

MAIZE GENETICS COOPERATION

NEWS LETTER

17

1943

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Department of Plant Breeding  
Cornell University  
Ithaca, N. Y.

MAIZE GENETICS COÖPERATION  
DEPARTMENT OF PLANT BREEDING  
CORNELL UNIVERSITY  
ITHACA, NEW YORK

December 10, 1942

To Maize Genetics Cooperators:

This is the annual call for copy for the next News Letter. I have set January 31, 1943, as the deadline date for this material. Please send copy to the Department of Plant Breeding, Cornell University, where it will be assembled and forwarded to me at Pasadena, California.

Since the emergency has doubtless made it impossible for some of you to continue your genetic studies, those who have material suitable for the News Letter should make an effort to get it to me on time.

Sincerely,

*RAEmerson*

R. A. Emerson

RAE:P



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## I. REPORTS FROM COÖPERATORS

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R. A. Emerson

Bureau of Plant Industry Station, Beltsville, Md.

Several backcross progenies involving genes located on chromosomes 3 and 7 were grown in 1941. They were not reported in the last News Letter as the data had not been summarized, hence they are reported now. A few additional backcross progenies were grown during the past season and are reported. Cold, wet weather following planting resulted in very poor stands in both seasons, but it is felt that the segregations obtained are not sufficiently distorted to modify gene order.

1. Backcrosses involving genes on chromosome 7.

		<u>gl</u> <u>ij</u> <u>bd7</u>							
		+   +   +							
0		1		2		1-2		Total	
<hr/>		<hr/>		<hr/>		<hr/>		<hr/>	
69	53	4	4	68	26	4	2		
122		8		94		6		230	

Linear order and map distances are: gl - 6.1 - ij - 43.5 - bd7  
(500 seeds were planted, 46.0% produced mature plants.)

		<u>gl</u> <u>sl</u> <u>ij</u>							
		+   +   +							
0		1		2		1-2		Total	
<hr/>		<hr/>		<hr/>		<hr/>		<hr/>	
268	182	32	52	2	5	0	2		
450		84		7		2		543	

Linear order and map distances are: gl - 15.8 - sl - 1.7 - ij  
(1,000 seeds planted, 54.3% produced mature plants.)

				<u>02</u>		<u>ra</u>		<u>gl</u>		<u>ij</u>							
				+		+		+		+							
<u>0</u>		<u>1</u>		<u>2</u>		<u>3</u>		<u>1-2</u>		<u>1-3</u>		<u>2-3</u>		<u>1-2-3</u>		<u>Total</u>	
273	213	24	28	6	3	49	56	1	1	5	7	0	2	1	0		
486		52		9		105		2		12		2		1		669	

Linear order and map distances are: 02 - 10.0 - ra - 2.1 - gl - 17.9 - ij  
(1,000 seeds planted, 66.9% produced mature plants.)



		02	ij	bd7		
		+	+	+		
0		1		2		1-2
						Total
69	56	24	44	38	44	7 17
125		68		82		24
						299

Linear order and map distances are: 02 - 30.8 - ij - 35.5 - bd7  
(500 seeds were planted, 59.8% produced mature plants.)

2. Backcross involving lg2 and genes on Chromosome 3.

		rt		+	lg2		a									
		+		Rg	+		+									
0		1		2		3		1-2		1-3		2-3		1-2-3		Total
<hr/>		<hr/>		<hr/>		<hr/>		<hr/>		<hr/>		<hr/>		<hr/>		<hr/>
58	77	7	6	36	38	28	35	4	2	4	3	15	11	0	1	
135		13		74		63		6		7		26		1		325



identified as to chromosomes involved.

Index number	Chromosomes	Index number	Chromosomes
a-33	1-3	F-2	2-10
c-43	1-3	a-101	3-5
g-3	1-3	a-22	3-8
c-15	1-3	a-94	3-9
a-37	1-5	a-26	4-9
a-80	1-6	c-31	4-9
B-49	1-7	F-22	4-9
D-5	1-7	B-45	4-10
B-42	1-8	B-10	5-8
C-36	1-10	B-70	5-10
a-29	2-4	a-66	6-9
c-40	2-8	F-33	8-10

4. One complex translocation (Index No. B-2) involves four chromosomes 1, 3, 4, and 5. It is closely linked to su. It is also close to bm with much suppression of crossing-over between bm and pr. No linkage information has been obtained on chromosomes 1 and 3.

5. Utilization of translocations with endosperm markers in the study of economic traits. In studying the inheritance of any difficult trait, a simple test can be made for linkage with an endosperm character such as su or wx, especially if the multiple recessive combination occurs in one of the commercial inbred lines. For example, in studying resistance to bacterial wilt, a resistant line can be crossed with a susceptible sugary, and the  $F_1$  crossed to a susceptible sugary inbred. Comparison can then be made between the resistance of plants from starchy vs. sugary seeds of the backcross ear. This tests for resistance genes in the central portion of chromosome 4. If this test is negative then a similar test can be made involving translocation 1-4a. (Resistant x su Tl-4a) x susceptible sugary inbred. A test of plants from su vs. su seeds then becomes a test for resistance genes in the long arm of chromosome 1. From the standpoint of testing technique, it means that su can be used as a marker for any chromosome or part of a chromosome for which the proper translocation is available. And the same recessive sugary inbred line can be used for all backcrosses. The suppression of crossing-over in the neighborhood of the translocation aids in making the method more efficient in detecting linkages. If an appropriate series of translocations existed, it would be possible to cover the entire chromosome complement with the use of one endosperm gene such as su.

The series of translocations available at present is not sufficient to cover all chromosomes using only one marker gene. By using two series, one with su, the other with wx, it is possible to have at least one translocation for each chromosome. More translocations are being isolated and it is hoped that, year by year, the series available for this purpose will be greatly improved and simplified.



Work on the inheritance of economic traits by using endosperm marked translocations is being taken up at several of the corn belt experiment stations. To facilitate these programs I have made the  $F_1$  crosses here at Pasadena with such translocations as are now available. These were:

su series - 1-4a, 2-4a, 2-4c, 4-5b, 4-5d, 4-6a, 4-8, 4-9a, 4-10b and a new 2-4 (a-29)

For sweet corn lines I was able to add 4-7a, a new 4-9 (F-22), 4-10 (B-45) and a multiple 1-3-4-5 (B-2)

wx series - 1-9a, 1-9c, 2-9b, 3-9a, 3-9b, 3-9c, 4-9b, 6-9a, 8-9a, 9-10b and new 4-9 (F-22), and 6-9 (a-66)

pr series - 1-5a, 1-5c, 2-5b, 3-5b, 3-5c, 4-5c, and 4-5d

The above is too large a series for completion of tests, except for such traits as can easily be tested in the seedling stage. But the additional  $F_1$ 's may serve as a reserve for checking any indications of linkage.

6. Use of translocations in corn breeding. Once any significant gene for an economic trait is located, it should be possible to transfer that gene to any commercial inbred line with only a minimum of alteration of the inbred line itself. In simplest form, the inbred line would first be crossed with the proper translocation (one near the locus of the gene). The  $F_1$  would then be backcrossed recurrently to the inbred line selecting always the semisterile plants. Then on selfing, the homozygous translocation inbred can be isolated. The next step consists of crossing the translocation inbred with the desired gene, and backcrossing to the translocation inbred. Then, on selfing and eliminating the translocation, the result should be essentially the inbred line homozygous for the desired gene. The length of time required is considerable, but can be reduced by various shortcuts. No great number of plants need be grown, nor is much labor required. And an economic gene could be transferred to any number of inbred lines simultaneously. This method is suggested only for such traits as are difficult to follow, such as for example resistance to disease, insects, drouth or cold. It is essentially an indirect method which controls the valuable but difficult character by substitution of pollen semisterility which can be easily and precisely followed.

E. G. Anderson

Columbia University, New York City

1. Relation between knobs and chromocenters of interkinetic nuclei. - Resting nuclei of maize stained with Feulgen contain discrete, deeply-staining bodies in addition to diffuse chromatic material. These deeply-staining bodies are called chromocenters. A good correlation was found between the number of chromocenters in the interkinetic nuclei and the



number of knobs present in the pachytene chromosomes. In strains free from conspicuous knobs but possessing B chromosomes a good correlation was found between the number of B chromosomes and the number of chromocenters. The chromocenters derived from B chromosomes are not as large as those from some of the larger knobs -- evidently all of the heteropycnotic material observed in the B chromosomes at pachytene is not represented in the chromocenter. That portion of the B chromosome immediately adjacent to the centromere of the B is more knob-like in appearance than other portions of the chromosome and it is believed that it is this proximal portion which forms the chromocenter. Plants free from conspicuous knobs and B chromosomes have a great majority of their interkinetic nuclei free from any structures which might be interpreted as chromocenters (except for the two nucleolar organizer regions on chromosome 6). That chromocenters often fuse is indicated by the range in number and size. Strains with knobs of approximately uniform size have chromocenters of uniform size -- barring fusion - while strains with different sized knobs have a marked range in size of chromocenters. The data obtained are summarized in the following table.

Tissue studied	Strain	Knob No. at pachytene	B chrom. No.	Number nuclei counted	Mean No. chromocenters	Range in number	Modal class
root	A	9	0	100	8.16	4-11	8
style	A	9	0	100	8.00	4-12	8
root	B	6	0	100	5.05	2-8	5
root	C	6	0	100	5.22	2-6	5
root	D	0	4	100	3.27	1-5	4
root	E	0	0	100	0.22	0-1	0

Occasionally the number of bodies classified as chromocenters was greater than the number of conspicuous knobs. This may be due to the misclassification of diffuse heterochromatin as chromocenters or more likely to the failure to distinguish small knobs at pachytene. Fusion of two or more of these small knobs might give rise to recognizable chromocenters. In every strain studied the number of chromocenters was determined before that of knob number. All preparations were stained with the Feulgen reaction.

D. T. Morgan, Jr.

2. The interaction of bronze (bz) with factors determining anthocyanin colors. - The bronze (bz) gene modifies the pigments involved in plant color. A B Pl bz plants are not purple but are a deep reddish-brown. A B pl bz plants have a bronze instead of a sun red color - the bronze color is also a sun color. A b Pl bz and A b pl bz plants are pigmented but the normal red pigment of the culm and glumes is transformed into a brownish pigment. The bronze gene is not concerned with the primary reactions determining the presence or absence of color but does modify in some way the pigment molecule. Aleurone color is also affected by bronze - the effect being a 'bronzing' of the purple (Pr) and red (pr) pigments. Pericarp



color is not affected i.e. plants of A P bz constitution have red pericarp. The action of bz on both the plant and aleurone colors may indicate a close chemical relationship of these pigments. The following linkage data on the location of bz have been obtained:

	Percent recombination	Number of individuals
<u>Yg2-Bz</u> self	13	2656
<u>Bz-C</u> B.C.	5	573
<u>Bz-C</u> self	5	3135
<u>Bz-Sh</u> self	8	454
<u>Bz-Sh</u> self	10	739
<u>Bz-Wx</u> self	24	454
<u>Bz-Wx</u> self	30	739
<u>Bz-V</u> self	33	739

On the basis of the above data, which are mostly  $F_2$ , the bz gene falls between Yg2 and C. Inasmuch as Dt is 7 units beyond Yg2 the revised linkage map of chromosome 9 is tentatively as follows:

<u>Dt</u>	<u>Yg2</u>	<u>Bz</u>	<u>C</u>	<u>Sh</u>	<u>Bp</u>	<u>Wx</u>	<u>V</u>
0	7	21	26	29	44	59	71

3. Gametophyte factor in chromosome 3. A gamete factor having an adverse effect upon the ability of pollen grains possessing it to effect fertilization has been located in chromosome 3. This new gamete factor is independent of the genetic constitution of the silks and hence is different in this respect from the gamete factors in chromosomes 4 and 5. Pollen with this factor is not visibly different from normal. Approximately 12.7% of the functioning pollen from heterozygous plants carry the gamete factor. The linear order in chromosome 3 is Lg2 A ga with the gamete locus some 10-12 units from A. Presumably it should lie close to etched (et).

4. The preference of Jap beetles for liguleless-1 leaves. The severe infestation of Japanese beetles in the summer of 1942 at Irvington, N. Y. made possible the observation that these beetles found the leaf tissue of liguleless-1 (lg1) plants very much to their liking. Leaves of all lg tester strains were nearly destroyed and many plants died. In all cultures segregating for lg1 an accurate classification for lg and Lg could be made from the amount of leaf tissue eaten by the insects. Lg plants adjacent to sister lg plants were nearly free from beetles while the lg plants literally swarmed with them. Plants homozygous for lg2 had the same, or nearly so at any rate, degree of infestation as did their normal sibs.

M. M. Rhoades



Connecticut Agricultural Experiment Station  
New Haven, Connecticut

1. A late flowering mutation arising in one of the long inbred Leaming strains, Cl4, shows no appreciable differences in plant or seed size at full maturity. At two weeks after planting the late plants are about half as tall as the normal inbred plants. These slower-growing plants are about six days later in silking but continue rapid growth longer and finally arrive at approximately the same height at the end of the season. This is an example of a deleterious recessive, not easily detected, that slows physiological activity.

