E. G. Anderson

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MAIZE GENETICS COÖPERATION

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I. Ernest Walter Lindstrom

On November 8, 1948 the corn research world lost, in the death of Ernest Walter Lindstrom, one of its most ardent workers. Dr. Lindstrom was born of Swedish parents in Chicago, Illinois, February 5, 1891. He early broke from the city tradition with sojourns in the forest of the Rockies as a student forester. His A.B. was gained from the University of Wisconsin in 1914. Three years later he obtained his doctorate from Cornell University, his thesis being on "Chlorophyll Inheritance in Maize." The culmination of this work marked the beginning of a long line of R. A. Emerson men who were to contribute so much to plant breeding. The thesis itself opened new avenues to our understanding of chlorophyll action. Emphasis was laid on the significance of many genes in the control of economic characters.

A pilot in World War I, Lindstrom returned to the Genetics Department of the University of Wisconsin, where he remained as an instructor from 1918 to 1922. In 1922, Lindstrom was called upon to organize a department of Genetics at Iowa State College. To this position Dr. Lindstrom brought not only his skills, but also those of A. Cornelia Anderson of Waukesha, Wisconsin, whom he married in 1921. Six years of fairly uninterrupted work demonstrated research skills and administrative capacity of such high order that 1927 found the Lindstroms in Europe at the invitation of the Rockefeller Foundation. A year spent in assisting the International Education Board in selecting researches of European investigators worthy of their support, and in contacts with the leaders and advanced students making these researches, convinced Dr. Lindstrom that he himself wished to return to his own research. The eight years following were marked by attacks on previously untouched problems. Through his efforts Iowa State College got a reputation for active, sound genetic work. But Lindstrom's matured judgment was increasingly called upon in selecting key personnel, for methods of teaching, and in choosing significant programs for research.

This background brought the almost inevitable step. In 1937, Lindstrom added the duties of Vice Dean of the Graduate School. His thought went to making education better, particularly in the Land Grant Colleges. But our country was not alone the gainer. In 1944-45 he gave a year of his life in assisting the Colombian Government to establish a Genetics Department in their National University of Medellin.

Dr. Lindstrom is survived by his wife, Mrs. A. Cornelia Lindstrom, and three children, Eugene Shipman Lindstrom, Mrs. William M. Buck, and Rosemary Vaughn Lindstrom. In his time he served as member, secretary, vice president and president of our

professional society. Characteristically, even near the end he looked to the future of his chosen field. Instead of flowers he requested that those who wished to commemorate his memory contribute to a fund for the support of a Genetic Library at Iowa State College. The far reaching response which this request has thus far received is significant of the high esteem in which Dr. Lindstrom was held by all his students and colleaques. In less than the allotted life span his has been a full career.

John W. Gowen

II. REPORTS FROM COÖPERATORS

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1. Albinism in my pedigree 481 (x) (formerly 472 (x), and derived from Maize Coöp pedigree 44-74-1 (x)) is linked with "embryoless lethal" by about 1.5% crossing over. The "embryoless lethal" (or germless) in the inbred line is only partially lethal and quite variable; and it is difficult to identify all of the cases from superficial kernel structure. In 481 progenies the proportion of conspicuous embryoless varies considerably, always being less than the expected 1/4 and usually being about 1/5, 1/6 or even less. Pedigree 481 - 93 (x) was an exception having approximately 1/4 conspicuously embryoless kernels and making it possible to obtain data on the number of crossovers. Pedigree 481 - 93 was one among 235 plants self-pollinated in pedigree 481.

481 - 93 (x)
259 seeds → 204 normal + 55 conspicuously embryoless
259 seeds → 197 greens + 2 albinos + 60 (did not germinate)

(Apparently 5 embryoless did not show, or there may have been some embryo-containing kernels which did not germinate.)

The 2 albinos were normal in stature, and were really crossovers in which genes for <u>embryoless</u> <u>lethal</u> and albino became separated to produce normal sized albinos.

481 albinos, generally, were very small and narrow leaved and evidently were the direct result of the linked embryoless lethal

character. Some progenies gave the expected ratio of 3 normal green : 1 albino, in which the albinos were normal in structure. Other progenies gave ratios in the neighborhood of 5 or 6 normal green : 1 albino, in which the albinos were small narrow leaved and generally abnormal in structure. These latter progenies were the ones with embryoless showing as a kernel character and whenever the ones that do not germinate were added to the albinos the ratio of green to albinos was always brought to the 3:1 expectation. This would indicate that the ones which did not germinate (extreme embryoless) were genetically homozygous albinos. Examples are:

(a) 472 - 10 (x) yellow seeds which were planted in field to produce 481.
240 green seedlings + 51 albinos (total 291) 4.7:1
(Total number of seeds sown was not determined.)
Out of a total of 291 seedlings there should have been 73 albinos.

(b) 481 - 13 (x)
Total seeds:

actual	439 yellow	+ 144 white	Total 583
expected	437 "	+ 146 "	

Yellow seeds	328	green	+ 69	albinos	+ 42	did	not	germinate
White "	101	"	+ 21	"	+ 22	"	"	"
Total	429	"	+ 90	"	+ 64	"	"	"

There were 583 seeds. On this basis there should have been 437 green seedlings and 146 albinos. The 90 albinos actually obtained were far short of expectation but, if the number which did not germinate is added, the value is close to expectation. This batch of seeds was not sorted for embryoless.

2. Pedigree 481 produced numerous Siamese twin seedlings with separations from below to above the first leaf. So far only one and two have been recorded for some progenies. The Siamese twin character may be associated with the embryoless lethal trait in heterozygous green plants. All Siamese twin seedlings observed have been green. The inheritance is still obscure.

3. Albinos and yellow seedlings guttate more water than do normal similarly-sized greens in the same progenies. No quantitative measurements have yet been made. Examination of a few root systems showed the chlorotic plants to have root systems just as big or bigger than the normal green seedlings. No quantitative measurements have yet been made on root size.

4. Yellow seedlings appear to grow faster and die sooner than albino seedlings. The albinos lived about 21 days at 80°F and the

yellows about 18 days. These were in sister progenies. To be sure of any trend or relationship one would need to study the life span of the yellow and albino seedlings in a progeny where they coexist. I have such progenies. The ratio in progenies not marred by embryoless is 9 green : 3 yellow : 4 albino. Could the carotene have an accelerating effect on food consumption and growth rate ?

5. Green seedlings grown from yellow seeds seemed to be significantly taller at the end of 21 days than green seedlings grown from white seeds in same progeny. There was also a corresponding weight difference, perhaps even more significant.

481 - 13 (x)

326 green from yellow seeds
Mean height = 31.8 cm σ = 3.6 cm
$S.E._M$ = ±0.2 "

100 green from white seeds
Mean height = 30.0 cm σ = 3.0 cm
$S.E._M$ = ±0.3 "

S.E. of Mean difference = 0.36 cm

$$\frac{\text{Difference}}{\text{S.E.}} = \frac{1.8}{0.36} = 5$$

Other progenies need to be measured in order to make sure of this relation. Could the carotene in yellow seeds have a significant effect on growth rate of seedlings ? Or are the growth genes in 481 linked with yellow endosperm ? Measurements on weight of yellow seeds and white seeds in same progeny show no difference.

6. A Mendelian recessive dwarf mutant appeared in 481 - 50 (x) . One-fourth of the seedlings were dwarf. I shall be glad to furnish seed to anyone interested in this dwarf.

7. In pedigree 4812 (formerly 474 - 13 and derived from Maize Co-8p 45-144 - 1 # 2) there were 23 out of 95 with "tassel-like" ear. The character is not like Ramosa in that the tip of the ear is also divided. The "tassel-like" ear has a framework which is exactly similar to the framework of a tassel. Limited numbers of seeds are formed on the basal portions of the branches. Seed will be furnished gladly to anyone interested.

8. Pedigree 4812 also segregated a lethal pale green which lived as long as any albino or yellow seedling would. It starts as a normal appearing green plant and then gradually becomes more and more yellow. There is also a bright green segregant in the pedigree. Progenies in which both pale green and bright green coexist give the ratio 9 blue green : 3 bright green : 4 pale green (or yellow). Some progenies are homozygous blue green, some homozygous bright green. Since pale green is lethal, it is impossible to

produce homozygous pale green progenies.

9. I wish to report a somatic mutation of albinism to green. A small amount of green tissue appeared in the first leaf of an albino in 481 - 71 (x). It was a progeny which segregated albinos. The first leaf stayed alive much longer than the first leaf of other albinos in the same and sister progenies.

H. C. Eyster

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1. Inheritance of variegated plant B^V in maize.

In 1939 (Genetics 24:109) we reported a case of a plant that developed fine streaks of color after B pollen was treated with ultra-violet light and applied to lg gl_2b v_4 plants. Treatment of the pollen was made by Dr. L. J. Stadler who first observed the abnormal plant. Cytological examination showed no chromosomal irregularities. Further genetic tests have indicated that this variegation is caused by a variegated B allele which has been designated B^V. Linkage relations of B^V with gl_2 and v_4 are approximately the same as with B.

Segregates of B^Vb plants produce only two types B^V and b with an occasional back mutation from B^V to B. Progenies studied were not set up to detect changes from B^V to b. Three point backcross linkage tests gave the following results:

Progeny		48:610	%	48:608	%	48:607 (F_2 not backcross)
Parental	+++	51		47		88
Combinations	gl_2bv_4	32		30		10
Recombinations		83		77		98
Region 1	+bv_4	25		20		19
	gl++	12		12		5
		37	20.9 (19)*	32	19.2 (19)*	24
Region 2	++v_4	23		18		21
	gl b+	29		31		14
		52	29.3 (21)	49	29.3 (21)	35

(more)

Progeny (Contd.)		48:610	%	48:608	%	48:607
Region 1 & 2	+b+	3		6		12
	gl+v	2		3		1
		5	2.8	9	5.4	13
Solid B		0		0		3
Total		177		167		170

Characters analyzed separately

+	102		91	
gl	75	42.4	76	45.6
$+=B^V$	88		80	
b	89	50.3	87	52.1
+	95		96	
v_4	82	46.3	71	42.5

* Numbers in parenthesis refer to crossover percentage in Cornell Memoir 180.

The crossover percentages correspond fairly close to those listed in Emerson, Beadle and Fraser (Cornell Memoir 180). They are considered to be in agreement when it is thought there was either perhaps some misclassification or differential mortality of v_4 and gl plants before classification. Plants were classified in the seedling stage and gl+, gl v_4, ++, and +v_4 plants were marked with different colored stakes that were present when the plants were classified for B^V and b in August. It will be noted the proportions of B and b plants approximate the expected proportions rather closely.

The fact that the linkage values of B^V correspond closely to B, also the fact that only the B and b plants occur (as a rule) in segregating populations, lead us to the conclusion that it is the B allele itself causing the variegation and not another gene causing B to mutate.

Occasionally B^V plants produce large sectors that are entirely purple, sometimes including a tassel branch. Pollen from such sectors applied to b plants produces mostly variegated plants, about the same proportion as pollen taken from a variegated sector. (Most of the data on the B^V inheritance are in the files at the Connecticut Experiment Station. They will be assembled and published soon.

2. Corn Grass - a possible ancestral type of maize.

In the 1947 Maize News Letter #21 we reported on a second "Teopod" mutation, that was also grown under the name of Corn Grass. Since the strain is quite distinct from Teopod, we prefer the original name of Corn Grass and are using the gene symbol CG since it is a dominant character. So far this stock has been maintained in the heterozygous condition although we expect to have a homozygous stock soon since it is being selfed in the greenhouse this winter.

Corn Grass plants respond markedly to different day lengths. In the field when grown during long days the plants tiller profusely and make a plant that resembles some of the native grasses much more than corn. (The differences between Corn Grass and normal corn are so great that students in taxonomic botany have failed to recognize Corn Grass as a relative of corn.) When Corn Grass is grown in the greenhouse with no supplemental light the plants assume a more upright position, produce fewer tillers and sometimes produce a tassel with functional pollen. Sowings at intervals of two weeks, beginning on August 15th, have demonstrated that the change in tillering takes place at the November 1st sowing. We expect to establish the date of sowing at which the normal Corn Grass type of growth will be resumed.

Corn Grass plants can be propagated asexually. In 1947 one clump was divided into four parts and the plants made good vegetative growth. In 1948 Herbert Everett at the Connecticut Station divided one clump of Corn Grass into 16 different plants which then continued to make a good growth. We are maintaining clonal lines of Corn Grass in the greenhouse at this Laboratory.

Attempts were made in 1948 to cause Corn Grass to mutate back to normal. Germinating seeds were X-rayed (75-600 r) and grown for a few days in a medium containing P^{32}. No vegetative mutants were observed. Higher dosages will be given in 1949; also Corn Grass plants will be grown in an area receiving continuous gamma rays in an effort to change Corn Grass to normal. This character behaves as a monogenic dominant. It could be due to a small chromosomal deficiency, or duplication. If it is a deficiency it will not be possible to secure a back-mutation; otherwise the chances of success seem fairly good.

Corn Grass has several of the characteristics that are required of an ancestral type.

A. It can be vegetatively propagated. Plants of such a type as Corn Grass could have been grown and propagated for centuries before mutating to a normal corn plant. In warm climates, perhaps it would be perennial.

B. The seeds are produced in "ears" varying from one

seed in a place to ears having a hundred seeds or more. (The larger ears are always produced in the greenhouse.) Most "ears" contain from one to ten seeds. Seeds from such plants would be easily dispersed and would give rise to a very few seedlings in one place. Hence, they would have wider dispersal than an ear of normal corn. Germinating seedlings would not crowd each other as is the case with a normal ear of corn.

C. A single gene change (at the most a change in a short chromosomal segment) is all that is necessary to make the step from Corn Grass to normal corn. It is rather remarkable that the difference between Corn Grass and corn can be due to a single gene, but the genetic evidence indicates this is so. Since the whole change from a grass-like ancestor to normal corn can be made at one "jump", is it necessary to postulate so many steps in the building up of an ear of corn ?

3. No supplemental light needed for certain corn plants.

The normal segregates from the heterozygous CG+ plants backcrossed to +, when planted at intervals of two weeks from August 15th, have been grown in the greenhouse without any additional light. The normal plants show no tendency towards sex reversal that is usually found in plants started in the early fall when the days are becoming shorter. Normal plants from several different sowing dates produced plants with good tassels and no silks at all in the tassel. Possibly the ++ plants received modifying genes from the Corn Grass. Or is corn perhaps not as sensitive to light as we have previously supposed ? No controls were grown so we cannot answer these questions. It is interesting that entirely normal corn plants can be grown in the fall of the year when the days are becoming rapidly shorter. The normal plants have been selfed and will be tested in the greenhouse this autumn.

4. Indeterminate plants id flower normally in greenhouse.

Indeterminate plants grown in the field never produce an ear or tassel. Such plants were dug before frost and transplanted into pails that were moved into the greenhouse. Also side branches of id plants were cut off and rooted, then put in pails of soil. Some of these vegetative cuttings made a normal growth, producing in November good tassels and silks. These plants were selfed so there will be available this year homozygous lines of id id plants.

5. Segregation for sucrose production in corn stalks.

F_2 and backcross progenies of the cross Tl x C 103 were grown and analyzed for production of sugar in the stalk juice. Progenies were grown both at Mt. Carmel, Connecticut, and at Yaphank, five miles from the Brookhaven National Laboratory. Sugar determinations were made by using a hand refractometer in the field. A

cylinder of corn stalk was cut from each stalk with a cork borer and a pair of blunt-nosed pliers was used to express a drop or two of juice onto the refractometer surface. With the Bausch and Lomb Hand Refractometer this amount of juice is sufficient for a reading with accuracy of half a per cent. Some of the samples at the Brookhaven Laboratory were analyzed for reducing sugars. There seems to be a fairly good correlation between refractometer reading and sucrose per cent. An excellent correlation exists in sugar cane for refractometer reading and sucrose per cent. So it is not surprising to find it in corn stalks.

The C 103 plants analyzed at New Haven gave readings of 10.8 to 15.3 for a total of 32 plants. At Yaphank 16 progenies ranged from 10.0 ± .67 to 15.1 ±.29, indicating that progress has already been made in selecting lines of C 103 that are fairly high in sucrose content.

The T1 lines examined at Yaphank varied from 8.1 ± .77 to 9.25 ±9.6, somewhat lower than C 103. Chemical tests in 1947 showed the sugar in the stalk of T1 to be composed largely of invert sugar, whereas the sugar of C 103 is largely sucrose. Possibly the hybrid T1 x 103 was not the best choice for the study of inheritance of sucrose percentage as undoubtedly the invert sugars of the T1 would cause a higher refractometer reading than comparable C 103 lines. Segregating progenies involving other lines crossed by C 103 are available for 1949 study. Another factor that may complicate the picture somewhat is the rather high variability within the C 103 line itself, and it is not known what particular C 103 line was used as the parent of the hybrid C 103 x T1. The rather wide range among progenies of C 103 for refractometer reading indicates that even supposedly pure lines can be quite heterozygous for factors which were not selected for or against.

