MAIZE GENETICS COÖPERATION

NEWS LETTER

22

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

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I. Rollins Adams Emerson

Rollins Adams Emerson, who founded and kept the Maize Genetics Cooperation in operation through many years, died in Memorial Hospital, Ithaca, New York, December 8, 1947. He was born at Pillar Point, Jefferson County, New York, May 5, 1873. Early in life he moved with his family to Nebraska and later attended the University of Nebraska from which he received the degree of Bachelor of Science in 1897. The two years following his graduation he spent in the Office of Experiment Stations of The United States Department of Agriculture and in 1899 returned to his Alma Mater where he served as Assistant Professor, Professor and Head of the Department of Horticulture until 1914. He gave a year, 1911-12, to advanced study at the Bussey Institution of Harvard University where the degree of Doctor of Science was conferred upon him in 1913. On July 1, 1914, he became Head of the Department of Plant Breeding in the New York State College of Agriculture at Cornell University, which position he held until his retirement from active administrative duties, October 1, 1942. As Emeritus Professor, he continued his work of research in corn genetics and his practical breeding work on celery and field beans.

Doctor Emerson's compelling scientific interest was in genetics and he was among the first to recognize the corn plant as material particularly suitable for genetic analysis. He became a leader in this field of research and through his work and that of his students he gained world-wide reputation and more is now known about the cytogenetics of corn than any other plant. To his initiative, inventiveness and persistent efforts are largely due the establishment of the ten linkage groups and for the location of a large number of genes in the linkage maps of the maize chromosomes. His analysis of gene interaction in relation to plant color, of multiple alleles affecting pericarp color patterns and his approach to a genic interpretation of quantitative inheritance in relation to ear row number and other characters of economic importance are classic examples of the best type of genetic research. Though the major part of his effort was directed toward theoretical genetics, he was also very much interested in the application of genetic principles to practical plant breeding.

His achievements as a scientist and his forcefully attractive personality brought to him students from all parts of the world. As a teacher he had the unique gift of imparting to others his own contagious enthusiasm and zeal for research. Students went out of his laboratory to positions of leadership and responsibility in numerous high ranking institutions in this country and abroad. Their noteworthy achievements and continuing devoted loyalty stand as an enduring monument to him.

In 1923-24 Doctor Emerson visited the principal maize

producing areas in South America and brought back a large collection of maize seeds for further genetical study. In 1935 he went to Yucatan at the request of the division of archeology of the Carnegie Foundation to collect information on the probable kinds of food crops grown and consumed by the ancient Mayan peoples.

Doctor Emerson's wide interest and outstanding ability won for him the distinctive honors of election to both the American Philosophical Society and the National Academy of Sciences. For many years he was a member of the National Research Council. In 1923 he was president of the American Society of Naturalists and in 1933 President of the Genetics Society of America. He was a charter member of the American Society of Horticultural Science and a fellow of the American Association for the Advancement of Science. Other affiliations were the American Association of University Professors, American Society of Agronomy and American Genetic Association. He was also a member of Gamma Alpha, Phi Kappa Phi, Sigma Xi and Phi Beta Kappa. For six years (1925 to 1931) he was Dean of the Graduate School of Cornell University.

At the time of the 1928 AAAS Christmas meetings a "Cornfab" was held in Doctor Emerson's room in a New York hotel and it was here that the idea of the Maize Genetics Cooperation was conceived. A mimeographed letter of April 12, 1929, and accompanying folder of linkage information was composed by him and this was considered News Letter No. 1. In January, 1933, Doctor Emerson began correspondence to obtain funds to operate the Maize Genetics Cooperation and the following year a grant for this purpose was made available by the Rockefeller Foundation. The seed stocks of mutant genes and the News Letter were continued and expanded largely through his keen interest and untiring efforts.

No statement regarding Doctor Emerson's achievements would be complete without mention of the fine personal qualities which endeared him to his friends and were known and appreciated by all who were privileged to have contacts with him. He is survived by two sons, two daughters, 13 grandchildren and one great-grandchild.

(Most of the information for the above notice was obtained from material contained in resolutions presented before the Faculty of the College of Agriculture of Cornell University by a committee composed of L. F. Randolph, B. S. Monroe, and F. P. Bussell, Chairman.)

II. REPORTS FROM COÖPERATORS

California Institute of Technology and
United States Department of Agriculture
Pasadena, California

Translocations in progenies showing chromosomes involved and giving in per cent of the arm length the distance from the centromere to the breakage point

Progeny No.	Chromosomes involved	Position of Breakage			
		1st chromosomes Arm		2nd chromosomes Arm	
		S	L	S	L
		%	%	%	%
F 10	1-2		10.		28.
B 75	1-2	26.			49.
c	1-2 c	75.			9.
a	1-3 a		13.		15.
A 33	1-3		62.		49.
d	1-3 d		63.	75.	
C 15	1-3	12.			11.
C 46	1-4		1.	1.	
B 2	1-4		6.		15.
D 5	1-4		11.		13.
A 57	1-4		33.	16.	
a	1-4 a		49.	66.	
c	1-5 c	0.	0.	0.	0.
I 24	1-5		56.	93.	
A 90	1-5		3.		9.
X 1-37	1-5		12.	51.	
A 37	1-5		33.	47.	
a	1-5 a		52.	35.	
A 61	1-5	18.		73.	
b	1-5 b	29.			18.
X 23-2	1-5	72.		71.	
X 41-13	1-6		6.		15.
a	1-6 a		21.		59.
B 92	1-6		30.		35.
c	1-6 c	17.			39.
A 80	1-6	30.		0.	0.
X55-16	1-7		23.		59.
B 94	1-7		42.		15.
I 17	1-7	25.			24.
B 49	1-7	79.		37.	
A 69	1-7	70.			67.
B 42	1-8		60.		82.
b	1-9 b		42.		54.

Continued

Progeny No.	Chromosomes involved	Position of Breakage			
		1st chromosomes Arm		2nd chromosomes Arm	
		S %	L %	S %	L %
c	1-9 c	61.			32.
A 50	1-10		36.		67.
B 98	1-10		17.		30.
a	1-10 a		23.		21.
C 36	1-10	9.			27.
C 47	1-10	72.			10.
K 7	2-3		5.		8.
d	2-3 d		73.		63.
c	2-3 c	51.		66.	
E	2-3 E	64.			34.
C 31	2-4		9.	19.	
X1-1	2-4		12.		18.
F 35	2-4		28.	5.	
84	2-4		32.		66.
a	2-4 a		29.		16.
x2-64	2-4		56.	51.	
c	2-4 c		77.	9.	
A 29	2-4		78.		13.
b	2-4 b		88.		54.
X47-4	2-4	8.		16.	
K 10	2-4	19.			30.
d	2-4 d	20.			25.
b	2-5 b		2.	2.	
a	2-5 a		16.		18.
A 74	2-5		89.		86.
K 3	2-5		90.		8.
B 69	2-5	12.		23.	
A 16	2-5	30.		50.	
X 14-122	2-5	79.		28.	
F 30	2-6		5.		90.
d	2-6 d		52.		57.
E	2-6 E		28.		22.
c	2-6 c		32.		20.
a	2-6 a		51.	9.	
84_2	2-6		80.		91.
b	2-6 b	69.			49.
B 108	2-7		16.		16.
C 44	2-7		77.		57.
b	2-7 b		41.		12.
c	2-7 c		48.	50.	
I 3	2-7		59.		24.
F 29	2-7		34.		64.
C 24	2-8		1.		1.
X 42-32	2-8		20.		22.
A 1	2-8		22.		19.
G 2	2-8		71.	42.	
A 36	2-8	17.		13.	

Continued

Progeny No.	Chromosomes involved	Position of Breakage			
		1st chromosomes Arm		2nd chromosomes Arm	
		S %	L %	S %	L %
I 10	2-9		29.	52.	
H 7	2-9		92.		32.
b	2-9 b	12.			12.
a	2-9 a	48.			85.
A -84	2-10		79.		39.
a	2-10 a		17.		53.
F 2	2-10	38.			76.
X4-108	3-5	0.	0.	99.	
b	3-5 b		54.		49.
X7-38	3-5		65.		23.
A 101	3-5	24.		12.	
a	3-6 a		7.		19.
A 53	3-6		44.		73.
b	3-6 b	82.		75.	
a	3-7 a	23.			17.
b	3-7 b	90.			3.
A-104	3-8		7.		3.
a	3-8 a		40.		60.
B-37	3-8		41.		14.
A-21	3-8		52.	45.	
Bur.	3-8	25.			85.
A 22	3-8	64.			23.
X23-158	3-9		5.		44.
c	3-9 c		15.	20.	
F 24	3-9		46.		18.
D 25	3-9		59.		17.
j p.	3-9		62.		55.
B 104	3-9		78.	75.	
c	3-10 c		27.		31.
a	3-10 a		28.		12.
b	3-10 b		61.	25.	
B 74	4-5		10.	13.	
X6-77	4-5		25.		43.
b	4-5 b		66.	66.	
d	4-5 d	21.			19.
c	4-5 c	45.			38.
a	4-6 a		33.		44.
X57-36	4-6	60.			51.
a	4-8 a	54.			48.
A 26	4-9		14.		15.
a	4-9 a		18.		50.
F 22	4-9	35.			42.
K 17	4-10		4.		1.
b	4-10 b		18.		57.
X12-57	4-10		92.		14.
B 25	4-10	75.			38.
A 77	5-6		29.		64.
c	5-6 c		81.	11.	

Continued

Progeny No.	Chromosomes involved	Position of Breakage			
		1st chromosomes Arm		2nd chromosomes Arm	
		S %	L %	S %	L %
X 23-41	5-6	29.		70.	
A 75	5-6	54.		91.	
c	5-7 c		38.		71.
B 21	5-7		59.	39.	
C 61	5-7		71.		60.
a	5-7 a		77.		71.
X27-44	5-7	84.			83.
C 52	5-8		7.	36.	
B 91	5-8		21.		28.
X27-87	5-8		37.	61.	
B 10	5-8	32.			40.
B 18	5-8	49.			7.
X 14-111	5-9		56.	68.	
X7-39	5-9		70.		40.
X10-6	5-9	21.			26.
A-49	5-10		14.	68.	
B 70	5-10		68.		60.
X 1-31	6-7		74.		61.
C 59	6-8		37.		42.
D 1	6-8		51.		78.
X 46-13	6-8		58.		90.
B 83	6-8		73.	72.	
X 25-78	6-9		17.		22.
A 66	6-9		20.		17.
C 23	6-9	54.			76.
a	6-9 a	79.			40.
C 27	6-10		15.		66.
b	6-10 b		17.		14.
D 13	6-10		21.	62.	
X17-15	6-10		84.		17.
I 22	6-10	95.		20.	
C 75	7-8		75.		60.
A 76	7-9		27.		20.
X 56-86	7-9		16.		18.
F 11	7-9	92.		24.	
C 12	8-9		30.		36.
X 26-8	8-9	11.			24.
b	8-9 b	77.			88.
F 1	8-10		37.		18.
a	8-10 a		68.	83.	
b	8-10 b	27.			14.
X 57-16	8-10	76.			67.

A. E. Longley

Progeny numbers copied as furnished.

Some observations on morphological characters.

1. Midget: Associated with seed size. Ears of heterozygous mi selfed or backcrossed to mi show variation in seed size. Larger seeds gave mostly normal plants and smaller seeds mostly midget.