2. Reciprocal crosses between inbred strains may show small differences in amount of growth in early stages after germination due to differences in embryo size or seed condition. These differences usually disappear by the time the plants flower. In crosses of a Rice pop inbred with very small seeds and a yellow dent inbred with large seeds marked differences were obtained in the reciprocals. Three weeks after planting the dent parent was nearly twice as tall as the pop parent and proportionally larger in overall size dimensions. At this stage the dent x pop  $F_1$  is taller than the dent parent while the pop x dent  $F_1$  occupies an intermediate position between the two parents. The hybrids and parents tassel and silk in the same order as their initial embryo weights: (1) dent x pop, (2) dent parent, (3) pop x dent, (4) pop parent. At the end of the season the two reciprocal crosses are equal in production of grain and in height and both are taller and more productive than either parent. Production of grain of the hybrid is about 15 times that of the pop parent and nearly twice as much as the dent. Both reciprocals reach full maturity at about the same time but the one that is smaller at the start continues rapid growth longer to reach eventually the same height and production of grain in approximately the same length of time. Since one of the hybrids starts smaller after germination and ends up larger in the amount of material produced than the larger parent, in the same period of growth, one is growing at a faster rate than the other.

The parents and reciprocal crosses also differ in the number of tillers. The dent inbred averages .03, dent x pop 2.06, pop x dent 1.24, and pop inbred 2.83 tillers per plant. The larger number of tillers is shown by the hybrid with the non-tillering seed parent. In these reciprocal crosses having the same genic constitution, tillering is an expression of initial vigor large enough to overcome any differences in maternal effect. Differences that may exist in the cytoplasm of these two widely diverse reciprocal crosses have no effect on the final reaction product between the external environment and the nuclear construction of the hybrids.

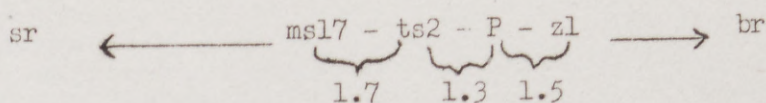
D. F. Jones

Cornell University, Ithaca, N. Y.

1. Aberrant pericarp-color ratios. - A few years ago I reported a recessive zygotic lethal, z1, with its locus near P in chromosome 1 of maize (Genetics 24: 368-384. 1939). The effect of z1 is to prevent,



with rare exceptions, homozygosis of genes with which it is closely linked, and thereby to change a 3:1 to a 2:1  $F_2$  ratio when zl is linked with a dominant gene or to prevent the occurrence of one class when linked with a recessive gene. When a plant heterozygous for zl is crossed with one lacking zl, there is, of course, no disturbance of ratios in the resulting progeny. The locus of zl, relative to other chromosome-1 genes is



Another case of disturbed pericarp-color ratios has occurred in at least three supposedly unrelated lines, all of which, however, are found to have had one individual plant as a common ancestor a few generations back, namely, a chromosome-1 marker with the genotype P br an gs. This suggests that the disturbance is associated with P rather than with its recessive allele.

Two selfed red-eared plants gave progenies totaling 83 red to 89 white, while three other selfed reds gave progenies with normal 3:1 ratios. The former also gave aberrant and the latter normal ratios when used as the pollen parent in crosses with white-eared plants. Fourteen cultures, resulting from white pollinated by heterozygous red, have had a total of 329 plants with red and 1148 with non-red ears. Some of these crosses have involved also Tl-3a, the totals being 404 T and 120 non-T. Two cultures involved msl7, P, and Tl-3a, from the cross:

$\text{ms} + + / \frac{+ \text{P} +}{\text{ms} + \text{T}}$ . This 3-point test gave the following results:

0	1	2	1,2	Total
18   152	0   6	10   18	0   2	
170	6	28	2	206
	2.9%	13.6%	1.0%	

The percent of recombination is: ms - P = 3.9, P - T = 14.6. The recombination value for P - T is less than that indicated by Anderson (News Letter 14 p.2. 1940). The striking thing, however, is the ratios of dominant to recessive markers, as follows:

$$\begin{array}{l} + : \text{ms} = 28 : 178 \\ \text{P} : + = 36 : 170 \\ + : \text{T} = 42 : 164 \end{array}$$

From these aberrant ratios it may be inferred that the locus of the disturbing element is to the left of msl7. Whether the disturbing factor is transmitted through the egg is not known. It is transmitted through the pollen. Only a part of the red ears of a culture that shows the aberrant ratio yield such ratios in the following generation.

The nature of the responsible gene, if gene it is, is not known. It is certain, however, that it is not a recessive zygotic lethal and not a



complete pollen lethal. So far as now known, it might be a pollen semi-lethal or a gamete factor, but if the latter, it differs in some respects from the Ga gene that disturbs the ratios of the starch-sugary pair and other characters of chromosome 4.

2. White-capped red pericarp. - In last year's News Letter I presented data which I interpreted as showing that white-capped red pericarp of such varieties of maize as Bloody Butcher is not allelic to ordinary red pericarp, P, as had been supposed, but is conditioned by multiple genes at least one of which is linked with red cob color and therefore with P. I presented data from  $F_2$ ,  $F_3$ , and backcrosses of the cross of colorless pericarp and white cob, W-W, with white-capped pericarp and red cob, C-R. From this cross, the four possible combinations of pericarp and cob colors were obtained, namely, C-R, C-W, W-R, W-W. Grades of pericarp color from 0, no color, to 6, the color intensity of the Bloody Butcher parent, were reported and the behavior in inheritance was shown to be that typical of quantitative characters.

This year I present data from further  $F_3$  cultures and also from  $F_4$  cultures. For brevity in the accompanying table, I have grouped together cultures which have about the same ranges of variation, and may, therefore, in so doing, have combined genetically heterogeneous material.

Certain conclusions may be drawn from these data: (1) - From the cross W-W x C-R, there have appeared in  $F_3$  or  $F_4$  in relatively true breeding form, the four possible combinations of pericarp and cob colors, namely, W-W (item 1), W-R (item 2), C-W (items 21, 28), and C-R (items 20, 25, 29, 30, 33). (2) - There have appeared types that breed relatively true for pericarp color while still segregating for cob color: W-R and W-W (item 3), C-R and C-W (items 22, 26, 27). (3) - Some cultures still show marked variation in intensity of pericarp color while breeding true for red cobs (items 11, 17) or white cobs (items 10, 16). (4) - In all cultures that have any pericarp color and that are segregating for cob color, the ears with red cobs have a higher mean grade of pericarp color than do those with white cobs. (5) - In a few cases, the ears with white cobs have no pericarp color while some or all of those with red cobs have more or less pericarp color (items 5, 6, 7, 18). (6) The gene or genes conditioning pericarp color in these instances (5 and 6 above) may be assumed to be in chromosome 1 near the locus of P. (7) - Selection is effective in establishing lines with diverse intensities of pericarp color.

From the trisomic cultures of Mr. Einset has come the suggestion that one or more genes affecting white-capped red pericarp color may be in chromosome 5. In a culture segregating for trisome 5 and for this type of pericarp color, the ears of trisomic plants had unmistakably more intense pericarp color than did those of disomic ones. This behavior is to be expected of characters that show a gene-dosage effect as white-capped pericarp color does. A beginning has been made in the use of the other trisomes in an attempt at a further genetic analysis of this pericarp color.

3. Differential dominance in number of kernel rows. - In the 1940 News Letter (14: 19-21), I reported differences in relative dominance of ten inbred lines of 12-row maize and of two 8-row inbred lines in crosses



F<sub>3</sub> and F<sub>4</sub> cultures of the cross W-W x C-R

Item No.	Number of cultures	Grade of parent	Cob color	Progenies						6: Total	Mean grade
				Pericarp-color grades							
				0	1	2	3	4	5		
1	3	0	W	134	-	-	-	-	-	134	0
2	2	0	R	116	-	-	-	-	-	116	0
3	2	0	{ R	73	-	-	-	-	-	73	0
			{ W	25	-	-	-	-	-	25	0
4	1	0	R	51	4	-	-	-	-	55	0.1
5	1	0	{ R	32	6	-	-	-	-	38	0.2
			{ W	15	-	-	-	-	-	15	0
6	1	1	{ R	2	10	-	-	-	-	12	0.8
			{ W	6	-	-	-	-	-	6	0
7	1	1	{ R	13	19	6	1	-	-	39	0.9
			{ W	8	-	-	-	-	-	8	0
8	1	2	W	6	8	16	12	-	-	42	1.8
9	1	2	{ R	9	5	12	10	-	-	36	1.6
			{ W	4	2	2	3	-	-	11	1.4
10	8	3	W	56	36	46	66	17	-	221	1.8
11	1	3	R	2	1	2	3	13	5	26	3.5
12	2	3	{ R	8	1	7	23	10	-	49	2.5
			{ W	9	2	3	6	2	-	22	1.5
13	3	3	W	-	14	17	29	8	-	68	2.5
14	1	3	R	-	6	16	13	11	-	46	2.6
15	1	3	R	-	-	-	6	5	-	11	3.5
16	1	4	W	14	3	8	11	19	5	60	2.6
17	2	4	R	13	20	12	25	12	3	85	2.1
18	1	4	{ R	-	6	4	10	4	-	24	2.5
			{ W	10	-	-	-	-	-	10	0
19	2	4	R	-	6	9	19	29	9	67	3.6
20	1	4	R	-	-	3	21	12	1	37	3.3
21	4	4	W	-	-	7	76	70	2	155	3.4
22	2	4	{ R	-	-	-	10	49	10	69	4.0
			{ W	-	-	4	13	6	-	23	3.1
23	2	5	{ R	9	7	4	16	17	21	75	3.2
			{ W	7	2	4	8	2	-	23	1.8
24	1	5	R	-	2	8	9	16	8	43	3.5
25	1	5	R	-	-	2	3	7	6	18	3.9
26	1	5	{ R	-	-	1	10	12	9	32	3.9
			{ W	-	-	3	6	-	-	9	2.7
27	1	5	{ R	-	-	-	1	8	16	25	4.6
			{ W	-	-	-	-	4	2	6	4.3
28	1	5	W	-	-	-	3	12	5	20	4.1
29	3	5	R	-	-	-	12	34	73	126	4.6
30	2	5	R	-	-	-	-	25	55	81	4.7
31	1	6	{ R	-	-	-	2	14	15	34	4.6
			{ W	-	1	2	6	-	-	9	2.6
32	1	6	R	-	-	1	3	9	34	59	4.9
33	2	6	R	-	-	-	-	12	42	87	5.2



of 12-row with 8-row lines. I now present further data on the crosses previously reported and tests of a few inbred lines not represented in the earlier report. The accompanying table includes the earlier as well as the later data.

Number of individuals and mean row number of F<sub>1</sub> crosses  
of 8-row with 12-row inbreds

12-row:	8-row lines					
lines :	1	51	Snf. W	Y. Flr.	Y. Flt.	R. Flt.
VI :	60- 8.9 :	54- 9.7 :	:	:	:	:
IV :	178- 9.1 :	72- 9.6 :	:	:	:	:
III :	75- 9.0 :	164-10.1 :	:	:	:	:
VII :	120- 9.2 :	91-10.1 :	:	:	194- 9.3 :	:
2 :	346- 8.9 :	391-10.5 :	103-8.8 :	79-8.8 :	114- 9.5 :	62-9.9
II :	89- 9.7 :	129-10.1 :	:	:	:	:
4 :	258- 9.4 :	177-10.6 :	:	:	:	:
39 :	625- 9.6 :	716-11.4 :	:	:	213- 9.7 :	:
G :	93- 9.1 :	37-10.1 :	137-8.6 :	:	217- 9.4 :	:
B :	221- 9.1 :	284-10.5 :	144-9.0 :	:	151- 9.7 :	81-9.5
b :	80- 9.8 :	58-10.4 :	78-9.2 :	87-9.4 :	:	:
c :	91-10.5 :	88-11.1 :	76-9.6 :	:	81-10.3 :	:

Averages of comparable means

:	9.4	:	10.4	:	:	:
:	9.5	:	10.5	:	9.0	:
:	9.4	:	10.5	:	9.1	:
:	9.4	:	10.6	:	:	9.7
:	9.0	:	10.5	:	:	9.7
:	:	:	:	:	:	:

Key to line designations:

1. Luce's Favorite (Wiggans)	VII. Early Pride
2. Onondaga White (Wiggans)	R. Flt. Red Flint
4. Bloody Butcher (Wiggans)	Snf. W. Sanford White
39. Golden Bantam (Purdue)	Y. Flr. Yellow Flour
51. Golden Bantam (Purdue)	Y. Flt. Yellow Flint
II. Westbranch	B } Segregates from crosses
III. Queen's Golden	G } of 8-row with 16-row
IV. White Pop	b } lines
VI. Dutton's Flint	c }

Of the 8-row inbreds, Sanford White and Yellow Flour are somewhat more nearly dominant even than Luce's Favorite, while Yellow Flint and Red Flint are less nearly recessive than Golden Bantam. Similar differences are shown by different 12-row lines. Such differences are well illustrated by the following frequency distributions for number



of kernel rows in crosses of two 12-row with two 8-row lines:-

<u>Cross</u>	<u>8</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>Total</u>	<u>Mean</u>
1 with 2	199	144	3		346	8.9
1 " 39	151	437	37		625	9.6
51 " 2	61	183	145	2	391	10.5
51 " 39	13	196	497	10	716	11.4

That these differences in behavior are conditioned by gene differences rather than by cytoplasmic diversity is indicated by the fact that reciprocal crosses are essentially alike. The following data from reciprocal crosses are all that are now available:

<u>Cross</u>	<u>8</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>Total</u>	<u>Mean</u>
2 x 1	69	58	2		129	9.0
1 x 2	79	55	1		135	8.8
39 x 1	65	227	19		311	9.7
1 x 39	70	187	10		267	9.6
39 x 51	9	135	371	5	520	11.4
51 x 39	3	32	67	3	105	11.3

It is not surprising that 12-row lines exhibit differences in relative dominance, because several of them at least are known to have different row-number genotypes. But 8-row types have been assumed to have the same genotype for number of kernel rows. Negative evidence in support of this notion is: (1) Crosses of 8-row inbreds have not resulted, in my experience, in the production of other than 8-row types. (2) Crosses of 8-row with 12-row inbreds have not resulted in types with more than 12 kernel rows. It is, of course, conceivable that genes responsible for the 8-row condition may be alleles with the same effect on row number but with somewhat different dominance behavior.