With the above limitations in mind the data are presented in table 1. They fit a normal frequency distribution rather well, indicating several factors, at least, are responsible for sugar production in the stalk juice.

The data in table 1 are presented to show the variability within inbred lines and also the range in segregating progenies. Plants that produce no ear or a very poor ear usually run higher in sugar than those that produce a good ear, although it should be noted that some plants that have produced good ears also had a high refractometer reading. It is plants of this type that might eventually have commercial possibilities. By further selection within C 103 lines it should be possible to increase the sucrose content of this line.

Table 1. Refractometer readings for maize inbreds, their hybrids and segregating progenies

Pedigree	Refractometer reading - class centers at 1.5% intervals											
	3.3	4.8	6.3	7.8	9.3	10.8	12.3	13.8	15.3	16.8	18.3	19.8
C 103 (plants) Conn.						5	11	13	3			
C 103 (progenies) N.Y.					1	1	3	7	4			
F_1 C 103 x T1 (Conn.)				1	4	2	7	4	1			
F_1 C 103 x T1 (N.Y.)		1	6	10	6	3	4	2	3			
T1 Conn. (plants)								1	1	1	3	
T1 N.Y. (plants)	3	5	13	9	7	5	7	3				
T1 N.Y. (progenies) (above plants)				4	1							
(T1 x C 103) F_2 Conn.	1	10	21	24	38	36	30	11	4	1		
(T1 x C 103) F_2 Conn. ears with poor set of seed							3	1	4	8		
(T1 x C 103) F_2 N.Y.	3	10	19	32	30	34	14	6	5	0		
(T1 x C 103) F_2 N.Y. ears with poor set of seed				1	1	4	2	4	13	5	13	7
(T1·C 103) x C 103 (Conn.)	2	5	8	17	18	27	28	21	4	2		
(T1·C 103) x C 103 (Conn.) ears with poor set of seed		3	16	17	37	3	1	12	9	10		
(T1·C 103) x C 103 (N.Y.)		3	16	17	37	32	21	12	7			
(T1·C 103) x C 103 (N.Y.) ears with poor set of seed		1	1	2	1	2	1	2	2	4	2	

In addition, a thorough search of existing lines might reveal some with a high sucrose content. Among the few we have sampled there is great variability. In table 2 are given a few of the inbred lines already examined with the average refractometer readings found.

Table 2. Refractometer reading of Su Su inbred lines

Inbred line	Place tested	Plants with good ears	
		No. examined	Average
C 102-1	Brookhaven Laboratory	1	8.4
C 102-2	" "	3	9.5
C 102-3	" "	8	12.4
C 102 x 103	" "	3	8.0
C 1 7 x 103	" "	1	10.0
Kr	" "	6	8.2
C 1 7	" "	10	9.2
K 4	" "	4	4.9
Oh. 40 B-1	" "	5	4.3
Oh. 40 B-2	" "	5	6.7
Ill. A-1	" "	2	7.5
Ind. 38-11 C.T.	" "	7	10.7
Ind. 38-11	" "	5	9.1
Ind. WF 9	" "	8	6.8
BC WF 9	" "	9	7.1
BC WF 9-2	" "	7	9.0
LK	" "	6	8.1
W 22	Connecticut	12	12.9

With such a range in refractometer readings among the few inbred lines sampled, it seems to indicate that an extensive examination of inbred lines should be made. When more information is available on the genetics of sugar production in inbred lines of corn, it should be possible to study more adequately the physiology of sugar production, perhaps using tagged Carbon^{14} as a tracer in such a study. The first step is to isolate lines that are pure for sucrose production and to try to ascertain the number of factors involved. This is being investigated further.

We wish to thank Dr. D. F. Jones and the Connecticut Experiment Station for their coöperation in growing some of the lines and for assistance in making the refractometer readings.

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The mutational potential of single R alleles.

The mechanisms responsible for the wide array of allelic variability found among cultivated races of maize are as yet uninvestigated. The present study was projected in the hope that some insight relative to problems of gene evolution might be gained.

Careful selection of parental allelomorphs, in any attempt to evaluate the mutational potential of single loci, merits full consideration. An underlying consideration is the likelihood that different alleles are derived from one another by single or repeated mutations, or by unit steps from some single or few archetype genes. On the basis of what is now known concerning the spontaneous mutational behavior of the gene R^r (Stadler, Genetics 31: 1946), it is conceivable that some parental alleles might yield mutants with intermediate phenotypic effects, while others might either fail to mutate at all, or yield a restrictive class of gene alterations indistinquishable from the bottom recessive. Mendelizing variations of the latter class may well represent intragenic changes, but, in the absence of wholly satisfactory criteria, it is equally plausible that they are, in effect, minute chromatin losses beyond the present level of cytological detection.

As a preview to the outcome of this projected study, in which it is planned to test something on the order of half a million gametes for mutation at a single locus, all previously identified mutants from r^{ch} were assembled in a single planting for comparison and further study of their properties. The writers are deeply grateful to Professor L. J. Stadler, who generously provided laboratory and field facilities for this study during the summer of 1948.

All mutants described here derived from a single extracted r^{ch} allele. Consequently, they are somewhat indicative of the evolutionary mutational potential for the locus.

From among all R^r and r^r alleles studied to date, r^{ch} was selected as the parental allelomorph for intensive study, since in plant color phenotype it represents the closest approximation to the wild type form. It is characterized by the broadest, most intense pigmentation pattern in the majority of susceptible tissues of the seedling and flowering plant. But, because this allele falls into the r^r category (colorless aleurone series), our study is restricted to mutational changes resulting in altered pigmentation patterns in only the vegetative, diploid tissues. It is hoped that further surveys of new collections will disclose R^r strains equivalent to r^{ch}

in plant color phenotype. A suitable $\underline{R}^{ch}$ stock, if found, would provide the nearly ideal parental gene for a study of gene evolution at this locus. Mutational changes, and their interactions, as they affect all aspects of $\underline{R}^{ch}$ action in the plant, seed, and pericarp, would then be available for analysis. It is a pleasure to acknowledge here the coöperation of Dr. E. G. Anderson, who has supplied us with a large number of new accessions among which $\underline{R}^{ch}$ alleles are being sought. Seed samples from other investigators, particularly of colored aleurone and cherry pericarp effect, would be appreciated.

The tentative designations and salient features of the mutants studied are given in table 1. Mutants, which arose in crosses effected with irradiated pollen, cannot yet be considered as alterations induced by the treatment. Further data bearing on the relative frequencies of the specific mutational changes in treated and controlled material are required before this question can be settled effectively. Such cautioned interpretation applies, in particular, to mutants distinguishable from the bottom recessive by their positive action, and which, moreover, are free from associated changes in gametophytic viability.

Table 1. Mutations of $\underline{r}^{ch}$

Mutant	Treatment	Remarks
r^{ch}-S1	none	transmits low rate of sectorials
r^{ch}-S2	"	" high " " "
r^{ch}-S5	"	" " " " "
r^{ch}-X32	X-ray	mutant lost - not pollen transmissible
r^{ch}-V1	U.V.	original mutant sectorial - stabilized to r^{ch} - not pollen transmissible
r^{ch}-V2	"	tests not completed
r^{ch}-V10	U.V.	stable intermediate allele
rg -S2	none	wholly green - male, female transmission normal
rg -S3	"	" " " " " " "
rg -S4	"	tests not completed
rg -X1	X-ray	wholly green - 50% pollen abortion, female transmissible
rg -X6	"	" " - tests not completed
rg -X7	"	" " - approx. 60% pollen abortion
r^{g} -V1	U.V.	" " - " 30% " "
rg -V2	"	" " - " 40% " "

As given in table 1 the mutants fall into four more or less well-defined categories: A. mutation to unstable alleles, B. mutation to stable alleles with intermediate effects, C. mutations to the bottom recessive with normal viability in the gametophyte, D. mutations to the bottom recessive, r^g, associated with reduced haplophase viability.

1. Mutations to r^g.

A sharp distinction cannot be drawn between mutants to r^g in groups C and D. It is expected rather, as Stadler and Roman have demonstrated in their study of A_1 mutants (Genetics 33: 1948), that an intergrading spectrum of effects could be assembled ranging from minute deficiencies to mutations indistinguishable from the bottom recessive. For the mutants of r^{ch} to r^g with lowered haploid viability, there is little doubt that these alterations may safely be ascribed to physical loss of the locus, or its inactivation. Earlier preliminary study of these forms by Perak, however, failed to disclose any gross abnormality in pachytene configuration. It is not implied that all mutations to r^g, though phenotypically alike, are identical in nature. There is no reason to assume that allelic compounds in this class might not have positive action in plant coloration. Appropriate tests of this hypothesis are now in progress.

2. Mutation to a stable intermediate, r^{ch}-V10.

The single mutant in group B, r^{ch}-V10, is of considerable interest. It represents what is probably the first mutation to an allele of intermediate effect within the r^r series. Though it arose in progeny of a mating effected with ultra-violet irradiated pollen, there is nothing to indicate that it is an induced alteration rather than a coincident spontaneous mutation. Further quantitative studies are clearly needed.

From seedling on, and just prior to flowering, plants carrying this allele in the homozygous state are nearly devoid of anthocyanin in all tissues. At tasseling and dehiscence, however, an intense depostion of pigment occurs in the tips of the staminate glumes. After flowering, a much reduced generalized coloration of the glumes is evident. In addition, considerable color is found in the silks, and also in the pericarp of ears known to carry the dominant form of the gene pl. These tissues are colored to about the same extent in plants carrying either the parental r^{ch} factor or the mutant r^{ch}-V10, though perhaps somewhat reduced in the latter. Objective tests of this suspected difference in action will be carried out in backcross progenies segregating for both alleles. Thus, r^{ch}-V10 represents a mutational change, the effect of which is permissive of coloration in some tissues pigmented by the parental r^{ch} gene, but fails to do so in others. It follows therefore that coloration of

the silks, pericarp, etc. is indicative of a gene-controlled reaction more or less independent of the action leading to pigment synthesis in other tissues. It was in this sense that independent coloration of the plant and aleurone led to the opinion that the action of $\underline{R}^r$ was due either to separable, more or less independent components of action of a single reduplicating unit, or to the action of two completely linked genes or subgenes of similar though divergent effect. The mutational origin of $\underline{r}^{ch}$-V10 seems to indicate that the plant color complex may be resolved into still other components of action.

Analysis of the action for $\underline{R}^r$ alleles has already shown that color intensity in the silks and pericarp vary independently in some alleles. It is not unreasonable to suppose therefore that single gene mutations might affect pigmentation in the one tissue, and not in the other. $\underline{R}^r$ alleles which yield wholly green plants but for coloration of the glumes or silks are described in the early literature. An allele yielding a green plant but with cherry pericarp effect has not yet been found. However, in light of the above, one might predict that type alleles of this nature are derivable from $\underline{r}^{ch}$-V10 or that they may already exist in the pool of allelic variability found in cultivated races.

3. Complex allelic interaction.

Preliminary studies further indicate the peculiar properties of the $\underline{r}^{ch}$-V10 mutant. In the cross $\underline{R}^r$-Tomi/$\underline{r}^g$ x $r^g/\underline{r}^{ch}$-V10, it was noted that the compounds ($\underline{R}^r$-Tomi/$\underline{r}^{ch}$-V10) exhibited a broader, more intense pigmentation when compared to the other segregates. Thus, some tissues not colored by either homozygote are found pigmented in their compound. This suggests a new type of allelic interaction not previously encountered at this locus.

4. Mutation to unstable alleles.

The unstable mutants of group A, as far as they have been studied, give substantially the same data and are therefore considered collectively. In each instance the mutant arose as a single plant in progenies that were screened for mutations. They were detected by the absence of coloration on the first emerging leaf tip, an area regularly colored in the $\underline{r}^{ch}$ stock. During seedling growth sectors for anthocyanin were observed on the epicotyl, coleoptile, leaf sheath, and blade. The appearance of the sectors was such as to indicate that the colored areas were related in cell lineage. Sectors of independent lineage were found on the same seedling in many cases. At flowering, some sectors were found that extended to the tassel. Branches with colored glumes threw anthers that were full purple to variegated in color, while green glumes outside the sector yielded anthers wholly green in color, or at best very faintly stippled with an occasional speck of anthocyanin. Where plants carried the gene Pl a bizarre sectoring of the pericarp was observed, similar in general aspect to

the phenotype given by occasional ears of the factor $\underline{P}^{v}$.

In the F_2 progeny of the selfed mutant ($\underline{r}^{ch}$-S_x/rg) approximately $\frac{1}{4}$ were wholly green. Presumably, these represent the $\underline{r}^{g}$ homozygotes. Among the remaining plants three classes of phenotypic effect were observed; those fully $\underline{r}^{ch}$ in phenotype and indistinguishable from the original parental allele, those similar in pigment pattern to $\underline{r}^{ch}$ but with a much reduced level of effect, and those which were sectorial in appearance. The size and frequency of sectoring varied widely in different plants.

The newly derived $\underline{r}^{ch}$ and the intermediate, now designated $\underline{r}^{ch}$-lt, show normal transmission rates in both male and female germ lines. Progeny tests totaling some 75 plants for either derivative gave no evidence of sectoring. Tentatively, they are presumed to be reverse mutations from an unstable allele similar in phenotype to $\underline{r}^{g}$. In the one case, the reversion is complete, and in the other only partial. Partial reversions constitute an available source of new intermediate mutations. The data is not sufficient to indicate whether these intermediate reversions are all alike or whether they represent different levels at which the unstable form can become fixed.

The behavior of variegated plants on outcrossing is instructive as to the nature of the sectoring process. A particularly favorable tassel sector was found in an $\underline{r}^{ch}$-S_3/$\underline{r}^{g}$ plant. An outcross test to sib ears of the $\underline{R}^{r}$-Catspaw/$\underline{r}^{g}$ strain was made using pollen from red anthers within the sector and also from green anthers just outside the sector. Among 70 plants grown from colored and colorless seed, from the cross involving green anthers, only two were found to be variegated. Sectors on these plants were small, infrequent, and not observable at all stages of growth. In a progeny of similar size and constitution, from the cross made with pollen from red anthers, 29 of the 70 plants showed sectoring or full $\underline{r}^{ch}$ color. By far, the majority of plants were sectorial rather than self-colored. There can be little doubt that the sectoring is a cell-specific phenotypic indicator for an altered state of the locus.

Tests of the male and female transmission rate for the sectorial quality show that different plants diverge widely in the extent to which they transmit this phenotype to their progeny. In one case, of 66 plants, half of which were expected to show the sectorial phenotype, only one sectorial was found in the test of female transmission and three in the test of male transmission. In a second instance, in a total of 163 plants, where half were expected to show the altered phenotype, 77 were found to be either $\underline{r}^{ch}$ or sectorial. The data also suggest that the rate of complete reversion is somewhat higher in the pollen than it is in the female germ line.

All data considered, it would seem as though a variable factor exists which controls both the time and frequency of mutation at the newly established unstable locus.

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A total of 385 translocations now have been analyzed cytologically to determine the position of the breaks. These data are summarized in table 1 by chromosome arms. The translocations in group 1 include those listed in last year's report with a few additions. Those listed in group 2 are recently acquired stocks.

Table 1. Frequency of chromosome breaks in each of the 20 maize chromosome arms

Group 1				Group 2			
Chromosome	Arm	Breaks No.	Breaks per u No.	Chromosome	Arm	Breaks No.	Breaks per u No.
1	S	21.5	.60	1	S	18	.50
1	L	31.5	.68	1	L	25	.54
2	S	14.	.47	2	S	12	.41
2	L	42.	1.14	2	L	15	.41
3	S	11.5	.56	3	S	13	.63
3	L	33.5	.81	3	L	19	.46
4	S	21.	.97	4	S	14	.62
4	L	21.	.58	4	L	20	.55
5	S	24.5	.90	5	S	18	.66
5	L	31.5	.97	5	L	27	.83
6	S	9.5	.80	6	S	11	.92
6	L	33.5	.91	6	L	21	.57
7	S	8.	.65	7	S	8	.65
7	L	26.	.76	7	L	22	.64
8	S	13.	1.15	8	S	15	1.33
8	L	27.	.75	8	L	27	.75
9	S	6.	.39	9	S	13	.85
9	L	32.	1.14	9	L	20	.71
10	S	8.	.82	10	S	5	.51
10	L	25.	.92	10	L	7	.26
Total		440	Mean .796	Total		330	Mean .597

To analyze these data further so as to show a variation in density of breakage points along the chromosome arm, a second table has been prepared.