K. L. Retherford

E. G. Anderson

2. Tassel-seed 6. Glumes on the cobs of Ts_6 plants are longer than on the normals and often bifurcated. The glumes of ts_1 ts_2 Ts_3 ts_4 and Ts_5 appear normal.

E. E. Dale

3. A recessive character found in one of the translocation lines has ears like silky 1 (Fraser) and is completely male-sterile with short abortive silks in the tassel. It does not appear to be associated with the translocation.

E. E. Dale

E. G. Anderson

Chicago Natural History Museum
Chicago, Illinois

In eastern Bolivia, where the wooded foothills of the Andes meet the forests and savannas of the Amazon tributaries, maize has several regional characteristics some of which have been briefly described in Botanical Museum (Harvard) Leaflets 12:257-291. In 1947, while a Guggenheim Fellow on leave from the Botanical Museum of Harvard, the writer made studies and collections of maize about Reyes and Rurrenabaque in the Department of Beni, Bolivia. This is the area which appears most promising for studies on the origin of maize.

There are two types of corn grown by the natives of this region; a crystal white flint similar to that of Paraguay, northern Argentina and southwestern Brazil, and a flour corn with a peculiar arrangement of the paired spikelets which permits an ear to have odd numbers of rows of grains over most of the ear just as readily as even numbers of rows. The leaves are narrower than leaves in other maize of Bolivia; most of the grains have a brownish-orange aleurone, while the cob and glumes exhibit a diversity in color

found nowhere else in Bolivia. Dr. James Cameron found that the chromosomes of a plant grown from an ear of this type lacked knobs.

In the same region, mainly restricted to the borders between forest and savanna, is Tripsacum australe in a wide range of forms. The plants range in habit from grasses one meter tall to much wider leaved, corn-like, succulent plants three meters or more in height. Some of the plants have paired spikelets and a wide variety of plant colors. A Brazilian Tripsacum australe has been described (Graves and Addison 1945) as lacking terminal knobs on the chromosomes.

Although no wild plant resembling wild maize was discovered, a good collection of maize and Tripsacum was obtained. Small amounts of these seeds are available to anyone interested in growing them for study. Plants grown from them will usually require short-day treatment to induce flowering.

Hugh C. Cutler

Columbia University
New York, New York

1. A viable pale green character easily classifiable as seedling and up to time of flowering was found in an F_2 population in a 3:1 ratio. Subsequent tests showed that this character is due to duplicate genes. One of these genes is in chromosome 6. The following data were obtained:

B. C. for Y and Pl and for the two pg genes

Y	y	Y	y	Y	y	Y	y
Pg	pg	pg	Pg	Pg	pg	pg	Pg
Pl	pl	pl	Pl	pl	Pl	Pl	pl
661	319	92	176	178	40	3	337

From these data the linear order and recombination values are:

Y--20.9--Pg--9.5--Pl

In one family the pg gene not in chromosome 6 was homozygous and a B.C. ratio of one green to one pale green was found. These data are:

Y	y	Y	y	Y	y	Y	y
Pg	pg	pg	Pg	Pg	pg	pg	Pg
Pl	pl	pl	Pl	pl	Pl	Pl	pl
128	93	32	23	27	11	3	1

Here the linear order is as above but slightly different recombination values were obtained:

Y-Pg	18.6
Pg-Pl	13.2

2. The interaction of Bh with recessive c has been discussed in a previous corn letter. Since the Bh gene is of more than usual interest an attempt was made to find its position in chromosome 6. The following B. C. data involving Y, Pl, and Bh were obtained:

Y	y	Y	y	Y	y	Y	y
Pl	pl	pl	Pl	Pl	pl	pl	Pl
Bh	bh	bh	Bh	bh	Bh	Bh	bh
163	176	69	83	3	1	0	0

Y-Pl	30.7%	recombination
Pl-Bh	0.8%	"

The most likely order is Y-Pl-Bh but owing to the long interval between Y and Pl and the short distance between Pl and Bh some doubt remains if this is the correct sequence. Tests are being made involving the new pg gene mentioned above in this letter. Two point data involving Pl and Bh were also obtained giving 1.4% recombination in a total of 781. Two point data for Y and Bh are as follows:

Y Bh	Y bh	y Bh	y bh
908	412	378	914

Y-Bh 30.2% recombination.

3. Gametophyte factor in chromosome 3. A gametophyte factor which has a deleterious effect on the functioning of the male gametophyte has been studied in some detail. The following conclusions have been reached from a large amount of data:

1. The linear order is ga et A lg_2 with ga about 6 units from et. (et is about 10 units from A.)

2. The percentage of functioning ga pollen, when equal amounts of Ga and ga pollen are present, varies from 2-8%. There is some, though slight, influence of the maternal silk constitution

on the percentage ga pollen which achieves fertilization.

3. There is no effect of ga on the female gametophyte and plants homozygous for ga have been obtained.

4. Some interesting data were obtained from plants heterozygous for ga and a-x2. a-x2 is an "allele" of A found by Stadler in his X ray studies; it probably is a deficiency. a-x2 pollen does not function as well as normal pollen but the extent is variable. There is a slight but significant elimination of a-x2 eggs. Crossing over is also reduced with a-x2 to approximately half the standard value for the et-A region. Pollen from plants of ga A/Ga a-x2 constitution consists chiefly of the two noncrossover classes (ga A and Ga a-x2). Crossovers give rise to Ga A and ga a-x2 pollen. The ga a-x2 pollen grains carry two harmful loci and never achieve fertilization. The other crossover class, Ga A, has a marked advantage over either of the two parental types. If only A seeds are analyzed from the cross of a a x ga A/Ga a-x2 it is found that a great majority of them (82%) are due to the functioning of Ga A pollen; i.e., there is a great excess of the crossover class. Ga a-x2 pollen grains have a striking advantage over ga A pollen but considerable variation was found in the frequency with which the two types functioned. When ga A/Ga a-x2 plants are selfed about 30% of the zygotes should be homozygous for a-x2. The abortion of these should lead to sterility on the ear. Surprisingly enough in the few ears so far obtained of this kind very little sterility has occurred. It is possible that we are dealing here with a case of selective fertilization; i.e., the a-x2 embryo sac rejects pollen tubes of the same constitution and only or chiefly accepts sperm of Ga A or ga A constitution.

4. Androgenesis. Three seedlings were found growing from one kernel. Each had its own root system. One of the three was a diploid but the other two were haploids. Fortunately the seed in question came from a cross in which the female parent was recessive for a and pl while the pollen parent was homozygous for the dominant alleles. The two haploid plants carried both the A and Pl alleles. It seems that we are forced to assume that two sperm nuclei developed into haploid sporophytes.

5. Tests for inversions in populations of corn from Central and South America. Inasmuch as inversions exist in different geographical races of many plant and animal species, it was deemed desirable to ascertain if this was true for maize. Through the generosity of P. C. Mangelsdorf F_1 seed of crosses between 65 Central and South American strains and a North American line were obtained. Two North American lines were used; one was homozygous for Tu while the other was a Pr tester. The great majority of the crosses were made using the Pr tester. Sporocytes from the F_1 plants were taken and held

until a pollen sample was examined. If aborted pollen was present, the P.M.C. were then examined. In none of the F_1 families involving the Pr tester was there any indication of structural differences. The homozygous Tu strain was used in five crosses. In one of the F_1 families only normal plants were found; in two of them half of the plants had about 20% aborted pollen due to a paracentric inversion; in two more families all of the plants possessed some aborted pollen - again due to a paracentric inversion. It seems certain that the Tu stock was segregating for an inversion.

M. M. Rhoades

A pink aleurone color, varying in intensity and giving a mottled appearance, was observed in stocks of corn homozygous a_1a_1 and heterozygous Dtdt. Crosses made in the summer of 1946, in the course of other studies with this stock, indicated an unusual mode of inheritance of this color factor called flush.

In general, of 105 ears examined, all were either 100% flush, 100% colorless, or segregating 1:1. Selfed plants from flush kernels of segregating ears had two classes of ears; some were altogether colored, and others segregated 1:1. Selfed plants from colorless kernels of these same segregating ears also had two classes of ears; some colorless and some segregating 1:1.

Further crosses made in the summer of 1947 indicated the same pattern of inheritance and especially the total lack of effect of the male parent in determining the phenotype of the offspring. When the female parent is homozygous for flush, all offspring kernels will be colored regardless of the male constitution, provided only that it comes from the same stock. When the female parent is homozygous colorless, all offspring kernels are colorless. When the female parent is heterozygous, all ears segregate 1:1. However, let us consider the genotype of these kernels. When a heterozygous plant is selfed, half the colored kernels of the offspring ear will be homozygous flush and half heterozygous. Half the colorless kernels will also be heterozygous for flush and half homozygous colorless. All these cases have been observed.

The data indicate that the expression of flush depends upon the presence of the allele for color in at least two of the three loci present in each aleurone cell. There is no dominance. This mode of inheritance resembles that of floury.

Linkage tests are in progress. Expression of flush is independent of Dt. It follows then that the aleurone color factors A_2 C and R are all homozygous dominant. When homozygous flush

plants were used as female times a_1-et tester stock, the offspring ears were all colorless, indicating the male carried some factor inhibiting expression of flush. However, when sib females were crossed to C.497 a_1 tester, some of the kernels on the offspring ear were pigmented faintly.

The variability in intensity of color seems to be affected greatly by both environmental conditions and modifiers. Careful grading of color intensity of several ears individually gave in each case a fairly typical normal distribution range with no appearance of sharp discontinuities or classes. When a pale flush heterozygote female was crossed to a deep flush male, the colored kernels on the offspring ear were, on the average, deeper in color than were the colored kernels on ears from crosses of sib females to pale flush males. Thus it appears that the male parent carries modifiers that can affect the intensity of pigmentation, but the male cannot determine whether or not the color will be present.

Under controlled environmental conditions this factor may be useful for a quantitative study of modifiers, and further work is in progress.

Ruth Sager

Cornell University
Ithaca, New York

Relation of plant vigor to number of kernel rows.

For a genetic analysis, it is obviously important to choose a quantitative character that is little affected by diversities of environment. To undertake it with such characters of maize as height of stalk, weight of plant, weight of grain and the like would be to court failure. The effects of soil heterogeneity and of weather diversity might be expected to mask genetic differences. There are two quantitative characters of maize, however, that are influenced only slightly by environmental diversity, namely, number of nodes or leaves on the stalk and number of kernel rows on the ear. The seedling leaves of maize are usually lost long before the plant has completed its growth and the first internodes are very short. While this does not make it impossible to record accurately the number of nodes, it makes accuracy more difficult. An even more important objection to the use of number of nodes in a genetic study in this latitude is the close correlation between number of nodes and lateness of maturity. One can find varieties of early and of late maize that are either relatively tall or relatively short, but

maize with a large number of nodes is, in my experience, always late in maturity.

Number of kernel rows can usually be determined accurately and with little difficulty. The only difficulties encountered are crooked or zigzag rows and tapering and fasciated ears on which the number of rows varies from butt to tip of the ear. These difficulties can be overcome largely by selection for straight rows and non-tapering and non-fasciated ears. When the use of such ears is not easily avoided, it has been my practice to record the number of rows at about one-quarter of the distance from the butt toward the tip of the ear. Since two ears on the same stalk occasionally differ in number of rows by two and rarely by four rows, I have used the upper - usually the better developed - ear.

