	<i>T. vulgare</i>	.....	P
		α CV	.....				<i>caudata</i> × <i>vulgare</i> , F ₁
Substitution	{	α CV × VV = α C ¹ V ¹ V*	.....				SB ₁
		α C ¹ V ¹ V × VV = α V ² V	.....				SB ₂
		α V ⁿ⁻¹ V × VV = α V ⁿ V (= α VV)	.....				SB _n
							⋮
Restoration	{	β CV	.....				<i>vulgare</i> × <i>caudata</i> , F ₁
		β CV × VV = β C ¹ V ¹ V*	.....				RB ₁
		β C ¹ V ¹ V × VV = β V ² V	.....				RB ₂
		β V ⁿ⁻¹ V × VV = β V ⁿ V (= β VV)	.....				RB _n

α and β : cytoplasm of *Ae. caudata* and *T. vulgare* respectively

C and V: genome type of *Ae. caudata* and *T. vulgare* (ABD)

P: parent; SB₁...SB_n: 1st...nth substitution backcrosses;

RB₁...RB_n: 1st...nth restoration backcrosses.

* B₁ individuals with the genome type C¹V¹V can be obtained from the union of unreduced gametes of F₁ and normal ones of *T. vulgare*. They show 21II+7I in MI. 7 univalents are derived from C-genome. They tend to be eliminated in the course of successive backcrosses.

Male sterility: α VV shows complete male sterility. Though 21 paired chromosomes are observed in PMC's and the meiosis proceeds normally, 2nd mitosis in the pollen grains does not occur and the tapete cells degenerate at early stage.

α V^bV, which involves one of the *caudata* Sat-chromosomes, is fertile to some extent; α V^bV^b has higher pollen fertility.

Change of genome constitutions: Sometimes some of the α VV and restored β VV strains exhibit the characters of *Ae. caudata*, such as non-waxy stem, and black spike. Pistillody occurred unexpectedly, suggesting certain change of genome constitution. This character is mainly inherited maternally and day length plays an important role in producing pistillody. α V^bV^b and β V^bV^b bear black spike character, which is assumed to be located on Sat-chromosomes from *Ae. caudata*.

Wheat-Rye

Triticale types: *Triticale* types (2n=56) were produced by doubling the chromosomes of F₁ hybrids between *T. vulgare* and *S. cereale* with the colchicine treatment. According to the performance test, even a strain Tc. No. 17 which was considered to be promising, was found not favorable for the practical cultivation.

Substitution and heteroploid types: (a) Substitution types ($2n=42$) occurred presumably by the reduction of chromosome number in the progeny of certain *Triticale* which revealed irregularities in meiosis. In No. 749-14 derived from *Triticale* No. 749, about 3 pairs of wheat chromosomes are substituted by rye chromosomes, and in No. 88c derived from *Triticale* No. 54, about 5-6 pairs. In both strains, the character "hairy neck" occurs as in *Triticale*. This perhaps shows that a gene (or genes) for the character is located in one of the substituted chromosomes.

(b) Substitution types ($2n=42$) and a heteroploid type ($2n=44$) were obtained in the progenies of (*T. compactum* × *S. cereale*) F_1 × *T. compactum*. They were classified into a number of groups according to the ear types.

In W.R. Nos. 86 (A), 182 (J) and 195 (U), each having $2n=42$, at least one pair of wheat chromosomes are substituted by the rye chromosomes. W.R. No. 194 (U) has 44 chromosomes, of which 42 are considered to be mostly homologous to those of wheat, while the remaining two probably involve the rye-chromosome portions. Ryes with wheat cytoplasm were obtained by the successive backcrosses of *Triticale* with rye pollen. As compared with the normal, their maturity is later and their culms are shorter; the development of seeds and the fertility are normal.

Agropyron

Agropyron is the largest and most interesting genus because it is not only related closely to *Triticum* but also to *Elymus*. Some species of *Agropyron* are hybridized with *Triticum*, and others with *Hordeum*. This indicates that *Agropyron* is the transition between wheat and barley. It involves more than 100 species which are distributed in different geographical regions and ecological localities in the temperate zone of the world.

