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I. Research Notes

The genetics of floral development in wheat

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"Basal Sterility" in wheat has been studied for a number of years for three principal reasons. Firstly, a progressive series of genotypes differing from each other in the extent of flower abnormalities open possibilities for a study of the hereditary component of morphogenesis. This presumably is the first time such an attempt has been made. Secondly, the work has uncovered the possibility that ancestral genomes, from which hexaploid wheat was built, possessed genetic systems for flower formation which have been replaced and, hence, have become non-functional. This phase of the study, therefore, is designed to shed light on the evolution of gene function in a high polyploid. Thirdly, interactions between genetic and environmental determinants of flower development have been discovered which are being further studied.

This report deals only with progress in the first and second phases.

Basal sterility is a condition in wheat, so far only found in speltoid mutants, in which flower formation in one or more basal flowers of some or all spikelets is impaired. The degree of flower abnormality varies from loss or reduction of the anterior stamen to complete absence of any flower parts. There is a pattern which is *variable* within the *ear*, where the apex tends to be least affected, but is *rigid* within *spikelets*, where the next higher flower never is more affected than the lower one, so that only if the basal (the first) flower is affected will the second one be affected, and so on.

We had previously shown (Frankel and Fraser 1948) that the normal flower development in *vulgare* is determined by a single gene closely associated with the gene *Q* which determines the *vulgare* characteristics. It is only in the absence of *Q*, i.e. in speltoids, that basal sterility is found.

We have been working with crosses between four speltoids, grading in flower development from almost complete normality to almost complete absence of the first three flowers.

The system appears as follows:

A. In *vulgare* (*Q* present):

Irrespective of presence or absence of other genes, the *vulgare* factor *Q* determines normal flower formation in the first and subsequent flowers.

B. In speltoids (*Q* absent):

(i) In the presence of a dominant gene, *A*, the second, and subsequent, flowers are normal.

(ii) The development of the first flower is conditioned by a polygenic series, presumably linked with *A*, with its plus (or minus) alleles determining the frequencies of normal (or abnormal) development of the first flower, between the extremes of "fertile" (St_F) and "1st flower sterile" (St_1).

(iii) In the absence of the *A* allele, i.e. in plants with the *aa* genotype, formation of the second and subsequent flowers is also conditioned by a polygenic series. There is evidence that this is identical with that conditioning first flower development.

In crosses between the speltoid series and unrelated *vulgare* wheats, it has been shown that all *vulgare* wheats tested so far possess some alleles which impair normal flower formation in the speltoid state. This has been confirmed by Mac Key (1954) in X-ray induced speltoids.

We conclude from the observations so far adduced that in the diploid ancestral genomes of hexaploid wheat, flower formation may have been conditioned by these gene systems now revealed in speltoids, and that under the cover of the later acquired *Q* factor these systems have become disused and are now in a state of gradual disintegration. To test further our interpretations, we are continuing the studies of the crosses already mentioned. Recent work includes crosses between our speltoid series and selected tetraploid and hexaploid wheats.

An awn suppressor located on chromosome 5B*

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In the F_1 between mono-5B (mono-V) of Chinese Spring and *Secale cereale* (Kyoto Univ. strain No. 230 7_{II}+B chr.), the following plants given in the table were obtained.

Chromosome number	Chromosome constitution	
	Wheat chromosomes	Rye chromosomes
29	20 (deficient for 5B)	7_{II}+2B
30	21	7_{II}+2B
31	20 (deficient for 5B)	7_{II}+4B

Spikes from plants without chromosome 5B were characterized by the presence of erect awns about 1-2 cm long, while those from plants with 5B had short, hooked awns about 5 mm long. Similar differences of awnedness were observed in the 34- and 35-chromosome plants in the F_1 of mono-5B × *T. timopheevi*.

These facts suggest that a gene (or genes) for suppression of awn development is located on chromosome 5B of Chinese Spring. This gene is not effective in Chinese Spring itself nor in hybrids with 4x *T. boeoticum*. (* This work was supported in part by a grant from the National Science Foundation to Dr. E. R. Sears.)

F_1 monosomic analysis involving a smooth-awn durum wheat

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Morphological examination of F_1 plants monosomic for chromosomes I through XIV from crosses of smooth-awn durum selection 396 with the Chinese series did not reveal the chromosome or chromosomes possessing the recessive smooth-awn factor(s) of the durum. Awns or awnlets of F_1 monosomic for chromosomes of the A and B genome except chromosomes II and XIII were barbed to a degree similar to their respective disomic sibs. No awns were produced on plants monosomic for chromosomes II or XIII.

At least three explanations are possible for the failure to locate the chromosome(s) concerned with the smooth-awn trait. The smooth-awn factor(s) may be located on chromosome II or XIII and the completely awnless condition of these monosomics makes detection impossible. A second alternative is that a factor located in the D genome of Chinese Spring may inhibit the expression of the recessive smooth-awn factor(s) in the A or B genome. This appears possible because awns of *Aegilops squarrosa* selections are coarsely barbed which suggests that the D genome possesses factors influencing barbing. A third explanation could be that the recessive smooth-awn character is incapable of expression in the hemizygous condition.

Chinese Spring possesses well-developed barbs on the keels of its outer glumes. Smooth-awn selection 396 has keels free of barbs but slightly scabrous. Keels of all F_1 monosomics of the A and B genomes were as barbed as their respective disomic sibs except for plants monosomic for chromosomes II and XIII. Plants monosomic for these chromosomes had fewer and less developed barbs than their disomic sibs. Apparently chromosomes II and XIII carry recessive factors conditioning barbing of keels. It is not known whether barbing of keels and awns is a pleiotropic condition.

Awn development of the F_1 monosomic plants revealed that smooth-awn durum selection 396 possesses the recessive alleles of *Hd* and B_2 factors located, respectively, on chromosomes VIII and X of Chinese Spring. In addition to these known factors,

selection 396 must possess a recessive factor (*aa*) for awn development on chromosome V, as plants monosomic for V had well-developed awnlets. F_1 plants nullisomic for chromosome XVI exhibited a high degree of awn development compared with plants with 35 chromosomes. Chinese Spring apparently has an awn-inhibiting factor (*BB*) located on chromosome XVI that suppresses one or more of the awn-developing factors derived from selection 396.

Under greenhouse conditions at Pullman, Washington, the culms of smooth-awn durum selection 396 are covered by a heavy waxy bloom, whereas culms of Chinese Spring are almost waxless. F_2 populations of the cross Chinese Spring×selection 396 indicated that the waxy condition is controlled by a single dominant factor. Except for F_1 plants monosomic for chromosome XIII, all A and B genome F_1 monosomics had waxy culms. Plants monosomic and disomic for chromosome VIII were less waxy than other plants, but not as waxless as F_1 plants monosomic for chromosome XIII. If selection 396 possesses a dominant factor (*Wx*) for waxy culms, it apparently does not express itself in the hemizygous condition. Plants of the *Wx wx* genotype have a waxy phenotype, whereas plants of *Wx- -* genotype, from which the *Wx* allele is absent, as well as *wx wx* plants, have waxless phenotypes. Perhaps *Wx* equals two units of a precursor for waxiness and *wx* equals one. If at least three units are needed to bring about the waxy condition, then *Wx wx* plants would form wax but *Wx- -* and *wx wx* plants, having only two units, would not develop wax.

Date of anthesis was strikingly late for plants monosomic for chromosome XIII; these monosomes flowered 11 days after their disomic sibs.

Future plans for the study of the smooth-awn trait involve the production of an amphidiploid between the durum and *Aegilops squarrosa* so that the effect of the D genome on expression of this trait can be studied.

Diethyl sulfate, a highly effective chemical mutagen, producing few chromosome aberrations*

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Treatment with a diethyl sulfate solution on barley seeds leads to high mutation frequencies; but of even greater significance is the fact that this chemical induces few chromosomal aberrations. The mutation rate, measured by the percentage of spikes segregating for chlorophyll mutants, and cytological analysis are as given in the following table.

The results and details of treatment conditions have been published elsewhere.[1)]

1) R. E. Heiner, C. F. Konzak, R. A. Nilan, and R. R. Legault, "Diverse Ratios of Mutations to Chromosome Aberrations in Barley Treated with Diethyl Sulfate and Gamma Rays". PNAS, in press September, 1960.

