WHEAT INFORMATION SERVICE

No. 26 March,1968

Wheat Information Service
Biological Laboratory, Kyoto University
Kyoto, Japan

CONTENTS

No. 26 WIS March, 1968

I. Research Notes

A staining technique for determining wheat pollen viability[1]

Richard E. WATKINS, Jr.[2] and Byrd C. CURTIS[3]

The objective of this research is to describe a simple staining procedure for determining the viability of wheat pollen grains. Stains previously used, such as potassium iodide or acetocarmine, indicate the complete morphological development of pollen grains but not necessarily the viability. The new method was developed to facilitate the testing of pollen viability after varying treatments of temperature and humidity following anther dehiscence.

Methods of determining pollen viability have been developed through the use of vital stains such as the tetrazolium salts. The development of 2, 3, 5-triphenyl tetrazolium chloride (TTC) and its application to biology has been reviewed by SMITH (5). The basis of the reaction is the reduction of the TTC salt to an insoluble red formazan, which imparts a reddish purple color to the living tissue. VEITEZ, as cited by ASLAM, *et al.* (1) found that a 2% TTC solution provided a reliable index of viability for maize pollen. On the other hand, OBERLE and WATSON (4) reported that TTC stained certain fruit pollen known to be inviable and concluded that the chemical was of no value as an indicator of pollen viability in the species tested.

NORTON (3) screened 12 tetrazolium salts to find the one most effective in determining the viability of plum pollen. 3 (4, 5 dimethyl thiazolyl 1-2), 2, 5-diphenyl tetrazolium bromide (MTT) gave the best results and was highly correlated (r=0. 99) with actual

1) Published with the approval of the Director of the Colorado Agricultural Experiment Station as Scientific Series Paper No. 1271.

2) Graduate Research Assistant, Wheat Research, Colorado State University, Fort Collins, Colorado, U. S. A.

3) Manager of Wheat Research, Cargill Inc., 1909 Osage, Fort Collins, Colorado, U. S. A.

germination tests. HECKER (2) found MTT to be of value in determining the viability of sugar beet pollen. His results prompted our research to develop a staining technique for determining the viability of wheat pollen.

The most satisfactory media in determining wheat pollen viability consisted of a sugar-gelatin MTT[4] mixture dissolved in water. The media was prepared as follows: Add 50 ml. of distilled water to 2.75 gms. of knox unflavored gelatin. Heat in a water bath, stir until completely dissolved. Dissolve 28.5 gms. of cane sugar in the gelatin solution. Add 0.0075 gms. of MTT for each 10 ml. of the sugar-gelatin solution. Mixing must be accomplished while the solution is hot. *Do not boil.* The hot staining media is then placed on 1.5 mm. deep depression slides at the rate of one drop per slide. The media is allowed to cool for 1 to 1.5 min. or until a semi-hard jel forms. Slides must be covered to prevent desiccation. The staining media which is not immediately used can be refrigerated and again reheated for later use.

Pollen grains to be tested for viability are dusted on the media which has been held at room temperature. Replace the slide cover. After one hour viable pollen grains will appear to have a dark purple color while the non-viable grains will remain colorless. The pollen grains can be easily counted by microscopic observation at 100×. This method determines the viability of pollen grains at the time they are dusted on the media.

Comparison of the staining method with actual pollen germination tests

In order to determine the accuracy and reliability of the staining method, a pollen germination media was developed for actual germination tests. Correlation studies were then made between the two methods of determining pollen viability.

The germination media is prepared in the following manner: One gram of agar and 30 gms. of cane sugar are added to 100 ml. of boiling distilled water. Mix constantly. After the sugar and agar are dissolved, 2 ppm of $MnSO_4$ and 5 ppm of H_3BO_3 are added.

The hot media is placed on deep depression slides and allowed to cool to a semi-solid form. Viable pollen dusted on the media and covered begins to germinate immediately. A protrusion is formed as the germ tube develops. Protrusions can be observed under the microscope at 450× to determine the occurrence of protoplasmic streaming. Viable pollen is identified by the rapid protoplasmic streaming in the protrusion; non-viable pollen forms only very small protrusions with no protoplasmic streaming. There is no further development of the germ tube. Viable pollen grains, on the other hand, form relatively long germ tubes before the cell bursts. Most pollen grains burst soon after the germ tube begins to develop. Correlations were made using the two methods for

4) Obtained from Nutritional Biochemicals Corporation, Cleveland, Ohio, U. S. A.

determination of pollen viability, viz., actual germination by the agar method and staining by MTT. Samples of pollen grains from the same anther were tested for viability by the two methods. Twenty tests were conducted on pollen grain samples in which the viability ranged from nearly 0 to 100%. A highly significant correlation coefficient of 0.99 was calculated. It is concluded that the MTT staining method is both accurate and reliable in determining the viability of wheat pollen.

Since the MTT staining method determines the number of viable pollen grains at the time of dusting on the media, this method can be used to determine wheat pollen longevity under varying environmental conditions.

Literature Cited

(1) ASLAM, M., M. S. BROWN, and R. J. KOHEL. 1964. Evaluation of seven tetrazolium salts as vital pollen stains in cotton, *Gossypium hirsutum* L. Crop Sci. 4 : 508–510.

(2) HECKER, R. J. 1963. Use of tetrazolium salts in determining viability of sugar beet pollen. Amer. Soc. Sugar Beet Tech. **12**(6) : 521–528.

(3) NORTON, J. D. 1966. Testing of plum pollen viability with tetrazolium salts. Amer. Soc. Hort. Sci. Proc. **89** : 132–134.

(4) OBERLE, G. D., and R. WATSON. 1953. The use of 2, 3, 5-triphenyl tetrazolium chloride in viability of fruit pollen. Amer. Soc. Hort. Sci. Proc. **61** : 299–303.

(5) SMITH, F. E. 1951. Tetrazolium salt. Science **113** : 751–754.

(Received Jan. 23, 1968)

Comparison of mutagenic efficiency between EMS and radiations in diploid wheat

Taro FUJII and Seiji MATSUMURA†

National Institute of Genetics, Misima, Japan

Triticum monococcum flavescens was used in this study. Seeds were soaked in water for two hours and then treated with 0.1, 0.3 and 0.5% EMS solutions for 22 hours. For comparison, the seeds soaked for 24 hours were subjected to 0.5, 1.0 and 1.5 kR of gamma-rays at 1 kR/hr intensity. Moreover, EMS and gamma-ray treatments were combined to examine the synergistic effect of both treatments. The treatments were so combined that for two hours steeped seeds were placed in EMS solution for 22 hours and gamma-ray exposures were applied after five minutes washing in tap water. EMS solution was made with distilled water without buffer, and steeping and treatment were carried out under the constant temperature of 20°C.

Germination rates were fairly good as nearly 90 percent in gamma-ray 0.5, 1.0 and 1.5 kR lots germinated, but the seedling height and survival rate decreased with increasing dosage. EMS treated lots were severely impaired in germination, seedling growth and

survival rate which was about 60 percent in 0.3% lot. About 70 percent of treated seeds emerged in 0.5% lot, but all youug seedlings died in early stage. Therefore, very low germination rate and no survivals were observed in 0.5% EMS treatment combined with 1.0 kR of gamma-rays.

Chlorophyll mutations induced by EMS and gamma-rays were scored in the X_2 generation, as shown in Table 1. Chlorophyll mutation rate was similar in EMS 0.1% and gamma-ray 1.0kR lots, but that in EMS 0.3% lot was very high. Mutagenic efficiency between gamma-rays and EMS could not be compared directly from the data presented in the table, since the former is an ionizing radiation and the latter is an alkylating agent. So the decrease of survival rates in the gamma-ray lot was plotted, and survival rates in EMS treated lots were adjusted at the appropriate points of the line representing gamma-ray treatment. According to the procedure, survival rates in 0.1 and 0.3% EMS treatments were almost similar to those of 1.0 and 1.5 kR lots of gamma-rays, respectively. Chlorophyll mutation frequency was nearly equal in gamma-ray 1.0 kR and EMS 0.1% lots. The rate of EMS 0.3% lot was about three times higher against that of gamma-ray 1.5 kR lot, while they showed similar survival rates.