Among nine species found in Japan, *Ag. caninum* L. and *Ag. repens* P. Beauv., are known to be introduced, while the remaining seven species are indigenous. Two indigenous species, *Ag. tsukushiense* var. *transiens* Ohwi ($2n=42$) and *Ag. ciliare* var. *minus* Ohwi ($2n=28$) are somewhat polymorphic and are found commonly almost everywhere in Japan, while the distribution of other species is comparatively restricted. *Ag. Mayebaranum* Honda ($2n=42$) is rarely found in the paddy field or in the ditch of paddy field side from Kanto to Kyushu. It is very interesting that this species is adapted to such moist places, while almost all species of *Hordeae* are rather adapted to the drier places. *Ag. yezoense* Honda ($2n=28$) is mainly distributed in the forest of Hokkaido, and rarely found in mountain region of Honshu. *Ag. Gmelini* var. *tenuisetum* Ohwi also rarely occurs in mountain region of Honshu. *Ag. caninum* L. is found only in Mt. Ibuki.

Ag. repens is found in Hokkaido and sometimes in Honshu. *Ag. Hatusimae* Ohwi ($2n=42$) is sterile and of intermediate type between *Ag. Mayebaranum* and *Ag. tsukushiense*, and, therefore, it is considered that this species is the hybrid between the two species.

Genome analysis in the Japanese species: Japanese *Agropyron* is not hybridized with *Triticum* but the hybridization between species of Japanese *Agropyron* is possible. As the results of their cytological investigation the genome formulae have been determined. The pentaploid hybrid between *Ag. tsukushiense* (IKL) and *Ag. ciliare* (IK) is completely sterile, though two species have two common genomes. The sterility was also observed in the other specific hybrids, *Ag. yezoense* (I^vK^v) × *ciliare* (IK) and *Ag. Mayebaranum* ($I^{m??}$) × *Ag. tsukushiense* (IKL).

F_1 hybrids between *Triticum* species and *Ag. intermedium* ($2n=42$) or *elongatum* ($2n=70$): Three species of *Agropyron*, *Ag. elongatum*, *intermedium* and *trichophorum*, easily hybridize with *Triticum*, except Einkorn wheats. We can obtain, however, the F_1 hybrids between induced tetraploid *T. aegilopoides* and *Agropyron* species. When *Agropyron intermedium* was used as *Agropyron* parent, the hybrids show the intermediate characteristics between their parents, while when *Agropyron elongatum* was used the hybrids resemble closely the *Agropyron* parent.

Most of the chromosome conjugations at the meiosis of F_1 hybrids, should be attributed to the autopolysyndesis of *Agropyron* chromosomes. In many cases, the F_1 hybrids are sterile due to the meiotic irregularities, but a few seeds can be obtained from backcrosses.

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(Change of Address, December 10, 1956)

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IV. News

Informal Meeting of Wheat Information Service

On the occasion of the 1956 Genetics Symposia, a group of wheat geneticists met at the Junidan-ya, Gion, Kyoto, Sept. 12, 1956, to discuss various problems as announced in WIS No. 3. Drs. J. W. Boyes (Canada), C. R. Burnham (U.S.A.), J. M. Capinpin (Philippines), B. C. Jenkins (Canada), A. Müntzing (Sweden), A. P. Pal (India), M. M. Rhodes (U.S.A.), L. Sachs (Israel), E. R. Sears (U.S.A.), J. M. Sirks (Netherlands), L. Stebbins (U.S.A.), Ö. Winge (Denmark), H. Kihara (Japan) and the members of the Committee of WIS attended.

I. Wheat Genetics Symposium: At the similar meeting in Bellagio in 1953, it was decided that the wheat genetics symposium will be held in Japan in 1956, if possible, but this was not possible to act up to realize. Therefore, it was discussed to transfer it to Montreal, Canada, when the 10th International Genetics Congress is held in 1958. On Dr. Pal's motion, a committee was set up regarding this problem; the members are Dr. Kihara (Chairman), Dr. Jenkins, Dr. Müntzing, Dr. Pal, Dr. Sears and Dr. Yamashita. (Refer to Dr. Jenkins' letters quoted in the following paragraphs.)