It should be obvious that conditions of growth could affect number of nodes and number of kernel rows, if at all, only during the early stages of the plant's development. Usually about five leaf primordia are found in the embryo of the mature kernel. In relatively young seedlings, all leaves or leaf primordia are visible and the tassel primordium appears, after which no more nodes can arise. Even the ear shoot is laid down and thereby the number of kernel rows determined relatively early in the life of the young maize plant.

Differential soil fertility. Some years ago, two 12-row inbred lines of maize, A and B, and the F_1 and F_2 of the cross, A-B, were grown during two summers on two small plots, one of almost pure sand and the other of very fertile soil. On the sand plot the plants were from two to four feet tall while on the rich soil plot they reached a height of seven to nine feet. An open-pollinated stock of the 16-row variety, Cornell 11, also was tested on the rich soil and sand plots. More recently three 12-row (2,4,39), two 8-row (51, XI) and one 16-row (Pr) inbred stocks were grown on relatively rich garden soil and duplicated on similar soil on which oats had been seeded heavily at planting time. The oats evidently robbed the maize plants of much of the available fertilizer elements, for, at the time of tasseling, the maize plants were only one to two feet tall and were more nearly yellow than green in color. A heavy side dressing of ammonium nitrate after the oat plants had been removed resulted in the development of usable ears on only a part of the plants. Frequency distributions of all the lots subjected to these differential soil-fertility tests are presented in table 1.

In every one of the 11 tests, the mean number of kernel rows was lower on the low-fertility plot than on the high-fertility one. Differences in means varied from 0.27 to 3.69. All lots combined, involving 1189 plants, showed a difference of 1.59. In general the differences are statistically highly significant, but of small magnitude. There is, therefore, no doubt that extreme differences in soil fertility influence mean number of kernel rows, and it

Table 1. Effect of extreme differences in soil fertility on number of kernel rows

Maize stock	Soil fertility level	Number of kernel rows										Total	Mean	Difference
		4	6	8	10	12	14	16	18	20	22			
XI	High	7	1	24								32	7.06	
	Low	23	1	12								36	5.39	1.67
51	High	1	6	52	2							61	7.80	
	Low	3	6	26	3							38	7.53	.27
A	High			1	11	35	6					53	11.74	
	Low			2	28	35	3					68	11.15	.59
B	High				5	49	16					70	12.31	
	Low			5	50	28	1					84	10.60	1.71
A-B F_1	High				5	33	30					68	12.74	
	Low			4	27	45	7					83	11.83	1.41
A-B F_2	High			1	14	52	24	1				92	12.22	
	Low			2	16	22	5					45	11.33	.89
2	High			5	8	29	10					52	11.69	
	Low	2	2	1	2	2						9	8.00	3.69
4	High			2	3	44	25	1				75	12.53	
	Low			5	2	2						9	9.33	3.20
39	High				2	49	14					65	12.37	
	Low			4	11	13						28	10.64	1.73
Pr	High						2	17	24	1		44	17.09	
	Low					4	13	7				24	14.25	2.84
Cornell	High					1	13	41	15	10	3	83	16.70	
"	Low					15	33	18	4			70	14.41	1.29
All tests	High	8	7	85	50	292	140	60	39	11	3	695	12.47	
	Low	28	9	61	139	166	62	25	4			494	10.88	1.59
												1189		

is equally without doubt that the relatively small differences in fertility encountered in any small experimental field in any one season may well be disregarded.

Heterosis. Since extreme differences in vigor of growth, induced by differences in soil fertility affect number of kernel rows to some degree, it is important to know what effect may be induced by hybrid vigor of plants, or heterosis. A comparison of mean row number of 13 12-row inbreds and of all the 78 F_1 crosses between them were made. Similar comparisons of mean row number of three 10-row inbreds with the three F_1s and of six 8-row inbreds and the 15 F_1s were made.

Of the 14 12-row inbreds 6081 and of the 91 F_1s 7217 individuals were recorded, an average of 434 per inbred and 79 per F_1. The average of the mean number of kernel rows for the inbreds was 12.14 and for the F_1s 13.03, a difference of 0.89 rows, presumably an effect of the greater vigor of F_1 plants. Some of the F_1s showed no significantly greater number of rows than the average of the two inbred parents, and two of them exhibited a slightly lower number. The fact that 89 F_1s showed plus and only two minus differences when compared with the averages of the inbred parents indicates a significant though small effect of plant vigor on number of kernel rows.

The three 10-row inbreds, with 1543 individuals recorded, had an average of mean row numbers of 10.33 and their three F_1s, including only 319 individuals, an average of 11.56, an average positive difference of 1.23 rows. If these records are combined with those from the 12-row lots, the 17 inbreds averaged 11.89 and their 94 F_1s 12.98 rows, a difference of approximately 1.1 rows. This supposed effect of plant heterosis is of the same order of magnitude as that earlier ascribed to differences in vigor of plant associated with extreme differences in soil fertility.

The seven 8-row inbreds and their 19 F_1s showed significant differences in only a few cases. There were 14 plus and five minus differences, and the average difference was only 0.18. This questionable slight effect of plant heterosis on number of kernel rows in case of 8-row inbreds and their F_1 hybrids parallels a similar lack of effect of excessive crowding compared with wide spacing of 8-row inbreds.

R. A. Emerson

Florida Agricultural Experiment Station
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1. Testing for overdominance. Testing for overdominance in grain yield by regression of F_1 on homozygous parent (1946 and 1947 Letters) has been done now with 17 sets of data to provide unweighted odds of 14:3 for overdominance.

Testing by regression of F_1 on mean performance of parent as proposed in the 1947 Letter has been done with many more sets of data to provide inconclusive results. Estimates of the natural selection equilibrium are mostly higher by this second technic than those obtained with the first, especially in the more recent tests.

A possible explanation of the discrepancy may be bias occasioned by each parent being rated with a different tester group in samples where each parent is crossed with every other parent.

Such bias may be avoided by resort to constant tester groups. Thus, if the sample of parents is divided into two groups and only crosses between groups are considered, each group is a constant tester for individuals of the other group. From any one of the many sets of records available on the 45 F_1s of 10 inbred lines many 5x5 or 4x6 tables may be extracted for analysis. Each parent must occur in only one group. The data table must be complete.

Under the assumption of no epistasy, which seems reasonably well warranted for corn yield, theory of regression analysis of data tables as outlined above is simple. The problem essentially is regression of individual F_1s on row and column means -- prediction of the single cross from general performance of the two parents. This problem has been solved by methods employed in the two previous Letters for regression of F_1 phenotype on parent phenotype per se.

If v_1, v_2, ---- v_n are proportions of A in the lines of one group, $\bar{v}$ is the proportion A for the whole group. Employ w similarly for the other group. Expectations for row and column means may then be expressed in terms of v and $\bar{w}$ for one set and, w and $\bar{v}$ for the other. Solving these expressions for v and w respectively and substituting in the general F_1 function provides the desired theoretical regression of F_1 phenotype on general performance of parents (phenotype);

$$F_1 = b_1G_1 + b'_1G_2 - b_2G_1G_2 + C$$

$$b_2 = -2k/nd(1+k-2k\bar{v})(1+k-2k\bar{w})$$

$$bp = (1+k-2kw)/(1+k-2k\bar{w});\ G_2 \text{ constant}$$

$$= (1+k-2kv)/(1+k-2k\bar{v});\ G_1 \text{ constant.}$$

The natural selection equilibrium gene frequency is (1+k)/2k. Thus, if any parent line has that gene frequency with respect to n loci considered, regression of the F_1 row or column which it heads on the parallel row or column of G (general performance, row or column means) has the expectation of zero. The test is carried through, as before, by calculating simple regressions (bp) of each row and column of F_1 on the parallel row or column of G. Regression of bp on G then provides the estimate of b_2, (which is the same for either rows or columns) and the estimate of G for bp = 0.

Sampling variances of these estimates from samples, e.g., of 25 F_1s must be large, but precision may be increased by analysis of additional sets of data. The three analyses we have run so far on yield data have not been very consistent.

We must note too that if the mean gene frequency $\bar{v}$ or $\bar{w}$ of either tester group should closely approach the equilibrium value, (1+k)/2k, genetic variance of G of lines of the tested group would approach zero. Estimates of bp and b_2 might then have little genetic meaning.

It is clear from the theoretical formulas for bp that mean bp has the expectation of plus 1.00, regardless of degree of dominance or of gene frequency. Calculated values for three analyses are: 1.0000, 1.0001; 1.0000, 0.9982; 0.9998, 0.9988. Deviations from the expectation of 1.0000 may be due to dropping decimal places and to metrical bias. These obtained values seem to be in agreement with the hypothesis that epistasy and metrical bias are of little moment in grain yield of corn. Further research is required to establish the sensitivity of this test for linearity.

It is also clear that the estimates of v and w for the parent lines are independent of homozygosity or heterozygosity of the parents. The analysis outlined here may be employed equally well with heterozygous clones or with lines isolated by mild inbreeding, provided, of course, that epistasy and metrical bias are not disturbing factors.

If calculated mean bp is found far from the expectation of 1.0000 in any case the estimates of b_2 and critical G must be suspected. Such deviation may, of course, be evidence of epistatic interaction.

In general, if v is the proportion A in any corn plant of a crossbreeding variety, the best estimate of phenotype, with respect to n loci, is a second degree function (v^2) if there is dominance bias, if mean k is not zero. If w is proportion A in any other plant, the best estimate of phenotype of F_1 is a second degree function (vw) as shown in previous Letters. Hence, the best estimate of F_1 phenotype from phenotypes of heterozygous parents is a fourth degree function if there is dominance bias.

This general function was reduced to second degree by employing homozygous parents in the technic outlined in the two previous Letters. In the present technic the fourth degree function is reduced to second degree by experimental design of constant tester groups. Row and column means are linear functions of gene frequencies of parents. In both cases the second degree function is reduced to first degree by holding one parent constant to calculate bp for each F_1 row or column. Thus, the least square fit of a straight line is done only where the Mendelian expectation is linear. Regression of bp on P or G is also theoretically linear under the stated assumption.

We may note that the difficulty of the fourth degree relation of offspring phenotype to phenotypes of heterozygous parents is avoided in some theoretical considerations by treating the case of no dominance, or by treating the case of complete dominance with mean gene frequency at 0.5. The difficulty does not appear if consideration is restricted to regression of offspring on parent gamete. Fisher, Immer and Tedin (Genetics, 1932) have avoided some of the difficulty by considering offspring of two homozygotes thus to obtain a mean gene frequency of 0.5. I think they are fitting straight lines, however, where the theoretical relations are curved if there is dominance bias. If so, their methods must be less efficient than those discussed above.

Fisher has noted that regression analysis and Analysis of Variance are fundamentally the same. Present technic may perhaps be employed or improved to study interaction of main effects and interactions of environmental factors with main effects and interactions of genes, where the same crosses are tested at different locations or with different treatments. Omitting any one parent to make an $(n_1 - 1) \times (n_2)$ table may provide specific information on that parent.

The six single crosses of four parents provide for three (2x2) tables equivalent to the three double crosses. In each case, the two tester groups are the parent single crosses; the four items in the table provide the predicted double cross.

2. Additional note. In terminology of genetics, each row and column alone of these tables is a sample from a distribution having the essential characteristics of a backcross. Such distributions are generated as the product of a constant gamete and a gametic array. This provides first degree regression of offspring phenotype on number of plus genes in the specific gamete from the array. This gene number in turn is related linearly to phenotype per se of homozygous parents or to mean phenotype of offspring of either homozygous or heterozygous parents. The backcross distribution is not skewed by dominance since the distribution merely reflects a gametic array.