4. Genetic diversity of 12-row lines. - Data indicating genetic heterogeneity of certain 12-row inbred lines of maize have long been available, but have not been reported heretofore in this "unpublished publication". A brief summary of some of these data follow.

Numerous 12-row lines have been obtained from various sources. Some (A, B, G, b, c) from crosses of 8-row flints with 16-row dents and others (III, IV, VI, VII) by selection from varieties of dent, flint, and popcorn. No 12-row type produces only 12-row ears. There are always some 10-row and 14-row ears and occasionally an 8-row or a 16-row ear. To determine whether a 12-row line is homozygous it is necessary to grow progenies from selfed ears of the more extreme variants. To get such selfed ears it is necessary to hand-pollinate many plants. This has been accomplished for the 12-row types involved in this account. A single example of the results obtained is given here.

Line b had in F<sub>9</sub> a distribution ranging from 8 to 16 rows with



frequencies of 4-18-49-14-1. In  $F_{10}$ , progenies from selfed ears of diverse row numbers were produced as follows:

Parent row number	Progeny					Total	Mean
	<u>8</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>16</u>		
8		1	19	7	1	28	12.6
10		5	22	9		36	12.2
12	2	3	27	6	2	40	12.2
14		4	25	3	2	34	12.2
16	4	4	34	9	1	52	12.0

The other lines gave similar results. It was concluded, therefore, that all were approximately homozygous. When any two of the nine 12-row lines were crossed, except only b x c, it was easily possible to establish lines of different row number. For example, the cross b x IV exhibited row-number ranges from 10 to 16 in  $F_1$  and 8 to 18 in  $F_2$  with these frequencies, respectively, 1-43-8-1 and 2-12-37-21-7-2. In  $F_3$  the following frequency distributions were observed:

Parent row number	Progeny						Total	Mean
	<u>8</u>	<u>10</u>	<u>12</u>	<u>14</u>	<u>16</u>	<u>18</u>		
8	34	12	2				48	8.7
10	2	1	33	7	2		45	12.3
14			6	16	14	1	37	14.5

Given different genes for row number in the several 12-row types, it should be possible, by multiple crossing followed by selection, to assemble the row-number genes of the several 12-row lines into a single line of high row number. In the accompanying table are shown the frequency distributions of all of the ears produced by seven inbred lines during several generations when selected for twelve rows and similar data from certain single, double, and multiple crosses of these lines when selected for high row number.

The seven inbred lines had frequency distributions ranging mostly from 8 to 16 rows with strong modes at 12 rows and means very near 12. During the five to eight generations shown in the table and among the total of more than six thousand ears, not a single ear had more than 16 rows. After repeated intermittent crossing followed by selfing with selection for high row number, lines have finally been established with modes at 24 rows and means near 23. Two of these lines have not produced an ear with so few as 16 rows.



Frequency distributions of number of kernel rows of inbred lines  
and their single, double, and multiple crosses

Inbred lines and crosses	Gener- ations: (F)	Number of kernel rows												Total	Mean
		8	10	12	14	16	18	20	22	24	26	28			
A	5-9	8	303	680	147	3	-	-	-	-	-	-	1141	11.7	
B	5-12	19	594	1267	411	1	-	-	-	-	-	-	2292	11.8	
G	3-13	2	107	701	500	27	-	-	-	-	-	-	1337	12.7	
III	3-8	2	39	242	55	6	-	-	-	-	-	-	344	12.1	
IV	3-10	8	65	305	47	-	-	-	-	-	-	-	425	11.8	
VI	4-10	5	126	406	144	3	-	-	-	-	-	-	684	12.0	
VII	3-9	-	55	284	81	4	-	-	-	-	-	-	424	12.2	
A x B	4-5	-	8	74	95	10	-	-	-	-	-	-	187	13.1	
A x G	4-5	-	-	50	136	52	1	-	-	-	-	-	234	14.0	
IV x VI	4-5	-	1	51	108	42	5	-	-	-	-	-	207	14.0	
VI x VII	5-6	-	-	43	109	73	9	-	-	-	-	-	234	14.4	
III x IV	5-6	-	-	38	105	62	16	-	-	-	-	-	221	14.5	
IV x VII	5-6	-	-	14	98	120	14	-	-	-	-	-	246	15.0	
A-B x VI-VII	5	-	-	7	7	36	17	5	-	-	-	-	72	16.2	
A-B x IV-VI	5	-	-	1	7	37	14	6	-	-	-	-	65	16.5	
A-B x III-IV	3-5	-	-	1	7	30	33	2	-	-	-	-	73	16.8	
A-G x VI-VII	5	-	-	4	9	35	30	12	-	-	-	-	90	16.8	
A-G x IV-VII	5	-	-	-	5	17	42	17	1	-	-	-	82	17.8	
III-IV x IV-VII	5	-	-	-	-	22	29	15	-	-	-	-	66	17.8	
III-IV x VI-VII	5	-	-	-	5	24	24	21	2	-	-	-	76	17.8	
A-B x III-IV	1	-	-	-	-	3	1	-	-	-	-	-	4		
A-B x VI-VII	1	-	-	-	5	22	18	3	-	-	-	-	48	16.8	
A-G x IV-VII	1	-	-	-	-	11	19	12	3	-	-	-	45	18.3	
III-IV x IV-VII	1	-	-	-	-	11	19	12	3	-	-	-	45	18.3	
A-B x III-IV	4	{	-	-	-	7	24	36	15	8	-	-	90	19.8	
A-B x VI-VII			-	-	-	3	19	28	19	10	1	-	80	20.4	
x			-	-	-	2	8	18	14	5	-	-	49	20.6	
A-G x IV-VII			-	-	-	-	-	-	-	-	-	-	-	-	-
III-IV x VI-VII															
A-B x III-IV	4	{	-	-	-	1	2	12	13	20	9	4	61	23.0	
A-B x VI-VII			-	-	-	-	3	20	18	27	6	1	75	22.4	
x			-	-	-	-	7	12	27	32	16	4	98	23.0	
A-G x VI-VII			-	-	-	-	-	-	-	-	-	-	-	-	-
III-IV x IV-VII															



I am now ready to admit that number of kernel rows in maize is a much more complex quantitative character than I assumed it to be when I began a study of its inheritance.

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Controlling starchy contaminations in sweet corn by the use of Ga. - The gene Ga converged on Purdue 51 gives inbreds whose hybrids ("sixty-three sixty-fourths" Golden Cross Bantam) are resistant to pollen contaminations by field corn. In testing it was not found practicable to duplicate field conditions since the inclusion of "unadulterated" Golden Cross Bantam as a check, diluted the proportion of available Ga pollen.

Where this dilution was greatest, with four check rows to one row with Ga, Ga reduced contaminations by  $71.6 \pm 20.4\%$  (S.E.). Where the proportion of Ga pollen was higher, the reduction was  $76.6 \pm 11.8\%$ . When the proportion was still higher (approaching field conditions) the reduction was  $82.0 \pm 12.3\%$ . Since the differences between these values are not significant, one can only guess that if Ga were introduced into both parents of the hybrid thus doubling the proportion of Ga pollen, Ga might under field conditions reduce contaminations by as much as 90%.

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Translocation 3-5d. - T 3-5d was isolated in an early dent corn from northern Wisconsin in 1938. (Shuman, John R., A chromosomal interchange in maize giving both chain and ring configurations and low sterility. Summaries of Doctoral Dissertations, University of Wisconsin Press 4: 57-58. 1940.) The strain was not subjected to any treatments known to induce chromosomal changes.

Interchange configurations at diakinesis were examined in 239 microsporocytes from a heterozygous plant, and 225 were classified as follows: 90.6% of the cells had chains of four chromosomes; 4.4% had four chromosomes in an open ring, 3.2% had closed rings of four chromosomes and 1.8% had 10 "bivalents". These observations were interpreted as evidence of a reciprocal translocation in which a comparatively short segment had been exchanged with a longer non-homologous one.

At Anaphase I, 79 microsporocytes from a heterozygous plant had an alternate disjunction of the chromosomes of the complex, and 97 showed an adjacent separation. These frequencies do not differ significantly from equality.



Diakinesis figures from hybrids combining the interchange under investigation with T 1-2a, T 2-9b, T 4-9a, T 6-8 had two independent complexes of four chromosomes and six bivalents; with T 3-8a and T 5-7a there was one complex of six chromosomes and seven bivalents; and with T 3-5b there was one complex of four chromosomes and eight bivalents. Hence chromosomes 3 and 5 were involved in the interchange; and it was labeled d since three T 3-5's were previously described.

Three plants heterozygous for T 3-5d had 24.4% of 2274 pollen grains aborted, and 26.8% of 1315 possible kernels missing from the corresponding ears. These two percentages do not differ significantly from each other, nor from the assumed 25% abortion.

Normal plants as the seed parent crossed with T 3-5d heterozygous resulted in 47.2% of 182 plants from two families with 25% pollen abortion. This per cent of partially sterile plants does not differ significantly from 50%, i.e. a 1 (normal) : 1 (25% sterile) plant ratio. T 3-5d heterozygous as the seed parent crossed with normal plants gave 37.4% of 251 plants from two families with 25% abortion. T 3-5d heterozygous plants sired produced 37.7% of 212 plants from two families with 25% abortion. Neither of the latter two distributions differ significantly from each other or from 33 1/3%, i.e. a 2 ("normal") : 1 (25% sterile) plant ratio.

It was therefore postulated that of the four equally frequent classes of spores expected in the heterozygote, only that class deficient for the longer interchanged segment is aborted. The class of spores deficient for the shorter segment but duplicate for the longer one survived through the seed - but not through the pollen parent - despite the fact that 75% of the pollen grains appeared normal. Normal plants, those heterozygous and homozygous for the interchange were morphologically indistinguishable. Plants homozygous for the translocation were completely fertile.

John R. Shuman

#### Missouri Botanical Garden

1. Maize from Michoacan. - Professor Ralph Beals of the University of California in making a detailed ethnographic study of two neighboring Tarascan villages in Michoacan, Mexico, collected 43 varieties of maize which were loaned me for study. There were 55 ears in all, from each of which I grew ten or more plants at the Blandy Experimental Farm during 1942. The ears were photographed, herbarium specimens were made of the leaves and tassels, measurements and notes were made on the living plants, and these data in condensed tabular form will eventually appear as an appendix to Professor Beals' monograph.

As a whole, the maize belongs to the race which Cutler and I have recently termed "Mexican Pyramidal". The ears taper sharply and regularly, most of them show more or less denting, and there is a strong but variable tendency to irregular rows. The plants are coarse



but the leaves break readily in the wind. They are very susceptible to smut. The tassels have few branches or none at all. At least three sub-races are grown in these two neighboring villages. For two of these there was enough material to define the central core of their variation. BLACK MAIZE is grown only below 8500 feet in gardens close to the homes. Characteristically it has large smoothly-dented kernels with blue or purple aleurone, on a tapering ear about 15cm. long. TULUKENIO varieties are grown only above 8500 feet in small isolated plots in the mountains. In size the ears vary from as large as Black Maize to very small nubbins. Their kernels vary greatly in size and shape but tend to be small, more or less pointed, and slightly dented. While a few have colorless seedcoats, most of them are lightly suffused or stained with red or reddish brown. None of them have dark aleurone. In such technical tassel characters as glume length, tassel branch number, and percentage of condensed internodes, the Tulukenio varieties are closer to Pima-Papago maize than to Mexican Pyramidal. The extreme variants of Tulukenio are small-cobbed, non-tapering, early seasoned, flinty, undented, and many tillered. They may possibly reflect a primitive small-cobbed race something like the maize of the prehistoric Basket Makers. Taken in conjunction with Mangelsdorf and Cameron's recent analysis of knob number in Guatemalan maize, the differences between the Tulukenio and the Black Maize varieties from the same village demonstrate the importance of considering altitude above sea level in interpreting the history and development of Zea mays.

Of the three Tulukenio varieties which were examined cytologically, two had 'B' chromosomes and the total knob numbers were 4, 4, and 7. The two Black Maize varieties which we examined had no 'B' chromosomes and had total knob numbers of 5 and 6. Most of the knobs were small, compared to those in the maize from western Mexico (Jalisco).

2. Glume bar and its inheritance. - Many central American and southwestern varieties of maize are characterized by a bar or spot of intense color at the base of the glume in the tassel. It is rather rare in modern dent corn; of eighty inbreds examined at Beltsville, 69 were without any indication of it and in only four was it strongly developed. In certain lines and under certain conditions it segregates sharply. It is apparently independent of both the B and R series though its expression is affected by them. It is easiest to score when the tassel has just emerged. I have used the following grades in scoring it:

readily apparent without handling the tassel .....	++
readily apparent only upon handling the tassel ...	+
of slight and variable expression .....	±
altogether lacking .....	0

The only data I have on its inheritance are derived from a series of inbreds from one strain of Papago Flour corn. In two cases the same lot of seed was grown in different places and different years. One second generation inbred was scored as all ++ at Cold Spring Harbor, L.I.; in 1941 and likewise at Boyce, Virginia in 1942. On the other hand the first generation inbred P-8 segregated sharply in Missouri in 1940, 10 ++ to 26 0. At Cold Spring Harbor in 1941 the second



planting gave a higher percentage of plants with glume bar but in many of these it was not strongly marked (43,+; 5,±; and 17, 0). In three of the inbreds glume bar segregated independently from the B and R loci. (Since the B and R allelomorphs in this material are apparently different from those in most genetic stocks, no attempt has been made to define them precisely).