II. Subscription for the WIS publication: Dr. Yamashita, managing editor, reported that it is possible to receive further contributions from the organizations which assisted in the previous publications. However, many of the opinions came to the agreement to raise a subscription for the publication of WIS, except a few that there is a risk of limiting the circulation by this action. This matter was also entrusted to the committee mentioned above.

Dr. Jenkin's letter of October 5, 1956 to Dr. J. B. Harrington, Plant Production Branch, FAO of the United Nations, Viale Delle Terme di Caracalla, Rome, Italy:

"At the time of the meetings of the International Genetics Symposia, 1956 recently held in Japan, a group of wheat geneticists met to discuss the possibility of holding a Wheat Genetics Symposium in 1958. Since the Tenth International Genetics Congress will be held in Montreal from August 20 to 27, 1958, it was thought advisable that a Wheat Symposium be held immediately prior to the congress. A committee, with Dr. Kihara as chairman and members including Dr. Pal of India, Dr. Müntzing of Sweden, Dr. Sears of United States, Dr. Yamashita of Japan, and myself, was immediately realized that in order to hold an International Wheat Symposium, financial support would be required. The desirability of such a symposium was expressed without question and in fact it was pointed out that a separate international meeting on wheat was long overdue.

It suggested that the Food and Agricultural Organization of the United Nations might be interested in supporting this type of meeting and I agreed to write to you in the hope that you would be able to obtain a contact with the proper authorities so that we could carry on negotiations for financial assistance. If the Wheat Symposium were held immediately prior to the Genetics Congress, it might permit some people to attend who would otherwise find it impossible because of the great expense involved in travelling long distances. Winnipeg was suggested as a possible site for this first International Wheat Symposium and I think that by 1958 our facilities will be such that this would be an ideal choice. Construction is nearing completion on a new building for the Canada Department of Agriculture on the campus and a new building for the Faculty of Agriculture has just been started. By 1958 we should not only have adequate physical facilities but the fact that Canada is prominently associated with wheat would make it a logical place for the first international meeting of this kind. I hope that you will be able to suggest some suitable leads which could be relayed to Dr. Kihara."

Dr. Jenkin's letter of November 16, 1956 to Dr. Hitoshi Kihara, Director, National Institute of Genetics, Misima, Japan.

"In accordance with our verbal agreement when I was in Japan I have written Dr. J. B. Harrington of the Food and Agriculture Organization concerning financial support for the proposed

International Wheat Symposium to be held in Winnipeg immediately prior to the Tenth International Congress of Genetics which is scheduled to be held in Montreal from August 20-27, 1958. In Dr. Harrington's absence I have received a letter from Dr. J. G. Knoll, Chief, Plant Production Branch, Agricultural Division, F.A.O. and I take the liberty to quote from his letter the following for your information.

'While we are naturally most interested in the intention to hold a Wheat Symposium in Winnipeg immediately prior to the Tenth International Genetics Congress in Montreal in August 1958, I regret to have to indicate that it will not be possible for FAO to offer any financial support to the Wheat Symposium much as we should like to do so. We have now practically completed our programs for 1958 and 1959 and, regretfully, our anticipated resources are much below our needs even for normal expansion of our activities.'

No doubt Dr. Harrington will himself write to me when he returns to his headquarters but it would seem to me that Dr. Knoll's statement is sufficiently complete that we will need to seek support elsewhere."

Exhibitions

Exhibitions including Silkworm, longtailed fowl, old documents, rice, Japanese morning glory, wheat, radish and goldfish were the big functions of the 1956 Genetics Symposia, and held with great success. Regarding the exhibition of wheat and its related genera, an excerpt is given in the supplement of the present number of WIS (pp. 16-24).

Kihara Institute in Yokohama

Kihara Institute for Biological Research, which was moved from Kyoto, has been almost completed in Yokohama, and received the visit of the participants of the International Genetics Symposia on September 10, 1956. The visitors were good eaters of 3x seedless watermelons produced at the institute. Her address is "Mutsugawa-cho, Minami-ku, Yokohama, Japan".