Table 2. Frequency of breaks, expressed in per cent, for the sum of each 5 micron section of the 20 chromosome arms beginning at the fibre attachment

Group	1st 5 u	2nd 5 u	3rd 5 u	4th 5 u	5th 5 u	6th 5 u	7th 5 u	8th 5 u
1	20.8	21.3	14.2	12.4	12.7	11.1	5.4	2.2
2	19.7	22.6	9.7	10.9	10.7	14.3	6.7	5.5

A. E. Longley

Viviparous$_5$ (vp$_5$) has been located in the short arm of chromosome 1 by means of a test with translocation B-1b. This viviparous shows pale endosperm color, premature germination and albino seedlings. A heterozygous vp$_5$ plant pollinated by TB-1b pollen gave some pale endosperm seeds which became dormant (deficient endosperm and hyperploid embryo), and also normal yellow endosperm seeds which germinated prematurely (hyperploid endosperm and deficient embryo). In addition to placing the gene in the short arm of chromosome 1, these data show that dormancy is in this case determined by the embryo itself, not by the composition of the endosperm.

D. S. Robertson

We are undertaking a genetical-biochemical study of the development of the endosperm of maize, centering about the "indole cycle" involving tryptophane, auxin, niacin, protein and carbohydrate relationships. This study is based largely upon the findings in Neurospora together with some information available in maize and other plants. Tryptophane appears to be formed by condensation of indole and serine, and in turn to give rise, through one chain of reactions, to niacin, and through a very different chain, to auxin (indole acetic acid). It may also become a protein constituent. How general this pattern may be is not known but the maize story will undoubtedly bear a strong resemblance to this part of the Neurospora story. Some additional features are evident, however.

1. During the development of the maize endosperm, an extremely high concentration of indoleacetic acid is built up, with a peak about the late milk or early dough stages, then dropping down to a lower level during the latter part of the development. A minor portion of this is in the form of free or active auxin, the balance recoverable upon hydrolysis ("bound auxin" or "auxin precursor"). The total amount formed is so great that if it is produced from tryptophane, it would seriously deplete the amount of tryptophane available for conversion to niacin or for protein building.

2. The niacin content of corn is low compared with wheat and most other cereals, which is of special interest as niacin acts as a pellagra preventative.

3. Zein, the principal reserve protein of the corn endosperm is deficient in tryptophane as well as lysine. From published accounts of cereal chemistry it appears that zein is formed chiefly in the later stages of endosperm development. The earlier formed proteins, globulin and glutelin, are rich in tryptophane and lysine.

4. There is a clearly defined correlation between sugary texture of the endosperm and the niacin content (Barton-Wright and Mather,

Cameron and Teas), also a relation between the amylose-amylopectin ratio and sugary genetic composition. The nature of these relationships is not clear.

5. Earlier work of Hixon, Sprague, and others have shown waxy starch to be composed entirely of amylopectin. Waxy corn also appears to have higher niacin content than the corresponding non-waxy; also higher auxin content.

We plan to chart the normal development by assaying a series of stages from pollination to maturity to determine the quantities present of the related components, such as free auxin, total auxin, niacin, tryptophane, carbohydrate, protein, etc. Using this as the expected standard behavior, a survey will be made of a large number of endosperm types differing from the standard by single gene differences, utilizing some of the known endosperm genes, and also a large selection of the numerous mutant endosperm types obtained from our studies on radiation effects. Those showing large departures from the standard will be studied further to determine, as best we can, the primary effect of the particular gene upon the indole cycle and the general consequences thereof. It is hoped that this will give us valuable information on the chemosynthesis of the tryptophane derivatives, which in turn may be of importance to our breeding program designed to increase the tryptophane or niacin content of commercial lines, or to modify the amylose ratio.

Assays for free auxin and total auxin have been completed for the ontogenetic stages of our standard normal (CC5/L317) and work is in progress on other series (Melvin Stehsel). Assays on niacin, carbohydrates, etc. are in progress on the same series (H. J. Teas, J. M. Cameron, Anna C. Newton). Sample assays of mature endosperm of several genetic types show that significant differences are to be expected. Favorable mutant endosperm types are being converted to the same general background as our standards and the bulk of our translocation lines.

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1. Formulae for predicting number of crosses from all-combination data.

The following formulae have been found to be useful in dealing with yield data of all-combination field trials. Letting "n" represent the initial number of inbreds, the well-known formula 1/2n (n-1) predicts the total number of single crosses, while 1/2n (n-1) (n-2) shows the number of three-way crosses which can be predicted from the single cross yields, and 1/8n (n-1) (n-2) (n-3) gives the number of double crosses which can be predicted from the same single cross yields. The following table shows the relationships obtained by use of these formulae with various numbers of inbreds used initially in making up the all-combination single crosses. In every case all reciprocal combinations are excluded.

Number of inbreds	Possible number of crosses of two inbreds	Possible number of crosses of three inbreds	Possible number of crosses of four inbreds
1	0	0	0
2	1	0	0
3	3	3	0
4	6	12	3
5	10	30	15
6	15	60	45
7	21	105	105
8	28	168	210
9	36	252	378
10	45	360	630

2. Chlorophyll deficiency studies.

Recently lines have been developed similar to the one reported in the 1945 Maize News Letter by Brunson, in which the dark kernels are always correlated to normal green seedlings, while the light kernels germinate to give chlorophyll deficient seedlings. Note also the Y_7 gene on chromosome 7 reported by Graner in Maize News Letter of 1947. These chlorophyll deficiencies range from albino to pseudo-normal pale green in color and, as reported in Genetics Abstracts (33:609 Everett 1948), are caused by the presence of an albino mutation and a subsequent suppressor gene mutation respectively. These deficiency types will be supplied to Cornell for distribution next fall by Eyster of the Kettering Laboratory who has offered to increase the stocks this summer in coöperation with the Connecticut Station. Studies of these chlorophyll types are in progress and will be described more completely in a future publication.

Herbert L. Everett

3. Cytoplasmic male sterility.

In 1946 a study was initiated to determine the cause of variability in pollen production among male sterile lines. This is the same character studied by Rhoades (Jour. Genetics 27:71-93. 1933). As a basis for further work, analyses of individual florets from a single plant were made. This eliminated the possible effects of genotype or environment. The results of such analyses do not give a continuous distribution of well-developed pollen grains normally distributed about a mean. Instead, a discontinuous distribution with peaks at 58-60, 37-39 and 13-15 per cent is had. This suggests the probability of a Poisson distribution. Since this factor cannot be transferred through the pollen, it can be assumed that the per cent of good pollen represents the class with 0 particles. Since 0 particles can be estimated by the formula e^{-m}, it can be seen that the values obtained in the frequency distributions are the equivalent of .5, 1.0, and 2.0 particles as a mean number per pollen grain initiated.

The particle number in the cells of the various florets is relatively constant although sufficient variability is found to cause frequency distributions to be polymodal. If anthers within a floret are compared, results suggest less variability between anthers than between florets. Distribution at megasporogenesis also follows the Poisson.

Warren H. Gabelman

4. Genes producing heterosis.

The recessive mutations of a degenerative nature such as dwarf plants, crooked stalk, pale chlorophyll, narrow leaf and others which show heterosis when crossed back to the normal inbred lines in which they originated, have now been extracted from these crosses and compared with the original lines. Both the normal homozygous dominants and the degenerate homozygous recessives come out of these crosses larger than they went in, as shown by preliminary tests. A statistical comparison of these extracted deviations is now being made. The indication is clear that other genes are involved. Whether these originated at the same time the visible alterations appeared, or whether they were previously in these lines and carried along by enforced heterozygosity has not been determined.

Additional evidence for genes having a small but significant effect on heterosis are being obtained from backcrosses using dominant gene markers that have no noticeable effect on yield, such as the normal alleles of glossy seedlings, white cob, white endosperm and colorless silk. After seven generations of backcrossing without selection, the resulting plants both with homozygous recessive and

heterozygous dominant gene markers are slightly larger in growth and earlier in flowering than the original lines. This indicates that there are many genes closely linked with these marker genes that have a small effect on heterosis.

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Another diploid Tripsacum from Mexico.

The first diploid Tripsacum known to Mexico was discovered by the writers in 1947 at Acahuizotla, Guerrero. This diploid was corn-like in that it had very broad leaves 12 to 15 cm. in width; thick, leafy stalks; a tall, robust growth habit and many spikes in the tassel. In fact the number of tassel branches, which ranged from 20 to 27 in the specimens that were collected for detailed study, exceeds the number found in most existing varieties of Mexican corn.

Following the discovery of this diploid in 1947, search for additional diploids was continued in that year and again in 1948. A very grass-like form of reduced stature, extremely narrow leaves and with but one or two tassel branches was collected from a steep, rocky slope along the highway to Acapulco in the very arid Cañada del Zopilote 273.5 kilometers south of Mexico, D.F. When this collection was made on September 11, 1947, most of the plants had flowered. A quantity of immature seed was collected as well as live plant material and herbarium specimens including spikes still shedding pollen. The very youngest available inflorescences still in the bud stage were preserved for cytological study. From subsequent examination of the immature staminate spikes a single sporocyte preparation was obtained which indicated that the plants were tetraploid. Not being fully satisfied with this determination (this preparation might have been from a tetraploid sector in an otherwise diploid plant) an attempt was made to germinate some of the seed in order to obtain seedling root-tip counts. This first attempt failed.

Returning from extensive explorations in the fall of 1948, which ranged as far north as Tepic in western Mexico and east to Vera Cruz, without discovering additional diploids except for more of the Acahuizotla type in that general locality, the 1947 collections were reexamined and another attempt was made to germinate samples of seed that had failed to germinate in earlier trials. Tripsacum seed often germinates very poorly, but seedlings frequently can be obtained from samples that cannot be germinated in the usual manner by utilizing the embryo culture technique.

A special effort was made to embryo culture the immature seed of the 1947 Zopilote collection. These plants were suspected of being diploid at the time they were first collected. Their reduced size, their very narrow leaves and the small size of their anthers and pollen as compared with the more typical specimens of T. lanceolatum, which they resembled most closely, suggested the size relationships that exist among the well-known diploid and tetraploid forms of T. dactyloides found in the United States. Five seedlings were obtained from the Zopilote seed and root tips were collected from three of them for cytological examination. All three seedlings were found to be diploids with 36 or approximately 36 chromosomes.

The discovery of a diploid Tripsacum of an extreme T. lanceolatum type in southern Mexico completes the assemblage of diploid representatives of all of the more important species complexes in the genus throughout its present range in the Western Hemisphere. Others reported previously include the diploid T. floridanum of southern Florida, the diploid of T. dactyloides which occurs from Kansas southward to Texas, the diploid T. australe of Brazil and the Acahuizotla diploid which resembles T. pilosum more closely than any other known species.

L. F. Randolph and
E. Hernandez

Crossability of corn and Tripsacum and the evolutionary history of the American Maydeae.

The cross incompatibility of Mexican and Guatemalan Tripsacum and corn has been demonstrated by three years of field experiments in regions of these countries where both Tripsacum and teosinte occur. The failure to obtain hybrid progeny from crosses involving the native corn of these regions supports the theory that corn, Tripsacum and teosinte originated from a common ancestor a long time ago. These experiments invalidate the alternative theory of Mangelsdorf and Reeves that important characteristics of modern varieties of corn originated in recent times from the natural hybridization of Tripsacum and corn in Central America and that teosinte is a product of such hybridization.

The very great diversity of existing types of corn, teosinte and Tripsacum in southern Mexico suggests that these plants have had a very long evolutionary history in this region and that the center of origin of corn and its near relatives was here rather than elsewhere in Central or South America. This simple interpretation is fully in accord with the Vavilov hypothesis that the center of origin of cultivated plants is to be sought in the regions of greatest diversity of the existing cultivated forms and their wild relatives.

The first hybrids of maize and Tripsacum were obtained by Mangelsdorf and Reeves in 1929. They crossed both the diploid and the tetraploid forms of T. dactyloides with diploid corn. These crosses, which they made in Texas presumably with southern varieties of corn, have been repeated at Ithaca.

In using vigorous commercial corn hybrids, chiefly from the northern corn belt, little difficulty was experienced in obtaining large numbers of hybrids. The cross between 2n corn and 4n T. dactyloides ordinarily was much easier to make than the 2n corn x 2n T. dactyloides cross; from some of the hybrid ears of the former cross seedlings were obtained with the embryo culture technique from more than 50 per cent of the corn ovules to which Tripsacum pollen was applied. Tetraploid corn crosses readily with tetraploid T. dactyloides but the hybrids obtained thus far were highly sterile.

Repeated attempts to obtain hybrids between the tetraploid Tripsacums of Guatemala and Mexico and the native diploid corn of the regions where the Tripsacum occurs have failed completely. The Guatemala trials were reported in an earlier News Letter, over 200 corn ear shoots having been pollinated with tetraploid Tripsacum pollen without obtaining any hybrids. Similar experiments conducted in Mexico with 50 or more ear shoots being pollinated at each of three different locations in 1947 failed to yield any hybrids. In 1948 additional tests were conducted in Mexico at the Jolostoc field station of the Rockefeller Foundation where Dr. E. J. Wellhausen very kindly made available stocks of 6 different types of Mexican corn. These were crossed with pollen of the Acahuizotla diploid Tripsacum, and a few crosses also were made with pollen of a broad-leafed 4n Tripsacum of the T. pilosum type. A total of 95 ears were pollinated, sufficient to test from 25,000 to 30,000 corn gametes for cross compatibility. Unfortunately, a very severe infestation of ear worms destroyed many of the ears completely and limited the test to approximately 2,000 gametes. No hybrids were obtained from any of the crosses made at Jolostoc in 1948.

Admittedly these tests of crossability of Tripsacum and corn in Mexico and Guatemala are not sufficiently extensive to warrant the conclusion that hybrids cannot be obtained from such crosses. Certain favorable combinations of genotypes not included in these tests might be compatible. But it can be concluded at present that there is a high degree of cross incompatibility among the combinations tested, and that Mexican and Guatemalan Tripsacum and corn cannot be crossed as readily as can the T. dactyloides and corn of the United States. Mangelsdorf and Reeves based their theory of the origin of corn on the crosses with T. dactyloides in Texas and did not subject their hypotheses to direct experimental verification in the region where natural hybridization of Tripsacum and primitive corn was assumed to have occurred.

The crossing experiments which I have conducted in Mexico

during the past two years and the cytological and field studies of the various forms of Tripsacum and teosinte native in Mexico and Guatemala have convinced me that corn and Tripsacum and teosinte have existed as separate entities for long periods of time in these countries.

Tetraploid Tripsacum occurs over wide areas in both Mexico and Guatemala and is extremely variable. Species limits are poorly defined in many localities. There is clear evidence of hybridization and recombination of characters which have been used in defining the species. Intermediates between the broad-leafed T. pilosum type and the T. lanceolatum type with narrow leaves are very prevalent.

Cytological examination of the tetraploids revealed the presence of multivalent association of chromosomes, indicating that they were of relatively recent origin and suggesting that the diploid ancestral species might still exist. It was postulated that the variability of the existing tetraploids was due to hybridization of diploid species similar to T. lanceolatum and T. pilosum, followed by chromosome doubling and segregation in the new tetraploid populations as they spread rapidly into the areas where they are found at the present time. Or, independent chromosome doubling in each of these species followed by hybridization of the autoploids derivatives could have accomplished the same result.

The problem then was to find the ancestral diploids. They were looked for, and both were found within 60 kilometers of each other in southern Mexico. As described elsewhere, the diploid of the T. pilosum type is a very tall, broad-leafed plant with a thick stalk and many spikes in the terminal inflorescence. The diploid of the T. lanceolatum type is a low grass-like plant, very leafy at the base and having a relatively short, slender stalk with only one or two spikes in the terminal inflorescence.

These new 36-chromosome forms are referred to as diploids although it is conceivable that they are themselves tetraploids of remote ancestral species having 18 or 20 chromosomes like Manisuris or corn. Sporocytes of the Acahuizotla diploid have been examined and 18 pairs of chromosomes were seen. There was no evidence of multivalents, and until evidence either of their autoploid or alloploid nature is forthcoming they will continue to be referred to as diploids. However, it should be pointed out in this connection that longstanding differences in chromosome number between the progenitors of maize and Tripsacum must have prevailed and must have constituted a formidable barrier to the establishment in nature of hybrids between them.

The evidence from the known distribution of diploid and tetraploid forms of Tripsacum as well as the cytological evidence indicates that tetraploidy in the genus became established in relatively recent times. Diploidy is found at the limits of the geographic range of the species: to the southward in Brazil, where the diploid T. australe

occurs and northward in the United States where the diploid form of T. dactyloides occurs as far north as Kansas. T. floridanum of southern Florida is also diploid. The tetraploid form of T. dactyloides in the United States may have originated as an autoploid independently of the alloploids of Mexico and Guatemala. Further study of the Tripsacum of northern Mexico is needed to clarify this situation.

Comparison of the existing forms of diploid Tripsacum reveals two distinct evolutionary trends. At one extreme are the grass-like types of T. lanceolatum and allied species, of which the new diploid from Cañada del Zopilote represents the highest degree of specialization in this direction. These types have a slender stem, narrow leaves and few tassel branches. They are adapted to survival in dry arid climates as well as in moist situations. Such forms thrive on steep, rocky banks in full sunlight as well as on moist, shaded, rocky ledges and occasionally in roadside ditches. At the other extreme are the more corn-like forms of the T. pilosum type which have thick leafy stalks, very broad leaves and are adapted to moist rich soil. The Acahuizotla diploid is of this type but there are tetraploids of very similar appearance and growth habit.