P-2. leaf sheath slightly sun red, anthers pink, glume bar +. First selfing, 29 plants all sun red but in varying degree, anther color and glume bar segregating as follows: pink anthers,+, 11; pink anthers, 0, 11; green anthers,+, 4; green anthers 0, 1.

P-6. leaf sheath green, bright pink anthers, glume bar ++. First selfing, 27 plants segregating sharply for glume bar and plant color as follows: red sheath, ++5; green sheath, ++, 13; red sheath, 0, 3; green sheath, 0, 6.

P-8. parental type unscored. First selfing, 66 plants all strongly sun red, silks green, segregating for glume bar and anther color, red anthers,+, 37; green anther,+, 15; red anthers, 0, 7; green anthers, 0, 7.

3. Average values for certain characters in Beals' collections from Cherán and Nahuatzen (Uruapan) Michoacan, Mexico.

	Black Maize	Tulukenio
Total number of ears	25	26
Row number (from collected ears)	14	14
Glume length in mm.	13	12
Tassel branch number	5	7
Percentage of condensed internodes in tassel	10	20
Percentage of sub-sessile upper spikelets	50	70
Pubescence of sheath	scattered	heavy
Tillers on ten plants	0	0-1

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1. Some Alleles of R. Detailed phenotypic comparisons were made between R alleles derived from relatively unrelated individual plants. The original stocks were mostly of strains cultivated by various American Indian tribes, specimens of which were supplied by J. H. Kempton. Twenty-two alleles with colored aleurone and colored plant effects (R<sup>r</sup> series) were included (abstract in Genetics, 28: 90-91). In addition a number of alleles of the r<sup>r</sup> series are included in a



later parallel study.

The effect of different R alleles upon plant color differs widely, as to both intensity and distribution of pigmentation. Since the associated independent effect upon aleurone color provides a completely linked marker, it is possible to identify even very slight differences due to the R alleles, as distinguished from the effects of modifying factors.

The series is non-linear, in that various cases occur in which one allele produces distinctly more effect than another upon some tissues and distinctly less upon others. Such cases might be expected to occur if the alleles differ only in the extent of their effect upon some single reaction, for it might be expected that pigmentation would increase with "strength of action" up to a given point and then decline, and that this optimum point might differ in the various tissues concerned. The effects observed do not fit this hypothesis in any reasonably simple form. They suggest rather that the effect of R alleles upon plant color is a complex of two or more types of action, independent in the sense in which the aleurone color effect and the plant color effect are independent.

For a major portion of the plant color effect, however, the reaction of different tissues is quite closely correlated. The R<sup>F</sup> alleles may be arranged in a single sequence to represent their effect upon occurrence and intensity of pigmentation in mesocotyl, coleoptile, seedling leaf tip and margin, seedling leaf sheath, mature plant basal sheaths, tassel glume, and anther. For example, the occurrence of seedling leaf tip color marks a level beyond which full anther color is developed and below which anther color is distinctly weak. Full coleoptile and mesocotyl color are reached below this level, though the color of these organs is deeper and more rapidly developed in the types with tip color. Distinct seedling sheath color does not occur until a higher level is reached, and is accompanied by deepened coloration of the tassel glumes and anthers. In their effect upon this character complex the R alleles studied may be regarded as differing merely in level of action, and the varying thresholds of response in the tissues studied provide a sensitive means of detecting differences in the level of action of the alleles compared.

L. J. Stadler and Seymour Fogel

2. New Alleles of A. As previously noted (News Letter, 1941: 44) the gene A<sup>b</sup> mutates spontaneously at a fairly high rate to a type resembling a<sup>P</sup>. The mutants, identified by the pale aleurone effect, produce plants which like a<sup>P</sup> produce both anthocyanin and anthoxanthin pigment. Nine of the mutants were checked for the dominant brown pericarp effect present in A<sup>b</sup> and a<sup>P</sup>, and all showed this effect also.

In plant color with B and Pl, the mutants were in general more deeply colored and more reddish than the standard a<sup>P</sup>. They varied rather widely in degree of redness, ranging from a deep brown to a maroon shade approaching purple at maturity. The original mutants, and various others which have occurred in later experiments with A<sup>b</sup>,



form an apparently continuous series between the two extremes. No mutant of  $\underline{A}^b$  to a colorless aleurone type or to a type producing only anthoxanthin pigment in the plant has been found.

Four representative mutants were selected for further study, to determine whether the differences in expression were due to differences in the mutant alleles. The factor  $\underline{et}$ , an X-ray induced chromosome 3 mutant, located 11 units distal to  $\underline{A}$ , was combined with one of the mutants and also with standard  $\underline{a}^P$ , and the phenotypic effects were compared in backcross progenies in which the various alleles could be compared in plant color (with  $\underline{B}$  and  $\underline{Pl}$ ) in sib plants. The results show that the four mutants represent distinguishable alleles of  $\underline{A}$ , each producing a mixture of anthocyanin and anthoxanthin pigments but differing in the relative quantity of anthocyanin produced. These are designated mahogany ( $\underline{A}^{b-m}$ ), cedar ( $\underline{A}^{b-c}$ ), chestnut ( $\underline{A}^{b-ch}$ ) and walnut ( $\underline{A}^{b-w}$ ).

The aleurone color of the mutant  $\underline{A}^b$ 's described, as identified in  $\underline{et}$ -marked segregations, is paler than that of  $\underline{A}^b$  or  $\underline{A}$ , but not so pale as  $\underline{a}^P$ . Seed separation may be made effectively in segregations against either  $\underline{A}$  or  $\underline{a}^P$ . There is also a recognizable difference in aleurone color between some of the mutant types, which sometimes is distinct enough for individual classification.

There are some interesting differences in the action of these pale aleurone mutants of  $\underline{A}^b$  and the two pale aleurone mutants at hand which arose from other members of the  $\underline{A}$  series.  $\underline{A}^{lt}$  (News Letter, 1941: 46) is an ultra-violet mutant of  $\underline{A}$ , which has a pale aleurone and reddish purple plant color, yielding anthocyanin and anthoxanthin pigment.  $\underline{A}^W$  is a mutant of  $\underline{a}$ , which occurred as a sector with pale purple anthers in a plant of  $\underline{a} \underline{Dt} \underline{B} \underline{Pl} \underline{Rr}$ . It also produces pale aleurone and a reddish plant color, yielding anthocyanin and anthoxanthin. Qualitative tests show a distinct difference in the anthocyanin produced by  $\underline{A}^{lt}$  and  $\underline{A}^W$ , on the one hand, and by  $\underline{A}^{b-m}$ ,  $\underline{A}^{b-c}$ ,  $\underline{A}^{b-ch}$ ,  $\underline{A}^{b-w}$ , and  $\underline{a}^P$  on the other.

The pale  $\underline{A}^b$  mutants, like  $\underline{a}^P$ , show little or no difference in the aleurone color of homozygous seeds vs. seeds heterozygous for  $\underline{a}$ . Both  $\underline{A}^{lt}$  and  $\underline{A}^W$ , in selfed ears of plants heterozygous for  $\underline{a}$ , show clearly cumulative effects, the heterozygous seeds being distinctly pale and the homozygous seeds often being indistinguishable from full  $\underline{A}$ .

In compounds among the pale  $\underline{A}^b$  mutants and between these mutants and  $\underline{a}^P$ , the plant color effect of the redder member is distinctly dominant, and in those cases in which aleurone color is distinguishable the darker type is dominant.  $\underline{A}^{lt}$  produces a redder plant color than the  $\underline{A}^b$  mutants or  $\underline{a}^P$ , but the hybrid  $\underline{A}^{lt}/\underline{a}^P$  is intermediate, with a pronounced increase in anthoxanthin content.  $\underline{A}^{lt} \times \underline{a}^P/\underline{a}$  yields progeny of two very distinct types, the  $\underline{A}^{lt}/\underline{a}^P$  plants showing a distinct dominant effect of  $\underline{a}^P$  on anthoxanthin production as compared with the  $\underline{A}^{lt}/\underline{a}$  sibs. This dominant effect of  $\underline{a}^P$  is not evident in crosses with  $\underline{A}$  or  $\underline{A}^b$ , so far as the appearance of the plants is concerned. It is evident, however, in crosses with  $\underline{A}^{br}$ , a  $\underline{Dt}$ -mutant obtained by Rhoades, (News Letter, 1941: 6)



which resembles A in plant and aleurone color but does not give red pericarp. In crosses of A<sup>br</sup> x a<sup>p</sup>/a there is a distinct diminution of red and increase of brown in the plant color of A<sup>br</sup>/a<sup>p</sup> vs. A<sup>br</sup>/a sibs. A similar effect is shown by cedar, chestnut and walnut, the only A<sup>b</sup> mutants tried in this combination. It is wholly absent in A<sup>br</sup> x A<sup>lt</sup>/a, the A<sup>br</sup>/A<sup>lt</sup> plants being indistinguishable from the A<sup>br</sup>/a sibs.

3. The Action of R and B. No anthocyanin pigment is produced in maize except in the presence of suitable alleles of A1, A2, and either R or B. For certain tissues B will serve as well or better than R; for others R is essential regardless of the presence of B. In those tissues which may be colored by the action of either R or B, the essential step in anthocyanin synthesis which is accomplished by R must be accomplished also by B, or it must be made unnecessary by some alternative step accomplished by B.

The effects of varying R action are shown by the phenotypes of the various R alleles, and a similar comparison may be made for B by comparing it with the weakened B alleles described by Emerson in 1921. Several additional B alleles intermediate in action between B and b have been picked up in exotic strains and in dent corn varieties. Their study is not quite as convenient as that of the R alleles, but is facilitated by the use of Anderson's chromosome 2 inversion to intensify the linkage with seedling markers. The B alleles, like the R alleles, differ in the occurrence and the intensity of the pigmentation of various organs, and in their major plant color effect they may be arranged in a single sequence of increasing strength on the assumption of different thresholds of response in different tissues. The order of response of the different tissues is however quite different from that found for the R alleles. The standard B used produces rather strong pigmentation of the seedling leaf sheath, coleoptile and mesocotyl, and deep pigmentation of the mature sheath, blade, culm, tassel, and cob. With successively weaker B alleles, blade color is restricted to the midrib and soon disappears, sheath color becomes weakened first in the lowermost sheaths and last in the middle sheaths. Glume color diminishes first at the tip region of the glume, and with successive steps is limited more and more closely to the base of the glume. In the weakest allele distinguishable from b, plant color is limited to a narrow transverse line at the base of the glume and to scattered streaks of color on the culms and sheaths of the middle internodes of the plant. The pigmentation of mesocotyl, coleoptile, and seedling sheath disappears early in this sequence, and most of the alleles give wholly colorless seedlings.

The response of R and B genotypes to sugar feeding of excised tissues (News Letter 1942: 31; Amer. Jour. Bot., 29: 17s) is sharply different. Sib plants of r<sup>ch</sup> b and B r<sup>g</sup> (with A1, A2, P1) are about equally colored in coleoptile and seedling leaf sheath. In later growth the latter becomes much more deeply colored in leaf sheath and blade. Excised leaf sections of the r<sup>ch</sup> plants, in seedling or later stages, produce anthocyanin abundantly with externally supplied glucose, the amount of anthocyanin varying with the glucose concentration. Seedling leaf sections of the B



plants produce no anthocyanin, regardless of the glucose concentration, and leaf sections taken at a stage when anthocyanin is being produced in the leaf show no effect of added sugar upon the rate of anthocyanin production. The presence of B in addition to  $r^{ch}$  does not increase the rate of anthocyanin production by the excised leaf sections, and the addition of B to weaker alleles of R, which produce anthocyanin at a lower rate than  $r^{ch}$ , does not increase their response to added glucose.

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1. The number 4 trisome is now available in a stock segregating for su 1. Also, all of the other trisomes, with the exception of number 1, are available in vigorous stock cytologically determined to be free of B chromosomes. To make these trisomic stocks more suitable for use in the corn belt and elsewhere, they have been outcrossed to different commercial inbred lines, including the corn belt lines Hy and 187-2 and somewhat earlier maturing New York State lines of Lucus Favorite and Cornell 11.

2. The embryo culture technic was utilized to obtain hybrids of tetraploid corn and tetraploid *Tripsacum*. Tetraploid corn was pollinated with a mixture of pollen from  $4n$  corn and  $4n$  *Tripsacum* by stripping down the husks and sprinkling the pollen over the silks exposed throughout their entire length. The husks were then drawn up about the ear shoot and held in place with rubber bands and a glassine bag to prevent excessive evaporation. Ears pollinated in this manner were harvested 18 to 21 days after pollination, the embryos of the partially developed kernels were excised and transferred to a sterile agar nutrient medium in 2 oz. bottles. After their root systems were well established, usually after 10 days to 2 weeks, the seedlings were transplanted to soil. The 56 chromosome hybrids are slow-growing and thus far show no evidence of hybrid vigor. At the present time (January),  $4n$  corn plants of the same age and similarly derived from excised embryos originating from pollinations made last August have passed the silking and pollen-shedding stage, while the hybrids are still making exclusively vegetative growth and show no evidence of stem elongation, although they are sturdy, healthy plants. Since these *Tripsacum*-corn hybrids, unlike those previously obtained by Mangelsdorf and Reeves, have two sets of chromosomes from each parent, they should be highly fertile; but this remains to be seen.