Table 1. Comparison of mutagenic efficiency of EMS and gamma-rays

Treatment	Number of head progeny	Number of head progeny with mutants	Mutation rate (%)
Control	174	0	
EMS 0.1%	114	8	7.02
0.3%	32	9	28.13
Gamma-ray 0.5 kR	131	3	2.29
1.0 kR	110	8	7.27
1.5 kR	89	9	10.11
EMS+gamma-ray 0.3% 1.0 kR	24	5	20.83

(Received Jan. 3, 1968)

Male-sterile durum: Interaction of *Triticum boeoticum and T. monococcum* cytoplasms with *T. durum* nucleus[1)]

S. S. MAAN and K. A. LUCKEN
Agronomy Department, North Dakota State University
Fargo, North Dakota, U.S.A.

Earlier, male sterility of 2n=28 (14^{II}) chromosome plants with the pedigree (*T. boeoticum*-type × *T. durum*) was reported (MAAN and LUCKEN, WIS Nos. 23-24 : 6-9, 1967). Further backcrosses have been accomplished and, even after six backcrosses, plants with *T. boeoticum*-type cytoplasm do not resemble the recurrent *T. durum* (N. Dak. accession 56-1) male parent. These male-sterile plants have thinner and weaker straw, narrower and shorter leaves, narrower heads, shorter and weaker awns, smaller seeds and more tillers than the *T. durum* parent. In each of the backcross generations an apparent segregation for weak and dwarf plants occurred and only relatively strong plants were selected for subsequent backcrosses.

Because the *T. boeoticum*-type plant used in the above cross was of doubtful origin, we also are substituting the chromosomes of *T. durum* and *T. aestivum* into the cytoplasms of *T. boeoticum*, *T. monococcum* and several amphidiploids involving these two species to observe male sterility effects.

At the time of the present report, male-sterile plants with the pedigree ♀ *T. monococcum* × ♂ *T. durum*[3] and four have been obtained. These plants have 2n=28 (14^{II}) chromosomes and do not yet resemble phenotypically the recurrent *T. durum* parent. Further backcrosses will be continued to accomplish complete substitution of *T. durum* and *T. aestivum* genomes into the cytoplasm of diploid wheats.

(Received Jan. 23, 1968)

1) Published with the approval of the Director, North Dakota Agricultural Experiment Station, as Journal Article No. *127*.

Studies with Israeli and Turkish accessions of *Triticum turgidium* L. emend. var. *dicoccoides* (KÖRN.) BOWDEN[1]

P. Seshagiri RAO and E. L. SMITH[2]

Two main races of *dicoccoides*[3] are recognized by HARLAN and ZOHARY (1966). These are the Palestine race and the Turkish-Iraqi race. The two races are geographically separated and morphologically distinct. SACHS (1953), working with a single representative from each race, showed that they were cytogenetically distinct. Morphological variation within the Turkish-Iraqi race led him to suggest that this race may also show variation in chromosome differentiation. According to HARLAN and ZOHARY (1966), the available evidence on morphological and cytogenetic relationships indicates that the Palestine race gave rise to most of the cultivated tetraploid wheats while the Turkish-Iraqi race contributed only to the *timopheevi* complex.

In order to examine the relationships of the two *dicoccoides* races more extensively, four Israeli and six Turkish accessions were studied morphologically and cytogenetically. Crosses were made between the Israeli and Turkish accessions. Also, both groups were crossed with a number of other tetraploid wheats including a *timopheevi* accession from the U.S.S.R.; a *turgidum* accession (available at the Oklahoma Agricultural Experiment Station); and *dicoccon* accessions from Ethiopia, India, the U.S.S.R., and Yugoslavia. In addition, *timopheevi* was crossed with *dicoccon* and *turgidum*.

The four Israeli accessions were morphologically similar and as a group could be distinguished from the Turkish accessions. The Israeli group had larger and more robust plants with lax heads and heavy awns. This group also differed from the Turkish group by having a larger number of hairs on the rachis edge, larger and tougher glumes, and a larger awn length to lemma length ratio. Data on chromosome pairing and fertility of the F_1 hybrids are shown in Table 1. Cytogenetically, the four Israeli accessions were similar. These accessions exhibited very close relationships with *dicoccon* and *turgidum* but their hybrids with *timopheevi* showed poor chromosome pairing and were completely sterile. Four of the six Turkish accessions were similar to the Israeli group in pairing relationships and seed set percentages. The other two Turkish accessions showed considerable cytogenetic differentiation. Turkish accession 11191 exhibited good

1) Published as Journal Series Paper No. *1614* with the approval of the Director, Oklahoma Agricultural Experiment Station.

2) Graduate Assistant and Associate Professor of Agronomy, Oklahoma State University, Stillwater, Oklahoma, U. S. A.

3) BOWDEN's (1959) system of classification has been followed in the present report.

Table 1. Mean chromosome pairing and fertility of F_1 hybrids

Cross		No. PMC studied	Mean chromosome pairing					Fertility (% seed set)
			I	II	III	IV	V & VI	
dicoccoides (I)[1]	× *dicoccon*	150	0	14.00	0	0	0	29
	× *turgidum*	50	0	14.00	0	0	0	80
	× *timopheevi*	150	6.62	7.62	0	1.53	0	0
dicoccoides (T)[2]	× *dicoccon*	150	0	13.80	0	0.10	0	83
	× *turgidum*	50	0	13.87	0	0.07	0	32
	× *dicoccoides* (I)	150	0	13.34	0	0.34	0	58
	× *timopheevi*	150	7.87	8.13	0.18	0.80	0.02	0
dicoccoides (T)[3]	× *dicoccon*	50	0.47	13.53	0.07	0.07	0	8
	× *timopheevi*	50	0.40	13.53	0	0.13	0	5
dicoccoides (T)[4]	× *dicoccon*	50	5.60	9.93	0.20	0.40	0.07	0
	× *dicoccoides* (I)	50	8.73	7.67	0.13	0.80	0.07	0
	× *timopheevi*	50	0.40	13.20	0.13	0.20	0	4
timopheevi	× *dicoccon*	150	7.42	8.18	0.18	0.87	0.04	0
	× *turgidum*	50	3.73	9.60	0.13	1.00	0.13	1

1) *dicoccoides* accessions AN 11140, 11147, 11150 and 11153 from Israel.
2) *dicoccoides* accessions AN 11182, 11186, 11187 and 11194 from Turkey.
3) *dicoccoides* accession AN 11191 from Turkey.
4) *dicoccoides* accession AN 11189 from Turkey.

chromosome pairing and some fertility in crosses with both *timopheevi* and *dicoccon*. Turkish accession 11189 showed close pairing relationships and some fertility with *timopheevi* but exhibited poor pairing and complete sterility in crosses with *dicoccon* and the Israeli group.

It appears that considerable cytogenetic variation exists within the Turkish-Iraqi race of *dicoccoides*. The results of this study tend to support SACHS (1953) suggestion that chromosome differentiation in this race may range from types having complete affinity to the Palestine race to types similar to *timopheevi*. A more detailed account and possible implications of this study will be published elsewhere.

The authors wish to express their appreciation to Dr. Jack R. HARLAN, University of Illinois, U.S.A., for providing the material and suggesting the problem.

Literature Cited

BOWDEN, W. M. 1959. The taxonomy and nomenclature of the wheats, barleys, and ryes and their wild relatives. Can. J. Botany **37** : 657–684.

HARLAN, J. R. and D. ZOHARY 1966. Distribution of wild wheats and barleys. Science **153** : 1074–1080.

SACHS, L. 1953. Chromosome behavior in species hybrids with *T. timopheevi*. Heredity **7** : 49–58.

(Received Jan. 17, 1968)

Production of monosomics in durum wheat

Akira MOCHIZUKI
Faculty of Agriculture, Kobe University, Kobe, Japan

Since 1959, the author has maintained three different monosomic lines originated from the backcross progeny of alien addition lines of durum wheat. These lines with 27 chromosomes showing $13^{II}+1^{I}$ at meiosis, are fairly fertile and transmit monosomic condition to selfed progeny. The deficient chromomes of these lines have not been identified yet, but the facts suggest that there are possibilities to have monosomics in tetraploid wheat without compensations of any homoeologous chromosomes.

In order to obtain the monosomics in durum wheat, mono- or nullisomics of *Triticum aestivum* var. Chinese Spring deficient for the A or B genome chromosomes were crossed with *T. durum* var. Stewart in 1963. After recurrent backcrosses of 34 chromosome F_1 plant ($13^{II}+8^{I}$) with durum in order to eliminate the seven chromosomes of the D genome, monosomic plants ($13^{II}+1^{I}$) were found in BF_2 families of four chromosome lines; 1A, 3A, 4A and 3B (Table. 1).