Any whole table is a sample from a distribution having essential characteristics of an F_2, the product of two gametic arrays. Offspring phenotype is a second degree function of gene numbers of two

parent gametes. Such distributions are skewed by dominance since regression is not first degree.

For simplicity present technics of treating the whole table as a series of backcrosses rather than as an F_2 is proposed. But, of course, there is no fundamental difference in the two viewpoints.

Fred H. Hull

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1. Teosinte derivatives. Additional studies to determine the linkage relations of the blocks of genes, or chromosome segments, which distinguish teosinte from maize are, in general, in agreement with the results reported in the 1947 Maize News Letter. In teosinte derivatives which contain two or more segments, one of the segments is almost invariably that on chromosome 4. There is no doubt that the segment on chromosome 4 is the most conspicuous of all the segments in its effects and is almost certain to be included in derivatives which exhibit strong teosinte effects.

The data from the 1947 tests are shown in table 1. Considered in connection with last year's data they show that the principal segments in Florida and Durango are located on chromosomes 1,3,4, and 9; in "New" teosinte on 3 and 4, and probably 1 and 9; and in Nobogame teosinte on 3 and 4, and probably 1.

The only data not in obvious agreement with the conclusions are the 1947 data on the derivatives from Durango teosinte which show a definite linkage with the marker gene on chromosome 10 in one cross and indications of linkage on chromosomes 2,6, and 7. These particular teosinte derivatives are descendants of an F_2 plant, however, rather than the result of repeated backcrossing to an inbred strain of maize. Hence, small segments or modifying factors on chromosomes other than 1,3,4, and 9 may be playing a part. Linkage relations of the characteristics which distinguish Durango teosinte from maize, as determined from F_2 populations, reported here in 1945, indicate that chromosomes 2,3,4,6,8,9, and 10 are involved. Teosinte apparently differs from maize primarily by three or four chromosome segments which involve chromosomes 1,3,4, and 9, but there are small segments, not easily detectable, or modifying factors on most or all of the remaining chromosomes.

That the chromosome segments from teosinte are transmitted in inheritance as definite and stable entities is shown by "New" teosinte progenies 1205 and 1156. These were derived from a single plant

in 1940 but have had separate lines of descent since that time. When these progenies were recently tested for linkage relations, chromosomes 3 and 4 were shown to be involved in both.

We also have one instance involving data presented last year, in which two stocks, each apparently carrying one segment, were crossed, to produce a stock carrying both segments. When the three different stocks were tested to determine the linkage relations of the segments, it was found that one parental stock involved chromosome 3, the other chromosome 4, and their two-segment derivative involved chromosomes 3 and 4.

Table 1. Linkage relations of teosinte segments

Pedigree number	Variety of teosinte	Number of segments	Linkage with chromosome number 1	2	3	4	6	7	8	9	10	Total number chromosomes tested
1195	Florida	1	-	-	-	+	-	-	-	-	-	450
1149	"	2	-	-	+	+	-	-	-	-	-	702
962	Durango	2	-	I	-	+	-	-	-	I	-	531
1151	"	2	-	I	-	+	-	-	-	I	-	621
963	"	2-3	-	I	I	+	-	-	-	-	-	657
1152	"	2-3	+	-	-	-	-	I	-	+	-	603
1153	"	2-3	I	-	-	+	I	I	-	+	+	1593
1206	New	1	I	-	-	-	-	-	-	-	-	1620
1205	"	2	-	-	+	+	-	-	-	-	-	1494
1156	"	2	-	-	+	+	-	-	-	-	-	1656
1154	Nobogame	2	-	-	+	+	-	-	-	-	-	1449
1155	"	2	+	-	-	+	-	I	-	-	-	1080
1207	"	2	-	-	+	+	-	-	-	-	-	1566

+ = Linkage
I = Indication of linkage
- = Independent inheritance

2. Pod corn. It was discovered this season that our homozygous stock of pod corn, as reported in a previous Letter, carries an allele intermediate between ordinary Tu and tu in its effects. We designate this tu^i. This raised the question of whether there are other weak alleles of Tu among living varieties. An examination of our collection of Latin American varieties indicates that many of the varieties of Mexico, Guatemala, Colombia, Ecuador, Peru and Bolivia may possess weak alleles of Tu. There is some genetic evidence for such a conclusion in F_1 hybrids of United States and Latin American

varieties with an inbred strain of intermediate tunicate. More than 100 such crosses (originally made to test for minus modifiers of Tu) were grown in 1947. The ears in different crosses varied from those in which the grains were completely covered with glumes to those in which the glumes were so reduced that the ears had the aspect of normal non-tunicate ears. Plus and minus modifiers for tunicate are undoubtedly responsible for part of this variation, but the major part is probably due to weak alleles of Tu possessed by many of the Latin American varieties.

The weak tunicate condition, like intermediate and strong tunicate, is often associated with a flexible cob. In two different crosses, one involving the Guarany maize of Paraguay and the other a variety from Guatemala, flexibility of the cob was associated with the Su gene on the fourth chromosome. In one of these crosses, the percentage of crossing over between Su and flexibility was 31 per cent, which is approximately the same as previously reported between Su and Tu. Apparently the flexibility of the cob of some varieties is due to a weak allele of Tu.

An examination of prehistoric ears from Peru indicates that all, or practically all, are similar to the weak tunicate condition found in some modern Latin American varieties.

There are indications that Tu is a mutable locus. The gene tu^{i} apparently arose as a mutation in our Tu stock. More recently we have found a chimera in a Tutu stock in which part of the seeds were covered with glumes and part were naked. Covered seeds, when grown, gave rise to TuTu, Tutu, and tutu individuals; naked seeds produced only Tutu and tutu plants. Numbers are too small to prove the case but are suggestive.

The case for pod corn as the ancestral condition of cultivated maize is now perhaps as complete as it can be on the basis of circumstantial evidence. These are the salient facts:

1. Ears resembling pod corn are represented on prehistoric pottery.
2. One prehistoric ear of pod corn is known.
3. The majority of prehistoric Peruvian ears appear to be a weak form of pod corn.
4. There are several historical references to pod corn in South America.
5. Many living varieties, especially those of South America, possess a weak allele of Tu.
6. The tu gene is mutable.

7. Pod corn possesses the principal characteristic which the comparative morphologist would expect to find in a wild maize ancestor.

3. Multiple-gene linkage testers. The nine-gene linkage tester previously described has proved useful in determining the linkage relations of characteristics whose inheritance is not clear-cut or perhaps quantitative. A single population of 150 to 200 plants is usually adequate for determining which chromosomes are involved. Linkages or indications of linkage have been found for the distichous ear, secondary pistillate florets, hispid and pilose conditions of the leaf sheath, flexibility of the cob, and susceptibility to aphids and smut. Data are given in table 2.

Table 2. Linkage relations of characters in maize.

Character	Linkage with chromosome number									Total number chromosomes tested
	1	2	3	4	6	7	8	9	10	
Distichous spike	-	-	-	-	-	-	-	-	+	1413
Secondary pistillate florets	-	+	-	-	-	-	+	-	-	666
Pilose leaf sheath	-	-	I	-	-	-	-	-	I	864
Hispid leaf sheath	-	+	+	-	-	-	-	-	-	666
Flexible cob	-	-	-	+	-	-	-	-	-	666
Susceptibility to aphids	-	-	-	-	-	-	-	I	-	1359
Susceptibility to smut	-	-	+	+	-	+	+	-	+	24264

+ = Linkage
I = Indication of linkage
- = Independent inheritance

Paul C. Mangelsdorf

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In November, 1947, I visited the place in Nayarit, in western Mexico, where Kempton found a giant variety of corn 25 or 30 years ago. (See Journal of Heredity 15:337-344. 1924.) The variety still grows there, but the ears are smaller than they were at the time of Kempton's visit. The longest that I found were about 15 inches. He reported some 24 inches in length. In addition to the large variety,

a smaller one is now also grown in the same valley. Although the two are planted two months apart, there is evidence of hybridization, and that is probably the explanation of the decrease in size of the large one.

I have a small amount of seed of both varieties and shall be glad to divide with others who are interested as long as the supply lasts. The large variety probably cannot be grown anywhere in the United States except in the extreme southern part.

Paul Weatherwax

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Only slight progress can be reported at present in the haploid studies. The problem of recognizing haploid plants in the seedling stage has proved to be much simpler than doubling the chromosome number in such plants (using colchicine as soon as the plants are tentatively identified). However, a homozygous diploid stock has been obtained from a Golden Cross Bantam haploid which was effectively doubled in a sector of the ear and tassel.

A few of the untreated or undoubled haploid plants set a seed or two when self-pollinated. In order to obtain pollen from these plants it was necessary to open the anthers manually.

Two types of genetic testers have been used to locate naturally occurring haploids; these are Randolph's brown, liguleless stock (a B Pl C R lg) and several purple plumule (Pu) stocks (38-11, Minn. 385A, Stadler's extract from Minn. 385A, etc.). The brown, liguleless tester has been more satisfactory than the purple plumule testers though on some seed stocks these do (as was hoped) permit a rough classification of the embryos in the dry kernels.

At present I am trying to develop better testers, particularly Pu testers, and am also checking the seedling characters of a number of stocks from which I would like to obtain haploids. I am also interested in the possibility of asexual increase of maize. Such increase of individual haploid plants before colchicine treatment would greatly increase the chances for effective doubling of a given haploid.

One kernel with twin embryos (side by side) was found in which one twin was haploid, the other diploid. On this account a number of other side by side twin embryos were grown out and either selfed or sibbed. No twins have been located in the seed crop of these plants.

Sherret S. Chase

John Innes Horticultural Institution
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Since 1938 there have been annual breeding studies with corn at this institution and in this contribution to Maize Co-op News Letter it may be useful for other workers to have a brief history of what we have been doing and what are some of our future aims.

Although corn had been used at the John Innes from time to time for genetical investigations, it was not until C.D.R. Dawson commenced a sweet corn breeding programme just before the war started that corn breeding began here in earnest. As a result of his tests, Dawson released to the seed trade two top crosses, known as the John Innes Hybrids.

However, during the war a number of staff changes took place and a new breeding programme was initiated by K. Mather who found that, owing to the differences in climate of southern England and those States where sweet corn is more commonly grown, even such types as Golden Bantam and Golden Cross Bantam failed to germinate fully here in sowings made before June. The first essential was, therefore, to obtain cold-hardy lines which would germinate in cold soil. This work has been continued annually, the principle being to breed from plants of different strains which survived February and/or March sowings in the field. On the whole, the results are gratifying and we are now multiplying stocks from our selections of Canada Gold and Golden Early Market. In addition, we have a strain of Golden Standard Maize, a dent originally imported from Holland, which has been improved to withstand the rigours of early field sowings.

For several years we have been running an experimental determination of the influence of sowing times on the behaviour of various strains of sweet corn and it now seems likely that sowings earlier than the beginning of June are more advantageous as the seedlings may have a better chance of avoiding frit fly (Oscinella frit) attacks.

Similarly, K. Mather has conducted numerous varietal trials of samples of sweet corn that have reached him from the U.S.A. Numerous crosses have been made and the new combinations tested, but, on the whole, few proved better than the lines we already had. Perhaps because of our cooler climate the ears of the different varieties tested have ripened unevenly, and it was decided that our best chances of producing an improved type of sweet corn for southern England would be to use the methods now so widely established in the U.S.A.; namely, to inbreed and select those inbred lines which had the best combining ability later on. A small experiment along these

lines was initiated.