3. Tetraploidy may be induced in the shoot apex of very young maize seedlings by introducing a dilute aqueous solution of colchicine through the cut end of the primary seminal root, or later in seedling development after the secondary seminal roots are established by introducing the colchicine solution through the base of the epicotyl following excision of the seed. Immersion alternately in .05% colchicine and water for 24-hour periods, usually for 4 days, effectively induced sizeable sectors of  $4n$  tissue that persisted to maturity and affected both tassel and ear shoot. In some instances both ear shoot and tassel apparently were entirely tetraploid, and selfing such plants produced tetraploid seed. External applications of colchicine to ear-shoots and seedlings prove



unsatisfactory as a practical method of chromosome doubling.

This seedling treatment technic is being adapted to the production of diploids from haploids in an attempt to obtain homozygous diploids from heterozygous maize stocks, especially commercial hybrids, in one generation.

4. The origin of the perennial rhizome habit of *Euchlaena perennis* Hitch. has puzzled students of species relationship in the tribe Maydeae for many years. All other American representatives of the tribe are annuals, with the exception of *Tripsacum*, which is perennial but grows in dense clumps and has very short rhizomes unlike the elongate freely-spreading rhizomes of perennial teosinte. The annual teosinte of Central America and Florida that has been examined cytologically is diploid. The perennial teosinte, known only from one very restricted area in Mexico, is tetraploid and has multivalent synapsis of its chromosomes and other characteristics which indicate that it is either a true autotetraploid or an allotetraploid of two closely related species or ecotypes.

Diploid forms of perennial teosinte and tetraploid forms of annual teosinte are unknown in nature. However, a somatic mutation from the annual to the perennial habit occurred in a plant of Durango teosinte grown in the greenhouse in 1931. The annual portion of this plant (1359-10) was diploid and its selfed progeny were diploid annuals with the exception of one plant (1625-B-1), which was tetraploid and perennial. The perennial rhizome sector of plant 1359-10 was propagated vegetatively, and several root-tips collected from it soon after it was discovered were examined cytologically and found to be entirely tetraploid. However, of 15 seedlings produced during the following flowering period from selfed seed of the perennial mutant one was triploid and 14 were tetraploid, and the mutant pollinated during this same period by tetraploid corn produced 11 tetraploids and one triploid, suggesting that diploid tissue persisted in the mutant sector up to the time the first crop of seed was produced sufficient to form at least 2 female gametes with a monoploid set of chromosomes.

The spontaneous occurrence of this somatic mutation from the annual diploid to the perennial tetraploid condition was interpreted as strong evidence in support of the assumption that *E. perennis* was simply a tetraploid mutant of *E. mexicana*.

To test this assumption further, tetraploidy was induced experimentally in stocks of Durango, Chalco and Florida teosinte with the heat-treatment technic. These artificial tetraploids had the annual growth habit of the parent diploids and exhibited no perennial characteristics whatever.

Another test of the relation between tetraploidy and the perennial habit involved the identification of parthenogenetic diploids in the progeny of *E. perennis* to determine whether they would be annual or perennial. In diploid maize parthenogenetic haploids occur with an average frequency of about 1:2000, and in tetraploid maize parthenogenetic diploids occur with an average frequency of about 1:1000. Data from greenhouse material of perennial teosinte (teosinte is a short-day plant which normally flowers during November in this latitude) accumulated during the past 10 years



indicate that haploid parthenogenesis is extremely rare in this species. In this experiment, the results of which are summarized in the accompanying table, various stocks of perennial teosinte were used, including a culture from rhizomes collected at the type locality in Mexico (El6-515), a seedling from seed harvested from the type material in Mexico (El3-533), selfed progeny of El6-515 (2660), selfed progeny of El3-533 (2661), the spontaneous tetraploid mutant (1359-10) and the tetraploid seedling (1625 B-1) from the annual portion of this plant.

Seedling progenies obtained from various perennial  
teosinte X diploid corn crosses, 1932-1941

Perennial teosinte stocks									
El3-533		El6-515	1359-10	1625 B-1	2660 16-515 selfed	2661 13-533 selfed	3449 2661 selfed	Misc.	
1932	15	80	42						
1933	1028	1417							
1934	565	126	485	317	1132	1141			428
1935	570	860	875	784	1040	415			
1936	149	1263	166	22	117	1156			
1937	16	1410	142	34	143	1081			137
1938	91	1345	310	47	265	1524			
1939		1125	263	44		1695	197		
1940	134	405	11	68		2490	20		
1941	177	1148	320	43	754		89	140	
Totals 2745		9179	2614	1359	3451	9502	306	705	
Grand Total		29,869							

Perennial teosinte is propagated vegetatively with the greatest of ease and no difficulty is experienced in maintaining individual clones indefinitely. To facilitate the identification of parthenogenetic individuals in the seedling stage, the perennial teosinte stocks were crossed with corn pollen of the constitution A B Pl C R<sup>E</sup> Pr or a B Pl lg. The triploid hybrid seedlings of these crosses would be purple and under suitable cultural conditions could be distinguished readily from maternal, weak sun-red seedlings. Parthenogenetic seedlings of paternal origin would be either purple with green anthers at maturity or green liguleless. One parthenogenetic maternal diploid



and one parthenogenetic paternal haploid were identified among the 29,861 seedlings from the perennial teosinte X diploid corn crosses grown during the period from 1932 to 1941 inclusive. The maternal diploid appeared in the 1936 progeny of culture 2661, which in that year contained 1156 seedlings. This exceptional diploid had the annual growth habit. It tillered profusely, but produced no rhizomes and after forming a few aborted tassels the plant died at about the same time annual teosinte plants of the same age mature and then die. The parthenogenetic haploid of paternal origin had narrow leaves and otherwise resembled teosinte in the early seedling state, except that it was a diminutive seedling and had the purple color of the pollen parent; later in ontogeny it became typically maize-like and was indistinguishable from ordinary maternal haploids of the same stock.

In addition to these two exceptional seedlings there occurred each year a small number of maternal tetraploid seedlings. These were at first assumed to be contaminations, but the prevalence among them of recessive chlorophyll mutants suggested that at least some of them may have originated from unfertilized, normally-reduced diploid eggs followed by chromosome doubling in early embryogeny. If this is happening, it would help to explain the low frequency of maternal diploids obtained from this perennial teosinte X corn cross.

The perennial rhizome habit of *E. perennis* does not behave as a simple Mendelian recessive. The  $F_1$  *perennis* X  $4n$  corn is intermediate in that it can be maintained by careful subdivision and occasionally produces short rhizomes. The character does not segregate sharply in  $F_2$  and back-cross progenies but behaves like typical quantitative characters that are dependent on the interaction of multiple factors. In these segregating progenies most of the plants tillered much more profusely than did the  $4n$  corn parent, but very few developed any appreciable rhizome system during the summer season. A much longer growing season than we have at Ithaca is needed to make really satisfactory classification for rhizome habit in material of this kind. However, it is apparent from the general character of the segregating populations and the intermediate nature of the  $F_1$  plants with respect to rhizome habits that a dosage effect is involved, and it is therefore conceivable that cumulative gene action accompanying chromosome doubling might transform an annual into a perennial in the presence of a suitable genotype.

Some such interpretation of the origin of the perennial rhizome habit of *E. perennis* is supported by the occurrence of the parthenogenetic maternal diploid lacking the perennial rhizome habit in the progeny of *E. perennis*, and by the occurrence of the spontaneous perennial, tetraploid chimera in an annual plant of *E. mexicana*. The persistence of the annual habit in the experimental autotetraploids of *E. mexicana* may mean that the stocks from which they were produced lacked the essential genes requisite to the production of the perennial habit in the tetraploid state. It is generally believed that most annual forms of teosinte possess admixtures of maize genes. This would provide ample opportunity for displacement of genes of annual teosinte having perennial prepotencies by maize genes with strong annual prepotencies and would account for the appearance of the perennial habit in some annual teosinte tetraploids and not in others.

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1. Corn Breeding in the Tropics. Perhaps a few observations on corn breeding in Venezuela, latitude N 12, would be of interest to geneticists in other parts of the world.

A preliminary survey of the existing corn varieties in Venezuela made in September, 1939, revealed that all of them were of inferior productive capacity with a tendency to grow extremely tall and set the ear high on the stalk. Most varieties had white seeds, primarily because the people depend to a large extent on "arepa", ground corn in the form of a small, thick pancake, for food. Yellow "arepas" are preferred in some regions of the country, but white "arepas" are more commonly used. For years, negative selection has been going on in corn because the people eat the best seeds and plant the leftovers.

Some of the best varieties and hybrids from the United States and from many tropical and subtropical countries, including Cuba, Puerto Rico, Santo Domingo, and Colombia, were collected and planted together with the Venezuelan varieties in three different experiment stations. The types from the United States were vigorous in the seedling stage but they came into flower too early, as was expected, due to the difference in length of day. They became weak and were attacked by many diseases and insects. A Puerto Rican variety, Mayorbella, obtained from Dr. Arturo Roque, was vigorous in the seedling stage, then became weak, and later vigorous again and produced relatively large ears. The Venezuelan varieties gave their usual rank plant growth but did not set desirable ears. A yellow seeded type from Cuba with sturdy stalk of medium height set two ears at the proper distance from the ground. This type outyielded the others by at least 100 per cent. In further tests it has made the unusual performance of giving relatively high yields all over Venezuela from altitudes of 40 feet to 4,000 feet. In three years in which six generations of mass selection have been made, it has become the most popular variety in the country in spite of its color.

Its origin is interesting. A representative from this government collected two varieties from Cuba in 1938, but the seeds of the two were mixed in handling. About two years later several hundred sound seeds were salvaged from a bag of weevil-eaten material, and from these seeds the present selection has been developed. This selected type is being distributed in this country and in other neighboring countries under the name of VENEZUELA-1.

The main project is the development of hybrid corn adapted to the climatic conditions of Venezuela. Six generations of inbreeding of the heterogeneous material has resulted in approximately 300 selected lines, some of which have a desirable appearance and have done well in topcrosses and single crosses. The first double crosses are now being tested.

It is interesting to note that most of the varieties collected from Venezuela and other countries of this latitude degenerate rapidly with intensive inbreeding. Outcrossing followed by sib crossing has been



accepted as the best practice for utilizing these varieties.

The Cuban type is a striking exception to this rule. Selfing has resulted in a multitude of types, but most of them are relatively vigorous and some are exceptionally impressive.

Inbreeding has resulted in the usual number of hidden recessives and the isolation of new mutations. Male sterile, barren stalk, brown midrib, virescents, white seedlings, zebra, tassel seed, cuzcoid, and many others have been observed.

A small but important change in breeding technique has been necessary due to the larvae of an octitid fly, Euxesto stigmatia Loew. It is not advisable to cut back the husks of the ear shoot to obtain a uniform brush of silks because the insects enter and destroy the ear. It is better to wait as long as possible for the silks to come out naturally before pollinating.

There can be no doubt that in the near future hybrid corn will be available for distribution in a country which has no seed companies and little knowledge of seed improvement. In the meantime, however, the type VENEZUELA-1, improved by mass selection, has been widely distributed.

2. Sweet Corn in Venezuela. The mutation to sugary corn which occurred in a variety of dent corn adapted to the climatic conditions of Venezuela (Maize Genetics Cooperation News Letter, April-1, 1941) has been the basis of the development of sweet corn in this country. This corn has been named VENEZUELA-2 and is now widely distributed throughout the entire country and in other South American countries that have requested it. Some of the details of its development may be of interest.

Until 1942, the majority of the people in Venezuela had never tasted true sweet corn and most of them had never heard of it. Some who had travelled in the United States, imported seeds of a few varieties and planted them in Venezuela, but the plants were always weak, badly diseased, attacked by insects and consequently unable to produce ears.

Corn known as "jojotos" has always been consumed in Venezuela and is sold in the markets of the cities. This is the native type, a mixture between dent and flint, that is harvested not in the milk stage but in the soft dough stage. It is eaten directly from the cob or cut off and used to make certain Venezuelan dishes such as "cachapas", a pancake-like preparation. The true sweet corn now available in Venezuela has such a contrasting flavor to the dent-flint mixture that it is widely accepted by the people of all classes.

In 1939 when a modern program of corn improvement was initiated in Venezuela, approximately 3,000 self pollinations were made in the best local and imported varieties to develop inbred lines. Some of the first generation ears were planted in progeny rows in 1940 and about 3,000 of the best plants were selfed. None of these second generation ears segregated for sweet corn. But one of the second generation plants gave, on selfing, an ear with 216 starchy kernels and 73 sugary kernels. Five plants in the same progeny gave ears with only starchy kernels.



Since there had been no sweet corn planted anywhere near these fields and no sugary kernels had appeared in the first two generations of inbreeding, it is extremely likely that this was a mutation to sweet corn.

Fortunately, it occurred in one of the most vigorous lines which had such desirable characters as deep green color, relatively early maturity, two ears per stalk and, most important of all excellent husk covering of the ears.

Some of the sugary seeds and the starchy seeds from this ear were planted and self-pollinated. As was expected the sugary kernels gave ears of 100% sugary type, whereas some of the starchy kernels bred true for starchy and others segregated sugary. Seeds from the sugary ears were planted. When these plants had tassels and pollen, a field of the original variety of starchy corn was nearing the completion of its flowering period. Ten plants in this field were pollinated with pollen from the sweet corn inbred. The seeds from these ten ears were mixed and planted in a small field at the Instituto Experimental de Agricultura y Zootecnia in January, 1942. Vigorous plants were obtained. There was no attempt to control the pollination. All of the ears segregated approximately 25 per cent sugary kernels.

The sugary kernels from these ears were planted in one field and the starchy kernels in another. There was no attempt to control the pollination in either field.

The ears harvested from the first field were of the sugary type, but there was considerable variation in the kernels. Some of them were entirely translucent while others showed various degrees of starchiness.