It is idle to speculate about the derivation of these forms at present; but it is obvious that fewer mutational steps would have been required for the evolution of corn from a prototype resembling the latter than from a prototype resembling the former species of Tripsacum.

In this connection it is perhaps significant that existing types of native corn in Mexico and Guatemala exhibit morphological variations similar to those described above for Tripsacum. There are narrow-leafed types with slender stalks and few tassel branches. There are also very broad-leafed types with thick stalks and many tassel branches, as well as innumerable combinations of these and other traits which are sometimes referred to as "tripsacoid". Resemblances of this sort indicate that Tripsacum and corn have many genes in common. This is to be expected in species so closely related that they can be hybridized. In fact it has been estimated that 85 per cent or more of the genes in cross compatible species are identical. In view of the cross incompatibility of existing forms of Mexican Tripsacum and corn, it seems highly improbable that the characteristics, which they have in common, were due to hybridization in the recent past. Most of these similarities probably were due to inheritance from a common ancestor. A limited number may have arisen more recently by independent mutation.

The persistence of the two extreme types of diploid Tripsacum, within a short distance of each other in southern Mexico in a region where teosinte and tetraploid Tripsacum are abundant over wide areas, suggests that this general region might have been the primary center in which the gradual differentiation of Tripsacum, Euchlaena and Zea from a common, but very remote, ancestral form took place. In this connection it may be significant that, at the present

time, this general region is near the center of the geographic range of both Tripsacum and Euchlaena. Furthermore, it is generally believed that the cultivation of corn originated among the prehistoric Indian civilizations that migrated into and through this area over a period of many centuries.

If Zea, Tripsacum and Euchlaena originated from a common ancestor in southern Mexico or elsewhere in this general region, the cross incompatibility of Tripsacum and corn in this area at the present time is understandable on the assumption that genic cross incompatibility was the isolating mechanism responsible for their delimitation and segregation. As differentiation proceeded and Tripsacum spread northward into the United States, geographical, ecological, or other isolating mechanisms may have operated to maintain the autonomy of new species such as T. dactyloides. Genic incompatibility might have disappeared or was never present in these northern populations. This is one possible explanation of the fact that T. dactyloides crosses readily with corn under certain conditions and the Tripsacum of southern Mexico and Guatemala does not cross readily when similar techniques are employed.

It is questionable whether natural hybridization of Tripsacum and Zea in recent times would have resulted in the origination of new species or a significant admixture of Tripsacum and corn germplasm. The experimental hybrids of Zea and Tripsacum are functionally male sterile and only occasional unreduced female gametes have been known to function in backcrosses to either parent. Thus the first generation hybrids cannot produce segregating populations. The plants of the first backcross to corn have 38 chromosomes including two sets of corn chromosomes and one set of 18 Tripsacum chromosomes; in these plants the Tripsacum chromosomes assort at random as univalents in meiosis and tend to disappear rapidly in later generations due to elimination at meiosis and selection against gametes carrying extra chromosomes. If the Tripsacum chromosomes are unable to substitute for corn chromosomes or exchange segments with them in the formation of functional gametes, their association with the corn chromosomes in these few hybrid generations before they are lost is devoid of evolutionary significance.

Corn plants lacking Tripsacum chromosomes have been recovered in the second generation backcross progenies, which appear to be phenotypically pure corn, and no evidence of segments of Tripsacum chromosomes has yet appeared in the cytological examination of these and other plants in the same cultures.

A study of the cytology and genetics of each of the 18 Tripsacum chromosomes comprising the haploid set in combination with two sets of corn chromosomes is now in progress. These "trisomics" should be favorable material for a critical analysis of the degree of homology existing among Tripsacum and corn chromosomes.

L. F. Randolph

Induction of mutations with nitrogen mustards.

Since 1946, a series of experiments were conducted to test the genetic effectiveness of tris - (B-chloroethyl) amine and di - (B-chloroethyl) methyl amine in maize. The methods of chemical treatment were: (1) soaking pre-germinated and dry seeds in 0.25% aqueous solution of the hydrochloride salt of the mustards at intervals of 2, 4, 6, and 8 hours; (2) exposing freshly shed pollen grains to the vapors of 0.4% solution of mustard salt buffered at pH-8.6, temperature 65° C, and (3) dipping the cut basal end of the tassel in a 0.25% solution of salts of both mustards at 10, 18, and 36-hour durations.

The usual technique for the identification of the genetic effects of mutagens was used, namely, a multiple dominant stock (C, Pr, Su, Lg_1, Bm_2 and B) was treated and the pollen grains applied to the silk of a multiple recessive stock (c, pr, su, lg_1, bm_2, and b). Endosperm deficiencies for dominant marker genes and dominant gene losses for plant characters are revealed by the appearance of the recessive characters in the F_1 seeds and F_1 plants respectively. The haplo-viability of the F_1 plants were checked by examination of the pollen grain fertility. Cytological examinations of sporocytes from plants exhibiting pollen sterility were made to determine the types of chromosomal aberrations induced by the mustards. Frequency of mutations for endosperm characters were determined from F_2 ears.

In the summer of 1948, X-ray and mustard gas treatments were carried out simultaneously so that the genetic effects of the two mutagens could be compared adequately.

Mutations were not obtained by seed treatment with the two mustards but there was an adverse effect on seed viability and phenocopies were produced. A high percentage of two-week-old seedlings arising from treated seeds exhibited a temporary chlorophyl-deficiency of the midrib. The 1208 plants that survived the seed treatment were all normal except for four plants that showed permanent sectorial chlorophyl deficiency which was not transmitted to the offspring.

The di - (B-chloroethyl) methyl amine proved to be more toxic to maize than the tris - (B-chloroethyl) amine. In most of the treatments where the former was used, the grain set was reduced to a minimum and seed abnormalities to a maximum. Although the mutagenic action of di - (B-chloroethyl) methyl amine is undoubtedly qualitatively the same as tris - (B-chloroethyl) amine, the former so reduced seed formation that the relation between dosage and genetic effectiveness was difficult to determine.

Tris - (B-chloroethyl) amine proved to be a very effective chemical mutagen when the multiple dominant tassel was dipped in a 0.25% aqueous solution of its salt. The results for the 18-hour

treatment were as follows:

1947 - Seeds examined = 1963

Deficiencies for gene C:	entire	- 9.4%;	sectorial	- 3.9%
Pr:	"	-10.3%;	"	- 1.6%
Su:	"	-14.8%;	"	- 2.5%

1948 - Seeds examined = 613

Deficiencies for gene C:	entire	-16.0%;	sectorial	- 2.4%
Pr:	"	- 5.2%;	"	- 0.7%
Su:	"	-17.9%;	"	- 3.4%.

The 36-hour treatment of the tassel yielded the highest percentage of endosperm deficiencies, but due to the great reduction in set of grains (especially in the 1948 experiments), the results can hardly be considered significant. When the tassel was given a 48-hour treatment, pollen grains were not shed at all.

The three endosperm characters, C, Pr, and Su, showed equal vulnerability to tris - (B-chloroethyl) amine or conversely - the mustard action on these genes is not selective. When the sectorial deficiencies for the 10-hour, 18-hour and 36-hour treatments were considered, the results showed a definite trend for increase in the number of sectorials as duration of treatment was prolonged.

The endosperm character mutations were determined from ears in the F_2 generation following treatment with tris - (B-chloroethyl) amine. The average mutation percentage for 10-hour, 18-hour and 36-hour treatments was for C - 1.6%, Pr - 3.3%, and Su - 1.4%. This mutation percentage for each gene should theoretically be equal to the percentage of the corresponding endosperm deficiencies because the male and endosperm gametes in the pollen grain should have the same chance of being acted upon by the mustard. But the endosperm mutations obtained were less frequent than the endosperm deficiencies observed. One of the feasible explanations for such a discrepancy is the low F_1 seeds viability which never exceeded 50% for any treatment. The mutation percentage shown by the F_2 seeds and F_1 plants is the minimum, for it represents only the mutations capable of survival in the environment in which these plants were grown. Many of the induced hereditary modifications may have been lethal but could not be detected. Attempts were made to grow the abnormal F_1 seeds in artificial media as excised embryos, and they were provided with the best environment our facilities could offer. Yet a high percentage of these seeds proved inviable. Of the 572 F_1 viable plants from the tris - (B-chloroethyl) amine treatments, 73 (12.7%) were semi-sterile. Cytological examinations of the sporocytes of these haplo-inviable individuals revealed the following chromosomal aberrations: translocations, inversions, deletions, laggards, sticky kinetochores and desynapsis of chromosomes at the first meiotic division. The cause of the defective pollen in other F_1 plants could not be detected cytologically. The number of semi-lethal plants and other

morphological monstrosities is directly proportional to the duration of the treatment.

Forty-four F_1 progenies revealed dominant gene marker losses: Gene B - 3.8%; Lg_1 - 2.4%; Bm_2 - 3.1%. Fifteen of these 44 had normal pollen and it was considered that these losses could be gene or point mutations; whereas, the rest all exhibited haplo-inviability which can be due to deletions, asymetrical exchanges or non-union of breaks in the chromosomes.

The highest endosperm deficiencies induced by X-ray radiations of pollen grains were: Gene C - 6.3% from 2000 r; Gene Pr - 3.0% from 2250 r and Gene Su - 3.7% from 2000 r. This mutagenic capacity of the X-rays is roughly equivalent to the 10-hour dipping treatment of the cut tassel using tris - (B-chloroethyl) amine which effected the following deficiencies: C - 6.6%; Pr - 1.1%; Su - 5.8%. The abundant production of sectorial deficiencies by mustard treatments, as contrasted to their scarcity in X-ray treatments, is a distinct difference between the genetic effects of the two mutagens.

Other chemicals were tested for mutagenic action. Acenaphthene, paradichlorobenzene, ethylene glycol, potassium thiocyanate and ethyl carbamate did not show significant endosperm deficiencies. But phenol, B-naphthyl amine, formalin, methylcolanthrene and ceepryn were considered to have mutagenic properties for maize, judging from the endosperm deficiencies they induced. Ceepryn proved to be very promising, since it produced an average of 9.8% endosperm deficiencies involving C, Pr and Su, computed on per-locus basis. From the results of the preliminary experiments on maize with these compounds the range of effective dosage has been determined.

D. L. Umali

Inheritance of kernel-row number.

During the months preceding Dr. Emerson's death he had been engaged in summarizing his work of many years on the inheritance of number of kernel rows in maize. It has been possible, with this material available which included some tabulated data and a partly completed manuscript, to go back through the records and construct a fairly complete picture of the results he had obtained. On the basis of the information collected a paper has been written and is being submitted for publication. The substance of the paper is outlined below.

The original material used consisted of thirteen 12-rowed, three 10-rowed and six 8-rowed inbreds. Even after many generations of inbreeding each line continued to show variability for row number, e.g., among individuals of the 12-rowed lines there were characteristically many with 10 and with 14 rows, and somewhat fewer with 8

and 16 rows on the ear. The lines were tested for homozygosity of row-number genes by demonstrating that selection of ears with diverse row numbers as parents had no differential effect on the mean row number of their progeny. Similar tests were conducted on F_1's between inbred lines with the same result; namely, that selection was ineffective.

The thirteen 12-rowed genotypes were crossed in all possible combinations to produce 78 F_1's. Of these 76 had deviations in the plus direction from the mid-parent value. The average increment was +0.85 rows. The six 8-rowed genotypes were also crossed in all possible combinations to produce 15 F_1's. Of these 10 had deviations in the plus direction from the mid-parent value. The average increment was +0.09 rows. The 8- and 12-rowed genotypes were then intercrossed in all possible combinations (except one) to produce 77 F_1's. Of these 45 deviated from the mid-parent value in a minus direction. The average increment was -0.15 rows. The deviations, with the possible exception of the data on 8-x8-rowed crosses, were statistically significant.

A plausible interpretation of these results was considered to be: (1) that the 8-rowed genotypes contained a preponderance of dominant genes for decreasing row number, that they differed from each other by relatively few of these genes and that the slight plus increment of average F_1 over mid-parent value could be accounted for by general hybrid vigor of the plant; (2) that the 12-rowed genotypes contained a more nearly equal number of dominant plus and minus modifiers for row number and that the greater plus increment of average F_1 over mid-parent value was due primarily to general hybrid vigor (not as greatly counteracted by a preponderance of dominant minus modifiers as in the 8-rowed lines), and (3) that the average minus deviation of the 8-x12-rowed F_1's from the mid-parent value could be accounted for by a preponderance of minus modifiers by which the 8- and 12-rowed genotypes were presumed to differ (sufficient in number or magnitude of effect to more than counteract the influence of hybrid vigor).

In order to determine whether the 12-rowed phenotypes differed from each other by genes for row number, segregating progenies (usually F_3 to F_5) from 66 F_1's (all possible combinations among 12 of the 13 inbreds) were selected for high and for low row number. Selection was effective in shifting the mean in at least 63 of these progenies. It was concluded, therefore, that 10 of the inbreds each differed from the other eleven by genes for row number and the remaining two could be the same as only one other line. This being the case, it should have been possible to accumulate additional modifiers in either direction by selection in progeny derived from crosses involving many lines.

Six extracted lines, each derived from crossing four original 12-rowed inbreds together, were developed by inbreeding and

selection for a high number of rows for five generations. The means of these four-line derivatives were raised above that possible in selections from crosses between two lines. Finally, three extracted lines of multiple genotype origin (each derived from intercrosses involving seven of the 12-rowed inbreds) were developed by inbreeding and selection for high row number for five generations. In the F_5 generation of these three lines the mode was raised to 22 kernel rows. It has been possible to show, therefore, that by hybridization among 12-rowed phenotypes, recombination and selection, modifying genes for increasing row number were accumulated so that the expression of this character was raised from 12 to 22 kernel rows on the ear.

H. H. Smith

Linkage between translocations and row-number genes.

As part of an extensive study on the inheritance of kernel-row number in maize, the late Dr. R. A. Emerson was interested in obtaining experimental evidence on the number and location of genes affecting the expression of this quantitative character. In tests similar to those of Lindstrom (Iowa Agr. Exp. Sta. Bul. 142. 1931) Doctor Emerson collected considerable data on apparent linkages between genes for kernel-row number and known marker genes. He concluded from his results, however, that some (if not all) of the associations observed were due to the effects of the "qualitative" genes themselves on row number.

In order to avoid this false evidence of linkage, a study similar to those of Burnham and Cartledge (1939) and Saboe and Hayes (1941) was planned. In this method chromosomal interchanges serve as genetic markers and plants heterozygous for a translocation show no apparent difference from normal other than reduced fertility. The semisterility, caused by abortion of approximately 50% of both ovules and pollen, is used as a "dominant" marker in backcross tests.

According to the records available Dr. E. G. Anderson and Dr. C. R. Burnham supplied Doctor Emerson with 36 different interchanges so chosen that each of the chromosomes was reasonably well represented. The locations of the points of breakage have been determined by Doctors Anderson and Burnham as shown in their published and unpublished data.

The interchanges were crossed repeatedly to a series of different 8-rowed lines in order to obtain, without loss of vigor, heterozygous interchanges in lines with 8-kernel rows on the ear. By the summer of 1947, 35 of the interchanges were present in a heterozygous condition in vigorous 8-rowed lines and at that time four 12-rowed inbreds were crossed to each of these lines. Although there was a tendency for the F_1 plants heterozygous for the interchanges to have a slightly lower mean number of rows than their normal

sibs, the differences were not significant at the 1% level of probability.

This year the backcross progeny will be grown and the plants classified for row number and semisterility. The data will be analyzed for evidence of linkages between genes for lower row number and semisterility or higher row number and fertility.

T. J. Mann

Ga 4 and pericarp-color ratios.

In three previous News Letters (17:8-10, 1943; 18:7-8, 1944 and 20:4-9, 1946), Dr. R. A. Emerson reported aberrant pericarp-color ratios and a gamete factor, Ga 4, which was shown to be responsible for the deficiency of P alleles in the progenies. It was shown that Ga 4 interferes with the functioning of pollen carrying it. When this gene is linked with P, plants heterozygous for P, when selfed or used as pollen parents in crosses with white, give progenies with an excess of white-eared plants instead of the respective 3:1 and 1:1 ratios as expected. No disturbance results when these plants are used as pistillate parents.

Before his death in 1947, Dr. Emerson had accumulated two more years' data like that which he previously reported. In addition he left a wealth of material of advanced generations involving crosses of Ga 4 with several translocations in the short arm of chromosome 1. A large amount of this material was planted in 1948 in order to obtain data for a more critical test of linkage relations. However, not enough significant data of this type was obtained to be of use yet. Hence the present report includes that data presented in the 1946 News Letter to which has been added similar data accumulated in the three years' records since.