Another series of investigations were conducted by A. J. Bateman in his studies of the spatial isolation required by seed crops in order to prevent their contamination with foreign pollen. He used corn as one example of a wind-pollinated species.

During the last year, through a grant from the Agricultural Research Council, I was able to work with W. R. Singleton at the Connecticut Agricultural Experiment Station so that I could see at first hand the methods of sweet corn breeding practised in New England, and it is hoped to introduce some American methods into our future work at the John Innes. In addition, I was fortunate enough to make a tour of the corn belt and hear some of the current problems of corn geneticists, many of whom have generously supplied lines of sweet corn for our cold-hardiness experiments.

Our programme for 1948 includes a continuation of the February selections which will include not only the John Innes selected lines, but also a series of inbreds and their hybrids obtained from W. R. Singleton and from the Central Experimental Farm in Ottawa; also a large trial of the stocks I brought back with me to see which behave well enough under our conditions initially before starting our inbreeding campaign and to study the reaction under field conditions of some of my cold-room selections. Finally we are proposing to see how our previously selected lines behave in various parts of this area of England.

G. Haskell

Tennessee Agricultural Experiment Station and
United States Department of Agriculture
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Dominant inhibitor of yellow endosperm.

Crosses between the white Huffman variety of corn and yellow inbreds from the corn belt suggested that some Huffman gametes carried a dominant inhibitor or partial inhibitor of yellow endosperm. Selfed progeny from one such cross supported this idea. As a further check, kernels thought to be homozygous for the inhibitor were planted in 1947 and the resulting plants were selfed and crossed onto two yellow progenies.

The dominant whites selfed were pure white. The crosses with a pure deep yellow (Ridgway orange 15) were much lighter, being

Ridgway's Cadmium yellow 17. The other progeny when selfed was Ridgway's Cadmium 19, but when pollinated by the dominant white was almost white, though with a faint yellowish tinge. The information obtained through these simple tests is sufficient for our purpose. We are sending seed of the homozygous dominant white to the Maize Genetics Cooperation at Cornell, so it will be available should any one have use for it.

J. R. Meyer

F. D. Richey

Miniature plants.

Miniature plants were found in 1944 at the Agricultural Experiment Station, Knoxville, Tennessee, in progenies which previously had been once or twice selfed. One of these was in an S_1 from the white variety, Huffman, from Tennessee. The other was in an S_2 from the Franklin yellow dent variety from Oklahoma. The parents had not been grown in the same season so that there was no possible opportunity for intercrossing. Both miniatures were propagated by selfing and/or crossing. In 1945 the white miniature was crossed with a plant heterozygous for the yellow miniature. This cross segregated in 1946 into a close approximation of 1 to 1. Crosses between the yellow miniature and white miniature made in 1946 were completely miniature in 1947.

The character is not workable because it cannot be classified with any degree of certainty in smaller-growing plants. It seemed of interest, however, to note this instance of a mutation at a specific locus arising in two completely unrelated stocks and then being found in the same field in a single season. It is not certain that the mutations were to the same allele, but, if different, these cannot be distinguished phenotypically in segregating material.

F. D. Richey

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1. Resistance to grasshoppers

A. New data on linkage with P. In a previous paper (Anales del Instituto Fitotecnico de Santa Cataline 2:25-52. 1940), we reported that gene ag, for resistance to grasshoppers, is in chromosome 1. In those cultures, F_2 and backcrosses, AG and P were linked in the coupling phase, giving about 20% recombination. Here we are reporting data from a three-point test, where Ag and P enter in the repulsion phase. Burnham's pa is present also. All data belong to two 1946 cultures.

Three-point test: $\frac{ag\ P\ pa}{+\ p\ +}$ x ag p pa

(0)		(1)?		(2)		(1+2)?		
ag P pa	+ p +	ag p +	+ P pa	ag P +	+ p pa	ag p pa	+ P +	Total
65	84	8	10	23	26	6	8	
149		18		49		14		230
		7.8%		21.3%		6.1%		

There is no question about ag being located to the left of pa. But, owing to the fact that single crossovers in region 1 and double crossovers appear with almost the same frequency, the relative position of ag and P is not settled. However, there is a slight indication favoring the sequence and approximate spacing of genes to be as follows:

ag 13.9 P 27.4 pa

B. Its linkage with P makes easier the task of transferring ag to commercial varieties as many of them (American dent varieties) are PWr (colorless pericarp and colored cob) and others are p (colorless pericarp and cob). The F_1 (PWr/p Ag/ag) in coupling or repulsion - as the case might be - is repeatedly backcrossed to the commercial variety and subsequently selfed selecting for that pericarp type which is linked with resistance. So the costly tests with insects are relegated to the final steps of the work. Susceptible PWr lines are changed into p resistant ones; and, conversely,

p susceptible lines are transformed into P^{WT} resistant.

A new aid in selection for resistant plants is afforded by the "basket-worm" (Oiketicus kirbyi Guilding). This insect is abundant in the Buenos Aires region. Its poliphagous larva feeds on the leaves of many horticultural plants causing great damage especially to trees and shrubs. These larvae attack the common varieties of maize, but not the one resistant to grasshoppers. When the small larvae emerge in the spring, they are spread by wind, covering all plantations. At this time, with a "at saturation" invasion over the experimental field of maize, it is easy to classify resistant plants from susceptible ones. This allows the elimination of most of the susceptible material before the final test with grasshoppers is made.

C. Regional tests were conducted at 50 geographical places in order to demonstrate the behavior of common varieties as compared to hybrids between selfed lines resistant to grasshoppers. The picture here enclosed shows the results of one of those tests, after a heavy invasion of grasshoppers. It is more demonstrative than any written description could be . (Ed. note: Dr. Horovitz's pictures are very striking and are on file at the Department of Plant Breeding, Cornell University, for anyone who might wish to see them.)

D. Relation between resistance to grasshoppers and resistance to other insects. The "amargo" maize (= ag) is resistant to the Acrididae: Schistocerca cancellata (= S. paranensis), Scyllina variabilis and Dichroplus arrogans, among which there are locusts and grasshoppers. It is also resistant to Oiketicus kirbyi, a lepidopterous belonging to the Psychidae. All of these insects are leaf-biters. (It must be said, by the way, that grasshoppers eat some restricted tissues of the "amargo" plant, as anthers, silks and the auricular region at the base of the leaf which is lacking chlorophyll.) On the other hand, "amargo" maize is not resistant to sucker insects (corn-aphides) nor to feeders on internal tissues as stalk-worm (Diathraea sacharalis) and ear-worm (Helliothis sp.).

As there is no corn-borer (Pyrausta nubilaris) yet in Argentina, we have had no opportunity to test the ag maize with this insect. But Marston, in Michigan, found resistance to corn-borer in a corn which came to him from Argentina under the name "amargo". Marston transferred that resistance to Michigan lines of maize. Some years ago, Marston kindly sent us samples of his new corn-borer resistant corn as well as the original "amargo" used by him as the source for resistance. All of them - Marston's original "amargo" included - have been proven completely susceptible to grasshoppers in our tests.

Resistance to corn-aphis and to corn-borer both might be due to the same causal condition; this having been suggested to us by the following words of Dr. R. A. Emerson in a letter of

May 22, 1944: "The corn breeders of our central states have found inbreds that show strong resistance to the corn borer and the same inbreds are also resistant to aphis." We have tested with grasshoppers many corn lines of different origin, and among them several American lines carrying indications of resistance to some insects as chinch bug, corn root worms or grasshoppers. All of these lines were susceptible to grasshoppers in our tests.

The entire information suggests the existence of a repellent substance in the leaves of "amargo" corn, its distribution being restricted to green tissues only. Such a substance, conditioned by gene ag, would be, perhaps, a general repellent for leaf biter insects. Resistance to corn aphis and to corn borer is due to a different cause - perhaps also a chemical repellent, but, anyway, different to the one causing resistance to grasshoppers and more widely distributed, especially through internal plant tissues.

S. Horovitz

A. H. Marchioni

E. Preliminary investigations on the nature of resistance of ag maize to grasshoppers.

(a) Temperature action on resistance. Leaves of resistant corn (ag), severed from the plant, were maintained at different temperatures before submitted to insects. Leaves kept at 0°C for increasing periods of time up to 96 hours did not change their resistant condition as proven in the subsequent test with grasshoppers. Leaves kept during five minutes at increasing temperatures up to 75°C, maintained their resistance. Treatments of leaves at 80°C during five minutes, slightly reduced their resistance. Treatments during a longer period of time at 80°C badly affect the condition of the leaves which did not withstand a 24-hour test with grasshoppers without drying out. Leaves treated at 100°C during one minute, became completely susceptible.

(b) Juice was obtained by pressure from leaves of both resistant and normal corn. The remainder of pressed leaves of each kind, was supplied with juice from either resistant or susceptible leaves, and afterwards tested with grasshoppers. Fresh leaves from resistant and susceptible plants, after being impregnated with extracted juices from susceptible or resistant leaves, behaved like untreated leaves. The results are as follows:

Rest of pressed leaves	Juice from pressed leaves	Behavior against grasshoppers (rest + juice)
ag	ag	Resistant
+	ag	Susceptible
ag	+	Resistant
+	+	Susceptible

ag = resistant plants
\+ = susceptible plants

These experiments show that resistance of leaves is apparently due to a thermolabile substance, not affected by low temperatures, but destroyed at 80°C. Such a substance seems to remain in the rest of pressed leaves rather than in the extracted juice.

The liquid obtained by rupture and maceration of leaves with a small amount of water, by shaking it into a test tube, in the case of resistant plants, gives a more abundant and persistent foam than that obtained from normal plants. The chemical search for saponins gave negative results. Likewise, the search for cyanoheterosides by Guignard's reaction also gave negative results.

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R. A. Nico

(c) Millon's reaction and resistance to grasshoppers. In order to investigate the nature of resistance to grasshoppers, plants of resistant maize were tested with reagents which served to identify some organic substances or groups of them. Millon's reaction which indicates the presence of phenolic-groupings, gave a marked difference between some susceptible varieties and the original resistant one. Tests with leaves from the resistant corn gave a red coloration. These tests were extended to selfed lines, and cultures segregating for resistant and susceptible plants, showing a correlation between total phenol contents (as evaluated as phenic acid) and resistance. But other genetic stocks, namely, one c sh wx A B pl (c tester) stock, coming from Cornell in 1933, though susceptible to grasshoppers, gave a red coloration with Millon's test. These results could signify that Millon's reaction and "behavior to grasshoppers", perhaps depends on two pairs of linked genes, but not on a single pair. Or, otherwise, the above results might be due to the kind of phenols possessed by different lines of maize in which case certain allelic differences manifested by Millon's reaction still could be due to the pair of genes Agag. The study of phenols

distribution throughout the plant shows that the largest concentration is found in green tissues already exposed to light. There is an intermediate concentration in leaves that have not yet been exposed to light. The lowest concentration is found in the still unfolded tassel, and in the whitish sub-ligular region of the leaf, both of which show susceptibility to grasshoppers.