Table 1. Chromosome numbers of the progeny obtained by recurrent backcrosses

Back cross	Line*	Number of plants	Frequency of the plants with various chromosome numbers				Year
			27	28	29	others	
	$1AS^3$	46	1	32	13	–	1965
	$2AS^3$	72	0	70	2	–	〃
	$2AS^4$	94	1	89	3	(1)	1966
	$3AS^3$	43	2	32	9	–	1965
	$4AS^3$	68	2	55	9	(2)	〃
$13^{II}+2^{I}\times14^{II}$	$5AS^3$	83	0	71	10	(2)	〃
	$5AS^4$	248	4	234	9	(1)	1966
or	$6AS^3$	39	0	29	9	(1)	1965
	$6AS^4$	127	7	95	24	(1)	1966
$13^{II}+3^{I}\times14^{II}$	$7AS^3$	45	4	28	10	(3)	〃
	$1BS^3$	176	4	109	55	(8)	〃
	$2BS^3$	87	0	75	11	(1)	1965
	$2BS^3$	94	0	53	33	(8)	〃
	$3BS^3$	61	1	39	20	(1)	〃
	$4BS^3$	35	0	17	16	(2)	1966
	$5BS^3$	96	0	62	28	(6)	〃
	$6BS^3$	10	1	6	3	–	〃
	$7BS^3$	38	0	30	7	(1)	〃

* S^3 or S^4 indicates BF_2 or BF_3 generation.

The chromosome numbers of BF_1 may vary from 27 to 35 theoretically. No plants with 27 chromosomes were observed in this generation and about five percent of BF_1 plants with 28 chromosomes were used for female plants of next backcrossing. These 28 chromosome plants are not distinguished clearly in their appearances but classified into two groups according to their meiotic associations. About 30 to 50 percent of them show $13^{II}+2^{I}$, and the rest 14^{II}. The former should be used for the female plant in every backcrossing.

One of the two univalent chromosomes of the female came from durum and the other must belong to the D genome. Bivalent or heteromorphic bivalents which are occasionally formed between the two univalent chromosomes suggest that the univalents concerned must be homoeologous and the association may prevent to form nullisomic gametes (13 chromosome gamete).

Frequencies of the monosomics in the backcross progeny varied from one to ten percent with the chromosome lines as given in Table 2. Although it increased in the

Table 2 Frequency of monosomics in the progeny of recurrent backcrosses

Maternal line	Freq. of monosomics	Monosomics germinated from	
		shriveled. seed	plumped seed
$13^{II}+2^{I}$			
$1AS^{3}$	1/ 33 3.3%	1/ 2 50.0%	0/ 31 0.0%
〃	5/125 4.0	3/ 6 50.0	2/119 1.7
$2AS^{4}$	1/ 94 1.1		
$3AS^{3}$	1/ 21 4.8	1/ 2 50.0	0/ 19 0.0
〃	2/ 58 3.4	2/14 14.2	0/ 44 0.0
$4AS^{3}$	2/ 68 2.9		
$5AS^{3}$	4/248 1.6	4/ 5 80.0	0/243 0.0
$6AS^{3}$	7/127 5.5	1/41 2.4	6/ 86 7.0
$7AS^{2}$	4/ 45 8.9	4/18 22.2	0/ 27 0.0
$1BS^{2}$	4/176 2.3	3/36 8.3	1/130 0.8
$6BS^{2}$	1/ 10 10.0	1/ 5 20.0	0/ 5 0.0
monosomics			
$1AS^{3}$	1/ 16 6.3	0/ 3 0.0	1/ 13 7.7
$3AS^{3}$	1/ 11 9.1	1/ 3 33.3	0/ 8 0.0
$4AS^{3}$	10/ 72 13.9	5/ 6 83.3	5/ 66 7.6
$3BS^{3}$	4/ 30 13.3	2/ 3 66.7	2/ 27 7.4
$1AS^{4}$	4/ 36 11.1	3/ 4 75.0	0/ 32 0.0
〃	2/ 19 10.5	2/ 2 100.0	0/17 0.0

progeny obtained from the backcross durum monosomics by durum, it is still low. However, the frequency will be high in plants obtained from shrivelled seeds. It is reasonable to consider that deficiency of only one chromosome in the tetraploid wheat caused poor development in endosperm formation and this fact is practically useful in examining monosomics. In case of 6A, it is not possible to classify them clearly into two groups: namely shrivelled and plumped seeds.

In 1966, new monosomics have been obtained in six other 2A, 5A, 6A, 7A, 1B and 6B lines, Consequently the monosomics have been established in all seven lines of the A genome and three lines of the B genome in durum wheat.

The monosomic plants show $13^{II}+1^{I}$ at meiosis and a little weak in seedling stage but set seeds and transmit the monosomic condition to their selfed or backcrossed progeny. There are some variations of the characteristics in each individual of monosomic lines because the substitution of of Chinese Spring chromosomes involved in these monosomics with that of durum are still only partially complete.

(Received Feb. 3, 1968)

Cytogenetic studies of X-ray induced erect-type mutants in common wheat. I.

Isamu UCHIKAWA

Laboratory of Cytogenetics, Biological Institute
Ehime University, Matsuyama, Japan

In the year 1961 the author found a new type mutants in X_2 generation of X-ray treated normal common wheat. The most conspicuous features of these mutants were dense erect spikes, tough and short straws and stiff erect leaves. The mutants with these characteristics were called "erect-type" by the author.

The erect-type mutants are classified into four groups from the cytogenetic point of view : the mutants with somewhat thick and short straw and uniformly dense spike (Type I), those with remarkably short and thick straw and uniformly dense thick spikes (Type II), those with remarkably tough, thick short straws and dense squarehead spikes (Type III) and those with thin but stiff short straws and short dense spikes (Type IV). The last one is frequently segregated in the offspring of Type III heterozygotes, besides those directly arose in X_2 generation.

These erect-type mutants, however, are clearly distinguished from the compactoids (UCHIKAWA 1955, 1960) and dense-eared mutants (UCHIKAWA 1963) in their morphological and cytological features.

1. Type I erect-type mutants

The mutants of this type directly arose as heterozygotes or chimeral plants in the X_2 offspring of X-ray treated normal plants. The arising rate was 0.84% in X_2.

The heterozygotes were fairly shorter in height and spike length, and larger in straw-diameter and spike-density than those of normal plants. The leaves of this mutant were erect. The germination rate and seed fertility were slightly inferior to those of the normal plants. The homozygotes of this type had more intensified characters than those of the heterozygotes.

The heterozygotes gave normals, heterozygotes and homozygotes in the ratio 1 : 1.9 : 0.7 respectively in the next generation. The heterozygotes and homozygotes of this type uniformly had 2n=42 chromosomes. In meiosis, the heterozygotes formed 21_{II} association most frequently in PMC's (91.17%), besides a few of $20_{II}+2_I$ (8.06%), $1_{III}+19_{II}+1_I$ (0.32%) and $1_{IV}+19_{II}$ (0.45%).

The homozygotes also formed 21_{II} in the majority of PMC's (95.1%), and in rare occasions the chromosome associations $20_{II}+2_I$ (4.15%), $1_{III}+19_{II}+1_I$ (0.32%) and $1_{IV}+19_{II}$ (0.52 %) were seen.

From these cytogenetic results, the author assumed that the Type I erect-type mutants may have been originated by gene mutation or by the occurrence of minute, microscopically undetectable, duplication in one of the chromosomes, which carried an erect-type promoting gene *ert* (or genes) loci region. The fact that the obtained segregation ratio was near the value of the simple Mendelian ratio and the results concering the erectoid mutation of barley obtained by GUSTAFSSON (1947), HAGBERG (1958) and the others supported the gene mutation assumption but the writer canot entirely deny some possibility of the occurrence of minute duplication from the fact that the $20_{II}+2_I$ chromosome association was seen of comparatively high freqency.

2. Type II erect-type mutants

The arising percentage of the mutants of this type in X_2 was 0.69%. The heterozygous plants were shorter in height and spike-length and they were larger in straw-diameter, spike-width and spike-density, but inferior in germination rate of seeds and seed-fertility to those of the Type I heterozygotes. The homozygotes had more intensified characters than those of the heterozygotes.

The heterozygotes gave normals, heterozygotes, homozygotes and a few of unexpected plants (subnormal and lax-eared) in a ratio 1 : 1.4 : 0.3 : 0.03 in the following generation.

The heterozygotes had 2n=42 chromosomes and they included one large chromosome each. The size of this large chromosome was as large as one segment of the long arm of a middle-sized chromosome duplicated. In meiosis of PMC's the 21_{II} chromosome association including one heteromorphic pair was most frequently observed (79.25%). The heteromorphic pair was frequently separated into two unequal-sized univalents (20.06%).

In this heteromorphic pair the smaller partner was of middle size and normal submedian form, but the other one was larger in size, especially longer in the long arm than that of the former. The larger chromosome might have consisted of one whole chromosome and one segment of the long arm of the homologous chromosome. In a few cases the chromosome associations were either $1_{III}+19_{II}+1_{I}$ (0.27%) or $1_{IV}+19_{II}$ (0.42%). In these associations, too, one heteromorphic pair or two unequal univalents were usually seen.