The ratios of red to white observed in all aberrant cultures of whatever generations are listed below, together with those in which heterozygous reds were used as pistillate parents. It will be noticed that the additional data have only very slightly changed the ratios reported in 1946.

Parent plants		Progenies			
Type	Number	Number plants		Ratio	%
		Red	White	R:W	Red
W/R (♾)	117	3816	3079	1.24:1	55.34
W/(W/R)	46	800	3156	1:3.94	20.2
(W/R)/W	54	1895	1919	1:1.01	49.7

In the first two types above, two variables determine the numbers of aberrant and normal cultures resulting in the next generation; namely, the amount of crossing over between Ga 4 and P, and the per cent of functioning Ga 4 pollen. Since these two variables cannot be measured simultaneously here, Emerson used the third type to evaluate the amount of crossing over alone. Since there is here no question of pollen differentials, the per cent of normal cultures, resulting from red ears, should be the per cent crossing over. He found this value to be 17.9. Of 37 additional reds tested in 1947, seven gave normal ratios, an indicated value of 18.9% crossing over. Since Ga 4 is shifted to white-carrying gametes when lost from red-carrying ones, Emerson made use of cob colors to obtain the number of whites that gave aberrant ratios (deficiency of whites) in the next generation. He thereby found a value of 12.5 for crossing over in 32 progenies tested. The per cent calculated from all of these 97 progenies is 16.5, a slightly higher value than that reported in 1946.

In parallel studies, Emerson used crosses of white with homozygous red, the latter being heterozygous for Ga 4 and used as the pollen parent, to measure the per cent of functioning Ga 4 pollen. This value was calculated to be 30%. Presumably, in order to get a further measure of this value as it is affected by different growing seasons, similar lots of data were obtained in 1946 and 1947. Out of a total of 106 progenies, 40 gave aberrant ratios in F_2, thereby giving a value of 37.7%. Recalculating this value for the total of 136 progenies that have been tested, we find that 36% of the pollen carried Ga 4 as measured by this method.

As in 1946, we see that observed ratios do not correspond at all well with calculated ratios that would result from using the above values for crossing over and functioning of Ga 4 pollen. Therefore, we may conclude that on the basis of the numbers involved and of the seasons in which they were tested, these methods of independent measurements are not satisfactory. Further data involving two genes linked with Ga 4 must be obtained to evaluate the variables simultaneously by the method of Mangelsdorf and Jones and applied to certain 1943 data of this type by Emerson. Evidence on linkage relations of Ga 4 remain inconclusive even with the data accumulated since 1945.

In order to test the hypothesis that Ga 4 acts to reduce the growth rate of the pollen tube, 10 red ears from an aberrant 1947 selfed culture were selected. One hundred kernels were planted separately from the butt and from the tip of the ears in 1948. Of these 10, three ears gave aberrant ratios. However, in none of the three was there a significant difference of aberrant ratios between the tip and the butt of the ear; in fact, one ear gave almost identical numbers of red and white from both areas. Therefore, there seems to be no relation between the distance the pollen tube must grow to effect fertilization and the greater success of the normal pollen.

James E. Wright, Jr.

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Parent-offspring regression.

If failure of ear-row breeding for yield is established but not fully explained, and if hybrids of second cycle lines are scarcely more productive than those of first cycle lines, explanations may be sought in peculiarities of the parent-offspring regression. It may be that both reputed failures will have the same explanation.

The present purpose is to propose the essentials of a variation of experimental approach. Practical details are omitted mostly.

Grow 1000 individuals of a common crossbred variety in such manner as to minimize environmental variations. Record an appropriate measure of vigor for each plant and sort into a frequency distribution of 10 groups or more. Breed within groups to obtain 10 progenies. Record the same measure of vigor for progenies as for parents. Plot means of parent groups against means of progeny groups to obtain the regression curve.

It will be of interest to learn if the curve has a positive slope throughout or if it may bend down at the right end as our present evidence might lead us to suspect. If this suspicion is verified, it will follow that the most elite individuals are not the best parents. It would then be of further interest to note the optimal parent grade - the highest point on the curve. It would also be desirable to determine variances of individuals within groups of progenies to learn if variance of those from the top parent group is greater than of those from the optimal parent group as we might expect if elite individuals have above-average heterozygosity.

The foregoing has been general so it may apply also with small animals which may be better suited than corn for such an experiment.

With corn, cross breeding may be done within parent groups or parents may be selfed. Both might well be done. Cross breeding should provide results of more general application. Further, the selection processes may be continued by choosing elite individuals again from the top group and "optimal" from the indicated optimal group, thus to compare effects of selecting from different sections of the range. Selfing may accentuate curvature of regression, and thus make experimental verification more certain, particularly of any downward trend at the right. Results from selfing would also bear more directly on the problem of which grade of parent plants may produce the stronger inbred lines.

Earlier regression studies with yield or vigor have not been

designed to detect much more than that the general trend was positive. From this it was concluded that elite individuals must be the best parents.

It may seem that a generally positive regression of offspring on parent for yield or vigor of corn - an appreciable heritability - is contradictory to a theory of overdominance. We may note that zero heritability and regression are expected only when there is an equilibrium of selection or vice versa. If the number of progeny left by every individual is proportional to its phenotype, the population should theoretically reach an equilibrium where heritability is zero. This condition may be met by "survival value" in nature. It is hardly to be expected with prized characters of varieties and breeds, which have been developed by culling less desirable individuals. From data of the above experiment, estimates may be made of progress from saving any proportion or any part of the population.

Where there is considerable extra advantage of heterozygosity, strong selection, saving the top one per cent or less may degrade gene frequency; selection may have a negative effect on the mean, even though initial gene frequency is below equilibrium. Paradoxically, weak selection, culling only 30 to 40 per cent, may improve gene frequency and the population mean. These considerations have suggested the above experimental approach and the hope that it may be effected with various characters of more than the one species.

Fred H. Hull

Iowa State College
Ames, Iowa

During the 1948 season 100 monoploid maize plants were obtained, all of maternal origin. Of these, 43 were from dent corns, 53 from sweet corns and 4 from genetic stocks. The average frequency of occurrence was about 1/900 in the dent corns and 1/375 in the sweet. Twenty-eight of the sweet corn monoploids were derived from a sample of 3,814 hybrid kernels of which Robson's Golden Cross Bantam was the seed parent. Ignoring this sample, the average frequency of occurrence in the sweet corns tested was 1/640.

About 1/5 of the monoploids yielded one or more kernels on selfing and about 1/3 set seed upon outcrossing. Most of the pollen used in selfing was obtained from diploid sectors in the tassels of the monoploids. The rate of spontaneous doubling of the chromosome complement in these plants appears to be fairly high, as evidenced by occasional anthers of normal (2n) size, full of viable pollen.

Sectors noted ranged from a part of a single anther to whole florets, tassel branches, and, in one case, the whole tassel. In colchicine treated plants more sectors were noted and the plants yielded about three times as many kernels per plant (average, 10 kernels) as the untreated controls on selfing and outcrossing. In cases where only one to three kernels were obtained germination tended to be poor.

In material being examined at present approximately 100 more maternal monoploids have been found and one paternal monoploid. From 300 to 400 monoploid plants should be available for study this season. In addition a number of homozygous lines derived from monoploids are being grown for study and increase.

Sherret S. Chase

John Innes Horticultural Institution
Merton Park, London, England

1. Sweet corn trials.

Seventy-seven hybrids and varieties which I had recently brought to England from the United States and Canada were compared with our two standard varieties, Canada Gold and Extra Early Bantam. There was a wide range of behaviour in germination, plant type, ear characteristics, smut and frit fly damage, earliness and yield. Not only was geographical origin important, but also the breeder in that region who was responsible for a particular hybrid. Some breeders in North America produced more suitable material for our conditions than others.

2. Inbreds.

American inbreds had a wide range of maturity and other characteristics in England. From my observations of all the leading inbreds, I am convinced that if we are to have really worth while ones in this country, they must be produced on the spot. I have, therefore, started inbreeding our selected cold-hardy lines of Canada Gold and other material in order to produce cold-hardy inbreds. These will be sown in February so that cold-hardiness selection is maintained as we continue to inbreed.

3. Supersonics.

In collaboration with Mr. Selman of King's College, London, I have also investigated the influence of supersonic treatment on sweet corn. Inspection of results indicates that supersonic treatment does have an effect in that weaker seedlings are killed off. Thus the averages of treated material, compared with the controls,

for such characters as growth, height, and tiller number, is slightly higher. But on allowing for this, it is found that supersonic treatment of various intensities has little, if any, influence. This disagrees with the results of Wallace but is in agreement with Hersh.

4. Cold hardiness.

The selections of cold-hardy sweet corn varieties have been continued. One line of Canada Gold germinated 84% for February sowing. Seed of this has been bulked and it has also been crossed with C 13 to see if it makes a hardy John Innes Hybrid No. 2.

5. Miscellaneous.

A summary of experimental work in sweet corn breeding at the John Innes is now published in "The Fruit, the Seed and the Soil" (Oliver and Boyd, Edinburgh) and edited by C. D. Darlington. Dr. K. Mather, who was formerly in charge of corn researches at this Institution, has now transferred to Birmingham University.

Gordon Haskell

Pioneer Hi-Bred Corn Company
Johnston, Iowa

Josephson and Jenkins (Jour. Amer. Soc. Agron. 40:) have shown that partial male sterility occurs in hybrids in which the inbred Ind. 33-16 is used on the female side of the cross. An analysis of the degree of pollen abortion in single cross combinations, involving 33-16, Ky27, H21 and C.I. 61, confirms the results of Josephson and Jenkins. Single crosses in which 33-16 was used as a seed parent produced an average of 46% aborted pollen, with considerable variation in the degree of sterility between plants. Crosses in which 33-16 was used as a male parent produced only normal pollen. Pollen abortion, but to a lesser degree (approximately 25%), was observed in crosses involving Ky27 as a female. Fertile and partially sterile plants were examined cytologically to determine whether or not the cytoplasmic male sterile condition was associated with abnormal chromosome behavior during microsporogenesis. Meiosis was normal in all plants examined. Pollen, in most cases, seems to degenerate prior to the first pollen grain mitosis.

In addition to this material, five cytoplasmic male sterile yellow single crosses supplied by Dr. D. F. Jones were also studied cytologically. Abortive pollen in these crosses ranged from 75 to 100%. As was true in the case of the white hybrids, microsporogenesis was normal in this material, including those plants that produced 100 % abortive pollen at anthesis. This condition appears to be

similar cytologically to that of several completely or partially sterile species hybrids.

William L. Brown and
Mary Ann Coyle

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(Department of Agronomy)

Evidence has been obtained that $\underline{su}_x$ is effective in reacting with su to increase amylose content as well as increasing the percentage of total sugars as Horowitz reported in last year's News Letter. The triple recessive su du $\underline{su}_x$ should be of interest now to see whether amylose content is further increased. In addition it would be of interest to determine whether the combination du $\underline{su}_x$ will increase amylose without causing extreme wrinkling. We expect to study wx in combination with these factors. Isogenic lines are being established in a dent inbred to get a more precise measure of gene effects on sugars, water soluble polysaccharides and starch formation of these various combinations as well as any new ones which seem to affect amylose content.

Table 1. Per cent of amylose in endosperm starch of eight lines of corn and reciprocal crosses between them

Series	Homozygous P_1	Recessives P_2	Per cent amylose			
			P_1 selfed	$P_1 \times P_2$	$P_2 \times P_1$	P_2 selfed
1	su wx	wx	0.0	0.0	0.0	0.0
2	wx	-	0.0	20.0	22.2	22.3
3	su wx	-	0.0	17.3	24.0	22.3
4	wx	su	0.0	20.9	24.9	26.6
5	su wx	su	0.0	21.3	24.6	26.6
6	-	su	22.3	24.3	24.1	26.6
7	-	$su^{am}du$	22.3	25.8	27.1	44.2
8	su	$su^{am}du$	26.6	25.4	27.5	44.2
9	-	su du	22.3	26.1	25.7	50.9
10	su	su du	26.6	28.2	30.4	50.9
11	$su^{am}du$	su du	44.2	49.3	49.2	50.9
12	-	su_x	22.3	24.2	26.9	35.9
13	su	su_x	26.6	25.3	26.7	35.9
14	-	$susu_x$	22.3	23.9	26.4	49.5
15	su	$susu_x$	26.6	25.8	36.9	49.5
16	su_x	$susu_x$	35.9	34.8	43.4	49.5

In our studies $\underline{su_2}$ seemed to give about the same amylose values as did $\underline{su_x}$ and crosses between $\underline{su_x}$ and $\underline{su_2}$ stocks were about the same. Some data involving selfs and crosses between dent, waxy, amylaceous sugary, Cameron's supersugary, sugary-x, Horowitz' supersugary, sugary, and sugarywaxy are summarized in table 1.

Herbert H. Kramer and
Roy L. Whistler

(Department of Botany and Plant Pathology)

Non-reciprocal cross-sterility in the popcorns.

In many intervarietal crosses between popcorns there is little or no seed set when the cross is made one way while the reciprocal cross shows a normal set of seed. The inability of South American inbreds to set seed when pollinated by Supergold inbreds has long been known as has the incompatibility of White Rice and Hulless with dent corns.

Our investigations during the summer of 1948 have shown that the phenomenon is widespread. A crossing block was set up with nine popcorn inbreds of diverse origins and one dent corn inbred. All the inbreds had been inbred for at least three years and some were inbreds of long standing. Within this crossing block all possible combinations of crosses were made reciprocally and the resultant ears were scored for sterility. Generally the results were clear-cut with either a full seed set or else a nearly barren cob with none to a few scattered seeds. Table 1 summarizes the reactions with + denoting a full set and - denoting incompatibility.

The point to be noted is that the inbreds fall into three groups: (I) those that will not pollinate one or more inbreds (Hy, S.G. 18 and 1708-4), (II) those that will not set seed when pollinated by one or more inbreds (S.A. 24, 1001-52, 4541-U, 845-1B and 4524-4), and (III) those that do not participate in incompatibility reactions as either male or female parent (A3-1 and 4519-41). Further, there is apparently no overlapping between groups. No inbred has yet been observed to function in one incompatibility reaction as a female and in another as a male parent.

These data suggest that cross-sterility is conditioned by the interaction of genic components of the first group with genic components of the second when inbreds of the first group are used as male parents. An alternative hypothesis would be the interaction of a gene or genes from Group I with the cytoplasm of Group II. However, the fact that the F_2's of crosses of a Group I inbred times a Group II inbred segregate for sterility to Group I pollen appears to obviate this possibility.

Table 1. Sterility test - 1948

	Dent	Supergold	Baby Golden	South American	Hulless	Black Beauty	Ohio Yellow	Red	Amber Pearl	White Rice
Male	Hy	S. G. 18	1708-4	S. A. 24	1001-52	4541-U	845-1B	4524-4	A3-1	4519-41
Female										
Hy	+	+	+	+	+	+	+	+	+	+
S. G. 18	+	+	+	+	+	+	+	+	+	+
1708-4	+	+	+	+	+	+	+	+	+	+
S. A. 24	-	-	+	+	+	+	+	+	+	+
1001-52	-	-	?	+	+	+	+	+	+	+
4541-U	-	-	?	+	+	+	+	+	+	+
845-1B	-	-	-	+	+	+	+	+	+	+
4524-4	-	-	+	+	+	+	+	+	+	+
A3-1	+	+	+	+	+	+	+	+	+	+
4519-41	+	+	+	+	+	+	+	+	+	+

Of Group I, S. G. 18 and Hy acted in an identical manner while 1708-4 would not induce setting in 845-1B and doubtfully in 1001-52 and 4541-U. In Group II, S. A. 24 and 4524-4 acted alike in not setting seed with S. G. 18 and Hy while 845-1B and possibly 1001-52 and 4541-U also were sterile with 1708-4. All Group II inbreds show a common inability to set seed when S. G. 18 and Hy are used as male parents with the further possibility that they may be sterile to 1708-4.

In 1947 ten Hulless inbreds were tested with six different dent corn inbreds and hybrids (H21, Ind. 210, Tr, H5, C 103, and Hy x Wf). Nine lines gave only sterile reactions while the tenth was perfectly fertile. The dent lines tested appear to carry uniformly the factor or factors giving an interaction with most Hulless lines.

In all cases investigated the inability of Group I inbreds to induce setting in Group II stocks and the failure of Group II inbreds to set with pollen of Group I seem to act as recessives in crosses with inbreds not of their own group. All crosses (without reference to which parent was used as a female) of Group I inbreds with Group II inbreds will give normal seed sets when pollinated by Group I, and pollen from the same crosses appears to induce normal seed sets in Group II inbreds. In this case, however, without linked markers it cannot be shown whether or not all gametes are functional on Group II stigmas.