Treatment	Mutation rate	Cytological analysis	
		Spikes observed	Interchanges observed
Control	0.16	175	0
60 kr x-rays	12.6	175	46
Diethyl sulfate	28.5	175	4

It also appears that treatments with dimethyl sulfate and ethyl methane sulfonate also yield few chromosomal aberrations.

During the past year we have treated wheat with diethyl sulfate, but as yet have no mutation data. Preliminary results indicated that longer seed treatment times were required to produce the desired seedling injury response in wheat than for barley. This may be due to the protection effect of duplicate genes afforded by the three sets of genomes in wheat, namely AABBDD.

It would seem desirable to use diethyl sulfate or other alkylating agents possessing similar characteristics for mutation breeeding where the transfer of chromatin material is not necessary or desirable.

Since diethyl sulfate has been shown to induce a high frequency of mutations at high rates of survival in both barley and bacteria, it would seem advisable to test it thoroughly with wheat.

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Radiation effects of fast and thermal neutrons on wheat: I. Genetic effects of neutrons on Einkorn wheat

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Thermal neutron irradiations were conducted in the thermal column of the Japan Atomic Energy Research Institute's Nuclear Reactor, JRR-1. Dormant seeds of *Triticum monococcum flavescens* were treated at five different distances (I~V) for 2 weeks (actually 990.8 kWh). The thermal neutron integrated flux, therefore, ranged from 4.4 to 37.5×10^{12} n_{th}/cm^2. The data are shown in Table 1. The irradiated seeds were almost uniformly injured in each treatment. There was no germination in (V) and about 2/3 of seeds germinated but about one half of the seedlings soon died in (IV). The higher the dosage of thermal neutrons, the more delayed were germination and growth of

Table 1. Effects of thermal neutrons on Einkorn wheat

	Thermal neutron flux ($\times 10^{12}$ n_{th}/cm^2)	Gamma-contamination (kr)	Germination (%)	Length of seedlings (index)	Survival (%)	Height of mature plants (index)	Fertility in X_1 (%)	Chromosome aberrations in PMC's (%)	Chlorophyll mutations in X_2 (%)
Control	—	—	100	100	100	100	89.2	0.0	0.0
I	4.4	4.8	98	101.5	90	102.2	71.5	8.5	—
II	7.0	6.7	98	82.7	90	92.8	52.9	15.1	15.2
III	11.8	9.7	96	69.5	82	91.3	47.2	20.6	16.4
IV	20.6	14.3	68	27.7	36	87.3	37.1	25.0	22.6
V	37.5	21.8	0	—	—	—	—	—	—

seedlings and the more reduced were survival rate, height of mature plants and seed fertility. The frequency of chromosome aberrations and chlorophyll mutations increased with the increase of dosage, as expected. If we assume that gamma-contamination for 10^{12} n_{th}/cm^2 is 430 r by Dr. KONDO's measurement with FRICKE's dosimeter, the 1 r equivalent effects produced by thermal neutrons are calculated as follows, compared with the results conducted last year by X- and gamma-irradiations at 10 and 20 kr:

for seedling growth, $1\,r = 2.0 \times 10^9$ n_{th}/cm^2

for seed fertility, $1\,r = 1.4 \times 10^9$ n_{th}/cm^2

for chromosome aberration, $1\,r = 1.2 \times 10^9$ n_{th}/cm^2

for chlorophyll mutation, $1\,r = 2.3 \times 10^8$ n_{th}/cm^2.

The exposure to 14 MeV neutrons obtained from (D, T) reaction was carried out in Oak Ridge National Laboratory.

Table 2. Effects of X-rays gamma-rays and fast neutron on Einkorn wheat

Dosage		Germination (%)	Length of seedlings (index)	Survival (%)	Height of mature plants (index)	Fertility in X_1 (%)	Chromosome aberrations in PMC's (%)	Chlorophyll mutations in X_2 (%)
Control		100	100	95.6	100	—	—	—
X-rays	10 kr	94	75.6	68.0	92.6	47.2	29.4	11.7
	20 kr	40	42.3	—	—	—	—	—
Gamma-rays	10 kr	94	84.9	76.0	97.4	61.5	26.6	—
	20 kr	60	14.4	16.0	95.2	52.7	20.0	—
Fast neutron	0.5 krad	100	90.7	93.9	92.2	50.1	10.5	5.1
	1.0 krad	100	72.4	90.0	88.6	52.6	23.7	9.8
	1.5 krad	96	50.5	66.0	73.9	33.6	28.6	20.0
	2.0 krad	94	31.0	4.0	82.7	7.7	—	—
	2.5 krad	74	6.6	0.0	—	—	—	—
	5.0 krad	60	3.8	0.0	—	—	—	—
	7.5~20 krad	16~26	1.8~3.8	0.0	—	—	—	—

Dormant seeds of *T. monococcum flavescens* were fixed at the distance 6.3 cm from the tritium target and the exposure periods were varied at constant dose rate 65.4 rad/min. The dosage ranged from 0.5 to 20 krad. At the same time X- and gamma-radiations were used from comparison at 10 and 20 kr in ORNL. The effects of both radiations seemed to be rather stronger than those found in the same experiments last year in our institute.

The data are given in Table 2. There was no germination or almost none at more than 2 krad of fast neutrons. At 0.5~2 krad survival rate, height of mature plants and seed fertility decreased and chromosome aberrations and chlorophyll mutations increased with the increase of dosage.

Relative biological effectiveness (RBE) for fast neutrons, compared with X- and gamma-rays, is calculated as follows:

for germination rate, 4, for seedling growth, 10,
for seed fertility, 12, for chromosome aberration, 8.

Radiation effects of fast and thermal neutrons on wheat: II. Relation of ploidy to chromosome aberrations

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Meiotic irregularities induced by various irradiations were compared in tetra- and hexaploid wheats. The experimental data are shown in Tables 3 and 4.

Chromosome aberrations induced by thermal neutrons operated by JRR-1 were mostly univalents and reciprocal translocations (④ and ⑥). Univalents and ⑥ were more prominent in 6x species than in 4x species. Average number of breakages per cell increased non-linearly with the increase of dosage, when a univalent was counted as one, ④ as two and ⑥ as three breaks. The number of breaks in 6x was about 3 times as high as in 4x species. No increase of breaks was found between two treatments, namely, (II) and (III) in both species. The number of breaks obtained by these treatments was comparable to that obtained by X- or gamma-rays of 10 kr subjected in ORNL. Seed fertility decreased with the increasing dosage in both 4x and 6x. The 6x was slightly more susceptible than 4x in this respect.

The plants irradiated at more than 2.5 krad of fast neutron in ORNL did not grow. Meiotic irregularities could be examined only in plants irradiated at 2.5 krad. All chromosome configurations in 4x species were easily analyzed. The number of breaks observed was 4.47 per cell, which was about twice as much as at X-irradiation of 20 kr. In 6x species, a few cells had one complicated multivalent and many fragments which made an estimation of the number of breakages difficult. Estimated only from clear aberrations it was 5.26 per cell. This estimation might be somewhat too low. Both X- and gamma-irradiations at 10 and 20 kr caused breakages in 6x species about 3

Table 3. Frequency of chromosome aberrations at MI in PMC's of tetra- and hexaploid wheats induced by thermal neutrons

Species	Dosage	Number of cells observed	Number of cells with						Number of cells having other aberrations	Average number of breaks per cell
			Fragments	Univalents	④	⑥	⑧	⑩		
T. durum Reichenbachii (2*n*=28)	Control	18								0.00
	I	33			7					0.42
	II	38		4	14				monosomic 1	0.86
	III	34		2	12					0.76
	IV	30	2	5	17	1	1			1.60
	V	7			12					3.42
T. vulgare erythrospermum (2*n*=42)	Control	13			2					0.30
	I	14		4	4					0.85
	II	24		12	20	3				2.54
	III	24		8	21	3		1		2.66
	IV	25	2	16	27	9	1		many fragments 4	5.16
	V	—								

Table 4. Frequency of chromosome aberrations at MI in PMC's of tetra- and hexaploid wheats induced by fast neutrons

Species	Dosage	Number of cells observed	Number of cells with						Number of cells having other aberrations	Average number of breaks per cell
			Fragments	Univalents	④	⑥	⑧	⑩		
T. durum Reichenbachii (2*n*=28)	Control	18								0.00
	X-10 kr	33		2	12	1				0.87
	X-20 kr	31		8	30	2			monosomic 1	2.38
	γ-10 kr	28		2	5	1				0.53
	γ-20 kr	27			19	2				1.62
	2.5 krad	23		4	18	11	2	3	⑭ 1	4.47
T. vulgare erythrospermum (2*n*=42)	Control	13			2					0.30
	X-10 kr	23	1	11	21	5			monosomic 1	2.95
	X-20 kr	6		2	10	7		1		8.00
	γ-10 kr	29		4	30	1				2.31
	γ-20 kr	14		14	17	7	1	1		5.57
	2.5 krad	15	1	12	17	11			many fragments 2 complex 1	5.26

times as many as in 4*x* species.