The homozygotes also had 2n=42 chromosomes, but they included two large chromosomes resembling the larger one of the heteromorphic pair of heterozygotes. In meiosis of PMC's, 21_{II} including one large pair were seen most frequently (90.71%), and in a few cells the chromosome associations $20_{II}+2_{I}$ (8.22%), $1_{III}+18_{II}+3_{I}$ (0.43%) and $1_{IV}+18_{II}+2_{I}$ (0.45%) were observed.

From these cytogenetic results, it is assumed that the larger chromosome of heteromorphic pair may be originated by the single translocation of one segment of the long arm of a chromosome, which involves the region of the erect-type promoting gene (*ert*) locus. This partial duplication of a chromosome may be the main cause of the occurrence of the Type II erect-type mutants.

Table 1. The quantitative characters of erect-type mutants (in average)

Phenotype	No. of offshoot	Height (cm)	Spike length (cm)	No. of spikelets	Spike density
Normal	25.3	125.2	12.2	24.8	20.3
I. erect-type hetero.	22.1	115.6	10.4	24.3	23.4
〃 homo.	18.4	90.1	9.1	24.1	26.5
II. erect-type hetero.	20.2	105.3	9.2	24.2	26.1
〃 homo.	14.6	78.2	7.6	23.9	31.5
III. erect-type hetero.	18.2	93.7	8.5	24.1	28.4
〃 homo.	9.3	62.4	6.4	22.8	33.5
IV. erect-type hetero.	16.5	85.6	8.1	22.4	27.7
〃 homo. A	10.2	77.1	7.6	21.6	28.4
〃 homo. B	8.6	72.3	7.2	20.9	29.0

Phenotype	Width of spike (cm)	Tip-awn length (cm)	Flag-leaf length (cm)	Flag-leaf width (cm)	Diameter of straw (mm)
Normal	1.0	3.1	29.6	1.6	3.1
I. erect-type hetero.	1.1	2.4	28.8	1.7	3.4
〃 homo.	1.3	2.1	25.1	1.8	3.8
II. erect-type hetero.	1.2	1.2	28.5	1.8	3.6
〃 homo.	1.3	1.0	23.4	1.9	4.0
III. erect-type hetero.	1.3	0.8	27.5	1.8	3.8
〃 homo.	1.4	0.6	22.3	2.0	4.5
IV. erect-type hetero.	1.2	2.2	23.8	1.3	2.3
〃 homo. A	1.1	2.1	21.6	1.2	2.0
〃 homo. B	1.1	2.0	19.3	1.1	1.9

1. Spike density was determined by the number of spikelets per 10cm in rachis.
2. Diameter of straw was measured at 10cm below the first node of the spike.

The abnormal segregation ratio of the heterozygotes 1 : 1.4 : 0.3 can be explained by the competition in fertilization between the male normal gametes with 21 chromosomes and the male mutant gametes with 20+1 dupl. chromosomes, and by a slight degree of the zygotic elimination of homozygotes. Accordingly, if the actual fertilizing capacity of male normal gametes and male mutant gametes may be about 10 : 4 respectively in rate, and those female gametes are produced in the ratio 1 : 1, the zygotes with 42, 41+1 dupl. and 40+2 dupl. chromosomes will be produced in a ratio 1 : 1.4 : 0.4 by free combination.

(Received Jan. 8, 1968)

Cytogenetic studies of X-ray induced erect-type mutants in common wheat. II.

Isamu UCHIKAWA

Laboratory of Cytogenetics, Biological Institute
Ehime University, Matsuyama, Japan

3. Type III erect-type mutants

The percentage of the occurrence of the mutants of this type in X_2 was only 0.38%. The heterozygotes were still more shorter in height and spike-length, and larger in straw-diameter, spike-width, leaf-width and spike-density than those of Type II heterozygotes. The seed germination rate and seed fertility were remarkably lower than those of Type II. The homozygotes had more intensified characters than those of the heterozygotes. The heterozygotes gave normals, heterozygotes, homozygotes and a few unexpected plants (Type IV erect-type heterozygote and lax-eared) in a ratio of 1 : 1 : 0.7 : 0.05 in the following generation.

The heterozygotes had 2n=42 chromosomes including one large V-shaped isochromosome. In meiosis of PMC's the majority of the cells showed 21_{II} including one heteromorphic pair (61.17%) or $20_{II}+2$ unequal univalents (37.71%), besides a few of $1_{III}+19_{II}+1_{I}$ (0.44%) and $1_{IV}+18_{II}+2_{I}$ (0.68%). In the heteromorphic pair or two unequal univalents, one smaller partner was middle-sized with a submedian attachment chromosome, and the other one was remarkably larger in size, about twice as long as the long arm of the smaller partner.

From these cytogenetic facts, it is assumed that the Type III erect-type mutants is originated by the duplication of the long arm of a chromosome, which bears the erect-type promoting gene (*ert*) or genes, and the isochromosome formation might be brought about by the misdivision of a chromosome.

The isochromosome bears the erect-type promoting gene in double dose. The abnor-

mal segregation ratio (1 : 1 : 0.7) can be explained by the competition between the male normal gametes with 21 chromosomes and the male mutant gametes with 20+1 isochromosomes, in which the normal gametes are about 10 times as effective as those of the mutant gametes, and a slight degree of the zygotic elimination of homozygotes.

4. Type IV erect-type mutants

The mutants of this type directly arose as heterozygotes or chimeral plants in X_2 generation of X-ray treated normal plants, (0.42%) but they occur red sporadically in the next generation of Type III heterozygotes (0.84%).

The heterozygotes had shortest spikes, thin straws and narrow leaves in all types of the erect-type mutants, but they possessed dense and erect spikes, stiff short straws and erect leaves. The seed germination rate and seed fertility were as low as 71.5% and 65.2% respectively in the heterozygotes.

The heterozygotes gave quasi-normals, quasi-Type III erect-type heterozygotes, Type III erect-type homozygotes, Type IV heterozygotes, Type IV homozygotes and lax-eared plants in a ratio 1 : 5.4 : 2.5 : 0 : 0.6 : 0 in the following generation. The segregated normals and Type III erect-type heterozygotes had each a slightly shorter height and spike-length. Therefore, the writer gave them a head sign "quasi" to distinguish from real type plants.

The homozygotes showed more intensified characters of the heterozygotes, but they included two forms of plants of which A-form being more vigorous and larger in plant appearance than B-form, which segregated in the next generation of the A-form. These two forms were also different in chromosomal constitutions.

The Type IV heterozygotes possessed 41 chromosomes including one isochromosome. In meiosis of PMC's, chromosome associations $20_{II}+1_I$ (69.5%) and $19_{II}+3_I$ (28.80%) were observed, besides a few of $1_{III}+18_{II}+2_I$ (0.68%) and $1_{IV}+18_{II}+1_I$ (1.07%). And these associations of chromosomes included without exception one isochromosome as a heteromorphic pair or two unequal univalents. The isochromosome of this type was closely similar to that of Type III heterozygotes both in size and form.

The A-form homozygotes, which segregates B-form in the following generation, had 41 chromosomes including two isochromosomes, and in meiosis of PMC's, chromosome associations $20_{II}+1_I$ (68.33%) and $19_{II}+3_I$ (30.24%) mainly were seen, besides a few of $1_{III}+18_{II}+2_I$ (0.62%) and $1_{IV}+18_{II}+1_I$ (0.8%). These associations were usually included a pair of or two equal isochromosomes.

The B-form homozygotes, which are more slender and shorter plants than the A-form, had 2n=40 chromosomes, and they formed 20_{II} including one homomorphic isochromosome pair (67.85%) or $19_{II}+2$ isochromosome univalents (25.66%), besides a few of $18_{II}+4_I$ (4.8%), $1_{III}+17_{II}+3_I$ (0.41%) and $1_{IV}+17_{II}+2_I$ (1.22%) in meiosis of PMC's.

The other segregates quasi-normals, quasi-Type III erect-type heterozygotes, Type

III erect-type homozygotes and lax-eared plants had the chromosome constitutions 2n=42, 2n=41+1 iso., 2n=40+2 iso. and 2n=41 respectively.