E. M. Sivori

2. Studies on su_x.

In the following table the effects of dosage of genes and interaction between su_1 and su_x can be appreciated. At the top of each cell in the table, the genotypic constitution of the endosperm with respect to su_1 and su_x is stated. Second row indicates grain phenotypes. Percentage numbers in the third row are total contents corresponding to the sum of reducing and non-reducing sugars, expressed as inverted sugar, and calculated on a dry matter basis. These figures represent the average of two or more analyses and could be better substituted by the nearest round unit without loss of accuracy.

It is interesting to note in this table that in super-sugary grains having the endosperm constitutions, $sususu$ $su_xsu_xsu_x$, the sugar content is 25% as compared to 5% found in ordinary sugary. This very high sugar content in super-sugary can be perceived even during milling operations previous to the chemical analysis, because the ground product sticks to the mill, the flour obtained is not powdery but forms granulous aggregates, its color being darker than that of the flour from ordinary sugary.

Increase in sugar content is due to the interaction between su_1 and su_x, and not only to doses of alleles. This is shown by the complete dominance of each normal allele in absence of interaction of su_1 with su_x. Moreover, in the tetraploid from ordinary sugary, whose endosperm cells contain six doses of su_1, the sugar content is 5%, just as much as in its own diploid whose endosperm cells contain four doses of su_1.

On homozygous su_1 background, as in those endosperm constitutions represented in the top row of the following table, sugar content raises in a marked progression with additional substitutions of su_x doses, for its normal allele.

On homozygous su_x background, as in those endosperm constitutions shown in the last column of the table, even a more striking progression in raising sugar content results from increasing su_1 doses.

Doses of su_1	$(su_1)\ (su_x)$	$(su_1)\ (su_x)$	$(su_1)\ (su_x)$	$(su_1)\ (su_x)$	Observations
	(sususu)(+++)	(sususu)(++su_x)	(sususu)(+$su_x su_x$)	(sususu)($su_x su_x su_x$) (super-sugary)	Endosperm
3	wrinkled	wrinkled	wrinkled	wrinkled	Phenotype
	sugar = 5.1%	8.2%	15.9%	24.9%	Sugar content
	(+susu)(+++)	(+susu)(++su_x)	(+susu)(+$su_x su_x$)	(+susu)($su_x su_x su_x$)	
2	starchy	starchy	starchy	wrinkled	
	sugar = 2.2%	2.1%	3.1%	8.7%	
	(+ +su)(+++)	(+ +su)(++su_x)	(+ +su)(+$su_x su_x$)	(+ +su)($su_x su_x su_x$)	
1	starchy	starchy	starchy	smooth sugary	
	sugar = 2.3%	2.0%	2.0%	4.8%	
	(+ + +)(+++)	(+ + +)(++su_x)	(+ + +)(+$su_x su_x$)	(+ + +)($su_x su_x su_x$)	
0	starchy	starchy	starchy	opaque	
	sugar = 1.8%	1.9%	1.8%	3.2%	
	0	1	2	3	Doses of su_x

It may be observed also that grains heterozygous for $\underline{su}_1$ are already neatly wrinkled (two doses $\underline{su}_1$) or smooth sugary (one dose $\underline{su}_1$). This fact is interpreted as an inversion of dominance; the ordinarily completely recessive wrinkled $\underline{su}_1$ becomes dominant over its starchy allele in grains which are homozygous for $\underline{su}_x$. The increased sugar content and wrinkledness, just described, will be referred to in this report as the "dosage interaction effect". This year we shall have tetraploid seeds homozygous for $\underline{su}_x$ and super-sugary in enough quantities for chemical analysis.

Unfortunately, such a high amount of sugar has not been corroborated in other super-sugary stocks. Some of them have gone down to 15% or even lower. But this is due, partly at least, to the fact that super-sugary grains deteriorate very easily before attaining complete maturity. This deterioration is caused by bacterial and fungous attacks that partially liquify its endosperm, destroy sugars and even seriously affect the embryo's vitality. In order to obtain viable seeds, super-sugary ears must be harvested not later than 30 days after fertilization and immediately dried in the shortest time. Sometimes grains, outwardly normal, have already lost their germinating ability and have tasteless endosperm.

In crosses of $\underline{su}_1$ with $\underline{su}_x$, the F_1 grains are starchy and the F_2 must be theoretically as follows:

9: starchy
1: $\underline{su}_x$ (opague, with a slight roughness, appreciated better under the incidence of light over the grain's surface)
1: $(+ + \underline{su})(\underline{su}_x\underline{su}_x\underline{su}_x)$ (smooth sugary that Dr. Shafer described in the 1946 Corn Letter as: "Dented and translucent, but not wrinkled".)
5: (wrinkled including four ordinary sugary and one super-sugary) We join these two classes because it is not easy to distinguish them from one another.

In some of our stocks Ga of chromosome 4 is present, and, of course, it must alter the normal ratios in segregating cultures. Nevertheless, this alone does not seem to account for the extraordinary ratios reported by Dr. Shafer in the 1946 Corn Letter, neither for the ones we ourselves obtained in some crosses, as those shown in the next table. Items 1 and 2 in the table are the reciprocal backcrosses to $\underline{su}_1$ involving the same two individual plants; at the same time, they are the F_2 with respect to $\underline{su}_x$. Owing to the type of interaction between $\underline{su}_1$ and $\underline{su}_x$, we have to bear in mind that there is the possibility of mistaking the genotype $(+/\underline{su})$ with $(\underline{su}/\underline{su})$; each one might be attributed to a given wrinkled grain before the progeny test is made. Item 3 is a backcross to $\underline{su}_x$ and at the same time is the F_2 for $\underline{su}_1$. The mother F_1 plant, 45.6013-3, having the genotype $(+/\underline{su},\underline{su}_x/\underline{su}_x)$ was produced by a wrinkled grain.

Item	Crossed plants			Progeny				
	Female	Male		Starchy	Opaque (su_x)	Smooth sugary	Wrinkled	Totals
1	45.6013-2	45.6012-6	Obs. numbers	52	12	0	71	135
			Obs. ratio	3.08	0.71	0	4.21	8
	wrinkled x starchy		n.i.	3	1	0	4	8
	su +/su_x	+/su+/su_x	Theoretical ratio i.	3	0	0	5	8
2	45.6012-6	45.6013-2	Obs. numbers	51	8	7	60	126
			Obs. ratio	3.24	0.51	0.44	3.81	8
	starchy x wrinkled		n.i.	3	1	0	4	8
	+/su+/su_x	su +/su_x	Theoretical ratio i.	3	0	1	4	8
3	45.6013-3	45.6012-2	Obs. numbers	152	12	26	143	333
			Obs. ratio	3.65	0.29	0.62	3.44	8
	wrinkled x starchy		n.i.	3	3	0	2	8
	+/su su_x	+/su +/su_x	Theoretical ratio i.	3	1	1	3	8

Theoretical ratio, n.i. = without "dosage interaction effect"
i. = with "dosage interaction effect".

The "opaque" grains observed in item 1 have presumably the (+susu)($su_x su_x su_x$) constitution and, according to the "dosage interaction" hypothesis, they should be wrinkled. With no dosage interaction effect these grains should be opaque, as actually was observed in this case.

The smooth sugary grains in item 2, according to dosage interaction hypothesis, should have the constitution, (++su) ($su_x su_x su_x$), and they should appear in one eighth of the population. In the observed ratio, smooth sugary appears in half that frequency, the other half being presumably changed into the opaque class. The smooth sugary class can only appear as a result of dosage interaction effect.

Comparing the ratio observed in item 3 with the ratio calculated according to dosage interaction hypothesis, it seems that part of what should be the "opaque" class (+++ $su_x su_x su_x$) actually appears as starchy; and part of what should be the smooth sugary class (++su)($su_x su_x su_x$) is changed into wrinkled.

The smooth sugary class with (++su)($su_x su_x su_x$) endosperm constitution is especially useful in breeding for high sugar content, when it is desired to transfer su_x to ordinary sugary stocks. The F_2 smooth sugary grains are chosen which certainly will be homozygous su_x with no danger of losing su_1 (heterozygous). The progeny of selfed plants from smooth sugary grains produces only opaque, smooth sugary and wrinkled grains. Fifty per cent of the latter are super-sugary and the other 50 per cent will segregate su_1. The super-sugary with (susususu)($su_x su_x su_x$) endosperm are those among the wrinkled grains, whose progeny produces wrinkled ones only.

The previously mentioned complicated segregations in certain stocks do not invalidate the practical usefulness of smooth sugary grains in selection, as outlined above. The use of smooth sugary in F_2 simplifies the procedure of selection, avoiding to resort to cross tests in order to detect and preserve su_x in wrinkled grains.

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3. Phenol reaction on maize grains.

It is known that grains of many varieties of wheat are differentially colored after being soaked for a certain time in a weak phenol solution. The same reaction was tested on maize seeds of different lines, and it was found that some of them do not take color at all, while others develop a grade of color which is characteristic for each line. Results of reaction can be estimated in

five grades, which we designate in increasing order of intensity from O to IV. Grade IV gives an almost black color like the one of $\underline{r^{ch}}$ gene producing "cherry pericarp".

The lines that do not develop color are very scarce. This reaction O is constant in the line and its progeny. In lines having pericarp colors it is difficult or even impossible to estimate the reaction. In the case of homozygous colored aleurone plants it is possible to obtain colorless aleurone seeds for the test, fertilizing the plant with pollen carrying I.

To make the reaction with maize, the procedure is as follows: In small, flat-bottomed test tubes, where a piece of filter paper is placed, one or two seeds from the same ear are introduced with two and one half per cent phenol solution, enough to cover the grains, allowing them to soak during 48 hours. After that period of time, the liquid is taken away and the tubes are covered with cotton wool until the grains acquire all the color they are able to develop. This happens after 48 hours at room temperature. After that, they are left to dry in the air on filter paper; then the observations are registered. As color develops, the pigment partially spreads from the grains to the surrounding liquid. If grains of grade O are present, they absorb color from the pigmented liquid. This is why grains from each ear must be tested separately.

Temperature has a marked influence on the speed of the reaction, the best being about 55°C. If treatment is made in ovens at this temperature, time for complete reaction is shortened considerably. In crosses of "phenol-O" with "phenol color" and their reciprocals, the F_1 seeds give the reaction of the mother. All grains from the same ear give identical reaction, no matter which is the constitution of the mother plant or of the pollen used. It is, then, a pericarp character.

Reaction speeds up in the presence of an oxidant such as peroxide water. After two hours of immersion, the grains take a brown or chocolate color similar to the one that depends on gene $\underline{Ch}$.

In grains heated before the test to 80°C, the ability to develop color is destroyed. It seems then that this character depends on the presence or absence of a diastase in the pericarp, which would produce coloration when phenol and oxygen are added.

Seeds retain for at least several years the ability to develop color. (We are indebted to Dr. R. A. Nico of the University of La Plata for the useful information on chemical aspects of this problem.)

Reaction was tested in other organs of the plant such as glumes, cob, pith, stalk, leaves and midribs, with negative results. In the growing seed, reaction is already apparent a week after

fertilization and perhaps earlier. Grains occasionally formed in the tassel of phenol-0 plants give a somewhat positive reaction.

We are transforming some ts stocks into phenol-0, in order to study the environmental conditions responsible for that variation. The phenol-0 stock used in crosses analyzed in this report came from a single sample of a genetic tester, a +/d, which was received from Dr. Brink, University of Wisconsin, in 1934, under the designation S-367 sib.

In crosses of "phenol-color" (I,II,III and IV) with "phenol-0" the F_1 is colored, generally with an intermediate grade, but sometimes F_1 plants from the same cross reach grade IV, and other plants, grades I, II and III.