X-irradiation produced breakages about 1.5 times as many as gamma-irradiation at 10 and 20 kr of 4*x* and 6*x*. There was no difference between sensitivities of 4*x* and 6*x* species in regard to X- and gamma-irradiation effects on fertility.

Studies on the induction of mutations by P^{32} in wheat: I. Chromosomal aberrations in R_2 generation, with special reference to the frequent occurrence of monosomics

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From the seeds of a variety, "Aoba-Komugi", treated with P^{32} in 1956, two plants having $2n=42$ were chosen: one from the seed treated with 5 μc, the other from one treated with 10 μc, respectively. Besides these, a monosomic plant which was found among plants treated with 5 μc was also studied. The meiotic chromosome behaviors of these R_1 plants are given in Table 1.

In R_2 generation, various aneuploids having $2n=40$ to 44 were observed as given in Table 2. The types of chromosomal aberrations were translocation, deficiency, non-pairing and their various combinations. But the author's special attention was attracted to the rather frequent occurrence of monosomic plants. Namely, the percentages of monosomics in the R_2 generation derived from R_1 plant having $2n=42$ were 12.77% and 17.74%, respectively. 21.31% of the progenies of a monosomic R_1 plant (5 μc) was again monosomic. However, the average percentage of monosomic with $20_{II}+1_I$ was 11.47% in the progenies of R_1 plants with $2n=42$, while 6.56% in the progenies of the monosomic R_1 plant. Among the R_2 progenies derived from the monosomic R_1 plant, there occurred the plants accompanying deficiency.

Table 1. Chromosome association in 3 R_1 plants

Plants with	Variation	I	II			III	IV	Others	Total bivalents*	Cells observed
			Open	Closed	Total					
$2n=42$ (5μc)	Range	0~2	1~4	15~20	17~21	0~1	0~2	—	20~21	50
	Mode	0	0	18	19; 21	0	0	—	20; 21	
	Average	0.8	0.8	17.3	19.5	0.2	0.4	—	20.5	
$2n=42$ (10 μc)	Range	0~4	0~4	12~17	14~20	0~2	0~2	0~1	18~21	50
	Mode	1	2	16	17	0	1	0	20	
	Average	1.5	2.0	15.2	17.2	0.6	0.8	0.2	19.9	
$2n=41$ (5 μc)	Range	1~5	1~5	10~15	15~18	0~2	0~2	0~2	18~20	50
	Mode	1	4	14; 15	15; 17	0	1	0	19	
	Average	2.0	2.9	13.5	16.4	0.2	1.0	0.3	19.3	

* Calculated a trivalent as one bivalent, and a tetravalent as two bivalents, respectively.

Table 2. Chromosome variations at metaphase I (PMC)

Chromosome number	$2n$ in R_1 / Main chromosome configurations / Plant No.
40	$19_{II}+2_I$
$40+1f$	$1_{III}+17_{II}+3_I+1f$
41	$20_{II}+1_I$
	$20_{II}+1_I$ (a small univalent with deficiency)
	$20_{II}+1_I$ (a small bivalent with homo-def. and a small univalent with deficiency)
	$1_{III}+18_{II}+2_I$ (a small univalent with deficiency)
	$1_{III}+19_{II}$
	$1_{III}+19_{II}$ (a small bivalent with homo-def.)
	$1_{III}+19_{II}$ (a small bivalent with homo-def., a heteromorphic bivalent)
	$20_{II}+1_I$ or $1_{III}+18_{II}+2_I$ (a heteromorphic bivalent)
	$20_{II}+1_I$ (a heteromorphic bivalent)
	Multivalent formation such as III, IV and V
42	21_{II}
	21_{II} (a heteromorphic bivalent)
	21_{II} (a small bivalent with homo-def.)
	21_{II} (a small bivalent with homo-def.; a heteromorphic bivalent)
	21_{II} or $20_{II}+2_I$ (a small univalent)
	$20_{II}+2_I$ (a small univalent)
	$20_{II}+2_I$
	$20_{II}+2_I$ (a small bivalent with homo-def.)
	$19_{II}+4_I$ (variable number of univalents from 2 to more)
	$1_{IV}+19_{II}$
	$1_{IV}+19_{II}$ (a small bivalent with homo-def.)
	$1_{III}+19_{II}+1_I$
	$1_{III}+19_{II}+1_I$ (a heteromorphic bivalent)
	Multivalent formation such as III, IV, V, VI and IX
43	$1_{III}+20_{II}$ or $21_{II}+1_I$
	$1_{III}+20_{II}$ (a small bivalent with homo-def.)
	$1_{III}+20_{II}$ (a small bivalent with homo-def.; a heteromorphic bivalent)
44	22_{II} or $1_{IV}+20_{II}$
Undetermined	frequent occurrence of univalents; formation of bridge and fragment
	Total

in R_2 generation derived from 3 R_1 plants

42 (5 μc)						41 (5 μc)						42 (10 μc)							Total
1	2	3	4	5	6	1	2	3	4	5	6	1	2	3	4	5	6	7	
1		1										1							3
1																			1
4	1	2	1	1	3		1		2	1		9	1	2	1				29
							1												1
								1											1
							1												1
						1	1					4	1						7
								1											1
								1											1
												1							1
															1		2		3
										2									2
8	9	6	13	5	8	4	1		1		7	6	15	9	1	18	4	8	123
												1		3	1		11	6	22
						1		2											3
								5											5
							1												1
										1				2			1		4
2	1	3	3	1	2		3			2	1	3	2		1	1			25
								1											1
1									1										2
				6	8	1						3	1	1					20
								1											1
					1					1	1								3
							1												1
							2			2	2								6
		1					1							2					4
						1				2									3
								1											1
					1														1
														1					1
17	11	13	17	13	23	8	13	13	4	11	11	28	20	20	5	19	18	14	278

Comparison of radiation effects of beta- and gamma-rays on Einkorn wheat

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Seeds of *Triticum monococcum flavescens* were soaked in ^{32}P and ^{131}I solutions for 2 days before sowing, to compare the radiation effects of beta-rays with those of gamma-rays. Radioactive solutions contained 0.15, 0.3 and 0.6 mc/gr of ^{32}P and 0.6 mc/gr of ^{131}I. Also gamma-irradiation with ^{60}Co was applied at the dosages of 2.5, 5 and 10 kr immediately after soaking the seeds in water for 2 days. The growth of seedlings, height of mature plants, single-spike fertility, and chromosome aberrations of treated plants in X_1 and chlorophyll mutations in X_2 were compared for beta- and gamma-irradiations. The data are shown in Table 1.

Table 1. Effects of beta- and gamma-radiations in Einkorn wheat

Dosage		Germination rate (%)	Length of seedlings (cm)*	Height of mature plants (cm)	Fertility (%)	Chromosome aberrations in PMC (%)
Control		98.0	8.75	95.3	89.2	0 (0.0)
Gamma-rays	2.5 kr	94.0	7.29	98.6	71.2	1 (2.3)
	5.0 kr	90.0	2.06	96.3	51.8	16 (64.0)
	10.0 kr	50.0	0.48	—	—	—
^{32}P	0.15 mc/gr	96.0	7.23	91.4	62.5	2 (6.1)
	0.3 mc/gr	90.0	2.69	56.5	56.5	7 (33.3)
	0.6 mc/gr	70.0	1.01	—	—	—
^{131}I	0.6 mc/gr	98.0	7.86	77.5	77.5	1 (2.1)

The higher the dosage of beta- and gamma-rays, the more delayed were the germination and growth of seedlings and the lower were the survival rate, height of mature plants and fertility. The relation between the inhibition of seedling growth and dosage of beta- and gamma-radiations coincides roughly with that between the decrease of survival rate or fertility and dosage. There was poor germination and little growth of seedlings at 10 kr gamma-irradiation and at 0.6 mc/gr ^{32}P beta-irradiation, both irradiations being markedly effective. 5 kr gamma-rays and 0.3 mc/gr ^{32}P beta-rays considerably inhibited the growth of seedlings and reduced the survival rate and fertility. But 2.5 kr gamma-irradiation was only slightly effective and the effects corresponded roughly to those of 0.15 mc/gr beta-radiation ^{32}P and 0.6 mc/gr ^{131}I solutions. The frequency of ears with chromosome aberrations in X_1-plants and head progenies with chlorophyll

mutations in the X_2-generation increased generally with the increase of beta- and gamma-radiation dosage. Again the effects of 0.15 mc/gr beta-radiation ^{32}P and 0.6 mc/gr ^{131}I solutions corresponded roughly to those of 2.5 kr gamma-radiation.