In the second field where theoretically one-third of the seeds planted were homozygous starchy (Su Su) and two-thirds heterozygous for sugary (Su su), the expected ratio of starchy to segregating ears was 1:2. Actually, there were 9,347 ears with all the kernels starchy and 22,147 ears segregating for sugary.

Theoretically, the segregating ears should have had a ratio of 5 Su to 1 su kernels. One hundred of these ears taken at random gave ratios from 20 Su : 1 su to 3 Su : 1 su, but the total count was 39,742 Su kernels and 9,099 su kernels, or a ratio of 4,36 : 1. This discrepancy from 5 : 1 ratio is probably due to a position effect of the plants in the field.

On October 7, 1942 a demonstration of the history of sweet corn in Venezuela was made to an audience in the auditorium of the Sociedad Venezolana de Ciencias Naturales. At the close of the demonstration, packages of the new sweet corn were distributed to all present. Considerable seed has been distributed since then.

From a scientific point of view this sweet corn will not be of maximum yield because it is the third generation of a cross between an inbred line and a variety. In spite of this, however, it is being distributed because it has yielded sufficiently well to give the public a taste of sweet corn.



Since the first ear of this corn was discovered it has been crossed with a number of selected varieties of ordinary corn which do well under the climatic conditions of Venezuela. The plants from these numerous crosses have been self-pollinated, and inbred lines are being developed in a number of types. When there is an abundance of inbred lines involving the sugary gene, they will be crossed to give hybrid sweet corn for Venezuela. In the meantime the other topcross type will be propagated.

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Studies of chromosome knob numbers of the maize varieties of Latin-America have been continued with the following results:

Country	No. Varieties	Range in Knob No.	Ave. Knob No.
Brazil	8	5-9	6.6
Colombia	2	12-13	12.2
Costa Rica	4	10-12	11.0
Cuba	6	11-12	11.2
Mexico	33	4-13	10.0
Nicaragua	15	9-14	12.8
Panama	4	12-14	12.6
Paraguay	5	2-6	4.8
Peru	15	1-2	1.3

Although the sampling of individual countries is still far from adequate, the data tend to support the previous conclusion, that low-knob varieties are confined in Central America to Western Guatemala and to the immediately adjoining regions in Mexico. In all other parts of Central America and Mexico and in Cuba as well, only high-knob varieties have been encountered. Western Guatemala and the adjoining state of Chiapas in Mexico continues to appear to be the center of maize diversity in Central America.

It appears also that Paraguay must now be added to Peru and Bolivia as a region of low-knob varieties in South America. Although only five varieties from Paraguay have been examined cytologically, the majority of varieties collected are of the same general type as these and will probably prove to have but few knobs.

Dr. Hugh C. Cutler has now spent more than a year in Brazil, Paraguay and Bolivia collecting native corn varieties and searching for wild maize. His first goal is being successfully achieved; the second is still elusive. Several reports of maize growing in the wild have been investigated with wholly negative results. The "wild" maize in each case was either cultivated maize obviously escaped from cultivation or not maize at all. The cultivated corn collected from Paraguay and



Southwestern Brazil is of considerable interest. The cobs are quite flexible; the pedicels on both staminate and pistillate spikelets longer than normal.

A variety of maize obtained from Amantina Island in Lake Titicaca in Peru at an altitude of about 12,500 feet, probably the highest altitude at which corn is grown in any part of the world has proved to be early and cold-resistant. These characters may make it valuable for plant breeding in spite of the fact that it is very susceptible to smut.

P. C. Mangelsdorf and James W. Cameron



## Maize Publications

There is presented here a partial list of publications on maize.

M.J. Murray and R. Morris

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## III. Inventory of Seed Stocks Propagated in 1942

In 1942 I planted and hand-pollinated only such stocks as were sent me last spring or as Dr. Welch told me should be replenished. A total of 140 ears were obtained.

- Co 42-1     $++$  p as  $\frac{gs}{+}$  +/sr  $\frac{+}{ts2}$  p  $++$   $\frac{bm2}{+}$  . 9 ears.
- " 42-2    + p as  $\frac{gs}{+}$  /sr  $p^{WR}$  + +. 7 ears.
- " 42-3    as/42-1. 5 ears.
- " 42-5    zb6 (from Burnham). 3 ears.
- " 42-6    br, smut resistant stock (from Burnham). 3 ears.
- " 42-7    A C R Pr cr, brown pericarp (from Burnham). 5 ears.
- " 42-8    A C R pr cr (from Burnham). 3 ears.
- " 42-9    a C R pr cr (from Burnham). 1 ear.
- " 42-10 }  $F_2$  of a C R  $\frac{na\ ts4}{+ +}$  (from Burnham). 14 ears.
- " 42-11 }
- " 42-12     $++$  /  $\frac{bt2}{+}$   $\frac{bt4}{+}$  (from Burnham). 10 ears.
- " 42-13 }  $\frac{T3-9a\ C\ sh\ +\ +}{+ + sh\ wx\ v}$  / pr Sh wx (from Burnham). 19 ears.
- " 42-14 }
- " 42-15    Homozygous T3-5d (from Shuman). 7 ears.
- " 42-16    T3-5d/+ (from Shuman). 4 ears.
- " 42-17    P gs bm2. 3 ears.
- " 42-18    P br f bm2. 2 ears.
- " 42-19    Tu/+. 3 ears.
- " 42-20    su  $\frac{Tu}{+}$  . 1 ear.
- " 42-21     $\frac{Tu}{+}$  gl3, segregating ws2. 7 ears.
- " 42-22 } su  $\frac{Tu}{+}$  gl3. 5 ears.
- " 42-23 }
- " 42-27 } su la. 3 ears.
- " 42-28 }
- " 42-31    y4 It a c r pr i. 3 ears.
- " 42-32 } y4 It/Y4 it. 14 ears.
- " 42-33 }
- " 42-34 }
- " 42-41    I wx ygb . 9 ears.



Supplement to News Letter 17

Two reports received too late for inclusion with the others are:

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University of Minnesota  
University Farm, St. Paul, Minnesota

1. There is an indication of linkage between interchange 1-9c (breaks near  $P_1$  and wx-l3-T), and the dominant white cap ( $W^C$ ), a small backcross population having:

$W^C$  = 12 normals + 29 semisteriles; yellow cap = 27 normals + 18 semisteriles; or about 35% c.o.  $\pm$  5% S.E.

2. Dr. Sprague furnished us with a complete set of his glossy testers. As reported last year, the Coöp gl 10 is the same as Hayes' gl 4 (shows 8% c.o. with wx). Tests show it is genetically different from Sprague's glossy 1, 2, 3, 4, 5, 6, 8, 9, 10 (probably different from 7), leaving gl 11 and 12 to be tested.

Also:	Coöp gl 3	- same as Sprague gl 3
	" gl 5	- " " " gl 5
	" gl 8	- different from Sprague gl 8

3. Crosses between interchanges involving the same two chromosomes were studied for pollen and ear sterility and as a possible source of viable deficiencies. If two are crossed which involve exactly the same loci in the two chromosomes, the  $F_1$  should show no sterility.

Where the breaks are not at the same loci, the result depends on the positions of the breaks relative to the spindle fiber. In certain cases gametic combinations should be possible which carry a deficiency for the piece between the breaks.

In a series of such crosses, one showed about 20% sterility and another 25% where the parents crossed with normals showed semisterility. Variation in size of the filled pollen grains was observed. Crosses with genes which have a chance of being near these loci have been made for deficiency tests; also crosses with sifted pollen.

4. Stocks of zebra-1, zebra-2, and zebra-3 have been revived from some old crosses made at Ithaca in 1929 or 1930. (These will be turned over to the Coöp)

C. R. Burnham

"Luiz de Queiroz" - University of São Paulo  
Piracicaba, São Paulo, Brazil

Since North American colleagues probably are not familiar with the working possibilities in the relatively new Department of Genetics and Cytology at Piracicaba, a few words will be said about it. Our College is situated in relatively flat country at 500 m. altitude and with a subtropical climate. There is a difference between summer and winter, more due to the difference of rain than of temperature. The total rainfall is of about 1 m. per year, but from June to September there is hardly any rain; but morning fogs from the river and heavy dew give still much moisture. Tropical crops grow well in the hot and rainy season (December to March) while cabbages, carrots, sweet peas, snapdragons, etc. grow in the winter and dry season (April to



September). The main crops of the region are sugar cane and oranges.

With irrigation corn may be grown practically the whole year around but we prefer, in order to get good ears, consecutive sowings from October to early February. There are only a few fungus diseases, and none of them serious. Insect attacks are generally only of small scale, though the sugar cane borer has recently become rather dangerous. The only really serious problem is the large scale attack by the grain weevils and moth, especially now with the difficulties of obtaining naphthaline.

### 1. Breeding Experiments

Ordinary Brazilian corn is composed of extremely heterogeneous and hardly improved varieties. Many of them seem to be equal or even inferior to the corn still grown by "wild" Indians. Modern breeding work has been started at Campinas and at Piracicaba.

A - Sweet Corn (Pedigree breeding): Sweet corn is practically not grown in Brazil and the imported strains which we have been able to observe hardly survive for more than a few generations. Since I had been engaged, while in England, in breeding for earliness, the scope of the experiment had to be revised completely. Extracts from the cross: (Tirol (white flint) x Golden Bantam) x Banting (Canadian, white early) were crossed with "Santa Rosa" (white dent) and with "Cateto" (orange flint) and we have now obtained several good lines of yellow-orange and of white sweet corn, well adapted to field conditions and resisting the heavy rains and winds; with mean plant height (without tassel): 2 m., mean height of ear: 1.2 m., time from sowing to silking: 65 days, one or two ears per stalk, absence of tillers, mean ear weight (dry): 100 g.

B - Early Corn (Pedigree breeding): Brazilian corn is very slow in growing, producing generally very tall plants with the ears at about  $\frac{3}{5}$  to  $\frac{2}{3}$  the height of the plant. Crosses were made between extracts of "Tirol x Early Canadian" (white flint, 40 days from sowing to silking) with Santa Rosa (white dent, 70-80 days to silking) and Cateto (orange flint, 60-70 days to silking.) It was not possible to combine tallness and earliness and it was difficult to suppress completely tillering in the early lines. Reasonably well adapted lines were obtained with the following characteristics; 45-50 days to silking, plant without tassel, 1.3 m., ear height 50 cm., mean ear weight 70 g per ear. Since the plants are completely different from the local varieties, it seems doubtful if these lines will be acceptable to the farmer, especially since earliness is not a necessity in the State of São Paulo.

The experiment was used to study the segregation of quantitative characters and to try out methods of statistical analysis. Some results may be summarized:

The standard error of distribution can be used as a measure of variability only if the means are of more or less the same magnitude. In order to compare  $P$ ,  $F_1$ ,  $F_2$ , etc.; a weighted measure has to be used. As can be shown theoretically, and has been proven experimentally, the coefficient of variation (standard error of distribution/mean x 100) should not be used,



but instead, a term called the "variance index": (standard error of distribution/square root of mean). Using this term, it can be shown for this index that, as expected:

$$(P) = (F_1) \quad (F_2) \quad (F_3) \dots\dots\dots$$

The segregation for earliness can be shown only by comparing  $F_3$  families. The inevitable phenotypic variation with an error of more in  $F_2$ .

In studying the relative position (height) of the ear, the ordinary coefficient of linear correlation  $r$  is of no use. The correlation for plant and ear height was found in all lines, hybrids or segregates, to be nearly constant and equal to 0.6 (positive and significant). However the index: "ear height"/plant height" should be used and it varies significantly with the following values: imported early lines 0.20, Brazilian commercial lines 0.60, some native corn up to 0.7 or 0.8 improved corn 0.5.

F. G. Brieger

C - Inbreeding and Outbreeding: Inbreeding was started in 1936 with "Santa Rosa", a commercial variety of white endosperm, essentially to obtain material for the demonstration of the value of the method. Single and double crosses are being carried on and a new population composed of several single crosses is also being tried. Recently work on orange flint and on orange dent corn was started also.

E. A. Graner

D - Population Breeding: Since it was thought that the method of pure-line breeding and subsequent crossing is a method too lengthy and costly for the actual status of maize growing here, an intermediate method is being tried out. Brazilian commercial corn is extremely heterogeneous, contains many defective plants and shows many undesirable traits. A vigorous selection was carried out, combined with selfing during a few (2-3) generations, and finally followed by sib and strain crossing. The results thus far obtained in small plots seem satisfactory and better than those obtained by mass selection without controlled pollination, though inferior, especially in homogeneity, to authentic hybrid corn.

F.G. Brieger and E.A. Graner

E - Late Sugary Strains: Some good sugary strains, very late for Connecticut, were given to us by Dr. W. R. Singleton and are now growing in our department. They include a strain segregating for a very late type that does not flower there but is expected to flower here. The plants in the field are now 40 days old.

E. A. Graner

## 2. Experiments about the Origin of Corn

A - Native Indian Corn: We were able to obtain through the help of Brazilian colleagues, of Dr. Cardenas of Cochabamba and of Dr. Cutler, authentic "wild Indian" corn. The Bolivia corn from Cochabamba grew very well at the low altitude of Piracicaba, flowered generally well, but



produced very poor ears. Material from the lowlands of Mato Grosso (Brazil), from Paraguay and the Bolivian Chaco is much more satisfactory. But in nearly all cases it was rather difficult to maintain the strains, since they degenerate very rapidly with more or less close inbreeding. The following material has been studied genetically.

"Acre" from the territory of Acre (Brazil). The plants are very tall without tillers, ears long and slender with 8 rows, grains large, round and soft, exhibiting the following colors: dominant purple (ACR Pr), red (pr pr) or recessive colorless (probably rr), brown aleurone (lost), yellow or white endosperm.