Number of cultures	Grade of parents crossed	F_1 plants Phenol reaction grades I	II	III	IV
1	IV x 0	2	1	4	6
1	0 x IV		1	2	6

The F_2 gives the ratio 3:1 between "colored" and "colorless" plants. In backcrosses to phenol-0, these classes appear in a 1:1 ratio. Among the colored ones different shades appear. We suggest fn symbol (phenol-0) for this character. The two following tables show the results of various crosses in F_2 and backcrosses. From the tables it can be inferred that the different grades are partly due to incomplete dominance and partly to modifiers of a principal gene (the dominant Fn) which conditions the presence of color. The hypothesis of multiple allelomorphs for colors is rejected.

Number of cultures	Grades of parents crossed including reciprocal	Grade of F_1 plants	Phenol reaction in F_2 plants: Color grades IV	III	II	I	Total colored Fn	Colorless (Grade 0) fn	Totals
3	IV x 0	- (x)	90	26	5	3	124	35	159
5	III x 0	I	99	60	82	42	283	91	374
1	II x 0	I	1	17	24	33	75	32	107
1	I x 0	I	0	0	8	18	26	2	28
	Total (Fn/fn) selfed						508	160	668

(x) No grains were reserved for testing these particular plants.

Number of cultures	Type of back-cross - including reciprocal	Phenol reaction of F_1 plants	Phenol reaction in progeny: Color grades IV	III	II	I	Total colored: Fn	Colorless (Grade 0): fn	Totals
3	(IV/0)/0	I; IV	35	2	1	0	38	39	77
5	(III/0)/0	I; II	5	19	14	28	66	63	129
1	(I/0)/0	I	0	0	0	4	4	2	6
	Total (Fn/fn)/fn						108	104	212

In the selfed progeny of crosses between different grades of "phenol color", as in crosses of F_1 by phenol-0, all progenies are "colored". The two following tables show the data obtained in these crosses:

F_1 Plant	Phenol reaction in the progeny: Colored Fn	Colorless fn	Totals
(IV/II) selfed	102	0	102
(III/II) "	55	0	55
(III/III) "	42	0	42
Total (Fn_x/Fn_y) selfed	199	0	199

* * * *

Type of cross - including reciprocal	Phenol reaction in the progeny: Colored Fn	Colorless fn	Totals
(IV/II)/0	245	0	245
(III/II)/0	54	0	54
(III/III)/0	111	0	111
Total (Fn_x/Fn_y)/fn	410	0	410

In crosses with other genes, fn showed independence with P (allele P^{wr} was used), gl_2, B; a, d, Pl, gl, ij, sh.

Nevertheless, it seems linked with g of chromosome 10 in F_2 crosses - in repulsion; summarized in the following table:

	$\frac{g \quad +}{+ \quad fn}$ selfed			
F_2				
+ + = 120	Segregation		X^2	P
+ fn = 53	G : g	:	0.428	0.70 - 0.50
g + = 51	Fn : fn	:	0.120	0.80 - 0.70
g fn = 1	f.linkage	:	16.043	very small

Recombination between G - Fn = 14.5%.

As g is located at 14 map units from R in chromosome 10, its 14.5% recombination with fn in this limited experiment suggests the possibility that "phenolase in the pericarp" might be another pleiotropic effect of the member of the allelomorphic series of R. Adequate experiments to solve this point are under way.

The study is prosecuted for the identification of Fn modifiers, which alter coloration. One of these modifiers, which in certain crosses is responsible for the difference between grade 1 and deeper grades, is linked with aleurone color, perhaps due to C of chromosome 9.

Additional information (1947).

1. (Phenol reaction) fn is located to the side of r, and probably allelomorphic to it. In a limited population from the backcross:

$$\frac{fn - rg}{+ \quad -r^r} \times fn - rg \quad ,$$

no recombination was obtained.

2. The phenol-O from Peru is allelomorphic with those previously found from other sources.

S. Horovitz
N. Horovitz

4. Physiological races of Puccinia sorghi in maize.

Some years ago, Vallega, (Anales del Instituto Fitotecnico de Santa Catalina 4:14-16. 1942) made a preliminary report of the local Puccinia sorghi population, describing the presence of two physiologic races: A-race which does not attack sugary corn line 13-b coming from Urbana, Illinois, and B-race which attacks that

corn. Though Vallega's rust samples were not kept, the supposed A - race was again easily isolated and is kept in our collection under number 1890. Later, we isolated three other physiologic races which have a differential behavior on the following maize lines:

13-b sugary corn from Urbana, Ill., U.S.A.
14-a " " " " " "
I.F. 3562 starchy corn from Cochabamba, Bolivia
I.F. 3861 - " " La Paz, Bolivia.

We maintain Vallega's designation of B-race, for that sample (Nr 1875) which attacks all differential varieties of corn. The remaining physiologic races behave as indicated in the following table:

Rust sample N°	Rust race	Reaction of the different maize varieties			
		14-a	13-b	I.F.3562	I.F.3861
1890	A	S	R	S	R
1875	B	S	S	S	S
1880	C	S	S	R	S
1882	D	S	SR	SR	S

S = Susceptible (large pustules without a surrounding necrotic area)
SR= Semi-resistant (small pustules with necrotic area)
R = Resistant (There is no pustule formation; only necrotic spots.)

The study of inheritance of resistance to A-race (sample Nr 1890) in the cross of 13-b with 14-a maize has been started. The results of inoculations of parents, F_1, F_2 and corresponding back-crosses to each one of the parents are shown in the following table:

Generation	Reaction to rust A-race		Total of inoculated seedlings	X^2	P
	Susceptible	Resistant			
P... 13-b	-	all	many		
P... 14-a	all	-	"		
F_1	279	1	280		
F_2	306	105	411	0.06	0.8
(13-b/14-a)/14-a	127	2	129		
(13-b/14-a)/13-b	63	68	131	0.37	0.7-0.5

Evidently, resistance to A-race in this cross depends on a single recessive gene, for which we propose symbol $\underline{rp_2}$. In the case of the original Rp gene located in chromosome 10 by V. Rhoades,

resistance is dominant. Line 13-b (su rp_2) was crossed with a susceptible tester possessing g and Mr of chromosome 10. The F_1 was completely susceptible and produced in F_2 results indicated in the following table:

F_1 genotype = $\frac{+\ g\ Mr\ +}{su\ +\ +\ rp_2}$

F_2:

+								su								Total
Mr				+				Mr				+				
+		g		+		g		+		g				g		
+	rp_2	+	rp_2	+	rp_2	+	rp_2	+	rp_2	+	rp_2	+	rp_2	+	rp_2	
198	51	85	33	110	26	3	1	71	24	26	6	23	10	0	0	667

Analysis of data of preceding table:

	Segregation	X^2	P
	Rp_2:rp_2	1.98	0.20 - 0.10
	su : su	0.36	0.70 - 0.50
	Mr : mr	0.31	0.70 - 0.50
	G : g	1.30	0.30 - 0.20
Linkage	Su:su and Rp_2:rp_2	0.66	0.50 - 0.30
"	G : g and Rp_2:rp_2	1.26	0.30 - 0.20
"	Mr:mr and Rp_2:rp_2	0.22	0.70 - 0.50

There is no evidence of linkage either between rp_2 and su of chromosome 4, or rp_2 with g and Mr of chromosome 10.

R. H. Batallanez

5. A new teopod.

A new teopod, Tp_2, also dominant as Lindstrom's Tp, was discovered by Professor A. E. Marino among his breeding stocks in a flint corn from Santa Fe, Argentina. Lindstrom's Tp is in chromosome 7 in the position gl Tp ij. The new Tp_2 shows independent inheritance from genes gl and ij, as shown by the data of the following triple backcross:

$$\frac{Tp_2\ \ gl\ \ ij}{+\ \ +\ \ +} \times + \ gl\ \ ij$$

Progeny:

Tp_2	+	Tp_2	+	Tp_2	+	Tp_2	+	
gl	+	+	gl	gl	+	+	gl	Total
ij	+	+	ij	+	ij	ij	+	
22	15	23	14	5	2	1	1	83

Recombinations gl - ij = 10.8%
" Tp_2- gl = 53.0%
" Tp_2- ij = 47.0%.

6. Mutable golden stock.

In the breeding material resistant to grasshoppers a new golden stock appeared. The normal plant 41.689-5 was selfed and in its progeny of 47 plants, there were 39 normal ones and eight golden ones. The new golden plant was crossed with the primitive g_1, for allelomorphism. In one of the cases all of the eight F_1 plants were normal, in other cases golden and normal plants appeared in variable proportions. In selfed lines of the new golden plant, some green plants also appeared. At first these results were attributed to foreign pollen or some other mistake. Later we saw that many plants of the new golden stock were mosaics with longitudinal green stripes. Some of these mosaic plants are even half green and others almost entirely green. In some others the main stalk is golden and the suckers are green.

Two of these mosaic-golden plants were pollinated with a g_1 tester stock, thus obtaining two small ears. Seeds were sown keeping in the ground the same order they had in the ear. Most of the plants obtained were green and a few were "mosaic". These latter plants came from grains more or less grouped in the ear forming rather irregular patches.

It seems that we have here a mutable allelomorph of golden-1 or possibly a condition that provokes its mutability - as in the case of Rhoades' Dt with respect to a. In case it were a modifier it would be a dominant, because in F_1's from the cross g_1 with "mutable golden", "mosaic golden" plants appear.

S. Horovitz
R. R. Ré

7. Zebra-necrosis.

Zebra-necrosis, for which we propose the symbol (zn) is a new character that produces necrotic transverse areas in the leaves. It appears in plants that have developed about half way to maturity.

The necrotic zones expand, covering the leaves almost entirely, producing a premature drying of the plant. The zn plants produce pollen normally and in vigorous stocks they even produce good ears. This characteristic appeared in the progeny of a selfed plant from culture 37,977 of the commercial variety "Colorado Klein". Zebra-necrosis is linked with Og as proven by the following backcross data:

Backcross: $\frac{+\ Og}{zn\ +}$ x xn +

Og +	Og zn	+ +	+ Zn	Total
36	4	10	44	94

Recombination Og - zn = 14.9%

S. Horovitz

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1. Unlinked characters.

Linkage tests with unlinked characters were generally unsatisfactory because of poor growing conditions. Groups of unlinked characters and the students working with them are: virescents - G. T. Den Hartog; yellow greens - F. S. Warren; glossies - Mr. Mattos. Other characters being tested are: fired seedling, lazy, nl_2, upright tassel, 4-rowed ear, mi, vp_5, bm_4 - Singh, White, Khan, Quinones, Anstey and Miss Ford. Mr. Mattos reports an indication of linkage between Y and gl_{11} with 30.8 ± 5.3%, but the numbers are small. Crosses to renew stocks and for new linkage tests were made.

2. Progress in development of the large "Oenothera-like" ring.

Progeny from selfing supposed crossovers combining translocations two at a time (F_1 = ring of 6) were grown. The test crosses of the normals to isolate stocks homozygous for each combination will be grown this summer. If successful, we will be ready for the second step - combining four translocations into one stock. Field work by:

F. H. White, F. S. Warren and Miss Ford.

3. Effect of temperature on crossing over.

The effect of low temperature on crossing over in T5-6c was studied by counting spore quartets. Exposure of plants to 36 to 38 degrees for one to seven days in the fifth week of growth appeared to increase the amount of crossing over.