From these cytogenetic findings, it may be inferred that the chromosomal difference between Type III and Type IV heterozygous erect-type mutants comes from the fact that the latter lacks one chromosome which the former possesses. Therefore, the loss of one chromosome, which carries the gene or genes for the development of the straw thickness and leaf-width, may be the main cause of the occurrence of the thin-short straws and

Table 2. Chromosome associations at MI in PMC's of erect-type mutants

Phenotype	2n	No. of PMC's examined	PMC's with					
			21_{II}	$20_{II}+2_{I}$	$1_{III}+19_{II}+1_{I}$	$1_{IV}+18_{II}+3_{I}$	$1_{IV}+19_{I}$	$1_{IV}+18_{II}+2_{I}$
Normal	42	2024	abs. 1964 % 97.04	44 2.17	4 0.20	—	12 0.59	—
I. er. het.	42	2470	abs. 1935 % 91.17	199 8.06	8 0.32	—	11 0.45	—
〃 hom.	42	1542	abs. 1465 % 95.01	64 4.15	5 0.32	—	8 0.52	—
II. er. het.	42	2612	abs. 2070△ % 79.25	524△ 20.06	7△ 0.27	—	11△ 0.42	—
〃 hom.	42	1864	abs. 1691△△ % 90.71	155△△ 8.32	—	8△△ 0.43	—	10△△ 0.54
III. er. het.	42	2511	abs. 1536* % 61.17	947* 37.71	11* 0.44	—	—	17 0.68
〃 hom.	42	1712	abs. 1278** % 64.65	415** 34.24	— —	8** 0.47	— —	11** 0.64
			$20_{II}+1_{I}$	$19_{II}+3_{I}$	$1_{III}+18_{II}+2_{I}$			
IV. er. het.	41	2337	abs. 1623* % 69.45	673* 28.80	16* 0.68	25* 1.07	— —	— —
〃 hom. A	41	1604	abs. 1096** % 68.33	485** 30.24	10** 0.62	13** 0.81	— —	— —
			20_{III}	$19_{II}+2_{I}$	$18_{II}+4_{I}$	$1_{III}+17_{II}+3_{I}$	$1_{IV}+17_{II}+2_{I}$	
〃 hom. B	40	1232	abs. 835** % 67.85	316** 25.66	61** 4.86	5** 0.41	15* 1.22	

△, △△..... One or two partially duplicated chromosomes were included in each configuration
* or **..... one or two isochromosomes were included in each configuration.

narrow leaves. The erect-type characters of the spikes, straws and leaves might be mainly brought by isochromosome formation, which carries an erect-type gene (*ert*) or genes in a double dose. The distinctive diminution of seed garmination rate and seed fertility of this type mutants might be caused by the physiological weakness of the plants due to the loss of one chromosome and duplication of an arm of a chromosome,

Abnormal segregation ratio quasi-normal : quasi-III. er. het. : III. er. hom. : IV. er. het. : IV. er. hom. : lax-eared 1 : 5.4 : 2.5 : 0 : 0.6 : 0 can be explained by the competition in fertilization of male gametes among 21, 20+1 iso.,19+1 iso. and 21 chromosome gametes, and some degree of zygotic elimination of the homozygotes. When the gametes with 21, 20+1 iso., 19+1 iso. and 20 chromosomes are formed in the ratio 0.2 : 1 : 0.2 : 1 respectively, and the actual fertilizing capacity ratio of these three kinds of male gametes are 15 : 8 : 1 : 1 respectively, the zygotes with 42 (quasi-normal), 41+1 iso. (quasi-III. er. het.), 40+2 iso. (III. er. hom.), 40+1 iso.-(IV. er. het.), 39+2 iso.-(IV. er. hom.) and 41-chromosome (lax-eared) may be produced in the ratio 3 : 16.6 : 8 : 12.2 : 2.6 : 15≒1 : 5.5 : 2.7 : 4.1: 0.9 : 5 respectively, besides very few 39+1 iso., 38+2 iso. and 40 chromosome zygotes. This ratio closely coincides with the actually obtained ratio 1 : 5.4 : 2.5 : 4 : 0.6 : 5, if some degree or zygotic elimination of Type IV homozygotes are expected. These explanations, however, involves some difficult points and it must be checked further on the results of the crossing experiments between mutants and normal plants.

Literature Cited

GUSTAFSSON, A. 1947. Mutation in agricultural plants. Hereditas **33** : 1–100.

HAGBERG, A. 1958. Cytogenetik einiger Gerstenmutanten. Der Züchter **28** : 32–36.

UCHIKAWA, I. 1960. Genetic and cytological studies of X-induced mutants in common wheat. I. On speltoid, compactoid, lax-eared, short-strawed, dense-eared and bearded mutants. Mem. Ehime Univ., Sect. II. Ser. B. **4** : 1–52.

_____, 1962. Genctic and cytological studies of X-induced mutants in common wheat. III. Further studies on dense-eared mutants. Ibid. **4** : 365–387.

_____, 1966. Genetic and cytological studies of X-induced mutants in common wheat. VII. On erect-type mutants. Ibid. **5** : 1–19.

(Received Jan. 8, 1968)

Differential effect of radiation in varieties of bread wheats

R. P. CHANDOLA
Govt. Agriculture Research Farm, Durgapura, Jaipur, Rajasthan, India

Effects of gamma-radiation on germination studies in six varieties of bread wheats (five hexaploids and one tetraploid) viz. R. S. 31-1, C591, R. S. 9-11, Jaipur Local, Kharchia (6x) and Malvi Ekdania (4x was reported earlier in this journal (CHANDOLA, 1966). An account of further critical observations on survival, seed and pollen fertility in these varieties is being given presently with an additional infromation available on some of these varieties on their behaviour towards X-irradiation and pile neutron treatments in the M_1 generations. Pile neutron treatment was secured for the seed material from the Atomic Energy Reactor at Trombay, Bombay and the X-irradiation was done at the Division of Genetiss, Indian Agricultural Research Institute, New Delhi. As these various sources of irradiation could not be compared among themselves in terms of total energy disseminated in each treatment it is considered worthwhile to at least compare the effectiveness of different doses in the same treatment in respect of the various varieties treated.

Pollen fertility as measured by stainability in acetocarmine was calculated in some M_1 plants belonging to each treatment. Seed fertility was studied from the earheads of the individual plants belonging to the M_1 generation by counting the total number of seeds per spike and calculating the average per spikelet. Observations from such five spikes drawn at random were taken to estimate the seed fertility per plant and in case of very low seed fertility in any plant readings from all the spikes were taken. These data are given in Table 1.

First column of Table 1 shows number of seeds actually sown in any control or treatment and the number of plants that finally survived, the latter being given in parenthses. From these data apparently, there seems to be a general decline in survival with the increasing dose in the same kind of treatment in any one variety as compared to its corresponding control. There is an identity in survival perecentage of the treatment 10,000r gamma-rays in Jaipur Local and Kharchia varieties of the hexaploid wheats and other varieties show a difference ranging from the lowest percentage in var. Malvi Ekdania (4x) being 73.7% to the highest in var. R. S. 9-11 being 97.8%. The last survival was observed in R. S. 31-1 and maximum in Malvi Ekdania among the 20,000r gamma-ray treatments. Among the 30,000r treatments the minimun survival was shown by var. Malvi Ekadania being 8.1% and var. Jaipur Local which has a survival percentage of 82.4. In the pile neutron treatments of the three varieties(R. S. 31-1, C591 and Malvi

Table 1. Data showing germination and survival, pollen- and seed-fertility in the M_1 genenation of the six varieties of bread wheats