"Chavantes" (from the State of Mato Grosso, Brazil). Very tall plants, segregating semi-dwarf, ears big and heavy, 12 or more rows, grains large, soft, white or sometimes tinged, purple (Pr), red (pr pr) or light pink (pericarp?). The constitution of these grains is probably AA CiCi RR as shown by the following test cross with C sh: (F<sub>2</sub>):

	: C <sup>i</sup> - Sh	: C <sup>i</sup> - sh sh	: CC Sh -	: CC sh sh	: Total
obs.	: 861	: 34	: 61	: 187	: 1.143

The dominant inhibitor C<sup>i</sup> is not completely dominant and varying percentages of the kernels with the constitution C<sup>i</sup>-Sh- are not white, but very pale purple and red. It seems as a whole that the Indians selected modifiers which reduce all possible color in the kernels as much as possible.

White endosperm is only incompletely recessive to yellow and there is present some kind of pericarp color which however becomes clearly visible only after outcrossing.

"Diamantino" (from Mato Grosso, Brazil). We received three lots of seeds. In all of them the ears originally were heavy and many rowed. The color of grains varied.

Diamantino I, had deep red pericarp (P) segregating normally after crossing.

Diamantino II, had dirty brownish-orange kernels, due to orange, white or colorless pericarp on yellow-orange endosperm and sometimes yellow-brown aleurone. The segregation for pericarp color was interesting in so far as its existence could be verified only in some years, and in one year only classification between orange and colorless pericarp was very easy. In this year orange pericarp was in some instances so intense as to give a bright red color.

Diamantino III, contained colored and colorless aleurone over orange endosperm, sometimes covered by orange pericarp (white cob). Absence of aleurone color may be due either to a dominant or recessive inhibitor. The former is certainly an allele to the C factor as shown by the linkage test with CC sh sh. But there are a large number of modifiers acting and disturbing the ratios. The ears collected after selfing fell into two groups. In the first there was an excess of colorless-shrunken grains combined with a deficiency of the colored-shrunken grains. In the other group of ears, besides this deviation,



there appeared a deficiency in the number of the normal grains and a corresponding excess is the colored-shrunken grains.

	C <sup>i</sup> - Sh :	C <sup>i</sup> sh sh :	CC-sh :	CC sh sh :	Total :	250
	:	:	:	:	:	:
1st group	1.270 :	146 :	52 :	232 :	1.700 :	425
1st group	771 :	99 :	201 :	212 :	1.283 :	328
	:	:	:	:	:	:

Plant color in most strains of all three forms of native corn, Acre, Chavantes and Diamantino, is either dilute purple or dilute sun red. But the culm is very frequently heavily colored, and this color seems, at least partially, independent from A-B-Pl mechanisms.

In the shucks various colors were observed which may be either "sun red", deep purple, dilute purple, red and reddish-brown.

Finally, the glumes and the whole base of the grains may be deep or light purple or red, independent from cob color. Apparently somehow this color depends upon the same factors as the color of the shucks.

So far the existence of these different colors in vegetative organs has been registered; but it has not yet been possible, owing to lack of time, to start on a detailed genetic analysis.

If we take all characters into consideration, it seems that the indigenous strains from Mato Grosso together with the material collected by Cutler in Paraguay and the Bolivian lowlands form a natural group. Similar traits may be found also in local forms, cultivated in São Paulo. In all of them there appears, with more or less frequency, all or some of the following characters.

Slender and long ears with flexible rachis. Grains half covered by their glumes. Kernels more or less round or pointed, containing soft starch. Anthocyanin generally absent in the aleurone owing to the presence of inhibitors at the C-locus. On the other side there is a tendency for the appearance of brownish-orange colors, in the aleurone, endosperm, and pericarp.

Three characters seem to me especially important: the brownish-orange color of the kernels which may be considered as an approximation to a natural "wild" color, the slender and flexible rachis and the development of large glumes which may be taken as a change in the direction of pod corn. Their widespread occurrence can hardly be considered as a coincidence, in view of the old hypothesis, recently taken up again by Mangelsdorf and Reeves, that pod corn is the most primitive of all the different types of maize and that the lowlands on both sides of the Rio Paraguay, i.e., the triangle formed by lower Bolivia, western Mato Grosso and Paraguay, may be the geographic centre of the origin of maize. On the contrary, I think our observations, very briefly reported above, support strongly this hypothesis.

F. G. Brieger

B - Pod corn: Has been obtained from two sources. "São Paulo Pod" and "Bolivia Pod". The latter was sent to us by Dr. Cardenas and later by Dr. Cutler. The other type came from one ear left casually in our department



by a student and about which we know only that it came from São Carlos, that is from an inhabited and cultivated region only about 300 Km. from São Paulo and where we cannot expect to find "native Indian" corn. In all its characters, except of course being pod corn, it corresponds to the Brazilian corn of the region.

The studies of Bolivian pod corn are still in the beginning and we have met again the difficulties mentioned above, that corn from the Bolivian highlands grows well, but hardly produces ears in our altitude. Thus we can say only so far that it contains a dominant Tu gene.

São Paulo pod corn is also due to a dominant gene which is normally transmitted through the female while there is a strong selection against Tu-pollen tubes. At the most, half of them may eventually function, but generally less.

The original ear was large and well filled with a slender but very hard rachis. The seeds covered by large glumes, were small and more or less pointed and stood at the end of a long pedicel, of about the same length as the seed itself. The tassels of the first tunicate generation grown had drooping branches, with nearly normal or somewhat enlarged glumes and occasionally some silks.

Owing to the degeneration after inbreeding, the original line had to be outcrossed, and native Indian corn was used for this purpose.

The Tu ears in later generations varied very much, the extremes being silkless sterile ears, sterile ears with abnormally large glumes, ordinary fertile Tu ears and, finally, fertile ears with the kernels hardly covered by their glumes. The rachis remained always thin and rigid. In extremely large fertile ears the circumference necessary for the base of the kernels differed very much from the circumference of the rachis. In these cases the rachis split open lengthwise, the rows of grains remaining together in fours, with one group of two remaining when the total number was not a multiple of 4.

A successful selection was carried out to increase femaleness in the tassel. Finally a heavily bearded tassel was obtained with some 400 seeds and in its offspring the majority of all tunicate plants were again heavily bearded. In some cases it seems that each spikelet contained at least one female or perfect flower.

These hermaphroditic tassels were very large and drooping from the beginning. With the setting of seeds they became very heavy and tended to upset somewhat the balance of the plants. But one must not forget that a tassel with a total length of 40 cm. is small on a plant of over 3 m. There seems to occur in these tunicate plants an increase in the number of nodes between tassel base and ear, but the internodes remain short and the corresponding leaves show transformations in the direction of shucks.

However the most interesting transformations are to be found in the structure of the spikelets. The ordinary spikelets of the tassel with two male flowers are substituted, in different tassels, by a large variety of other combinations: 1 male or sterile and 1 female or perfect flower,



2 female flowers, 1 female and one perfect flower. But the most outstanding cases occurred in the spikelet of one tassel where one male flower was followed by up to four female flowers. At the same time a tendency appeared for splitting the ends of the individual silks into two arms, often of unequal size. Thus the Tu gene causes the appearance of characters long lost in the group of the Maydeae and the related Andropogoneae: many flowered spikelets.

The observations, reported above were mainly made on plants heterozygous for Tu. Owing to the elimination of the Tu pollen tubes, the number of Tu-Tu homozygotes must naturally be small. The phenotype of the homozygotes registered with certainty so far does not exceed the limits of variation of heterozygotes.

If we leave aside the effect of provoking the excessive development of glumes in the ear, then we may consider as next important feature in "São Paulo Pod" corn the accentuation of female tendencies in the tassel and the reappearance of characters lost in the phylogeny of many grasses: the re-establishment of hermaphroditism in individual flowers and the occurrence of spikelets with more than two flowers. But this does not necessarily mean that the immediate wild ancestors had these characteristics and may thus have belonged to another group of grasses, not the Maydeae or Andropogoneae. We may have to deal with still older characteristics of primitive grasses.

Recently Mangelsdorf and Reeves have modified the theory that pod corn with its covered grains in the ears is an approximation to the wild ancestor of maize, assuming that this ancestor was a plant without the lateral ears, but with covered seeds in the tassel. If this would be true, we should expect that the lateral branches, instead of having still normal, but sterile ears, should also terminate in some sort of bearded tassel. Selection in this direction has been started, but in order to obtain positive results it seemed necessary to substitute the modifiers of cultivated corn by modifiers of a "wild" form. This seemed possible only by crossing pod corn to teosinte.

F. G. Brieger

C - Hybrids between teosinte and "São Paulo Corn" - Hybrids were produced between teosinte and heterozygous "São Paulo Pod" corn, consisting of tunicate and non-tunicate plants.

The tu plants in  $F_1$  corresponded as a whole with the descriptions given by other authors, and we shall withhold discussion until the analysis of  $F_2$  and backcrosses, now under way, are terminated.

The  $F_1$  tunicate plants, however, showed many unexpected characteristics, some of which only will be mentioned here:

The Tu effect on the tassel was completely recessive-hypostatic and it was impossible to classify the  $F_1$  plants as in the original "São Paulo Pod", according to the transformation of the tassel. Thus the tassels of Tu plants and their normal tu sisters were identical.

The ears, however, were very different in Tu and tu hybrids. In the latter the rows were mainly single, or when the paired row was not suppressed, they contained female spikelets only. Two paired rows appeared generally in



the Tu plants, one being an ordinary female spikelet, with one sterile and one female flower, while the other spikelet became pedicelled and contained two male flowers. Furthermore, there was a pronounced tendency to produce not only 2 double rows, but 3 or even 4.

The scales formed by the rachis and which cover more or less the grains in teosinte or in tu F<sub>1</sub> plants, were smaller and soft in Tu plants while the glumes became pointed.

The rachis and glumes of the tu hybrids are extremely horny, and it was very hard work to shell the seeds. On the other side, the rachis in Tu F<sub>1</sub> plants is extremely brittle and it was nearly impossible to harvest complete mature ears, since they fell apart immediately after removing the shucks.

Thus the Tu gene has a very different phenotypic effect in pure corn and in teosinte-corn hybrids. In the former we observe a pronounced tendency to introduce femaleness into the tassel, while in the latter maleness appears in the ears, or better on the lateral branches. A selection experiment is under way with the end of fixing this condition, just as it was possible to fix more or less the bearded tassel.

The fact that the Tu-gene acts in nearly opposite directions according to the modifier complex present, should warn us not to draw premature conclusions on gene action. The appearance of covered kernels is a universal effect of the Tu gene, while everything else depends upon the modifier back-ground. The Tu F<sub>1</sub> plants described above seem to me much more likely to be a replica of an ancestral wild grass than the Tu corn plants with bearded tassel, especially considering the following points: a) the rachis is extremely brittle: b) the lateral branches are not suppressed, but grow perfectly normally, producing terminally a tassel or an ear, and laterally still more branches or higher order with a varying number of additional ears: c) instead of a reduced or sterile ear, we encounter ears, where one female spikelet tends to be associated with a male spikelet.

While I think that the general structure of the Pod-Corn-Teosinte hybrid is a more likely reproduction of a hypothetical wild ancestor of corn as compared with the bearded Pod Corn, I do not believe that this ancestor actually was a hybrid.

There have been proposed several hypotheses to explain the morphological nature of the many ranked corn ear. Here again our Pod-Corn-Teosinte hybrids offer valuable material since the paired spikelets are often different, one being sessile and the other pedicelled. In two-ranked ears or in tassel branches we find in general a very regular situation. Both sessile spikelets are localized near the ventral side of each alveolus and the pedicelled spikelets on the dorsal side. But this symmetry seems to be the consequence of some physiological conditions. In many-ranked ears I did not find a regular position of two spikelets of the alveoli of each double row. The sessile spikelet may be on the left or on the right side of the pedicelled spikelet.

Other interesting observations could be made in some of the F<sub>2</sub> plants. In several instances, an alveolus contained one sessile spikelet



and one "branch" which carried one spikelet more or less in the middle and another at the end. If the pedicel was shortened three spikelets appeared close together in the alveolus. In one instance an alveolus contained 4 spikelets which probably were derived from two reduced branches with 2 spikelets each.

Finally all observations seem to indicate that the only constant orientation of the alveolus may be the longitudinal row, sometimes obscured by a twisting of the rachis, or altered by the intercalation of new double rows. The appearance of 3 rows of alveoli, the transition of this arrangement into one with either 2, by suppression, or of 4 double rows, by intercalation, is quite frequent. The alveoli may be all at different levels, or at the same level. Neither yoking nor a spiral arrangement could be observed with any regularity.

Thus the Tu F<sub>1</sub> and F<sub>2</sub> plants offer very interesting material, especially when studied at flowering time and not when their ears have become hard and mature. There cannot be any doubt that this material will finally permit a critical discussion of the hypothesis of the nature of the ear and the formulation of a new, combined theory, containing to some extent elements of older views. But the final discussion will be delayed until the analysis of the mature F<sub>2</sub> and backcross ears is completed.

F. G. Brieger

D - A histological study was carried out on several strains of native and cultivated corn and of a North-American pop corn. The structure of the latter was identical with that described by Randolph. In corn of the Paraguay river group, as defined above, the following structural elements were the most striking:

The spikelets appear to have a pronounced pedicel.

At the lower base of the pedicel and at its sides a scaly outgrowth of the rachis appears which thus surrounds the alveolus on three sides, and which corresponds to the cover of the kernels in Tripsacum and Euchlaena.