Robigo

(An excerpt of the correspondence from the editor): "A 'Reporting Leaflet' for all the experts of the world to discuss their ideas, suggestions, observations, results, etc. on problems connected with cereal rusts." "The aim of Robigo is to establish a solid and long lasting bond among all the rust experts, no matter the country where they perform their task, conveying to them, in an accurate and rapid way, informations regarding common problems as well as each one's work. In that way we hope to promote an effective collaboration which may result in a greater and faster progress." "It is also well to remember that Robigo will not be used for long articles, but short and concise information in the form of tables, maps charts or few paragraph reports." "All correspondence relating to Robigo, should be sent to: Ing. Agr. José Vallega, Director del Instituto de Fitotecnia, Castelar, Argentina."—José Vallega

"Karakoram"

A documentary film entitled "Karakoram" which runs about 80 minutes was produced by the Nihon Eiga Shinsha and distributed by the Toho Company in Tokyo, Japan. This is a record of the Kyoto University Scientific Expedition to the Karakoram-Hindukush led by Dr. H. Kihara in 1955, which has caught the countries with unaffected and scientific eyes. Besides the activities of the members, including Dr. K. Yamashita, Mr. S. Nakao and others, the sublimity of nature, and the strange and exotic customs of the people are all brought to the screen in Eastman-color.

Back Numbers of WIS

Back numbers of WIS, Nos. 1, 2 and 3, are available. They will be sent free on application.

V. Announcement for the Next Issue, No. 5

WIS No. 5 will be ready for publication in April, 1957. It is open to all contributions dealing with informations on methods, materials and stocks, ideas and research notes related to wheat genetics and cytology, including *Triticum*, *Aegilops*, *Agropyron*, *Secale* and *Haynaldia*.

Contributions should be typewritten in English. The authors are cordially requested to present *not later than April 15, 1957*, their manuscripts which should not exceed two printed pages. Lists of stocks are not required to conform to this page limit. No illustrations can be accepted for publication.

Manuscripts and communications regarding editorial matters should be addressed to:

Dr. Kosuke Yamashita
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Kyoto University, Kyoto, Japan

VI. Acknowledgement

The cost of the present publication has been defrayed by contributions from the following Japanese organizations, to which we wish to express our sincere thanks.

Flour Millers Association, Tokyo, Japan
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Showa Sangyo Co., Ltd., Tokyo, Japan
Nitto Flour Milling Co., Ltd., Tokyo, Japan

We should like to express our sincere gratitude for favorable comments regarding WIS Nos. 1, 2 and 3 and valuable contributions for the present number. Increased support for further issues would be appreciated.

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Explanation of the Figure on the Cover

An ear of an amphidiploid, *bicornis-monococcum*

(E. R. Sears, s. page 9)

Information in WIS is to be regarded as tentative and must not be used in any publication without the consent of the respective writers.

Errata of WIS No. 3

- * Cover ii, line 22 from bottom: for "Sakanaga", read "Sadanaga".
 - Page 9, line 9 from bottom: for "39.7", read "23.3".
 - 11, • 12 from bottom: for "late", read "later".
 - 15, • 16 from top: for "1935", read "1953".
 - 15, • 19 from top: for " $21_{II}+2_I$ ", read " $21_{II}, 20_{II}+2_I$ ".
 - * • 20, • 2 from bottom: for "Sarker", read "Sarkar".
 - * • 23, • 11 from bottom: for "Sakanaga", read "Sadanaga".
 - 32, Table 1] Arrangement of materials has been changed as given in Supplement
 - 33, Table 3] of the present number of WIS (s. page 20).
 - 33, Table 2: 2nd column: for "1", read "20".
3rd column: for "20", read "1".
 - * • 36, line 15 from bottom, for "Sakanaga", read "Sadanaga".
 - * • 37, line 5 from top: for "Harington", read "Harrington".
-

* The editor wishes to apologize especially for the errors of the authors' names.

WHEAT INFORMATION SERVICE

No. 4

昭和 31 年 12 月 23 日 印刷

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