Material & Treatment		I Germination & survival in %	Ia Survival in %	II No. of progenies	II Pollen fertility in %	III Av. no. of seeds /spikelet	IV Increase or decrease in %
R.S. 31-1	Control	100(97)	97.0	18	98.7	3.23	·
	Gamma-rays						
	10,000 r	93(89)	95.7	32	88.4	3.42	+ 5.86
	20,000 r	82(58)	70.7	21	77.6	3.12	− 3.40
	30,000 r	90(50)	55.5	10	69.6	2.63	−18.56
	X-rays						
	16,000 r	98(83)	84.7	26	84.9	3.16	− 0.22
	Pile neutrons						
	1.5×10^{12}cmp/cm^2	90(82)	91.1	17	91.8	2.71	−16.09
	4.5×10^{12} mp/cm^2	80(76)	95.0	18	85.6	2.68	−17.05
	5.0×10^{12} mp/cm^2	72(62)	86.1	23	87.6	2.63	−18.56
	13.5×10^{12} mp/cm^2	60(1)	1.66	1	60.3	1.48	−44.86
C. 591	Control	100(99)	99.0	30	99.2	3.84	——
	Gamma-rays						
	10,000 r	96(86)	89.6	17	80.6	3.29	−14.32
	20,000 r	85(68)	80.0	27	8.92	2.91	−24.21
	30,000 r	81(53)	65.4	6	0.99	2.57	−33.07
	X-rays						
	16,000 r	96(82)	85.4	19	0.69	2.86	−25.82
	Pile neutrons						
	1.5×10^{12}np/cm^2	90(88)	97.7	24	1.78	3.24	−15.62
	4.5×10^{12}np/cm^2	80(73)	91.3	36	7.97	3.03	−21.09
	5.0×10^{12}np/cm^2	82(69)	84.1	21	8.36	2.86	−25.52
	13.5×10^{12}np/cm^2	78(56)	7.71	19	0.09	2.68	−30.20
R.S. 9-11	Control	100(98)	98.0	16	8.08	3.10	——
	Gamma-rays						
	10,000 r	92(90)	97.8	26	6.37	3.30	+ 3.06
	20,000 r	80(62)	77.5	23	8.27	3.06	− 0.12
	30,000 r	78(41)	52.5	7	0.99	2.86	−10.30
Jaipur Local	control	100(96)	96	31	8.28	2.58	——
	Gamma-rays						
	10,000 r	96(86)	89.6	19	5.97	2.48	− 3.87
	20,000 r	84(67)	79.7	27	7.66	2.16	−16.28
	30,000 r	74(61)	82.4	6	8.49	2.10	−18.60
Kharchia	Control	100(98)	98.0	23	8.68	2.62	——
	Gamma-rays						
	10,000 r	95(85)	89.4	41	6.67	2.49	− 4.96
	20,000 r	80(61)	76.2	39	2.98	2.26	−13.74
	30,000 r	72(56)	77.7	29	8.29	2.18	−16.75
Malvi Ekdania	Control	100(96)	96.0	18	6.28	2.46	——
(4x)	*Gamma-rays*						
	10,000 r	80(59)	73.7	31	0.27	2.12	−13.82
	20,000 r	62(52)	83.8	36	1.56	2.02	−17.88
	30,000 r	86(7)	8.1	7	1.38	1.31	−46.74
	Pile neutrons						
	1.5×10^{12}np/cm^2	92(63)	68.4	26	1.37	9.83	+15.04
	4.5×10^{12}np/cm^2	78(58)	74.3	20	8.97	2.25	− 0.40
	5.0×10^{12}np/cm^2	78(43)	55.1	35	78.3	2.24	− 8.94
	13.5×10^{12}np/cm^2	60(11)	——	——	——	——	——

Ekdania) the dose 4.5×10^{12}np/cm^2 showed a rise in the survival percentage than the lowest dose of 1.5×10^{12}np/cm^2 in vars. R. S. 31-1 and Malvi Ekdania being 95% and 74% respectively. In rest of the higher the dose the lower is the survival is the rule in this kind of treatment. In the X-ray treatments of 16,000r of the two varieties R. S. 31-1 and C591 the percentage of survival is reduced as compared to control almost to an identical degree.

Again from the data given in Table 1 it will be seen that pollen fertility was reduced in the treated material particularly at higher doses. Thus it was observed that the maximum reduction in the pollen fertility with 10,000r gamma-rays is caused in the vars. C591 and Malvi Ekdania. This reduction is almost equal in the vars. R S. 31-1, R. S. 9-11 and Jaipur Local which is 77-78% and is minimum in the vars. Kharchia and Malvi Ekdania at the 20,000r dose treatment. The reduction in pollen fertility ranges from 68-70 per cent in all the varieties except Malvi Ekdania (4x) where it has further reduced to 61% at the 30,000r dose of gamma-rays. The X-ray treatment which was given in a single dose of 16,000r to only two varieties R. S. 31-1 and C591 shows a difference in the reduced pollen fertility viz. 85% in the first variety and 91% in the latter. In pile neutron treatments with only three varieties R. S. 31-1, C591 and Malvi Ekdania, the various differences are noticeable in respect of various doses and varieties. The minimum dose 1.5×10^{12}np/cm^2 reduced the pollen fertility to the same extent of 91% in the two vars. R. S. 31-1 and C591 while in var. Malvi Ekdania it came further down to 81%. Dose 4.5×10^{12}np/cm^2 reduced the pollen fertility to 86% in R. S. 31-1; 88% in C591 and 79% in Malvi Ekdania. 5. 0×10^{12}np/cm^2 dose reduced pollen fertility to 88% in R.. S. 31-1 and 78% in C591 and Malvi Ekdania both. The last and heaviest dose 13.5×10^{12}np/cm^2 not only disabled all the treated seeds for survival in var. Malvi Ekdania but also reduced the pollen fertility to a considerable extent i. e. to 60% in var. C591 and to 60.3% in R. S. 31-1.

Seed fertility was estimated in the irradiated material and their respective controls and results are summarised in Table 1. From the data it will be seen that all the wheat varieties were not equally sensitive to different types of irradiation and to different doses in the same variety of wheat when seed fertility is taken as an index of radio-sensitivity. The 10,000r gamm-ray treatment increased seed fertility by +5.86% in var. R. S. 31-1 and by +3.06% in var. R. S. 9-11. In other varieties this treatment generally reduced the seed fertility ranging from −3.87% in Jaipur Local to −13.82% in Malvi Ekdania. The highest reduction due to 20,000r treatment was recorded in var. C591 being 24.25% and lowest in var. R. S. 9-11 which was −0.12%. The 30,000r treatment showed the highest reduction of seed fertility in var. Malvi Ekdania being −46.74% and lowest as −10.30% in var. R. S. 9-11. Among two X-irradiations var. R. S. 31-1 showed a reduction of −0.22% while var. C591 showed as high as −25.82%. On viewing the data in Table 1 for effect of pile neutrons comprising of four doses in three varieties.

Malvi Ekdania registers an improvement by +15.04% with 1.5× 10^{12}np/cm^2 dose while in other two varieties this reduction is almost the same being −16.09% in R. S. 31-1 and −15.62 in C591. With the dose 4.5× 10^{12}np/cm^2 the lowest reduction was found in var. Malvi Ekdania (4x) being −0.40% and highest in var. C591 being −21.09%. In the same way var. Malvi Ekdania showed lowest reduction as −8.94% and var. C591 had the highest reduction in seed fertility as −25.52% as far as the dose 5.0× 10^{12}np/cm^2 is concerned. The highest dose of 13.5× 10^{12}np/cm^2 being lethal to var. Malvi Ekdania reduced the fertility of seed to the highest level in the other two varieties being −44.86% in R. S. 31-1 and −30.20% in var. C591.

In conclusion the data are suggestive probably of the fact that the superior radio-resistance of the hexaploid wheats as regards their survival at the lowest doses of gamma-rays and universally with the four pile neutron doses. This is also true in case of pollen and seed fertility both in regard to the gamma-ray and pile neutron treatments. As reported earlier (CHANDOLA, 1966) that unlike varieties are differently susceptible to irradiation, have at this stage also showed the same variation among themselves. As may of the induced mutations in bread wheats are chromosomal in origin, the aggravation in the amount of chromosomal damages induced by radiations becomes externally visible in subdued survival and pollen and seed fertility since the occurrence of too may chromosomal structural changes might lead to disturbed conditions in the life cycle of plant material under consideration. These conclusions are further supported by the types of mutations obtained in the M_2 progenies of these wheat varieties, the data regarding which are intended to be presented in the near future.

(Received Jan. 13, 1968)

Production of wheat varieties resistant to rusts with the use of radioactive cobalt

Hosni A. MOHAMED and Mouaa N. El BARHAMTOUSHY
Bahtim Experiment Station Cairo, U.A.R.

In earlier studies (1, 2), some mutants were observed in a wheat field raised from the seeds exposed to different doses of radioactive cobalt. Mutants were selected on basis of their morphological characters. The most interesting of these mutants was a tipped awned mutant from Tosson. This mutant was observed in the R_2 during the growing season 1961/62 in one of the seed plots previously exposed to 30,000r. Tosson was till last year a commercial wheat variety, it is an awned wheat variety susceptible to the three wheat rusts, namely the black stem rust, the orange rust and the yellow rust. Seeds of this plant were sown in the growing season of 1962/63 and each plant was harvested separately ; ten plants were selected and sown in the growing season 1963/64.

Further selection was practiced during the next seasons. Planting was in the rust nursery and notes were recorded for the three rusts and agronomic characters. During the growing season, resistant plants were labelled.

Characters studied were the presence of awns and rust reaction. The tipped awned ear character was dominant and segregtion occurred in some of the progenies during the growing seasons but not thoroughly studied as a number of plants for each line was not enough to draw a decessive conclusion. Calculating the number in some of the plots during the 1963/64 growing season, it was 294 tipped awned plants and 90 awned plants which account to 3 : 1 ratio or one gene may be responsible for this character. X^2 value was *0.510* and the P value was *0.50-0.20*.