These findings generally confirm the experiments performed last year. If we assume that the effects of beta-radiation are confined to the embryo, we find by calculation that the 0.15 mc/gr ^{32}P solution equals about 2 krad. This, too, will account for the obtained data.

Studies on the induction of mutations by P^{32} in wheat: II. Some relations between chromosomal aberration and seed fertility in R_2 generation

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278 R_2 plants were divided into 4 classes according to the presence or absence of chromosomal aberrations or morphological variations as given in Table 1. Table 2 was compiled based on the relation between chromosomal aberration and seed fertility. Among plants with normal pairing of 21_{II}, there were some individuals which showed low seed fertility less than 50% without accompanying any visible morphological changes, while there were some others with chromosomal aberrations which showed normal seed fertility as high as the control plants. This means that it is not safe to select plants in practical breeding only by the external characters or by the seed fertility without cytological examinations.

Table 1. Percentage of plants with or without chromosomal aberration, morphological variation or both in R_2 generation

Chromosomal aberration	Morphological variation	Number of plants examined	%
present	present	113	40.7
〃	absent	42	15.1
absent	present	37	13.3
〃	absent	86	30.9
Total		278	100.0

Table 2. Relation between chromosomal

Chromosome number	Main chromosome configurations / Morphological variation* / Seed Fertility
40	$19_{II}+2_{I}$
$40+1f$	$1_{III}+17_{II}+3_{I}+1f$
41	$20_{II}+1_{I}$
	$20_{II}+1_{I}$ (a small univalent with deficiency)
	$20_{II}+1_{I}$ (a small bivalent with homo-def. and a small univalent with deficiency)
	$1_{III}+18_{II}+2_{I}$ (a small univalent with deficiency)
	$1_{III}+19_{II}$
	$1_{III}+19_{II}$ (a small bivalent with homo-def.)
	$1_{III}+19_{II}$ (a small bivalent with homo-def.; a heteromorphic bivalent))
	$20_{II}+1_{I}$ or $1_{III}+18_{II}+2_{I}$ (a heteromorphic bivalent)
	$20_{II}+1_{I}$ (a heteromorphic bivalent)
	Multivalent formation such as III, IV and V
42	21_{II}
	21_{II} (a heteromorphic bivalent)
	21_{II} (a small bivalent with homo-def.)
	21_{II} (a small bivalent with homo-def.; a heteromorphic bivalent)
	21_{II} or $20_{II}+2_{I}$ (a small univalent)
	$20_{II}+2_{I}$ (a small univalent)
	$20_{II}+2_{I}$
	$20_{II}+2_{I}$ (a small bivalent with homo-def.)
	$19_{II}+4_{I}$ (frequent occurrence of univalents)
	$1_{IV}+19_{II}$
	$1_{IV}+19_{II}$ (a small bivalent with homo-def.)
	$1_{III}+19_{II}+1_{I}$
	$1_{III}+19_{II}+1_{I}$ (a heteromorphic bivalent)
	Multivalent formation such as III, IV, V, VI and IX
43	$1_{III}+20_{II}$ or $21_{II}+1_{I}$
	$1_{III}+20_{II}$ (a small bivalent with homo-def.)
	$1_{III}+20_{II}$ (a small bivalent with homo-def.; a heteromorphic bivalent)
44	22_{II}, or $1_{IV}+20_{II}$
undetermined	frequent occurrence of univalents; formation of bridge and fragment
	Grand Total
	Total number of plants with chromosomal aberration

* — or + designates the absence or presence of morphological changes.

aberration and seed fertility

over 90%		over 80%		over 70%		over 60%		over 50%		over 40%		over 30%		over 20%		over 10%		Total	−	+
−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+	−	+			
								0	2			0	1					3	0	3
				0	1													1	0	1
1	1	0	2	2	7	0	8	0	2	0	2	0	2	0	2			29	3	26
		1	0															1	1	0
												0	1					1	0	1
				0	1													1	0	1
				0	3	0	1	0	1	0	1	0	1					7	0	7
										0	1							1	0	1
								0	1									1	0	1
				0	1													1	0	1
		1	0	1	0	0	1											3	2	1
										1	0	0	1					2	1	1
26	2	41	4	18	13	0	7	1	9	0	1			0	1			123	86	37
4	3	0	6	2	1	0	3	0	2							0	1	22	6	16
2	0			0	1													3	2	1
		1	0	1	2					1	0							5	3	2
		0	1															1	0	1
		1	0	0	1	1	1											4	2	2
3	0	5	1	1	5	0	3	0	2	0	2	0	1	0	1	0	1	25	9	16
		1	0															1	1	0
												0	1	0	1			2	0	2
2	0	5	0	1	4	1	3	0	3			0	1					20	9	11
						0	1											1	0	1
2	0					0	1											3	2	1
0	1																	1	0	1
						0	1	0	3	0	1			0	1			6	0	6
		0	1			0	1	0	1			0	1					4	0	4
		1	1					0	1									3	1	2
												0	1					1	0	1
								0	1									1	0	1
												0	1					1	0	1
40	7	57	16	26	40	2	31	1	28	2	8	0	12	0	6	0	2	278	128	150
14	5	16	12	8	27	2	24	0	19	2	7	0	12	0	5	0	2	155	42	113

Susceptibility of the *albina* mutant of Einkorn wheat to leaf and stem rusts, *Puccinia triticina* and *P. graminis*

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The susceptibility of the *albina* mutant of *Triticum monococcum flavescens* to stem and leaf rusts was tested in the phytotron (20°C in daytime, 15°C at night) at the second leaf stage with *Puccinia triticina* 21 B and *P. graminis* f. sp. *tritici* 21. At first *albina* seedlings were kept in a sowing box and then they were placed in water culture with WHITE's nutrient medium (1943) to which 3 percent sucrose was added. They were inoculated by brushing. Rust readings were made 7 to 16 days after inoculation. The degree of susceptibility was determined by the types of lesions formed on the leaves. The tests were repeated 2 to 3 times.

Albina exhibited susceptibility to leaf and stem rusts, while the normals were resistant to the former and susceptible to the latter. The uredosori of stem rust on *albina* were much larger than those on normal plants. Thus, susceptibility of host plants to leaf and stem rusts belonging to obligate parasites is not necessarily connected with quantitative differences in chlorophyll. A difference in another component may be the cause of a higher susceptibility of *albina* to leaf rust. Studies concerning amino acids await further experiments.

Recovery of chlorophyll content in some mutants in Einkorn wheat, *Triticum monococcum flavescens*

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Viability of the *virido-albina* mutant is poor, but the chlorophyll content becomes almost normal when the plants are placed in the phytotron. On the other hand, double recessive plants *virido-albina—basi-viridis* II look like *albina* and, even in the phytotron died without developing chlorophyll, while both parents have the ability to recover. Moreover, the new chlorophyll mutants, *basi-viridis* III, *virido-albina* II, and *xantha-alba* I, obtained from irradiation experiments, which have little chlorophyll at the seedling stage, also have shown the ability to develop almost normal chlorophyll content. From these findings, it appears that in certain chlorophyll mutants the recovery of chlorophyll content might be initiated in the presence of a small amount of chlorophyll

in the leaf tips.

In an experiment, the green tips of the leaves were cut off and the plants were placed in the greenhouse and in the phytotron at seedling stage or later, when the young plants had developed 5~6 leaves. The batch in which the green parts were removed did not grow, and the plants died after about 2 weeks, while the batch containing uncut plants continued to develop.