The spikelets of Paraguayan corn which when mature had the kernels half covered by glumes, had at flowering time the same structure as "São Paulo Pod" corn with well developed glumes.

F. G. Brieger and H. C. Cutler

#### E. Tripsacum australis:

Seeds and rootstocks of this species collected by Cutler were planted. Only two seedlings germinated and grew slowly. One of the rootstocks gave a large plant which started to flower in November and is still in bloom. The second is starting now in January.

F. G. Brieger and H. C. Cutler

It has 18 normal pairs at meiosis.

E. A. Graner



### 3. Genetics of Aleurone Color

It is generally accepted that the presence of anthocyanin in the aleurone is due to the presence of certain alleles of the locus:  $A1 - A2 - C - R$ . But, as I have pointed out elsewhere, the action of the genes at these four main loci is conditioned by the coordinate action of the modifier complex. This could be shown by several selection experiments.

A line of red brittle, originally from Cornell, served to demonstrate that by selection, completely colorless ears may be obtained. In the original line occasionally a colorless grain occurred, and it was possible, by selection for higher number of colorless grains and for paler color of the still colored ones, to extract a line which was completely colorless. When backcrossing to colored lines, no clear segregation could be obtained.

Some of the brittle kernels of the original line appeared to be nearly black, which was attributed to the effect of an intensifier absolutely linked with  $bt$ , or to the action of the respective  $bt$  allele itself. All selection against this factor was useless. In the extracted colorless lines there still appeared a segregation for a recessive gene, producing deep black brittle kernels. Thus a gene which in the original material was only an intensifier and as such difficult to analyze and classify, became in the extracted lines a recessive determiner of anthocyanin color.

Since no crossing over has been observed so far, we suppose that the original line contained two alleles of  $bt$ : the ordinary  $bt$  without effect on aleurone color and the new allele  $bt^r$  which causes a deep black color and which is epistatic, when homozygous, over the modifier complex which dominates otherwise the action of  $ACR$ . In formulas, we represent the situation:

$bt$	$bt$	$A1$	$A2$	$C$	$R$	+ original modifier group	= purple (Pr) or red (pr pr)
$bt^r$	$bt^r$	$A1$	$A2$	$C$	$R$	+ " "	= black (Pr or pr pr)
<hr/>							
$bt$	$bt$	$A1$	$A2$	$C$	$R$	+ extracted modifier group	= colorless
$bt^r$	$bt^r$	$A1$	$A2$	$C$	$R$	+ " "	= black

The opposite result was obtained in "Chavantes" which as mentioned above has probably the constitution:  $A1 A2 C^i R$  where  $C^i$  represents a dominant inhibitor at the  $C$  locus. Pale purple (Pr) or red (pr pr) kernels occurred in the original material and, by selection, ears could first be extracted which segregated colored kernels in various proportions until finally fully colored ears appeared.

A corresponding situation was found in "Diamantino III" where a sharp segregation occurred for black or orange kernels. But black grains gave ears which segregated for a recessive orange while orange kernels gave ears segregating for a recessive black. The classification was generally



easy, but the ratio colored : colorless did not correspond to any standard Mendelian ratio.

It is remarkable that some lines segregate normally in some crosses, and show the modifier effect in others. Thus a "Golden Bantam", when crossed to a cc sh sh - test line was shown to be AA CC rr giving a 9:7 ratio in F<sub>2</sub>, but crossed with the red-brittle line a mono-factorial segregation was obtained only in part of the offspring and a selection for both low and high ratios of colorless was successfully carried out.

These results may be summarized in the following form:

There are some lines where the modifier complex is well established and in balance with the determiners, not interfering with their action. Such lines give sharp segregations with normal Mendelian ratios.

Other lines have an unbalanced modifier complex and here selection experiments may give positive results. Thus it was possible to shift the color from red to white in the red-brittle line and from white to purple or red in "Chavantes".

The experiments are being continued and it is hoped that eventually a more complete understanding of the physiological action and interaction of determiners and modifiers may be obtained.

The selection line of "Chavantes" was very instructive in showing that we must distinguish between modifiers which act as plant characters and others which are evidently only aleurone characters. It may at first seem strange that aleurone characters may be dependent upon genes of the mother plant, and not only upon their own genes. However the effect of plant genes upon the endosperm seems to be quite general. The difference between flint and dent, between round or pointed kernel, to a large extent the difference between flint and floury, are inherited as a plant character. Now, if sporophytic genes control the type and distribution of starch in the kernel, there is no reason why one should not accept the same for the formation of anthocyanin.

F.G. Brieger and George O'Neill Addison

#### 4. Yellow-orange Endosperm

Studies on the genetics of the yellow-orange endosperm started at Piracicaba, Brazil, (1937), were continued at Columbia, Missouri, in 1942, through the help of a fellowship from the Guggenheim Foundation.

A deep orange endosperm from Brazil (commercial strain) was used and crossed with several white endosperm strains. These crosses gave only segregation for one pair of factors. Some were continued until F<sub>4</sub> and the white endosperm strains checked proved to be yl yl Y3 Y3. Crosses with some white endosperm testers segregated again 3 colored : 1 colorless and showed independent assortment for chromosome 2 (lg 1), 4 (su 1) and 9 (df 3) indicating that the yellow gene segregating should be the Y1 in chromosome 6.

The same deep orange strain when crossed with a tester received from Dr. Jose Ma. Andres, Argentine and called A-(alal B-) (Pl-yl yl) showed a clear segregation of 9 orange : 3 yellow : 4 white. The numbers of 3 ears



taken at random are the following:

No. of the ear	Orange	Yellow	White	Total
40 - 12D ± 1942	156	42	61	259
31 - 12D ± 1942	154	56	62	272
Sib 49 x 17 12D 1942	137	43	49	229
<hr/>				
Total	447	141	172	760

Linkage was found with the Pl gene (repulsion phase) and all yellow seeds were albescents al, the white ones segregating 3 Al: 1 al. As the al gene is probably the same as y3 or very closely linked to it, it could be said that the deep orange Brazilian strain has both Y1 and Y3. The linkage with chromosome 2 in this cross was also shown by the segregation of B. The al strain when crossed with lgl showed absolute linkage (repulsion phase). By the segregation of A it was found that chromosome 3 was not involved.

The 9 : 3 : 4 instead of a 9 : 7 ratio as found by Perry and Sprague (1936) seems to indicate the existence of another complementary gene, probably to Y1, which probably is a plant character, since its segregation was not shown in the F<sub>2</sub> seeds. The F<sub>2</sub> plants are now growing, but have not flowered to this moment.

The F<sub>1</sub> of the same cross was used at Columbia, Missouri, for crossing with other Y-testers, received from Dr. H. S. Perry and the plants are growing at Piracicaba. Some unexpected ratios, were found in these crosses and will be checked in the next generation.

The deep orange Brazilian strain planted at Columbia did not flower there. So this strain could not be crossed with other testers. However, it was possible to use an Argentine strain called Colorado Casilda and belonging to Dr. L. J. Stadler's collection. This strain has practically the same color as that of the Brazilian one and its name indicates the same variety used by Dr. J. Ma. Andres in Argentina (1939) and giving results similar to those reported here. This Argentine variety will be now crossed to the orange Brazilian strain, but to save time, it has been crossed to testers for all chromosomes. The collection of testers used was prepared at Columbia, Missouri, and includes material from Cornell (Coop) and from other corn geneticists of the States. These crosses are being checked now at Piracicaba, Brazil, where the plants are just flowering, but the situation is rather complicated since we do not know the background of the testers used with respect to the Y genes. Also, it should not be expected that we have to deal with only one sporophytic gene but several may be acting as modifiers, giving the shades found in different yellow-orange endosperm strains.

Other strains of yellow-orange corn of different origin are also being tested. Some pop-corn ears from Brazilian material showed segregation approximately of 3 white : 1 yellow-orange, and we don't know if we have here to deal with a new Y factor or only with an inhibitor of the known Y genes.



Seeds of Y4 and It received from Dr. W. R. Singleton proved to be identical with Y1 and Y3, respectively. I think also the Y2 of Dr. W. Eyster in chromosome 5 is the same as Y1; so, the general situation of the yellow-orange endosperm for the present could be simplified with only the Y1 and Y3 as complementary factors and one or more plant-character genes modifying its shade or being complementary to them. Besides this should be kept in mind, the possibility of the existence of other seed genes for yellow endosperm color, as reported by Dr. G. F. Sprague (1938).

E. A. Graner

## 5. Yellow Aleurone

In the crosses with deep orange endosperm of Brazilian strains and white ones, segregation of a yellow-aleurone gene was found. The interaction of this gene is very variable and in some back-grounds difficult to classify. Also, the dosage in the endosperm makes the problem difficult since it was found that "simple" is not different from "nuliplex" white seeds when the yellow-aleurone strain is used as male parent. Until now it is possible to say that this gene did not show linkage with chromosome 2, 3, 5 and 6. Thus, it is not the Bn2 reported by Dr. G. F. Sprague (1934). It has now been crossed with the Bn1 in chromosome 7 and with testers for the remaining chromosomes. The gene gives, in some cases with the yellow-orange endosperm, a segregation of 12 orange : 3 yellow-aleurone : 1 white or 15 colored : 1 colorless.

E. A. Graner

## 6. Linkage Tests

A small number of linkage testers, of Cornell origin, was brought over from England and some others from Cornell. It was soon evident that these North-American strains are difficult to grow in Brazil. They were all rather small and weak, so that it was necessary to plant them in especially prepared beds. They seem to grow and produce reasonably well when planted in the first part of summer, that is, during the period when the length of the day is still increasing. For crossing purposes, it was always advisable to make several successive plantings, with the hope that sometimes the flowering period of the strains to be crossed may coincide.

Crosses between these imported lines and local lines, such as Cateto, or with native Indian corn (Diamantino III) Chavantes, etc.) were carried out and the extracts from these hybrids, are promising.

F. G. Brieger

A good collection of recessive and dominant genes in all chromosomes was organized at Columbia, Missouri with material received from Cornell (Coop) and from Drs. L. J. Stadler, H. Roman, L. F. Randolph, H. S. Perry, C. R. Burnham, R. A. Brink, W. R. Singleton and others. The plants are now growing at Piracicaba, Brazil, and they are growing very reasonably. After some experience we think it possible to grow in Brazil some of the American strains in the months of November to January, when we have the maximum of light, about 15 hours a day. Plants sown in December are flowering in 50 days as compared with the same strains in Columbia, Missouri, flowering in 55 days.



The problem of genetical tests for Brazil consists in the transference of the genes to late Brazilian strains, but we don't think this solution satisfactory since some segregating plants will be so late as to make our work difficult.

The principal genes in all chromosomes were crossed in Columbia with an Argentine strain and the hybrids look good for our conditions. We think it will be possible to isolate the segregating genes in this background and in plants not too late and promising for Piracicaba.

Deficiency testers produced by X-ray in chromosomes 3, 4, 5, 6, 9 and 10 were introduced into our collection from material of Dr. L. J. Stadler. The deficiency in chromosome 5 is linked with Pr, in chromosome 6 with Yl and in chromosome 9 with I. The deficiencies in chromosome 3, 4, and 10 were crossed respectively with Rg, Tu and Og in order to get these dominant genes linked with them.

Translocation-B testers from Dr. H. Roman for chromosomes 1, 4, and 7 were also brought to Brazil. The Tb-4 test has been useful in checking the su gene in many of our experiments.

A collection of trisomics from Cornell will be crossed with the respective recessives in order to facilitate its conservation without the necessity of cytological work.

The use of all these tests was started at Columbia, Missouri, in checking new mutants and will be continued at Piracicaba, Brazil.

E. A. Graner

#### 7. Brazilian Stock Treated by Ultra-violet

A Brazilian hybrid corn that flowered normally at Columbia, Missouri, was treated by ultra-violet. Pollen grains were treated and used for pollinating untreated plants. The 600 seeds collected from 3 ears were sown in Brazil, giving good germination (80%). The plants are growing and the mutants in this background, proper for Piracicaba, will be used as testers after their localization in their respective chromosomes.

E. A. Graner



November 22, 1943

To Maize Geneticists:

In the Indian Journal of Genetics and Plant Breeding (2: 184-186. 1942) is a review by B. S. Kadam entitled: Maize Genetic Cooperation News Letter No. 16. 1942. The review of this News Letter seems to me to have been fairly well done. The point at issue is that no request was made for permission to publish such a review. News Letter No. 16 included this statement:

"The presentation of data in these news letters is not to be regarded as constituting publication. These data should not, therefore, be used in published papers without the consent of the authors."

The above statement was quoted in connection with the review and no data were published in the review. It includes only summary statements about the reports contained in the News Letter. It is evident, therefore, that Kadam obeyed the letter of the quoted injunction. I cannot, therefore, do what I was at first inclined to do, namely, to notify him that his name would be removed from our mailing list.

We have for years sent the News Letter on request to numerous workers in other fields of genetics. The principal objection that I see to such use as Kadam has made of these Letters is the confusion that may come from it. The Letters are not available in the libraries of the world. Such reviews as that published by Kadam are apt to bring numerous requests for the originals. Perhaps Cook was not far wrong in his objection to such "unpublished publications". The question that I wish you would answer for me is: should we send the News Letters only to workers in maize genetics? Please give me your opinion.

Sincerely,

RAE:P

R. A. Emerson

This is being sent to -

E. G. Anderson  
R. A. Brink  
C. R. Burnham  
H. K. Hayes  
M. T. Jenkins  
D. F. Jones  
E. W. Lindstrom

Barbara McClintock  
P. C. Mangelsdorf  
L. F. Randolph  
M. M. Rhoades  
G. F. Sprague  
L. J. Stadler