With regard to the genetic constitution of Group I it can be shown that the inability of another Supergold line (S. G. 16) to pollinate S. A. 24 is due to a single recessive factor. The F_1 (S. G. 16 x S. A. 24) will give full seed sets when used to pollinate S. A. 24 although as mentioned above it cannot be shown that all gametes are functional. When the F_1 is backcrossed to S. G. 16 approximately one-half of the backcross progeny will show a sterility reaction when used to pollinate S. A. 24 while the other half give normal pollinations. This is shown in table 2.

Table 2.

Pedigree	Ability to Pollinate S. A. Plants	
(S. G. 16 x S.A. 24) x S. G. 16		
6358 - 2, 3, 4, 5, 7, 10, 12, 15	+	(9)
- 6, 9, 11, 13	-	(4)
6852 - 2, 3, 4, 5, 11, 12, 14, 16	+	(8)
- 6, 7, 8, 9, 10, 13, 15, 17	-	(8)
S. G. 16 x (S. G. 16 x S. A. 24)		
6359 - 1, 4, 6, 7, 9, 14, 15	+	(7)
- 2, 3, 5, 10, 11, 12, 13	-	(7)
6381 - 1, 2, 7, 9, 10, 11, 15	+	(7)
- 3, 4, 5, 6, 8, 12, 14, 16, 17	-	(9)
Total	+	31
	-	28

The genetic constitution of Group II inbreds has also been investigated. In the summer of 1948 a detasseling plot in which the male parents were the dent corn hybrids Ind. 813 and 210 was set up. The female rows were reciprocal crosses of an S_2 Hulless inbred with an open-pollinated South American stock together with the F_2's and reciprocal backcrosses to the South American stock and to the S_4 generation of the Hulless inbred. The original Hulless parent and the line used in backcrossing were also included in the test. The ears were scored for sterility at harvest. The sterility of the Group II varieties is apparently a plant character since, in general, the seed sets were either normal or almost entirely lacking without the semi-sterility that would be expected if it were an ovule factor. The original Hulless inbred was shown to be heterozygous for the factors conditioning sterility, since it segregated for normal and sterile plants while all the plants of the S_4 inbred were completely sterile. Analysis of the backcrosses and F_2 progeny has led to the tentative conclusion that there are three complementary genes conditioning the ability of the Hulless and South American stocks to set seed with dent corn pollen. The presence of the homozygous recessive alleles at any locus will result in sterility when pollinated by dent corn.

It is postulated that non-reciprocal cross-sterilities in the popcorns are due to the interaction of the genic components of the lines of popcorn (and dent corn) designated as Groups I and II. In at least one case it is known that the interaction between a Group I inbred and a Group II inbred is conditioned in the Group I inbred by a single recessive factor. In two Group II stocks it has been postulated that three complementary genes are operative and the presence of the homozygous recessive at any locus gives plants with a sterile reaction to Group I pollen. It is further suggested that these sterility mechanisms offer a solution to the problem of producing hybrid popcorn seed free from dent corn contamination. A backcrossing program is underway at Purdue to transfer sterility factors to dent corn pollen into the best Supergold inbreds.

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1. Phenol reaction.

In a local maize from Barquisimeto (Venezuela) an fn (colorless phenol reaction) was found. Tested with the previous fn (News Letter No. 22:35-39. 1948) they proved to be alleles.

The phenol reaction is a pericarp character. Nevertheless, the colorless genotype fn gives in the recently formed grain a colored

reaction. The expected "colorless" reaction of the fn grains appears in more advanced stages of the kernels. Considering the pericarp as a dead tissue, the above result suggests that the diastase involved in the "colored" reaction is not originated in the pericarp itself, but in another tissue from which it spreads to the pericarp. If so, this diastase, perhaps, would be found in every corn, but in the fn (colorless genotype) there would be an inhibition to its diffusion to the pericarp of the growing kernel. It is generally observed that the pericarp gets a deeper color near the basal region of the embryo.

Dora M. de Zerpa

2. Zebra-necrosis.

Zebra-necrosis is linked with Og giving about 14.9% of recombination in a backcross population of 94 individuals (News Letter No. 22:42-43. 1948).

The following data were obtained in a backcross with zn and g in a population of 253 individuals.

$$\left(\frac{+\ g}{zn\ +}\right) \times zn\text{-}g$$

Family	+ +	g +	+ zn	g zn	Total
48-1525	13	20	22	13	68
48-1526	6	22	29	3	60
48-1527	10	21	25	5	61
48-1528	8	23	27	6	64
Total	37	86	103	27	253

Recombination zn-g = 25.3%

zn is to the left of g, but the present experiment is inconclusive in establishing the position of zn in relation to Og. A three point test is now being carried out including Og, zn and g.

J. M. Guevara

3. ms_x and j_x.

The offspring of a selfed plant of the "Chuco" variety of corn contained male sterile and japonica type. Both characters are recessive and transmitted through pollen and eggs. The following limited data suggest that they are linked. We use for them the

symbols $\underline{ms}_x$ and $\underline{j}_x$.

$$\left(\frac{+ \quad +}{ms_x \quad j_x}\right) (x)$$

Family	+ +	+ ms_x	j_x +	j_x ms_x	Total
1	10	5	1	4	20
2	12	2	1	2	17
Total	22	7	2	6	37

Recombination $\underline{ms}_x$-$\underline{j}_x$ = 22.8% ±0.08%.

P. M. Obregon

4. $\underline{su}_x$ and $\underline{su}_2$ (Eyster).

These are allelomorphic.

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Waxy endosperm starch from the genotype $\underline{su}_1$ $\underline{su}_1$ Du Du wx wx is 100% amylopectin, while $\underline{su}_1$ $\underline{su}_1$ Du Du Wx Wx starch is about 60% amylopectin and 40% amylose, and $\underline{su}_1$ $\underline{su}_1$ du du Wx Wx is about 35% amylopectin and 65% amylose. It was conceivable that in the combination $\underline{su}_1$ $\underline{su}_1$ du du wx wx the gene du might interfere with the usual effect of wx so that some amylose would be formed, giving an endosperm which would stain blue with iodine. This apparently is not the case. Selfed ears from four F_1 plants of the genotype $\underline{su}_1$ $\underline{su}_1$ Du du Wx wx each gave distinctly less than the normal 25% of red-staining kernels, but this can be attributed to the well-known behavior of Wx wx pollen on $\underline{su}_1$ $\underline{su}_1$ silks. Two F_2 plants obtained from red-staining (wx wx) kernels were selfed and also outcrossed to a $\underline{su}_1^{am}$ du tester to determine their genotype as regards du. The outcross ears were half sugary and half starchy, indicating that the tested plants were Du du. The two selfed ears had 301 kernels, all red-staining. Presumably about one-fourth of these were homozygous du, yet still produced only red-staining amylopectin. The pollen of these two plants was also 100% red-staining, even though half of the grains were du.

Linkage data has been obtained which adds to Mangelsdorf's evidence that du is on chromosome 10. The numbers of plants are small but the results are convincing. Translocation 4-10b su_1 Du of E. G. Anderson was crossed with a + su_1 du line. The F_1 was backcrossed by + su_1^{am} du, yielding starchy seeds (su_1^{am} su_1 Du du) and sugary seeds (su_1^{am} su_1 du du). The two types were separated at planting and the following data on pollen sterility obtained:

Plant genotype	No. plants	Pollen	
		Semisterile	Normal
su_1^{am} su Du du	15	15	0
su_1^{am} su du du	10	0	10

This is linkage of Du with the translocation with less than 4% crossingover.

Translocation 9-10b Su_1 Du was crossed by + su_1 du and the F_1 backcrossed by + su_1 du. The resulting seeds included four endosperm types as follows:

(1) Su_1 Su_1 su_1 Du Du du — Starchy; smooth cap
(2) Su_1 Su_1 su_1 du du du — Starchy; deep cap depression
(3) su_1 su_1 su_1 Du Du du — Sugary
(4) su_1 su_1 su_1 du du du — Sugary
; not easily separable.

Type (1) in this material was easily separable from type (2) and the following pollen data were obtained on the resulting plants:

Plant genotype	No. plants	Pollen	
		Semisterile	Normal
(1) Su_1 su_1 Du du	19	19	0
(2) Su_1 su_1 du du	19	1	18

Du again shows linkage with the translocation with 2.6% crossingover. Chromosome 10 was the common member in the two translocations used.

James W. Cameron

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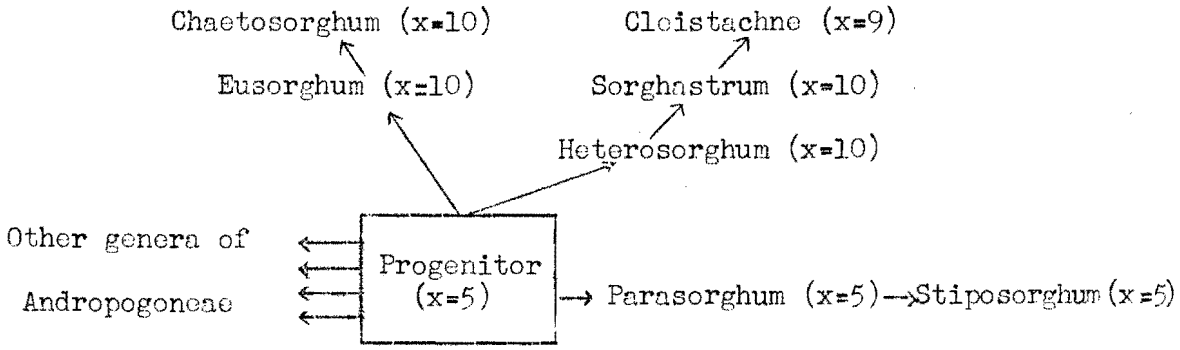
A cytotaxonomic study of the genus Sorghum made clear the need for a taxonomic revision. Six subgenera have been established on the basis of cytology, morphology, and distribution. The subgenera Parasorghum and Stiposorghum have a basic chromosome number of five. The pachytene chromosomes of species in the subgenus Stiposorghum compare favorably with those of Zea mays. The other four subgenera, Eusorghum (S. vulgare), Chaetosorghum, Heterosorghum, and Sorghastrum, have "basic" chromosome numbers that are multiples of ten. These four groups may have had their origin in tetraploid progenitors. The closely related genus Cleistachne has a basic chromosome number of nine. This advanced genus may have originated from a tetraploid Sorghum ancestor after a chromosome had been eliminated. The following diagram illustrates the probable course of evolution:



The probable center of origin of the genus and probably of the tribe Andropogoneae may be found in southeastern Asia. This hypothesis successfully meets the greatest number of objections.

It is interesting to speculate whether the tribe Tripsaceae which is closely related to the Andropogoneae also may have had its origin in southeastern Asia. Genera are found in the Tripsaceae with the basic chromosome number of 5, 9, and 10. The genus Coix with the basic chromosome number of five is restricted to southeastern Asia; Tripsacum, an advanced genus, with a basic chromosome number of nine is found in the New World with a genus (Zea) having a basic chromosome number of ten. Whereas Zea mays may have originated in the New World, its ancestral form may have had its origin in southeastern Asia.

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1. Illinois chemical strains.

The 49th generation of the Illinois experiment on selection for chemical composition was grown in 1948. Mean analyses for the first and the last five generations of this experiment are shown in the following table:

Year	% oil		% protein	
	High oil	Low oil	High protein	Low protein
1896	4.70	4.70	10.92	10.92
1940	12.57	1.36	19.92	6.19
1941	13.73	1.02	17.76	5.79
1945	12.62	1.53	17.60	6.27
1946	14.01	1.21	20.07	5.76
1947	13.45	.76	19.24	5.11

As a test of the genetic stability of these strains for chemical composition, after 48 generations of selection, a "reverse selection" experiment was begun in 1948. In addition to selection in the original directions, each strain is being selected for chemical composition in the opposite direction. The mean analyses of the seed lots used in starting "reverse selection" are shown in the following table:

	% oil		% protein	
	High oil	Low oil	High protein	Low protein
Regular selection	14.61	.54	21.20	4.63
Reverse selection	11.79	1.03	16.63	5.93

C. M. Woodworth and
Earl R. Leng

2. Short-plant types.

A number of apparent mutations to short-plant types have been collected during the past ten years. Several appear to represent types not previously described, and some have given indications

of potential value as breeding material. None of the types so far collected can be considered "dwarfs", in the maize genetics terminology commonly used. The most conspicuous feature of all our stocks is a marked shortening of the internodes, particularly of those below the ear-bearing node. Node number is little, if any, different from that of normal types.

Three of the short-plant types, received from widely separated hybrid seed corn producers, have been shown by F_1 and F_2 data to have the same major internode-shortening gene. One of these types ("Oakes dwarf") has been described previously (Maize News Letter 15: 29. 1941) and its "dwarfing" gene may be located on chromosome 3 (Maize News Letter 16:21. 1942). Data from F_1 and F_2 indicate that the gene involved is not d_1.

Certain crosses between the types carrying the same major shortening gene have produced ears nearly as large as those of standard hybrids on plants which are 45 to 55 inches tall (to base of tassel). Some of these types may have promise in the breeding program. Several approaches to their use are being attempted.

Other short-plant stocks differ from the "Oakes dwarf" group in genes affecting internode length. F_2 data from several crosses between these and the "Oakes dwarf" group suggest 9:3:4 segregations, but the different short-plant segregates cannot readily be distinguished from each other. A number of other stocks, mostly mutant types found in standard inbred lines, are now under test to identify the genes involved. Brachytic stocks and Singleton's C 30 (reduced) are also being included in these tests. There appears to be a need for a comprehensive survey and analysis of the various short, midget, miniature, reduced, and dwarf types to clarify the genetic relationships involved, and some revision of terminology may be necessary.

Earl R. Leng and
C. M. Woodworth

3. Direct effect of pollen on kernel size.

Studies on quantitative inheritance in corn in progress at this station for several years have included investigations on the inheritance of kernel size. In many of these experiments, open-pollinated seed of the types being studied has been used for kernel-weight determinations. Data of Kiesselbach (Nebr. Agr. Exp. Sta. Res. Bul. 33, 1926) have indicated that direct effects of pollen on kernel size in dent corn were not large. However, observations of such effects produced by pollen of certain inbred lines suggest that this may not always be the case. The dent inbred line R4 has been found to have a consistently depressing effect on kernel size when used as a pollen parent. Data illustrating the magnitude of this

effect are presented in the following table:

Tester (seed parent)	Weight of 100 kernels, grams: Ky27 as pollen parent	R4 as pollen parent	Difference
White O. P. variety	51.80	41.92	9.88
Illinois Low Protein (white)	36.56	30.53	6.03
Henry Moore Y. D.	36.10	31.97	4.13
Lancaster Surecrop Y. D.	29.46	27.73	1.73

The complete data are expected to be ready for publication shortly.

4. Association of endosperm color, vivipary, and chlorophyll deficiency.

A stock received from one of our hybrid seed producers in 1943 segregates 3 yellow : 1 white when plants heterozygous for endosperm color are selfed. Yellow kernels usually have normal embryos and produce normal green seedlings; white kernels are usually viviparous and produce albino seedlings. Two green seedlings have been produced from approximately 200 white kernels; one of these is now being grown in the greenhouse to determine if it is a crossover type or the result of heterofertilization. No albino seedlings have been produced from yellow kernels. Enough viviparous yellow kernels have been found to suggest that the kernel color-vivipary association is the result of relatively close linkage and not of multiple effects of a single gene. The latter possibility for the association of endosperm color and chlorophyll deficiency cannot as yet be ruled out.

Earl R. Leng

5. More oil and protein added to standard inbred lines of corn.

A high content of oil and protein has been added to six widely-used inbred lines of corn by breeding. These lines were crossed to the Illinois High Oil and to the Illinois High Protein Strains of corn. Then the hybrids were crossed back to both parents. After that the backcrossed progenies were selfed for three years. Selection was carried on for high protein by picking ears bearing hard, flinty kernels, and for high oil by picking ears bearing kernels with large germs. No chemical analyses were made until tests were started to determine combining ability. Then it was found that practically all of the new lines were considerably higher in protein content or oil content than the original standard lines used as parents.

The protein content of these new lines ranged from 11 to 22 per cent compared to a range of 11 to 14 per cent for the original standard lines. Oil content ranged from 4 to 10 per cent compared to a range of 2 to 5 per cent for the original inbreds.

Another point of importance is that backcrosses between the first hybrids and the chemical strains gave new lines with higher oil or protein content than backcrosses between the first hybrids and the standard inbred lines. For example, inbred 187-2 was changed from 4.3 to 7.1 per cent oil when backcrossed to 187-2, but from 4.3 to 9.8 when backcrossed to the High Oil Strain. Likewise, inbred L-317 was changed from 11.9 to 16.9 per cent protein when backcrossed to L-317, but from 11.9 to 22.8 per cent when backcrossed to the High Protein Strain.

Studies are in progress to determine whether the new lines, although higher in protein or oil than the original lines, will produce as high yielding and otherwise desirable hybrids.