On the other hand, recovery of the chlorophyll content in the *virido-albina* mutant in agar culture with WHITE's solution to which 3 percent sucrose was added was faster than in soil culture. After 20 days in agar culture the plants recovered to normal green, while it took about one month for the recovery in soil in the phytotron. Thus, it seems that agar culture is more suitable for increasing the chlorophyll content than soil culture. But, the cut batches of *virido-albina* died also in agar culture. *Albina* mutants and *albina* like plants obtained from tne cross between *virido-albina* and *basi-viridis* II were also sown on agar, but they never developed any chlorophyll. It is well known that chlorophyll and radiant energy are the essentials of photosynthesis, the most important process for plant growth. The *virido-albina* mutant, mentioned above, could not survive when the green parts of the leaves were cut off. A small amount of chlorophyll was necessary for priming the process of further chlorophyll development (cf. Fujii 1959: Jap. Jour. Genet. 34).

Amount of amino acids in the chlorophyll mutants of Einkorn wheat

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Amino acid content in several chlorophyll mutants of *Triticum monococcum flavescens* was examined at the seedling stage. Four *albina*, one *chlorina* and one *virido-albina*, which has the ability to recover the chlorophyll content, were used in this examination. Normals were used as control. Free amino acid was extracted from young leaves with 75% ethanol, and several amino acids were separated by two dimensional paperchromatographic method. Seven kinds of free amino acids, namely aspartic acid, glutamic acid, glycine, alanine, glutamine, phenyl alanine and leucine, were detected. Four *albina* and one *virido-albina* had all of them, while leucine and alanine were not observed either in normals or *chlorina*. *Albina* and *virido-albina* mutants showed larger amounts of all amino acids than the normals and *chlorina*. Moreover, non-identified spots a and b were observed in all strains, and the size of spot a was larger in normals than in *albina*.

Kinds and amount of organized amino acids were also determined by the same chromatographic method by hydrolysis of fresh leaves. About 14 kinds of organized

amino acids were observed in normals, while only 10 kinds were found in *albina*.

Among these components, cysteine, histidine, proline and methionine etc. were not observed in free amino acids, but in *albina* strains only traces of these were found. Other organized amino acid components occurred in larger amounts in normals than in *albina*. Leucine, glutamine, alanine and the non-identified spot (a) contained in free amino acid, were not observed in organized amino acids. Therefore, they may be easily transferable. From these results, the *albina* strains have a larger amount of free amino acids and a smaller amount of organized amino acid than the normals.

The D genome of hexaploid wheat

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The sequence of investigations, originated by Kihara, Sears, Sax and others, which let to the conclusion that the D genome of hexaploid wheat was derived from *Aegilops squarrosa* is well known. Nevertheless as an outstanding example of phylogenetic deduction it merits reiteration.

Initially, as a result of the study of meiotic chromosome pairing in hybrids, it was established that one of the genomes of the tetraploid *Aegilops cylindrica* was also present in the hexaploid wheat, *Triticum aestivum*, but not in any of the tetraploid wheat species. Thus hexaploid wheat and *Ae. cylindrica* had the dinkel, or D, genome in common.

Subsequently one of the two genomes of *Ae. cylindrica* was demonstrated to be derived from *Aegilops caudata*. This was the C genome. Moreover the investigation of hybrids between *T. aestivum* and *Ae. caudata* showed that these two species had no common genome. Consequently when the other parent of *Ae. cylindrica* was found to be *Ae. squarrosa;* and synthetic *Ae. cylindrica* was produced as the tetraploid from the *Ae. caudata* × *Ae. squarrosa* hybrid, the problem of the D genome was essentially solved.

More or less simultaneously, and independently, McFadden and Sears, and Kihara, were able to synthesise hexaploid wheat as the amphiploid from tetraploid wheat *Ae. squarrosa* crosses. The regular meiotic pairing in hybrids between the natural and synthetic hexaploids confirmed that *Ae. squarrosa* was indeed the source of the D genome.

Hitherto, however, the final link in the chain of evidence—that dependent upon the cytological analysis of a hybrid between hexaploid wheat and *Ae. squarrosa*—has been lacking. However the appropriate hybrid was produced recently at Cambridge, following the pollination of 20 florets of *T. aestivum* Chinese Spring by *Ae. squarrosa* pollen. One seed was produced and its embryo was cultured by Rommel's method. The hybrid plant grew vigorously, although it was completely sterile. It was intermediate to its

parents in most characters, although the rachis was non-fragile, like that of the wheat parent.

Meiotic behaviour was analysed at first metaphase of meiosis and the mean pairing is shown in Table 1, and the distribution of cells with different pairing conditions in Table 2. Usually there were seven bivalents per cell and most of the bivalents were closed rings, often with three or four chiasmata.

Table 1. Mean pairing at metaphase I

Number of cells observed	Univ.	Biv. (rods)	Biv. (rings)	Biv. (total)
100	14.46	2.14	4.40	6.54

Table 2. Distribution of cells with different pairing conditions

Pairing conditions	Number of cells
20 I 4 II	1
18 I 5 II	4
16 I 6 II	35
14 I 7 II	60

From these data it is clear that *T. aestivum* has seven chromosomes which pair very closely with those of *Ae. squarrosa*. Thus final confirmation is provided of the equivalence of the chromosomes of *Ae. squarrosa* and those of the D genome of wheat.

Naturally these new data lead to further comparisons and problems, two of which will be briefy mentioned. First the pairing between the D genomes of *T. aestivum* and *Ae. squarrosa* is much closer than that between the A genomes of *T. aestivum* and *T. monococcum*. This presumably reflects the more recent separation of the D genomes, which have consequently diverged less in structure and gene content than the A genomes.

Secondly, it is notable that no more than seven bivalents, and no multivalents were observed. Thus there is no more pairing than can be accounted for by associations within the D genome. This suggests that pairing in euhaploids of *T. aestivum* can rarely occur between A and B genome chromosomes. Indeed examination of the results of Sears and Okamoto, on the chromosomes which pair in euhaploids, shows that the majority of pairing is either between A and D genome chromosomes or within the A genome. Thus diploidisation appears to be more effective for the A and B genomes than for these two genomes and the D genome.

Continuous spontaneous crosses between *Aegilops cylindrica* and *Triticum aestivum*

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The observation of speciation in nature, even in its early stage, is always an exciting experience. Although numerous spontaneous interspecific and intergeneric crosses are reported in literature, the following observation deserves attention because it has been taking place annually for a long time.

In 1913, the Hungarian botanist A. Degen found a peculiar looking *Aegilops* on a Danube Island, St. Andrew, about 30 miles north of Budapest. In 1917 he described this form as a new species and gave it the name *Aegilops Sancti-Andreae* Deg. In 1954 the author made an excursion to the island with Mr. Z. Zsak, a former assistant of Dr. Degen.

Plants fitting the description of *Ae. Sancti-Andreae* were easy to find along wheat fields but only in places where *Aegilops cylindrica* was growing close by, mainly in the ditches. Looking for seeds we found that the plants were sterile. This and the presence of *Ae. cylindrica* led to the supposition that the plants originated from spontaneous crosses between *Ae. cylindrica* and *T. aestivum*. This was later confirmed by a chromosome count of $2n=35$. In a survey of approximately 300 plants, six seeds were found, four of which were small and shrivelled, the other two appearing normal. The small seeds did not germinate, but from the normal seeds two partially fertile plants were obtained. These originated from spontaneous backcrosses with wheat as the cytological examinations revealed.

We visited the area again in 1955, and in 1956 to search for backcross derivatives and alloploids. The sporadic formation of alloploid seeds would be quite probable if the regularity and frequency of hybridization were considered; cultivation, however, would interfere with their survival. In 1956 we found three partially fertile hybrids but no alloploids. These were growing in the border of the wheat fields at a depth no greater than about 10′. The plants were normally harvested with the wheat thus giving the backcross derivatives only a very slim chance to survive.

St. Andrew Island adjacent areas along the bend of the Danube seems to be a peculiar ecological niche which promotes speciation. In a number of genera species and lower taxa have been described from that area.