The most interesting was segregation in rust reaction. As previously mentioned, the original wheat variety is susceptible to the three wheat rusts. Descendants of the grown plants were resistant to one or more of the three rusts and susceptible to the others. Certain of these progienies were only resistant to the stem rust, others resistant to the orange rust, still others resistant to the yellow rust and susceptible to the other two rusts. Also, other lines were resistant to two of the three rusts. In the third group, lines were segregating in their reaction to one or more of the three rusts. Selection in the field was confined to resistane to rusts, and some of the plants possess high resistance to the three rusts. Further studies on the selected plants were usually carried out in the laboratory. In this growing season (1967/68), four lines were included in a preliminary yield trial. Plants of these lines resemble the original parent with respect to all mophologic characters. However, they were all highly resistant to the three rusts.

References

(1) MOHAMED, Hosni A., Abdel Aziz M. OMAR and Mousa N. El-BARHAMTOUSHY 1965 Effect of radioactive cobalt on wheat II. Induced mutations. Bahtim Experiment Station Tech. Bull. 79.

(2) _____, _____, and _____ 1965 Effect of radioactive cobalt on characters of some wheat varieties. Wheat Information Service Nos. **19-20** : 16-17.

(Received Jan. 15, 1968)

Meiotic behavior of B chromosomes of rye after transfer to hexaploid wheat

A. MÜNTZING, H. JAWORSKA, and C. CARLIBOM

Institute of Genetics, Lund, Sweden

In the LINDSTRÖM strain of hexaploid wheat with B chromosomes from rye (*Secale cereale*), the B chromosomes are retained without difficulty in spite of the fact that much meiotic elimination occurs and that the strain is spontaneously self-fertilizing.

A striking feature of the LINDSTRÖM strain is that the B chromosomes frequently undergo structural changes resulting in new types of B chromosomes : some of them are isochromosomes produced by mis-division of the centromere ; others must be products of

deletions. The large iso-B chromosome has exactly the same appearance and tendency to undergo interarm pairing in the LINDSTRÖM strain as in rye. In certain plants with one large iso-B chromosome and one standard B chromosome heterobivalents were formed between these chromosomes.

Meiosis was studied in plants with 1, 2, 3, 4, and 6 B chromosomes of the standard type. Though a certain number of B bivalents are formed in the plants with two to six B chromosomes, meiotic pairing is on an average poor and the frequency of univalents is much higher than in the corresponding strain of rye. The reason for this difference must be an influence of the wheat chromosomes or the wheat cytoplasm on the rye chromosomes. Poor bivalent formation among the rye chromosomes, resulting from such an influence, does not only occur in the LINDSTRÖM strain but also in alien addition types with 42 wheat chromosomes and an additional pair of rye chromosomes as well as in strains of *Triticale* containing two complete genomes of rye.

(Received Jan. 16, 1968)

II. Genetic Stocks

Necrosis genes in common wheat varieties from Australia, Tibet and Northern Europe[1)]

K. TSUNEWAKI and T. HORI

Laboratory of Genetics, Kyoto University, Kyoto, Japan

We have undertaken further investigations on the geographical distribution of necrosis and chlorosis genes, using common wheat varieties from Australia (73 varieties), Tibet (18 strains), Sweden (35 varieties), Norway (13 varieties) and Finland (15 varieties). The Australian varieties were obtained from Dr. I. A. WATSON, University of Sydney, and all the rest from the Swedish Seed Association; their helps are greatly appreciated.

Those varieties were crossed to three testers, Jones Fife, Prelude and Macha, and their F_1 phenotypes were observed as to necrosis and chlorosis. Based on this observation, their genotype formulae were determined, that are given in Table 1. Detailed analysis of the results was published in the Japanese Journal of Genetics (42(4): 245~250, 1967).

1) Supported by a grant from the Japan Society for the Promotion of Science as part of the Japan-U. S. Cooperative Science Program.

Table 1. Phenotypes with respect to necrosis and chlorosis of F_1 hybrids between three testers and 154 common wheat varieties from Australia, Tibet and Northern Europe, and their genotype formulae

Country	Variety name	Tester			Genotype of tested variety
		Jones Fife $ne_1Ne_2\,ch_1Ch_2$	Prelude $Ne_1ne_2\,ch_1Ch_2$	Macha $Ne_1ne_2\,Ch_1ch_2$	
Australia	Alliance	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Amber	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Anvil	+	+	c	〃
〃	Atlas	+	n	c	$ne_1Ne_2ch_1Ch_2$
〃	Aussie	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Austan	+	+	c	〃
〃	Austtalavera	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Bald Early	+	+	+	$ne_1ne_2ch_1ch_2$
〃	Bald Knob	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Baldmin	+	+	c	〃
〃	Baldry	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Baringa	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Baroota Wonda	+	+	c	〃
〃	Beewar	n/+	+	c	$Ne_1/ne_1ne_2ch_1Ch_2$
〃	Bena	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Billy Hughes	+	+	c	〃
〃	Binya	+	+	c	〃
〃	Bobin	n/+	+	c	$Ne_1/ne_1ne_2ch_1Ch_2$
〃	Bobs	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Bombard	+	+	c	〃
〃	Bomen	+	+	c	〃
〃	Bonus	+	+	c	〃
〃	Boolaroo	+	+	c	〃
〃	Boonoo	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Booral	n	+	c	〃
〃	Boureong	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Bowes	+	+	c	〃
〃	Bredbo	+	+	c	〃

(Table 1. cont'd.)

Australia	Bunge	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Bunyip	+	+	c	〃
〃	Burrill	+	+	c	〃
〃	Cadet	+	+	c	〃
〃	Cadia	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Caliph	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Canaan	+	+	c	〃
〃	Canberra	+	+	c	〃
〃	Canimbal	+	+	c	〃
〃	Cargo	+	+	c	〃
〃	Carinda	+	+	c	〃
〃	Carrabin	+	+	c	〃
〃	Cedar	+	+	c	〃
〃	Cleveland	+	+	c	〃
〃	Coreen	+	+	c	〃
〃	Cowra	+	+	c	〃
〃	Empire	+	+	?	$ne_1ne_2ch_1$?
〃	Eureka	n	+	?	$Ne_1ne_2ch_1$?
〃	Federation	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Festiguay	?	+	c	? $ne_2ch_1Ch_2$
〃	Festival	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Fife	+	+	c	〃
〃	Ford	+	+	c	〃
〃	Free Gallipoli	+	+	c	〃
〃	Gabo	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Gala	n	+	c	〃
〃	Gallipoli	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Gamenya	+	+	?	$ne_1ne_2ch_1$?
〃	Geeralying	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Gresley	+	+	c	〃
〃	Heron	+	+	c	〃
〃	Jonathan	+	+	c	〃
〃	Kenora	+	+	c	〃

(Table 1. cont'd.)

Australia	Mendos	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Mengavi	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Nabawa	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Penny	+	+	c	〃
〃	Spica	+	+	c	〃
〃	Thew	+	+	c	〃
〃	Turvey	+	+	c	〃
〃	Wandilla	+	+	?	$ne_1ne_2ch_1$?
〃	Waratah	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	White Federation	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	Yalta	n	+	c	〃
〃	Yandilla King	+	+	c	$ne_1ne_2ch_1Ch_2$
Tibet	Collection from Maoniu	+	+	c	〃
〃	〃 〃 Taofu	+	+	c	〃
〃	〃 〃 Dorje Drag	?	+	c	? $ne_2ch_1Ch_2$
〃	〃 〃 〃	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	〃 〃 〃	+	+	c	〃
〃	〃 〃 Chingo	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	〃 〃 Maoniu	n	?	+	$Ne_1ne_2ch_1ch_2$
〃	〃 〃 〃	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	〃 〃 〃	+	+	c	〃
〃	〃 〃 〃	+	+	c	〃
〃	〃 〃 Dorje Drag	?	+	?	? ne_2ch_1 ?
〃	〃 〃 〃	n	+	+	$Ne_1ne_2ch_1ch_2$
〃	〃 〃 〃	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Origin unknown	+	+	c	〃
〃	〃 〃	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	〃 〃	n/+	+	c	$Ne_1/ne_1ne_2ch_1Ch_2$
〃	〃 〃	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	〃 〃	n	+	c	$Ne_1ne_2ch_1Ch_2$
〃	〃 〃	+	+	c	$ne_1ne_2ch_1Ch_2$
Sweden	Atle	+	+	c	〃
〃	Atson	+	+	c	〃

(Table 1. cont'd.)