C. M. Woodworth and
R. W. Jugenheimer

6. Ear-to-hill selection is more efficient than ear-to-row selection in corn.

A direct comparison was made of the efficiency of ear-to-row versus ear-to-hill selection in corn breeding. Three hundred selected ears of corn were planted ear-to-hill. In order to simulate ear-to-row procedure, 60 of these ears, taken at random, were planted in five hills each. Two of the three plants in all hills of both systems were self-pollinated and also crossed with the single-cross tester (WF9xHy). Preliminary results of the performance of the test crosses indicate that the ear-to-hill technique was more efficient than the ear-to-row procedure.

7. Preliminary screening of large numbers of entries.

A simple, inexpensive performance test was designed for the preliminary screening of relatively large numbers of entries. Each three-way cross from the ear-to-hill studies was planted in replicated, single-hill plots. Its performance was compared to that of the single-cross tester grown adjacent to it.

The better lines obtained by the preliminary tests might be grown in larger populations for additional selection within families if deemed desirable. The remaining material also might be compared in standard yield tests to determine the superior inbred lines and hybrids.

8. Corn hybrids differ in harvestability.

In tests or harvestability with the mechanical picker, some hybrids were picked much cleaner and more nearly completely than others. Corn hybrids differed in

a. Time required to harvest
b. Ear droppage
c. Ears left on plants by harvester
d. Husks left on harvested ears
e. Shelled corn lost on ground.

In a series of comparable single crosses in 1947, 20 per cent of the ears of K180 crosses were left in the field by the mechanical harvester compared to only 5 per cent of the ears of C.I.7 and H7 crosses. Individual hybrids ranged from 0 to 31 per cent of the ears left in the field. On the average ears of K180 crosses had about 1 gram of husks compared to 6 grams of husks on ears of K148 crosses. Individual hybrids ranged from 0 to 10 grams of husks left on harvested ears. A correlation of +0.8 was obtained between percentage of ears left by the harvester and percentage of lodged plants at harvest. One hundred and fifty-two double crosses ranged from 0 to 16 per cent of the ears left in the field by the mechanical harvester, and from 1 to 9 grams of husks left on harvested ears. These differences were statistically significant.

In 1948, 88 double crosses, and 45 single crosses, involving all possible combination of 10 inbred lines, were compared for differences in mechanical harvestability. Under conditions of little lodging, the differences in number of ears left in the field by the mechanical harvester usually were not significant. However, the double crosses ranged from 1 to 17 grams of husks left on each harvested ear and the single crosses from 0 to 18 grams. Differences of 3 grams or more were significant. U. S. 13 had an average of 1 gram of husk per harvested ear compared to 17 grams per ear for U. S. 537W. The inbred lines performed similarly to their average performance in single crosses.

Since more than 75 per cent, or nearly 7,000,000 acres, of the Illinois corn acreage is harvested with mechanical pickers, harvestability is an important characteristic.

9. Ear parents of double crosses must grade well.

A high percentage of regular flat kernels is desired of a single cross used as a seed parent of a hybrid. This is so because it results in a larger amount of salable seed from a given acreage. Every extra bushel of salable hybrid seed corn produced per acre in Illinois represents an additional million dollars to our hybrid seed corn industry.

Extensive tests have been made in Illinois to locate better

grading seed parents. Using a specially-designed experimental grader, single cross parents were found to differ greatly. For example, 65 per cent of the seed of K201x38-11 graded large flat or extra large flat compared to only 5 per cent of the same grades of K4x38-11. Forty per cent of K4x38-11 graded small flat compared to only 2 per cent of K201x38-11. Also, K201x38-11 had only one per cent cull corn while K4x38-11 had 11 per cent of cull corn.

R. W. Jugenheimer

10. Stalk lodging in inbred lines of corn caused by 2,4-D spray during flowering.

Spraying inbred lines of corn with 2,4-D solution during flowering caused extreme differences in lodging. The material included 160 inbred lines from 15 states and the United States Department of Agriculture. Most of these lines are widely used in the hybrid corn programs in the Corn Belt.

The plants were sprayed with one-half pound of amine acid in 100 gallons of water per acre. The application was made with a small hand sprayer on July 13, 1948, when most of the lines were tasseling.

Each plot consisted of two hills with three plants per hill. Two plots of each line were sprayed, making a total of four hills or 12 plants per line. On July 24, the plants were graded for lodging. The amount of lodging was graded as follows:

a. No lodging
b. Light lodging
c. Average lodging
d. More than average lodging
e. Very bad lodging.

A difference of 1.5 grade between any two lines was significant at the one per cent level. The following lines graded 2 or less and were most resistant to lodging: A111, A116, A158, A12, A340, A334, Os420, Hy2, K63, Kys, K201C, B10, and CI.21E. The following lines graded 5 and lodging badly: A7, Os426, L289, Ind. H5, Mo2RF, Iowa 159, Ind. 33-16, Ky 39, Ky 58, CI.187-2, K148 and CI.5.

The land was free of weeds at the time of spraying. The application, however, fairly well controlled the weeds that came up after the application of 2,4-D spray. It is believed that this type of application might be valuable in controlling weeds that often appear after pollination in breeding or genetic nurseries.

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Relation of crossing over to mutation of A^b.

Previous studies indicate that A^b and its mutant A^d derivatives are non-linear in action. The former produces purple plant and aleurone color; the latter are associated with pale phenotypes. A^b and A^d types produce a brown pericarp which is dominant to the red effect of A. Moreover studies involving different doses and combinations of the A^d alleles are difficult to interpret on the basis of a simple relation between gene and agent. It is possible to explain the action of these alleles if it is assumed that they are compound in the sense that each is composed of two or more physically distinct determinants. To test this possibility in the case of A^b, experiments were conducted to determine whether there is a relation between crossing over and the mutation of this allele.

The genes lg_2 and et, which lie, respectively, 33 units to the left and 13 units to the right of A in the long arm of the third chromosome, were used as markers. The recombination value for the lg-et interval is 0.42. In view of this high frequency A^b a plants were employed rather than the homozygotes since this permits the use of a as a third marker gene. Since mutants of the A^d type have never been obtained from a it is certain, after testing to establish their nature, that the mutants obtained in these experiments originate from A^b.

Individuals having the constitution A^b/lg a et were grown at Princeton in 1947 and crossed with lg a et pollen. To avoid contamination the plants were started and flowered earlier than any others in the field; all pollinations were made by hand. Among the resulting progenies which contained 27,936 purple seeds (A^b contributed by the egg) seven pale seeds were obtained which produced pale plants and whose progeny tests showed that they carried a mutant allele. Progeny tests grown at the California Institute of Technology in the summer of 1948 established that these plants carried a mutant gene of the A^d type.

Tests of the mutant individuals showed that six of the seven A^d-bearing strands contributed to the eggs by the heterozygous parents represented recombinations for a and et (Table 1). The expected frequency for recombination in this region is 0.128, taken from table 2, which summarizes the data on crossing over in the lg-a and a-et regions; the data are from ears in those families which produced the mutant individuals. Although the numbers are small, the high frequency (0.858) for recombination in the a-et region among the mutant A^d strands suggests a relation between crossing over and mutation of A^b.

Table 1. Cross: $\underline{A^b}/\underline{lg\ a\ et}$ x $\underline{lg\ a\ et}$

Mutant plant	Constitution of the $\underline{A^d}$-bearing strand			
	Non-crossover types	Crossover types		
		Region I	Region II	Regions I and II
1A-1			$\underline{Lg\ A^d\ et}$	
8A-1			"	
9A-1			"	
14A-1			"	
19A-1			"	
78-1		$\underline{lg\ A^d\ Et}$		
78H-1				$\underline{lg\ A^d\ et}$

Table 2. Summary of the data on crossing over in the lg-a (Region I) and a-et (Region II) segments from progenies of backcrosses of the type: $\underline{A^b}/\underline{lg\ a\ et}$ x $\underline{lg\ a\ et}$

Total	Crossovers					
	Region I		Region II		Regions I and II	
	No.	Frequency	No.	Frequency	No.	Frequency
17,298	5,714	0.3303 ±0.0036	2,220	0.1283 ±0.0025	405	0.0234 ±0.0004

This interpretation is supported by evidence from experiments in 1948 conducted on a large scale. As before, marked heterozygotes carrying $\underline{A^b}$ were crossed with lg a et pollen which in addition carried Dt. The precautions against possible contamination were the same as in the previous experiment. While progeny tests of suspected mutants from these crosses are not yet available those seeds, which were pale and dotted, were selected and classified for normal versus etched (et) phenotype. Since dots have never been observed on endosperms carrying $\underline{A^b}$, a and Dt, the presence of dots on the selected seeds may be taken as evidence of their mutant character. Of the total of 34 pale, dotted seeds obtained, 30 were crossover types for the a-et interval; as in the previous experiment there was a preponderance of the crossover class. The 34 pale seeds occurred individually on ears. From classification of the remnant seeds on these ears a frequency of 0.1389 ±0.0045 was obtained for recombination between a and et; this is to be compared with 0.882, the value for recombination in the same region among the 34 mutants.

In the cases of five of the total of 41 mutants from both experiments the $\underline{A^d}$-bearing strands delivered to the eggs were non-crossover types for the a-et region. It is possible that these are

due to mutations of $\underline{A}^b$ which are not associated with crossing over at that locus; if such mutations do occur they would fall predominantly in the noncrossover class. However, in view of the relatively great length of the a-et segment (13.2 units as an average of the two experiments) it is a more plausible explanation that the apparent noncrossovers are cases of double exchange, one occurring at the locus of $\underline{A}^b$ giving rise to the mutation, the other occurring somewhere between this locus and that of et, thus reconstituting the parental combination.

The evidence suggests that $\underline{A}^b$ is composed of at least two components, separable by crossing over. If these are designated alpha and beta, the latter being more distal, the $\underline{A}^d$ mutants may be described as having alpha and lacking beta; this follows since the strands carrying $\underline{A}^d$ were predominantly of the nonparental class for et, the more distal marker.

On this basis it is possible to account for the non-linear action of $\underline{A}^b$ in terms of its compound nature. For example, the dominant brown pericarp effect of $\underline{A}^b$ may be argued to reside in the alpha component ($\underline{A}^d$) since the $\underline{A}^d$ mutants also show this effect. It is possible that the $\underline{A}^d$ mutants, which also are antimorphic in their action, are in turn compound. This possibility, along with others which logically suggest themselves, is being investigated. It is an inviting prospect that the complex action of a number of the A alleles may be resolved on the basis of their compound nature rather than in terms of genic agents having relatively complex interactions.

John R. Laughnan

1. An abstract on crossover chromosomes in unreduced gametes of asynaptic maize was published in Genetics, 1947, in which it was stated that the diploid egg cells, presumably arising from sporocytes with all or nearly all univalent chromosomes at metaphase I, contained crossover chromosomes. Our studies on the genetic constitution of diploid gametes from asynaptic plants have been continued and the data now at hand would seem to permit the following conclusions to be drawn: For regions in both chromosomes 2 and 9 there is a significant increase in the amount of crossing over in asynaptic plants. This is true for both haploid and diploid gametes. As an example, the frequencies of crossover and noncrossover strands in haploid gametes for two regions in chromosome 2 are given below.

Asynaptic plants			Normal sibs	% recombination	
(0)	Ws Lg Gl	230	339		
(0)	ws lg gl	239	305	ws-lg	lg-gl
(1)	Ws lg gl	62	81	as 20.1	30.5
(1)	ws Lg Gl	64	64	As 14.7	21.1
(2)	Ws Lg gl	115	106		
(2)	ws lg Gl	100	103		
(1-2)	Ws lg Gl	21	1		
(1-2)	ws Lg gl	25	1		
		856	1000		

The most striking difference among haploid gametes from asynaptic and normal plants is the great increase in the frequency of double crossovers in asynaptic plants. The analysis of diploid gametes is slow and comparatively little data have been obtained, but it is obvious that in these diploid eggs the frequency of crossover strands also is very high. Comparable results have been obtained for the C-sh and sh-wx regions in chromosome 9.

M. M. Rhoades and
Ellen Dempsey

2. In the Maize News Letter for 1943, I reported on the preference of Jap beetles for liguleless-1 leaves. During the summer of 1942 it was observed that in several different cultures segregating for $\underline{lg}_1$ that the damage caused by the feeding of the beetles was much greater on liguleless than on normal plants. Inasmuch as all of the segregating families were descendents from one liguleless stock, it was possible that another gene in chromosome 2 was involved in the taste difference. More information on this problem was obtained when seed from a large number of selfed ears in seven open-pollinated varieties were grown. In five of the varieties, progenies were found segregating for $\underline{lg}_1$ and in every instance the preference of the Jap beetles for the liguleless plants was striking. The lg alleles in these five varieties probably arose as independent mutations since the varieties came from widely separated parts of the country. Apparently the lg gene makes the leaf tissue more palatable to Jap beetles as well as affecting the development of the ligule and other morphological characters.

M. M. Rhoades

3. The inversion present in Mangelsdorf's homozygous Tu line (see my item 5 in the 1948 News Letter) proved to be in the long arm of chromosome 3.

M. M. Rhoades

4. In the 1947 News Letter I mentioned a complex translocation involving chromsomes 3 and 5 in which a break had occurred in 5L midway between the knob and the end, while the centromere of 3 had been fractured. The distal portion of 5L had become translocated to 3S. The linkage relations of genes in chromosome 3 have been determined with respect to the point of translocation, which is the centromere in this case. Due to the fact that directed segregation of the chain of 3 (in strains with two normal chromosomes 5, one normal 3 and the interchanged 3's) may occur with certain modifiers present, it was not feasible to use pollen abortion as the marker for the translocation, and root-tip counts were resorted to. Plants with 20 chromosomes had the intact chromosome 3 while those with 21 chromosomes had 3S and 3L as separate entities. The following data were obtained:

Lg2-A	36	% recombination	
C-Lg2	36.5	" "	(C represents the centromere)
C-Rg	14.8	" "	
Lg2-Rg	16.0	" "	
C-A	50	" "	.

Anderson and Randolph state that the centromere lies between d_1 and ts_4. The data obtained in the study of this translocation permit a more definite location and show that the centromere lies between d_1 and Rg, with Rg lying between ts_4 and the centromere. The linkage map is shown below (C standing for the centromere):

cr	d	C	Rg	ts_4	ba	na	A	et	ga_7
0	18	25	40	47	64	75	103	115	121

M. M. Rhoades

Chlorophyll formation and chloroplast development in maize mutants.

Cytological investigations of the chloroplasts in the white, luteus, virescent and pale green mutants revealed that complete correlation does not exist throughout between the size of the plastid and the chlorophyll content of the leaf. The correlation is positive in the whites, where the plastids are very small and are present in the form of proplastids; positive in the virescents where the plastids increase in size from proplastids to normal full-sized plastids as greening proceeds in the leaf; and exists also in the pale greens when the plastids are just slightly smaller than normal. In the case of the luteus mutants there does not seem to be any obvious relationship between plastid size and chlorophyll formation. Some of the mutants that contain only a trace of chlorophyll have very small plastids while others with just as little chlorophyll have plastids of almost normal size. The same holds true for the mutants with a

comparatively high chlorophyll content. Many have large plastids but some contain only the very small plastids.

By means of the chromatographic adsorption technique it was found that all of the luteus mutants studied contained a small amount of both chlorophyll A and B in addition to carotene and xanthophyll. In the very pale luteus plants the amount of chlorophyll present is so small that it is completely masked by the yellow pigments in the leaf.

All of the pale green mutants studied were also found to contain both chlorophylls.

The absorption spectra of the green pigments in the luteus and pale green plants, obtained with a Beckman Spectrophotometer, confirmed that they actually were chlorophyll A and B. This rules out the chlorophylls as the cause of the lethality of many of the pale green mutants.

One luteus mutant was found in which the formation of chlorophyll B is delayed until at least four days after the formation of chlorophyll A. At low temperatures (62°F) chlorophyll B formation can be delayed for about two weeks. This affords the possibility of ascertaining whether or not photosynthesis can proceed in the presence of chlorophyll A only.

Drew Schwartz

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1. The gene, glossy-5, gives no evidence of linkage with bm pr ys in chromosome 5. The gene, glossy-8, appears to be linked with pr ys, confirming the earlier report, but the order is not determinable from the data.

T. H. Anstey

2. A high bt stock has been established from the stock originally reported by Jenkins in an a_2 stock. One plant of one stock tested has a Ga factor in chromosome 2 as well as in chromosome 5.

Leola E. Ford

3. Three virescents (X-ray or U.V. mutants) obtained from Stadler (labeled here vS-1, vS-2, vS-3) have the following results from intercrosses:

vS-1 was found to be different from v_1, v_2, and v_4
vS-2 " " " " " " v_1, v_2, v_3, and v_{13}
vS-3 " " " " " " v_2, v_3, and v_{13} .

G. T. DenHartog

4. A method of calculating gametic frequencies s to z and coincidence from three-point F_2 data from an individual heterozygous for three pairs of factors AaBbCc.