Spring- and winter-types of artificial autopolyploids and amphidiploids in *Triticum* and *Aegilops*

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Species, variety and cross-combination[1]	Chromosome number (n)	Genome type	Growth[1] habit
Autopolyploid :			
T. aegilopoides boeoticum No.1 (W) 4x	14	AAAA	W
T. durum Reichenbachii (S) 8x	28	AAAABBBB	S
Ae. umbellulata typica No.2 (W) 4x	14	$C^uC^uC^uC^u$	W
Ae. longissima No.1 (W) 4x	14	$S^1S^1S^1S^1$	W
Ae. sharonensis typica No.1 (I) 4x	14	$S^1S^1S^1S^1$	S
Ae. bicornis typica No.1 (I) 4x	14	$S^bS^bS^bS^b$	I
Ae. uniaristata No.1 (W) 4x	14	$M^uM^uM^uM^u$	W
Ae. squarrosa typica No.2 (W) 4x	14	DDDD	W
Ae. ovata No.1 (I) 8x	28	$C^uC^uC^uC^u$-$M^oM^oM^oM^o$	W
Amphidiploid :			
Ae. caudata (W)×*Ae. umbellulata* (W)	14	CCC^uC^u	S
Ae. uniaristata (W)×〃 (W)	14	$M^uM^uC^uC^u$	W
〃 (W)×*Ae. squarrosa* (W)	14	M^uM^uDD	W
Ae. umbellulata (W)×〃 (W)	14	C^uC^uDD	I
〃 (W)×*Ae. bicornis* (I)	14	$C^uC^uS^bS^b$	I
Ae. sharonensis (I)×*Ae. umbellulata* (W)	14	$S^1S^1C^uC^u$	W
Ae. bicornis (I)×*Ae. squarrosa* (W)	14	S^bS^bDD	W
Ae. comosa (W)×*Ae. bicornis* (I)	14	MMS^bS^b	I
Ae. crassa (S)×*Ae. squarrosa* (W)	21	$DDM^{cr}M^{cr}DD$	S
T. aegilopoides (W)×*Ae. bicornis* (I)	14	AAS^bS^b	W
Ae. longissima (W)×*T. aegilopoides* (W)	14	S^1S^1AA	W
Ae. sharonensis (I)×〃 (W)	14	S^1S^1AA	W
T. Timopheevi (S)×*Ae. umbellulata* (W)	21	$AAGGC^uC^u$	S
〃 (S)×*Ae. squarrosa* (W)	21	AAGGDD	S
〃 (S)×*Ae. longissima* (W)	21	$AAGGS^1S^1$	S
T. monococcum (I)×*T. Timopheevi* (S)	21	AAAAGG	S
Ae. sharonensis (I)×*T. durum* (S)	21	S^1S^1AABB	S
T. dicoccoides (W)×*Ae. squarrosa* (W)	21	AABBDD	W
T. durum (S)×〃 (W)	21	AABBDD	S
T. turgidum (S)×〃 (W)	21	AABBDD	S
T. persicum (S)×〃 (W)	21	AABBDD	S
〃 (I)×〃 (W)	21	AABBDD	S
T. orientale (S)×〃 (W)	21	AABBDD	I
Ae. ovata (?)×*T. durum* (S)	28	$C^uC^uM^oM^oAABB$	S

1) S=spring type, I=intermediate type, W=winter type

Addition of individual chromosomes of *Agropyron* to durum wheat

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Jenkins and Mockizuki (1957) produced an amphiploid *T. durum-Ag. elongatum* (AABBEE) from the F_1 hybrid between *T. durum* var.. Stewart and *Agropyron elongatum* (2*x*), and in the following year, I obtained a pentaploid hybrid (AABBE) from the cross of the amphiploid with durum parent. The first monosomic addition line was obtained in the self progeny of an aneuhaploid (ABE+1) occurred from the pentaploid hybrid. Other monosomic addition lines were successively obtained from the repeated backcrossings of the pentaploid hybrid with durum parent. Thus in 1959, a series of the seven monosomic alien addition lines was established.

The monosomic addition lines have 29 chromosomes, i.e. 28 wheat chromosomes and one *Agropyron* chromosome in addition. The alien chromosomes transferred from *Ag. elongatum* are designated as e_1, e_2,...., and e_7, respectively. An attempt was made to produce disomic addition lines in order to maintain these alien chromosomes in wheat. Consequently five disomic addition lines (28 wheat chromosomes+ee) have been obtained in the self progenies of five different monosomic addition lines (e_1~e_5).

However, e_6 and e_7 disomic lines have not yet been obtained though a large number of the progenies of the respective monosomic addition lines were examined. This might have been caused by a low transmission rate of those chromosomes through male gametes.

Phenotypes of the addition lines are different in respect with certain characters from Stewart durum, as given in the following table.

Chr.	Ear type	Ear density	Leaf	Vigor	Maturity
e_1		slightly compact	slightly narrow	slightly weak	
e_2	spelta	lax	slightly narrow		late
e_3		slightly compact	broad	vigorous	
e_4			non-waxy, long, narrow	weak	
e_5		slightly compact	loose leaf sheath		
e_6	spelta	lax	slightly narrow		late
e_7	square head		stiff	vigorous	late

The vigor and fertility of the monosomic addition lines are not so different from durum parent, but are reduced in the disomic addition lines. There seems to be a general tendency that some phenotypes of monosomic addition lines are more exaggerated in disomic addition lines.

Disomic line e_4 (e_4e_4) has some such conspicuous characters which were presumably

transferred from *Agropyron* as non-waxy, very narrow long leaves, tight leaf sheath etc. Futhermore, this line is weak having virescent leaves with light yellow stripes like Ca- or Mg- deficient plants. Its fertility is about 3 per cent, while the other disomic lines show 30 to 70 per cent. These disomic addition lines are fairly stable, producing only a small proportion of progeny with deviated chromosome number.

In regard with the relationship between durum wheat and *Agropyron*, it is of interest to observe meiotic associations between wheat and *Agropyron* chromosomes in monosomic addition lines. If an alien chromosomes has no homology with any of the wheat chromosomes, the monosomic addition line shows $14_{II}+1_{I}$, while some chromosome associations is expected between them if a homologous segment is present. Actually no chromosome associations were observed between wheat and alien chromosomes in the lines e_4, e_6 and e_7. While trivalent associations were observed ($1_{III}+13_{II}$) in the lines e_1, e_2 and e_3, and trivalent or pentavalent associations ($1_{III}+13_{II}$ or $1_{V}+12_{II}$) were frequently observed in the line e_5. The pentavalent association suggests that both arms of the e_5 chromosome are partially homologous with two different wheat chromosomes.

From these results, it can be concluded that four chromosomes are at least partially homologous between Stewart durum and *Agropyron elongatum* ($2x$).

II. Exploration Results of the BMUK 1959

Some aspects regarding the collected materials of *Triticum* and *Aegilops* from the Eastern Mediterranean Countries. I.*

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1. Introduction

As already reported in the WIS Nos. 9~10, the Botanical Mission of the University of Kyoto (BMUK 1959 in abbreviation) was organized in 1959 with the financial assistance from the Rockefeller Foundation. The main purpose was to collect as many species and varieties of *Triticum*, *Aegilops* and the related genera as possible, with special reference to the origin of Emmer wheat. Namely, B-genome collection was the main concern of the BMUK. The itinerary and the lists of collections were reported preliminarily in the WIS Nos. 9~10. The identification of the species in the lists was based on the collected samples, and we have found a few corrections are necessary.

We traveled mainly by airplane, train, bus, ship, jeep, and car, but a horse carriage or a bicycle was also used for a local survey. When we traveled by jeep, we stopped at any places for the observation and collection. By this way, therefore, a thorough survey of distribution was made along the routes, while by other ways only the spots of distribution were marked. Habitats of *Triticum* and *Aegilops* along the exploration routes are given in the appended map.

The seeds of the collected materials were planted in the fall of 1959, and the first generation in Kyoto has been observed in 1960. Results of further investigations by respective authors will be published successively in series, as soon as they are completed.

2. *Aegilops mutica* from Turkey and Syria

Aegilops mutica: $2n=14$, genome symbol-MtMt

In 1954 we obtained 2 strains of this species by the courtesy of Dr. Hyland, U.S.D.A. Washington D.C., U.S.A., but we failed to maintain them. A few years later the species was obtained again by the courtesy of Dr. Jenkins, Winnipeg, Canada, but it was again difficult to maintain due to its high sterility, which was presumably caused by the frequent occurrence of B-chromosomes. For these reasons, our cherished desire was to

* Contributions of the BMUK 1959, No. 1.

collect more materials from its original habitats in Turkey, known by Eig (1929). When we arrived in Ankara in the middle of May, the season was a little too early, but when we visited there again in June after our trip to Italy and Greece, various species of *Aegilops* were at height of shooting even in the garden of the Japanese Embassy in Ankara. "Turkey is really the home of *Aegilops*" was our straight impression.

(a) **Distribution:**

The habitats of *Ae. mutica* were as follows.