Sweden	Blanka	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Brons	+	+	c	〃
〃	Diamant I	+	+	c	〃
〃	Drott C	+	+	c	〃
〃	Ella	+	+	c	〃
〃	Emma	+	+	c	〃
〃	Extra-Kolben	+	+	c	〃
〃	Fylgia I	+	+	c	〃
〃	Karnvor	+	+	c	〃
〃	Kärn II	+	+	c	〃
〃	Line from Dalsland	+	+	c	〃
〃	Line from Värmland	+	+	c	〃
〃	Old Swedish line	+	+	c	〃
〃	Pondus	+	+	c	〃
〃	Progress	+	+	c	〃
〃	Rival	+	+	c	〃
〃	Ring	+	+	c	〃
〃	Rubin	+	?	c	ne_1 ? ch_1Ch_2
〃	Safir B	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Selected line of indigenous wheat	+	+	c	〃
〃	Spring wheat from Värmland	+	+	c	〃
〃	Sv Koblen	+	+	c	〃
〃	Svenno	+	+	c	〃
〃	Swedish spring wheat I	+	+	c	〃
〃	Vårpärl	+	+	c	〃
〃	(Population from Degeberga)	+	+	c	〃
〃	(Population from Halland)	+	+	c	〃
〃	(Population from Kalmar)	+	+	c	〃
〃	(Population from Älghult)	+	+	c	〃
〃	(Population from Hjorted)	+	+	c	〃
〃	(Population from Dalsland)	+	+	c	〃
〃	(Population from Östervallskog)	+	+	c	〃
〃	(Population from Dalarna)	+	+	c	〃

(Table 1. cont'd.)

Norway	Ås	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Ås II	+	+	c	〃
〃	Ås 076-13	+	+	c	〃
〃	Börsum	+	+	c	〃
〃	Budda	+	+	c	〃
〃	Farm II	+	+	c	〃
〃	Fröya	+	+	c	〃
〃	Nora	+	+	c	〃
〃	Nordmöre	?	+	c	? $ne_2ch_1Ch_2$
〃	Norröna	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Särimner	+	+	c	〃
〃	Snögg II	?	+	c	? $ne_2ch_1Ch_2$
〃	Trym from Möistad	+	+	c	$ne_1ne_2ch_1Ch_2$
Finland	Apu	+	+	c	〃
〃	Club wheat (land wheat)	+	+	c	〃
〃	F 01751	+	+	c	〃
〃	F 02903	+	+	c	〃
〃	Hopea	+	+	c	〃
〃	Kiuru	+	+	c	〃
〃	Pika II	+	+	c	〃
〃	Sopu	+	+	?	$ne_1ne_2ch_1$?
〃	Tammi	+	n	c	$ne_1Ne_2ch_1Ch_2$
〃	Tera	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Tonko	+	+	c	〃
〃	Vrm 50024	+	+	+	$ne_1ne_2ch_1ch_2$
〃	Population from Vihanti	+	n	c	$ne_1Ne_2ch_1Ch_2$
〃	Population from Velamo	+	+	c	$ne_1ne_2ch_1Ch_2$
〃	Population from Alavus	+	+	+	$ne_1ne_2ch_1ch_2$

+ : normal, n : necrotic, c : chlorotic, ? : no hybrid obtained or genotype partially undetermined, / : segregating phenotypes or heterozygous locus

(Received Aug. 13, 1967)

III. News

Program of the Kyoto University Scientific Expedition to the Sahara and the Surrounding Areas (KUSES) December 1967–March 1968

Introduction

For the past ten years, Kyoto University has carried out investigations in various fields of natural and cultural sciences in East Africa. On the basis of thus accumulated data, Kyoto University has now planned a scientific expedition to the Sahara and the surrounding areas as mentioned below. All the senior members are well experienced in respective fields as they have joined the previous expeditions

Members

(a) Senior Members

Kosuke YAMASHITA (Leader) : D. Ag., Professor, School of Liberal Arts & Sciences, Kyoto University, Botanist & Geneticist

Toichi ASAI : D. M., Director, Naniwa Hospital, Osaka, Surgeon

Sasuke NAKAO : D. Ag., Professor, Laboratory of Plant Breeding, College of Agriculture, University of Osaka Prefecture, Agronomist & Ethnobotanist

Tadao UMESAO : D. Sc., Assistant Professor, Research Institute for the Humanistic Studies, Kyoto University, Social Anthropologist

Shigenobu KIMURA : Assistant Professor, Fine-Arts College of Kyoto City, Fine-Arts Historian

Yasuo OHASHI : Assistant Professor, School of Liberal Arts & Sciences, Kyoto University, Linguist

Yuichi WADA : Assistant Professor, Kwansei-Gakuin University, Linguist

Sadao SAKAMOTO: D. Ag., Researcher, National Institute of Genetics, Botanist & Geneticist

Toshinao YONEYAMA : Assistant Professor, Konan University, Social Anthropologist

Yutaka TANI : Instructor, Research Institute for the Humanistic Studies, Kyoto University, Historian

Junzo KAWATA : Assistant Professor, Saitama University, Cultural Anthropologist

Naomichi ISHIGE : Instructor, Research Institute for the Humanistic Studies, Kyoto University, Cultural Anthropologist

Kuzo DOGURA : Member of the Society of African Studies, Kyoto University, Human Ecologist

(b) Student Members

Teruo OMOTO	Kazuhisa EGUCHI	Masaru AKASAKA
Katsuyoshi FUKUI	Shigeto NISHIMURA	Shuzo HASEGAWA

(c) Assistant Members

Kaori NISHIOKA	Hideo NISHIGAYA	Toshikazu FUKUDA
Rikuro SUGIYAMA	Satoru KOBAYASHI	Osamu KUMASEGAWA
Akira NAKAGAWA		

General Schedule

Departure from Tokyo-16 November and on; arrival at Algiers-26 November, 1967 and on. Investigations in the Sahara, the Niger Basin, the Ennedi and the Abyssinian Plateau, from December 1967 till March 1968. Return to Japan - end of March 1968.

Main subjects

1) Botanical Team:
Rich collections of the primitive forms of emmer wheat are expected from the Abyssinian Highland where is one of the centers of diversity of cultivated plants after Professor VAVILOV's theory.

2) Agronomical Team:
Studies of the development from gathering stage to cultivation stage in the Mediterranean Coastal Regions, the Central Sahara, the Sahel, the Niger Basin and the Sudanic Belt from Niger through Sudan to Ethiopia.

3) Fine-Arts Team: (a) Survey of the remains of the prehistorical rock arts in the Sahara.
(b) Comparative survey of ancient Egyptian fine-arts and those of Meloe and Kush Empires.
(c) Survey of Greco-Roman and Islamic fine-arts in the Mediterranean Coastal Regions.
(d) Survey of Christian fine-arts of Middle Age in the Abyssinian Plateau.
(e) Survey of primitive arts in the Niger Basin and around the Chad Lake.

4) Linguistic Team:
(a) Phonetic and lexicological studies in Mande languages, Songhay dialects and Hausa dialects.
(b) Collection of Ethno-linguistic data.
(c) Description of little known languages in East Niger, Chad and Cameroon.
(d) Tape recording of the above mentioned languages.
(e) Socio-linguistic studies in the above mentioned languages.

5) Medical Team:
(a) Clinical survey of tropical diseases in the Sahara and the surrounding areas.
(b) Physical influcences of tropical climates on Japanese members.

6) Anthropological Team:
(a) Anthropological and ecological survey of tribes in the South of the Sahara.
(b) Studies in the development of the Kingdom of the South of the Sahara.
(c) Social structure of the Oasis villages in the North Africa.
(d) Trade routes throught the Sahara.

IV. Editorial Remarks

Announcement for future issues

WIS Nos. 27 and 28 will be published during the fiscal year from April, 1968 to March, 1969. Manuscripts for those issues are accepted any time, and they will go to press in sequence as soon as they cover planned pages of each number.

WIS is open to all contributions regarding methods, materials and stocks, ideas and research results related to genetics and cytology of *Triticum*, *Aegilops*, *Agropyron*, *Secale*, *Haynaldia* and related genera. Contributions should be typewritten in English. The manuscripts should not exceed three printed pages. Lists of stocks are exempted from this page limit. One text-figure (smaller than $7 \times 7 cm^2$) will be accepted for each article, if indispensable.

Communication regarding editorial matters should be addressed to:

K. YAMASHITA

Wheat Information Service
Biological Laboratory
Yoshida College, Kyoto University
Kyoto, Japan

Acknowledgement

The cost of the present publication has been defrayed partly by the Grant in Aid for Publishing Research Results from the Ministry of Education, Government of Japan, and partly by contributions from the Flour Millers Association, Tokyo, Japan. We wish to express our sincere thanks to those organizations. We should also like to express our sincere gratitude for faborable comments regarding WIS Nos.1～25, and valuable contributions for the present numbers. Increased support for future issues would be appreciated.

The Managing Editor

Explanation of the Figure on the cover

A wheat growing family near Addis Abeba, Ethiopia (K.Y. 1968).
A man holds a head of wheat in front of his face.