The observed zygotic F_2 frequencies are given the symbols a to h; their expected frequencies in terms of the gametic frequencies s to z are given in table 1.

Table 1.

Observed zygotic frequency	Phenotype	Gametic frequency	Phenotypes in terms of gametic frequencies
a	ABC	s	$s^2+2sz+2sv+2st+2sw+2sy+2su+2sx+2vw+2tw+2wu+2ty+2tv+2xu$
b	ABc	t	$t^2+2tx+2vx+2tv+2tz$
c	AbC	u	$u^2+2uy+2vu+2vy+2uz$
d	Abc	v	v^2+2vz
e	aBC	w	$w^2+2wx+2wy+2wz+2xy$
f	aBc	x	x^2+2xz
g	abC	y	y^2+2yz
h	abc	z	z^2

The frequencies of the gametes s to z can then be calculated as follows:

For z, $z^2 = h$, then $z = \sqrt{h}$.

For y, $(z+y)^2 = h+g$, or $z+y = \sqrt{h+g}$, and $y = \sqrt{h+g} - z$.

Similarly for v and x. $x = \sqrt{f+h} - z$ and $v = \sqrt{d+h} - z$.

For w, $h+f+g+e = (z+y+x+w)^2$ then $w = \sqrt{h+f+g+e} - (z+y+x)$.

Similarly for t and u. $u = \sqrt{c+d+g+h} - (v+y+z)$ and
$t = \sqrt{b+d+f+h} - (v+x+z)$.

For s, $a+b+c+d+e+f+g+h = (s+t+u+v+w+x+y+z)^2$
then $s = \sqrt{a+b+c+d+e+f+g+h} - (t+u+v+w+x+y+z)$.

Corn was selected which was segregating for glossy, liguleless and virescent$_4$, on which this method could be tried. Table 2 shows the classification of this material according to phenotype.

Table 2. Classification of corn seedlings segregating for glossy (gl), virescent$_4$ (v_4), and liguleless (lg), in F_2

GlV_4Lg	GlV_4lg	Glv_4Lg	Glv_4lg	glV_4Lg	glV_4lg	glv_4Lg	glv_4lg	Total
483	256	179	108	230	6	57	1	1320

The analysis of these data follows:

$z = \sqrt{1} = 1$
$y = \sqrt{57+1} - 1 = 6.6158$
$x = \sqrt{1+6} - 1 = 1.6457$
$v = \sqrt{1+108} - 1 = 9.4403$
$w = \sqrt{230+57+6+1} - (x+y+z) = 7.8849$
$u = \sqrt{179+108+57+1} - (v+y+z) = 1.5181$
$t = \sqrt{256+108+6+1} - (v+x+z) = 7.1753$
$s = \sqrt{483+256+179+108+230+6+57+1} - (t+u+v+w+x+y+z) = 1.0517$.

These calculated values may be arranged in a more orderly fashion as follows:

Class of gamete	Gametes	Relative frequency	Actual frequency
Noncrossovers	v_4 Gl lg V_4 gl Lg	v+w = 17.3252	.4769
Single crossovers in v_4-gl	v_4 gl Lg V_4 Gl lg	x+y = 13.7911	.3796
Single crossovers in gl-lg	v_4 Gl lg V_4 gl Lg	u+x = 3.1638	.0870
Double crossovers	V_4 Gl Lg v_4 gl lg	s+z = 2.0517	.0565

Crossing over in region 1 = .4361
" " " " 2 = .1435
Coincidence = $\frac{\text{observed doubles}}{\text{expected doubles}} = \frac{.0565}{.0626} = .90$

Russell T. Johnson

5. Chromosome segregation in heterozygous translocations.

Segregation from chains appears to differ from that in rings. In the chain-forming T1-6b and T5-6b heterozygotes (break in satellite) with short interstitial segments (region between centromere and translocation break), very little adjacent 2 segregation (homologous centromeres go to the same pole) occurs. In rings with short interstitial segments adjacent 2 segregation occurs in 14 to 36% of the sporocytes (differing in different translocations). In chains with long interstitial segments, adjacent 2 segregation also appears to be very low as shown by T5-6c/+ which forms chains at diakinesis in 30 to 40% of the sporocytes, yet has little, if any, of this type of segregation.

If chromosomes that crossover go to opposite poles, as the evidence indicates, then a species with directed segregation would show varying degrees of sterility associated with a ⊙ 4, the amount dependent on the frequency of crossing over in the interstitial segments, the maximum being 50%; since half of the spores in each quartet, which follows such crossing over, abort.

In the search for directed segregation, translocations with short interstitial segments are being used in crosses with material of different origin.

C. R. Burnham

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Effects of irradiating corn tassels with slow neutrons.

Work is in progress in our laboratory on determining the genetical and cytological effects of irradiating maize pollen with slow neutrons. The work has been under way for two years.

Seed for these tests was furnished by Dr. L. J. Stadler. The female plants were of the genotype aaprprsusu and the male plants of the genotype AAPrPrSuSu.

In 1947, the corn for irradiation was grown at the Agricultural Experiment Station, Lincoln, Nebraska, and in 1948 at the Pfister Associated Growers corn breeding nursery, Naperville, Illinois. In addition, tassels for the 1947 tests were secured from Dr. C. R. Burnham at St. Paul, Minnesota. Irradiations were made by placing the tassels in the thermal-neutron column of the heavy water pile at the Argonne National Laboratory in Chicago. The flux was 7×10^{10} neutrons per square centimeter per second at the position of the tassels. In the 1948 tests, an X-ray treatment of 1200 r units was also included for comparison.

Table 1. Mutations affecting the entire F_1 aleurone or endosperm of individual kernels with respect to three marked loci and percentages of defective kernels from crosses of aaprprsusu plants by AAPrPrSuSu plants, the tassels of which were irradiated with slow neutrons[1] or X-rays.

Treatment	A locus		Pr locus		Su locus		Kernel development	
	Total no. kernels examined	Per cent kernels colorless	Total no. kernels examined	Per cent kernels red	Total no. kernels examined	Per cent kernels sugary	Total no. kernels examined	Per cent kernels defective
Control	11,326	.10	11,178	.02	11,320	.01	11,380	.55
X-ray (1200 r)[2]	6,544	5.64	5,923	.86	6,081	3.26	6,690	8.97
Neutrons								
½ minute[2]	3,167	.95	3,131	.10	3,166	.44	3,246	2.34
1 minute	8,244	.82	8,160	.12	8,261	.46	8,470	2.42
2 minutes	9,308	4.33	8,777	.89	9,164	2.38	9,992	8.30
4 minutes	6,203	8.83	5,484	1.51	5,522	4.45	7,761	28.93
8 minutes	1,925	13.04	1,660	1.45	1,515	5.61	3,335	54.81
16 minutes[3]	47	25.53	35	0	49	12.24	208	76.44

[1] Flux was 7×10^{10} neutrons per square centimeter per second.

[2] Data from 1948 crop only.

[3] Data from 1947 crop only.

Table 2. Mutations (chimeras) affecting sections of the F_1 aleurone or endosperm of individual kernels with respect to three marked loci and percentages of kernels with sections defective in development, from crosses of aaprprsusu plants by AAPrPrSuSu plants, the tassels of which were irradiated with slow neutrons[1] or X-rays.

Treatments	A locus		Pr locus		Su locus		Kernel development	
	Total no. kernels examined	Per cent kernels mosaic for colorless	Total no. kernels examined	Per cent kernels mosaic for red	Total no. kernels examined	Per cent kernels mosaic for sugary	Total no. kernels examined	Per cent kernels mosaic for defective
Control	11,314	1.24	11,176	.10	11,319	.03	10,217	.04
X-ray (1200 r)[2]	6,176	1.39	5,874	.37	5,883	.34	6,090	.20
Neutrons								
½ minute[2]	3,137	1.20	3,128	.19	3,152	.16	3,170	.06
1 minute	8,176	1.38	8,149	.23	8,225	.11	7,431	.04
2 minutes	8,904	2.56	8,699	.37	9,018	.22	6,671	.24
4 minutes	5,659	2.36	5,466	.58	5,286	.38	4,931	.52
8 minutes	1,675	4.12	1,636	.91	1,430	.83	1,113	1.42
16 minutes[3]	35	2.78	35	0	49	0	--	--

[1] Flux was 7×10^{10} neutrons per square centimeter per second.

[2] Data from 1948 crop only.

[3] Data from 1947 crop only.

Observations on mutations affecting the entire F_1 aleurone or endosperm of individual kernels with respect to the three marked loci for the various treatments are presented in table 1. Percentages of kernels with the F_1 tissue defective in development, as determined by external appearance of the caryopsis as a whole, are also shown for the various treatments.

Mutations involving the same characters but affecting only sections of individual kernels (chimeras) are reported in table 2.

The F_1 generation from seed produced in 1947 was grown at Lincoln in 1948. Plantings were made directly in the field on May 21 and June 8, except that at the first planting date the defective seeds were planted in the greenhouse. The results from this planting in the greenhouse are not included because of rodent injury. Combined data on stands from the various treatments for the two planting dates are presented in table 3.

Table 3. Stand of F_1 plants from crosses of normal by normal with tassels irradiated at various lengths of time with slow neutrons. Combined data from plantings made at Lincoln, Nebraska, on May 21 and June 8, 1948.

Length of time tassels exposed to neutron irradiation	No. of kernels planted	Stand of plants	
		No.	Per cent
Control	279	256	91.8
1 minute	337	297	88.1
2 minutes	346	286	82.7
4 minutes	429	206	48.0
8 minutes	328	101	30.8
16 minutes	38	2	5.3

E. F. Frolik and
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1. Pink aleurone color.

A pink aleurone color, phenotypically resembling that described by Ruth Sager in Maize News Letter No.22, has been observed in stocks of corn homozygous a_1 C R pr in y. Data covering two generations do not indicate maternal inheritance, however, as reported

by the Columbia worker.

Attention was first drawn to the presence of this pink aleurone in stocks segregating for an undetermined germless condition. On selfed ears homozygous a_1 C R pr in y and segregating Gm gm, a ratio of 3 white to 1 pink aleurone was noted. All of the pink kernels were germless. Upon close examination, however, some of the non-germless kernels were found to be slightly mottled with pink. Others showed no pigmentation. Selfed plants from non-germless pigmented kernels produced ears resembling the ears from which they came. Non-germless colorless kernels produced ears in which all of the kernels were colorless if germless was not segregating. If germless was segregating, the germless kernels were very slightly pigmented.

When this a_1 C R pr in y Gm/gm stock was crossed with a related homozygous A C R pr in y Gm line, the kernels were all intense red as expected; but upon selfing a new phenotype, "rust" aleurone, appeared in the ratio 9 intense red : 3 rust : 4 white on half of the ears harvested in 1948. The other half segregated the expected 3 intense red : 1 white, and some of the near-colorless kernels showed the pink aleurone color exhibited by the one parent stock. Likewise on the ears segregating rust, some of the kernels were very slightly mottled pink even though germless was not segregating on any of these ears. It is not possible at this time to conclude that the pink aleurone color, observed in the presence of recessive a_1, is related to the rust aleurone color produced apparently in the presence of A_1 even though both conditions appeared in the same stock.

The germless condition must be a strong modifier of the pink aleurone color, since on non-germless kernels a few clumps of aleurone cells on the crown of the kernels may be pigmented to give a very faint mottled appearance, whereas on germless kernels the pigment is rather evenly distributed and more intensely developed. Germless and pink aleurone are separable. F_2 data indicate that they are not linked.

There is likewise some indication that in may modify the pink aleurone color - and possibly the rust color. Since most of the stocks involved in this work have been in in, this gene may have been a factor in the original detection of these aleurone phenotypes.

Data from the F_2 of the mating homozygous a_1 C R pr in y (carrying pink aleurone) x homozygous A R Pr In y (c sh wx), where the rust phenotype also appeared, indicate that (1) the rust phenotype may be modified in the presence of these several segregating genes to various shades of brown and (2) the expression of rust depends upon a gene linked with c sh wx. Whether this gene is bz has not been determined.

Robert I. Brawn

2. Mutagenic action of nitrogen mustard.

Experiments on the mutagenic action of the nitrogen mustard, methyl-bis (B-chloroethyl) amine, on corn were begun in 1947 and continued in 1948. In general, the treatments consisted of exposing freshly collected pollen samples to vapors of the methyl-bis (B-chloroethyl) amine just before the pollen was applied to the pistillate parent. The exposure was made by introducing 0.2 ml. pollen samples, distributed uniformly over the flat bottom of a shallow 20 mm. diameter vial, into a chamber containing vapors of the nitrogen mustard.

TREATMENT - In 1947, the exposure was made in a desiccator containing a fan for circulating the air and a filter paper moistened with methyl-bis (B-chloroethyl) amine. For the 1948 experiments, the treating apparatus was redesigned to allow variation of both the vapor concentration and exposure time. This apparatus consisted of a 22 cm. U-tube filled with very small glass helices covered with methyl-bis (B-chloroethyl) amine, a mercury-filled gas burette, and a 300 ml. treating chamber. Dry air at the atmospheric temperature was drawn through the U-tube where it became practically saturated with vapors of the B-chloroethyl amine. Variable quantities of this dry air containing these vapors were then introduced through the gas burette into the treating chamber. This chamber contained a moist filter paper to maintain a high humidity and a magnetically operated fan placed so it would circulate the air-vapor mixture through the pollen. The time of exposure of the pollen to the air-vapor mixtures was varied from one to five minutes, and the quantity of vapor introduced into the chamber ranged from one to 24 ml. The final concentration of methyl-bis (B-chloroethyl) amine in the treating chamber, as approximated from volatility data, probably varied from about one to 24 micrograms of amine per liter. Since the exposure time as well as the concentration was varied in the 1948 treatments, the "mortality product" or product of the concentration multiplied by the time varied from one to 120.

RESULTS - Most of the seeds obtained in 1947 by pollinating normal plants with treated pollen were shrivelled. Many of these seeds, including some very small ones, proved to be viable and gave thrifty plants. The poor seed development was associated with grossly impaired endosperm formation. Tassel samples collected from the plants reared from these seeds were scored for defective pollen to obtain an estimate of the frequency of chromosomal abberations resulting from the treatments. One hundred eighteen plants among 760 sampled were scored as having a significant proportion of defective pollen. This is a frequency of 15.5 per cent. Among 58 controls none produced defective pollen. Seven hundred fifty-six ears from self-pollinated plants were harvested. Sixteen seeds from each were planted in the greenhouse and the seedlings scored for chlorophyll deficiencies. Five families segregated for such deficiencies. This

is a frequency of 0.66 per cent. There were no chlorophyll deficient plants among the controls. A subsequent planting of 300 kernels per segregating family was made. The numbers of defective seedlings obtained from each of four families were 60, 68, 77 and 80. One ear had too few kernels for this test. The pollen treated in 1948 was from a a C R P Pl Pr B Y Su Sh Wx lg_1 stock. The pistillate parent to which the pollen was applied was a multiple recessive A C r^g p pl pr b y (Su su or su) sh wx Lg_1 stock. Use of pollen, which had been subjected to a treatment of a mortality product of one, resulted in almost normal appearing ears. Use of pollen, which had been subjected to a treatment of a mortality product of 120, resulted in partially filled ears with a high proportion of defective kernels. The kernels on these ears are now being classified for endosperm mutations. The following mutations in the endosperm have been observed: sugary, waxy, white, red aleurone and shrunken. Mosaic kernels are more frequent than mutations affecting the entire kernel. The frequency of mutations increases with the severity of the treatment. Plants will be grown from these seeds in 1949 and scored for mutations carried by the embryos.

Pryce B. Gibson, Lloyd Wilson,
R. A. Brink, Mark A. Stahmann

III. MAIZE PUBLICATIONS -- 1948

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IV. SEED STOCKS PROPAGATION

Most of the 116 cultures propagated the past summer were planted to renew viability and seed supply of old stocks. Further attempts were made to clean up certain of the stocks which had previously been outcrossed to adapted inbreds for the purpose of adding vigor to these stocks. In addition, stocks of two new genes and two new multiple-gene chromosome 5 linkage testers were incorporated into our supply. These are listed below with the Coöp culture numbers.

1. Richey's dominant inhibitor or partial inhibitor of yellow endosperm . . . . . Co 48-71
2. Randolph's $\underline{a_2}$ $\underline{bt}$ $\underline{bv}$ $\underline{pr}$ . . . . . Co 48-75
3. $\underline{A_2}$ $\underline{bt}$ $\underline{bv}$ $\underline{pr}$ . . . . . Co 48-21
4. Horovitz's early grasshopper resistant, $\underline{ag}$ . . Co 48-76

The last may be of special interest to corn breeders in those states where the grasshopper is a serious menace. Therefore, in addition to selfing this line, we crossed it to two adapted New York inbreds. Plenty of seed of both are now available for anyone who may want them.

If any other coöperator has a supply of gene stocks which were not listed in our inventory in the 1948 News Letter, it would be helpful if he would forward a small supply to the Coöp for incorporation into our seed supply.

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