I.	Turkey:	Amasya-Corum
II.		Yozgat-Cerikli
III.		Ankara
IV.		20 km west of Ayas
V.		70 km south of Ankara
VI.		Polatli-Günyüzü
VII.		Denizli
VIII.	Syria (U.A.R.):	Kemshly

I–VI are in the continuous area where we traveled by jeep. Accordingly, it can be said that *Aegilops mutica* occurs in the belt of 100–150 km wide from W 36° N 41° to 31° N 39.5°, which is the center of its distribution. Denizli (W 29° N 37.8°) is a little away, but this is considered to be nearly the southwestern limit of its distribution.

The collection from Kemshly in the east-northern corner of Syria (U.A.R.), manifested that this species occur there in a common population mixed with *Ae. speltoides*, *Ae. Aucheri* and *Triticum aegilopoides*. Here is far away from the centre of its distribution in Turkey, but will be the south-eastern limit of its distribution. This fact will suggest that *Ae. mutica* would occur also in the neighboring south-eastern region (Güneydogu Anadolu Bölgesi) of Turkey.

In each habitat in central Turkey, it was found that var. *typica* and var. *loliacea* and the intermediate type form a common population as shown in Tab. 3.

(b) **Variation:** Variation was noticed with respect to the following characteristics.

a. Glume pubescence: pubescent vs. glabrous
b. Ear: long vs. short
c. Spikelets: long vs. short, number of spikelets
d. Floret: number of florets in a spikelet
e. Ear density: dense vs. lax
f. Waxiness: waxy vs. non-waxy
g. Glume color: yellow vs. violet

(c) **Flowering habit:** The glumes open early in the morning and the anthers shed abundant pollen grains, as in the case of *Secale*, *Ae. longissima* and *Ae. sharonensis*. This habit will bring about the spontaneous cross-pollinations, which enrich the manifold

combinations of variations in the wild population. It is, therefore, not appropriate to classify the varieties on the basis of such difference as caused by a Mendelian single gene, which flows freely from individual to individual by the natural cross in the wild population.

(d) **Seed fertility:** All the original samples from Turkey, except the one from Denizli, showed high seed fertility. However, in Kyoto the progenies showed rather lower fertility. This is probably due to the unfavorable condition of Kyoto. Namely, the flowering time of *Ae. mutica* meets with the rainy season in Kyoto. A few original specimens from Turkey which showed lower fertility may presumably be due to the B-chromosome effects.

(e) **B-chromosomes:** Regarding B-chromosomes Dr. Mochizuki (s. page 31) has studied rather extensively with the materials grown in Kyoto as given in the following table (Tab. 1).

Table 1. Frequency of B-chromosomes

Number of plants with 1 B-chromosomes	2	3	4	5	Total	Number of plants without B's	Total Number of examined plants	Authors
18	25	9	2	1	55	366	421	Mochizuki
3	7	—	—	—	10	35	45	Yamashita, Kikuchi & Sekinada

(f) **Observations in Turkey:** The data of the morphological analyses of the wild population of *Aegilops mutica* in Turkey (June 13, 1959) are given in Tabs. 2 and 3.

Table 2. Habitat IV (80 km WWN of Ankara or 20 km W of Ayas)

Var.	Glume: pubescence	color	waxiness	ear[1]	Number of plants	Pollen-fertility
typica:	pubescent	yellow	non-waxy	dense	0	
				lax	0	
			waxy	dense	0	
				lax	0	
		violet	non-waxy	dense	0	
				lax	2	
			waxy	dense	1	99.9%
				lax	30	
loliacea:	glabrous	yellow	non-waxy	dense	0	
				lax	0	
			waxy	dense	2	
				lax	0	
		violet	non-waxy	dense	9	
				lax	9	
			waxy	dense	21	99.5%, 97.8%
				lax	26	92.7%

1) A dense ear has long spikelets, while a lax ear had short spikelets.

Table 3. Habitat II (Yozgat-Cerikli, 20 km E of Kirikkale)

Var.	Number of plants	Number of spikelets per ear
typica	11	12–19 (Mode:16)
loliacea	30	12–19 (Mode:15–16)

(g) **Observations in Kyoto:** The seeds obtained from the original samples collected in Turkey were planted in the fall of 1959 and the segregation with respect to pubescent vs. glabrous was observed in Kyoto in 1960 (Table 4).

Table 4. Segregation

Hab. No.	Original strains		Segregation[1)]
II	pubescent	5	all segregated.
	glabrous	8	7 not segregated, 1 segregated.
III	pubescent	1	segregated.
	glabrous	1	segregated.
IV	pubescent	7	all segregated.
	glabrous	6	4 segregated, 2 not segregated.
V	pubescent	2	1 segregated, 1 not segregated.
	glabrous	1	not segregated.
VII	pubescent	5	4 segregated, 1 not segregated.
	glabrous	3	2 segregated, 1 not segregated.

1) Segregation of pubescent from glabrous or of glabrous from pubescent.

The patterns of segregation observed in Kyoto were as follows (Table 5).

Table 5. Segregation

Original strains		Segregation (number of plants)		
		pubescent	glabrous	Total
pubescent	18	90	69	159
glabrous	8	18	61	79

Seed fertilities of the original samples from Turkey and of the progenies in Kyoto are listed in the following table (Table 6).

Table 6. Fertility

Hab. No.	Original samples[1]		Progenies[2]	
	pubescent	glabrous	self	free
	%	%	%	%
I	—	52.3	—	—
II	17.9~97.1 (76.4)	61.9~85.3 (73.3)	0~9.26	0~95.8
III	95.4	77.2	0~0.01	0~32.3
IV	62.6~82.9 (66.4)	40.7~86.2 (63.1)	0~1.82	0~98.5
V	62.6~82.9 (67.8)	68.2	0~14.4	0~46.4
VII	25.0~50.0 (32.6)	11.2~32.0 (22.7)	0~3.55	0~74.7

1) The samples from Habs. VI and VIII were not full ripe. Figures in parentheses indicate the averages.
2) High fertility was obtained when the plants were protected from the rain damage under the venyl roof.

3. Section Sitopsis of *Aegilops* from Egypt (U.A.R.), Jordan, Lebanon, Syria (U.A.R.) and Turkey

In the section Sitopsis are involved *Ae. speltoides*, *Aucheri*, *longissima*, *sharonensis* and *bicornis*. 4 species of them were collected (Table 7).

Table 7. Collection of Sitopsis species of *Aegilops*

Habitat	Species and variety
Egypt (U.A.R.):	
Matruh	*Ae. bicornis* var. *typica*
20 km W of Alexandria	〃 var. *typica* & var. *mutica*
Jordan:	
Suburbs of Hebron	*Ae. longissima*
Basin of the Jordan River	〃
Amman - Salt	〃
Ramtha	〃
Lebanon:	
Suburbs of Baalbek	*Ae. longissima*
Syria (U.A.R.):	
Deraa	*Ae. longissima*
Kotana - Arne (35 km W of Damascus)	〃
Kemshly	*Ae. speltoides* & *Aucheri*
Hama-Aleppo (40–60 km N of Damascus)	*Ae. Aucheri*
Turkey:	
Aleppo-Kerhamli	*Ae. Aucheri*
Suburbs of Kirikhan	〃
Suburbs of Ankara	*Ae. speltoides*
Amasya - Corum	〃 & *Aucheri*
Suburbs of Corum	*Ae. speltoides*
Suburbs of Cerikli	〃 & *Aucheri*

Ae. bicornis ($2n=14$, genome symbol S^bS^b) was collected along the highway from Alexandria - Matruh, Egypt (U.A.R.).

Ae. longissima ($2n=14$, genome symbol S^lS^l) was collected from the skirt area of Mt. Hermon in Jordan, Syria (U.A.R.) and Lebanon.

Ae. speltoides ($2n=14$, genome symbol SS) and *Aucheri* ($2n=14$, genome symbol SS) were found as either simple or mixed population in Aleppo-Antakya and Kemshly in Syria (U.A.R.) and Ankara-Amasya in Turkey. Intermediate type between *speltoides* and *Aucheri* was often found also. According to Eig (1929), the intermediate type is known as var. *polyathera*, but we wonder if it is appropriate to classify it as a variety.

Dr. Täckholm, Department of Botany, Cairo University, Cairo, Egypt (U.A.R.), kindly suggested us to explore along the Mediterranean coast region of Sinai for the collection of Sitopsis, but the arrangement of the trip was not successful because of the military tension in there.

4. Einkorn from Syria (U.A.R.), Turkey and Greece

Triticum aegilopoides, *T. Thaoudar* and *T. monococcum:* $2n=14$, genome symbol-AA.

In the suburbs of Ankara, wild Einkorn was found here and there. We selected a habitat 33.6 km W of Ankara for our detailed survey (s. the picture on the cover.). The data with respect to the awn length of the second floret were as follows (Table 8).

Table 8. Awn

Long	Short[1)]	Total
28	22	50

1) Short includes the intermediate type here.

Long vs. short of the awn of the second floret is the specific feature to identify *T. aegilopoides* (short) and *T. Thaoudar* (long), but these features were found mixed in a common population as seen from the table. The progeny test was carried out in Kyoto this year. The results were as follows (Table 9).

Table 9. Progeny test

Original sample	Progeny in Kyoto
T. aegilopoides	⟷ *T. aegilopoides* ⟷ *T. aegilopoides*+intermediate type
T. Thaoudar	⟷ *T. Thaoudar* ⟷ *T. Thaoudar*+intermediate type

Percival (1921) pointed out the occurrence of the intermediate type, and he included *T. Thaoudar* in *T. aegilopoides*, while Schieman (1932) established a collective species

T. boeoticum instead.

The variation in the color of glume and awn, viz. black, brown and white, was common. We also found plants having empty glumes with black margin on the ventral side of a spikelet. Early vs. late headding was also noticed. Some specimen had spiral culm which has been proved to be a heritable character. Individuals with various combinations of these characteristics occurred in a common population.

Dr. Suzuka, one of the members of the mission, found a wild population of *T. aegilopides* in Vasilica, Greece. Most of the collected samples from there were immature and poor, but only one had a well grown long head. All the specimens from Greece were proved to be *T. aegilopoides* type practically with no awn on the second floret. Neither *Thaoudar* nor intermediate type was found there.

In Kemshly, Syria (U.A.R.) wild Einkorn was also collected, including the *Thaoudar* and intermediate types but none of the *aegilopoides* type. It is interesting to note that in the wild population in Kemshly as well as in Ankara, Sitopsis species of *Aegilops* such as *speltoides* and *Aucheri* grew mixed with wild Einkorn.

When we visited Professor O. Tosun, Ankara University, we were kindly informed that *T. monococcum* is cultivated in the following districts, viz. Kastamonu (ENN of Ankara), Dursunbey (SW of Bursa), Baklikesir (between Bandirma - Gönen) and others. According to the information, we drove westward from Ankara until we found the wide cultivation of *T. monococcum* on the hill side in the north of the Apolyont Lake (W of Bursa) and also between Bandirma and Gönen. This species was cultivated single or mixed with oats or barley for the fodder use. Sometimes, however, *T. monococcum* is used for human food as *pilauf*. According to a Turkish-German dictionary *pilauf* is "Bulgur Weizen, der erst aufgekocht, an der Sonne getrocknet und dann zerkleinert wird". They consume as wheat meal with butter and salt. It was very interesting to see the present cultivation of such primitive type of wheat.

The variety has been proved to mature nearly as early as our X-ray induced early mutant of *T. monococcum vulgare* in Kyoto.

5. Wild Emmer from Syria and Jordan

T. dicoccoides ($2n=28$, genome symbol-AABB) known by the name "Wild Emmer" was found in the skirt area of Mt. Hermon in Syria (U.A.R.) and Jordan. The plants grew sparsely between lime stones. The habitats were:

I. 7 km west of Katana in Syria
II. Cheikh Meskine - Suweida (20 km from Suweida) in Syria
III. Amman - Salt (25 km from Amman) in Jordan.

Specimens collected from the habitat III were full ripe and identified well as *T. dicoccoides* var. *Kotschyanum*, one of the most common variety in the area of Mt. Hermon. As the specimens from the habitats I and II were immature, they were not well identi-

fied, but glumes of the specimens from Hab. I were known to be pubescent. This is the specific character of var. *spontaneovillosum*.

The plants grew in the wilds next to the *durum* field in the habitats I and II. An intermediate type between *durum* and *dicoccoides* was also found. This is probably the hybrid between the two species occurred in nature. Unfortunately the collected specimens were immature and no seeds were obtained for the progeny test. Percival (1921), stated that *T. dicoccoides* var. *fulvovillosum* is the derivative from the hybrid between *dicoccoides* and *durum*.

Habitat III was the area surrounded by barbed wires which protect from grazing. The wild Emmer was found there in a mixed population with *Aegilops*, wild rye and wild oats.

A note on the B-chromosomes in natural populations of *Aegilops mutica* Boiss. in central Turkey[1]

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Plants in the first generation in Kyoto and Sasayama, Japan, from the original materials, which were collected by the BMUK[2] from four different locations in central Turkey in 1959, have been used for the present studies.

In order to find B-chromosomes, young leaf meristems of a total of 573 plants were cytologically examined. B-chromosomes were found in all the populations varying in the number from one to five in invidual plants. Plants having two B-chromosomes were most frequent. The data are shown in the following table:

Number of plants with 1 B-chromosomes	2	3	4	5	Total	Number of plants without B's	Total number of examined plants
18	25	9	2	1	55	366	421

The B-chromosomes found in these populations seem to be identical with those that were previously reported (Mochizuki, 1957). They are euchromatic, are smaller than the smallest ordinary chromosomes of the complement, have median centromere and are unstable in the root tissue.

As an exceptional case, a deficient type of B-chromosome was found together with standard B's in a plant collected in a place near Ankara. This new type of B-chromosome is telocentric and forms a heteromorphic pair with a standard B.

1) Contributions of the BMUK, No. 2.
2) Abbreviation of the Botanical Mission of the University of Kyoto, 1959, led by Dr. K. Yamashita.

III. Editorial Remarks

Cover Sheet

Cover sheet for binding previous numbers of WIS, Nos. 1~10, is now ready for distribution.

Back Numbers

Requests for the back numbers of WIS have largely increased, and we have laid down the subscription price for the back numbers as follows:

Separate numbers:

No. 1~No. 8.....180 yen, or 50 US cents equivalent (each)

Nos. 9~10 .....270 yen, or 75 〃 〃 equivalent

Bound volume of Nos. 1~10 ..... 1,800 yen, or 5 US dollars equivalent

New Circulation List

Inquiries whether persons are interested in receiving future issues were forwarded together with the last numbers of WIS. Any one who has not yet returned the answering form is cordially requested to do so immediately. A new mailing list is now in preparation on the basis of replies.

New Members of the Coordinating Committee

Dr. A. Müntzing from Sweden, Dr. B.P. Pal from India and Dr. E.R. Sears from U.S.A. have been invited as the members of the Coordinating Committee of WIS.

Announcement for the Next Issue, No. 12

WIS No. 12 will be ready for publication in March, 1961. It is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics and cytology of *Triticum*, *Aegilops*, *Agropyron*, *Secale* and *Haynaldia*.

Contributions should be type written in English. The authors are cordially requested to present—**not later than Feb. 20, 1961**— their manuscripts which should not exceed 2 printed pages. Lists of stocks are not required to conform to this page limit. No illustrations are accepted for publication.

Manuscripts and communications regarding editorial matters should be addressed to:

Dr. Kosuke Yamashita
Wheat Information Service
Biological Laboratory
Kyoto University, Kyoto, Japan

A Map of the Habitats of *Triticum* and *Aegilops* along the Exploration Routes of the BMUK 1959

Aegilops

- ○ *umbellulata*
- ◉ *ovata*
- ⏢ *triaristata*
- ◐ *columnaris*
- ○ *biuncialis*
- ● *variabilis*
- ● *Kotschyi*
- ◉ *triuncialis*
- ◑ *caudata*
- ◖ *cylindrica*
- △ *Heldreichii*
- ▲ *uniaristata*
- ∴ *mutica*
- □ *speltoides*
- ⊡ *Aucheri*
- ⊠ *longissima*
- ⊠ *bicornis*
- ⧺ *crassa*
- ⧺ *ventricosa*

Triticum

- ◇ *aegilopoides*
- ◈ *monococcum*
- ◆ *dicoccoides*

Routes

—— Jeep or Car

---- Train or Bus

Plane-routes are not marked.

Members of the Botanical Mission of the University of Kyoto Kyoto, Japan, 1959 (BMUK 1959)

K. YAMASHITA
O. SUZUKA
M. TANAKA
S. NAKAMURA

Explanation of the Figure on the Cover

Triticum aegilopoides in the suburbs of Ankara, Turkey
(Photo. by K. Yamashita, June 1959).

Acknowledgement

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The Managing Editor

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