S. I. Khan

4. Chromosome segregation in rings. (See Genetics Soc. Amer. Records 13:14-15. 1944.)

Translocations involving chromosome 6 were used for further study of chromosome segregation in the ring. The data from three translocations with the break in chromosome 6 in the short arm are summarized in table 1. The quartet type with one diffuse-nucleolate spore results from a single crossover or a 3-strand double occurring in the interstitial segment (between the translocation point and the centromere). The three stocks in which this crossover value is low are the ones in which both types of adjacent disjunction occur (plane 1 = non-disjunction of nucleolar organizers, plane 2 = non-disjunction of homologous centromeres). The one stock in which this crossover quartet value is high (heterozygous T5-6c without the inversion) is the one in which no plane 2 adjacent disjunction could be measured. As a working hypothesis for this type of cross-shaped pachytene configuration (2 short spokes, each between 2 long ones), it is suggested that the genetic crossover length of the interstitial segment (between the translocation point and the centromere) may be the factor determining segregation. Chromosomes that crossover in this segment practically always pass to opposite poles (evidence from position of division I plane in spore quartets), hence plane 1 segregation does not occur in them. Plane 2 segregation would occur only in those in which no crossovers were present in the interstitial segment. When the interstitial segment is short, most of the chromatid tetrads show no crossing over in this region and both types of adjacents would be expected. This was observed in the three stocks with low crossing over in the interstitial segment; alternate: adjacent (plane 1 + plane 2) being in a 1:1 ratio. The spore quartets with two spores diffuse-nucleolate may result from non-crossovers or the 2-strand and 4-strand doubles. Since in T5-6c a fair estimate of the genetically recoverable doubles is about 12%, about 12% of those quartets are from this source, leaving only 5.5% to come from non-crossovers in which plane 2 segregation might occur. Observed pollen sterility should have been about 2.2% less than the predicted, a value too small to measure. Actually the observed abortion was a little less than the predicted. Genetic crossover length of the interstitial segment seems to be much more important

than physical length, and equal lengths of segment in different translocations, involving different chromosomes along with chromosome 6, have different genetic crossover values.

In those translocations having the break in chromosome 6 in the long arm, only the plane 2 segregations can be recognized; these result in non-disjunction of the nucleolar organizers. The preliminary data are in the table. Cytological length of the interstitial segment shows no clear-cut relation to the frequency of plane 2 segregation. This is not surprising if the genetic length is the important factor. In the III-IV Drosophila translocation data, reported by Brown (Univ. of Texas Publ. 4032. 1940), plane 2 segregations were practically absent, although interstitial segment length varied from short to very long. The three with a short interstitial segment (long translocated piece) were the ones with the lowest frequency of plane 1 adjacent segregation, while the three with a long interstitial segment (short translocated piece) were the ones with the highest frequency. In these plane 1 gametes (non-disjunctional for the translocated piece, disjunctional for the interstitial segment and the remainder of the chromosome), crossing over in the translocated piece appears to have been greatly reduced, while in the interstitial segment where genetically measurable it appeared to be similar to that in the heterozygous translocation. Here two adjacent spokes of the "cross" were very short.

It is possible that the translocations will fall into different groups as regards position of the 4 "cross" spokes as seen at pachytene; each group having its own balance between several factors affecting segregation in the ring.

I am indebted to Dr. Barbara McClintock for originally suggesting the problem, and furnishing the seed stocks of T6-10, T5-6c, T5-6c I-5a, and I-5a. I wish to acknowledge the assistance of Mrs. Gertrude Stanton Joachim and Mr. C. H. Li in these studies.

5. Crossing over within inversion 5 a (I-5a).

In the stock homozygous for T5-6c, the 5^6 chromosome is now attached to the nucleolus and the centromere is a considerable distance away. In T5-6c, the entire short arm of 6 was interchanged with a very short piece of the end of the long arm of chromosome 5. In the I-5a inversion in chromosome 5 the two breaks are at about .7 of the long arm and adjacent to the centromere in the short arm bringing about a shift in centromere position. Pollen and spore quartet counts were made on plants (10 pairs of chromosomes) homozygous for T5-6c and heterozygous for I-5a. Single crossovers within the inversion result in the typical crossover type of spore quartet (one diffuse-nucleolate spore). Of the double crossover type that may occur within the inversion the 3-strand type results in the crossover type quartet, the 4-strand type results in a quartet with two diffuse-nucleolate spores, and the 2-strand one results in a normal quartet.

Table 1. Spore quartet and pollen data for translocations

	Spore quartets						Pollen abortion		Non-crossover quartets		
		2 dif-fuse spores	1 dif-fuse spore		% 2 dif-fuse	% 1 dif-fuse	Predicted	Obs.	% alternate	% adjacent Plane 1	% adjacent Plane 2
	Normal			Total							
Group I. Break in short arm of chromosome 6											
T5-6c + / + +	809	742	2678	4229	17.5	63.3	49.2	46.9	52.2	47.8	0
T5-6c I-5a / + I-5a	4434	1996	759	7189	27.8	10.6	33.0	49.0	51.1	31.0	17.9
T2-6a / +	1738	598	25	2361	25.3	1.1	25.9	52.1	47.9	25.6	26.5
T6-10b / +	1819	429	126	2374	18.1	5.3	20.7	42.9	57.5	19.1	23.4
T5-6c + / T5-6c I-5a	946	16	782	1744	0.9	44.8	23.3	20.7			
T5-6c I-5a / + +	710	491	169	1370	35.8	12.3	54.8	55.4			
T5-6c + / + I-5a	3285	1439	3871	8595	16.7	45.0	51.5	60.5			
Group II. Break in long arm of chromosome 6											
het. 1-6a	3398	623	5	4026	15.5			51.5			
" 2-6c	204	32		236	13.6			ca 50			
" 2-6d	198	98	4	300	32.7			ca 50			
" 2-6 (6049)	166	34	3	203	16.7			46.5			
" 2-6 (6052)	940	10	2	952	1.1			38.0			
" 3-6 Conn.	434	59	45	538	11.0			30.8			
" 5-6a	116	38	3	157	24.2			47.4			
" 5-6(5786-1)	162	82	7	251	32.7			49.0			
" 6-8a	293	65	4	362	18.0						
" 6-9b	2258	823	16	3097	26.6			35.2			
Group III. Break in nucleolar organizer											
het. 1-6 Conn.	307	2	6	315				26.0			
Group IV. Break in satellite											
het. 1-6b	4332	4	3	4339	0.09			26.3			
" 5-6b	2504	19	8	2531	0.8			19.9			

Observations show 45% of the quartets with one diffuse-nucleolate spore and 0.9% with two. If the double crossover types occur at random, the latter value indicates a very low frequency (3.6%) of double crossover quartets. It probably indicates a reduction in the frequency of double crossing over caused by the inversion. This leaves about 43% of quartets resulting from single crossing over within the inversion. Determination of the number of genetically recovered doubles within the inversion in such a stock should give an indication of any great deviation from randomness of the different double crossover types.

6. Heterozygous T5-6c, heterozygous I-5a. (Data in table 1.)

$\frac{\text{T5-6c}}{+}\ \frac{\text{I-5a}}{+}$. The observed 12.3% of crossover type quartets is similar to that observed in the T5-6c/+ homozygous inversion, since only the crossovers between the new inverted position of the centromere and the translocation point in chromosome 5 are recognizable as crossover type quartets. The presence of the heterozygous inversion has not reduced crossing over in this region adjacent to it.

$\frac{\text{T5-6c}}{+}\ \frac{+}{\text{I-5a}}$. In this type, crossovers within the inversion are also recognizable. The observed value, 45%, of crossover type quartets is comparable within a few per cent with that which occurs in heterozygous T5-6c without the inversion, i.e., 63.3%. Since 45% of crossovers were observed in homozygous T5-6c heterozygous I-5a where crossing over in the short interstitial segment could not be measured, it appears that crossing over is reduced by T5-6c and by the inversion in heterozygous condition.

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1. The $\underline{Y}_7$ gene, complementary to $\underline{Y}_1$ and $\underline{Y}_3$ in producing yellow-orange endosperm ($\underline{Y}_7$ = albino seedling. Revista de Agricultura 22:42-54, 1947) is now definitively located in linkage group 7. The data obtained in F_2 for eight ears (repulsion phase) are as follows:

+ +	+ gl_1	y_7 +	y_7 gl_1
961	464	391	4

2. The lemon-yellow seeds of Dr. Merle T. Jenkins (designated yellow in my nomenclature) referred to as y_8 (News Letter 21:33. 1947) did not show differences in color from the yellow seeds, Y^d, of my Brazilian material (Revista de Agricultura 22:42-54. 1947). The F_1 seeds had the same color as the parents and no segregation could be observed in F_2. It is suggested that y_8 and Y^d are alleles.

3. A new gene producing pale-yellow endosperm, provisionally called Y_6, was isolated from Brazilian strains. Crosses with a white seed tester shows normal 3 pale-yellow : 1 white segregation. The pigments belong to the carotenoid group as indicated by the extraction with methyl alcohol. Proper tests and crosses are being conducted this summer in Brazil in order to check the Y_1 gene in chromosome 6. If the yellow pigment should be due to the Y_1 gene and the pale-yellow color determined by a new selected modifier, I should prefer to change the designation Y_6 to Y^R (R = reduce, $Y^dY^dY^rY^r$ = pale yellow), since I prefer numbers to designate genes conditioning the presence of yellow-orange pigments in the endosperm (Y_1, Y_3, Y_5, Y_7)and letters to designate differences among its shades (Y^D, Y^R).

4. Two seeds, similar to sugary except that the corrugated part was only from the middle to the top of the grain, were detected in a commercial dent strain of Brazil, called "Armour". One plant secured was crossed with the su_1 la (chromosome 4) and the F_1 seeds were apparently pseudo-sugary. Other generations are being investigated this summer.

5. Stocks for linkage tests involving all 10 chromosomes that I made up while in the United States in 1942 by crossing North American lines with an Argentine strain and later selected in Brazil, have now been crossed with Brazilian material in order to improve their vigor.

E. A. Graner

I. Breeding work

1. Breeding program.

Since relatively little has been published about the main varieties of our region, which extends from the State of Minas Gerais in the North to the Argentine in the South, a short resumé shall be given.

A. Orange hard flints

Cateto is the dominant type in the States of São Paulo and Minas Gerais. The plants are generally tall to very tall with the first ear at about two thirds of the height of the culm. Silking occurs at about 80 days after planting. The kernels are of light orange color and of medium size. The ears are slender, often conical, and weigh from 80 to 150 grams each, approximately.

A special variety is the so-called "Cateto de palha roxa" with purple colored husks and glumes on dilute purple or sun-red plants.

Cateto Rio Grande from the State of Rio Grande do Sul, is earlier (70 days to silking), the plants are smaller, but very strong, the ears cylindrical and heavy, weighing from 150 to 230 grams each.

Colorado - The plants are considerably smaller than the above mentioned types with an average height (without tassel) of about 1.60 m. The ear is formed below the middle of the plant. The kernels are of a deep orange color and of medium size. Silking at about 64 to 68 days.

Cuarentino - The smallest and earliest variety, silking after 60 to 64 days. Plant height 1.00-1.30 m. Ear relatively low in the second quarter of the plant, rather short and thick, from 80 to 120 grams. Kernels are deep orange, small, and very tightly compressed.

The most frequent unfavorable plant characters found were: white, yellow or striped seedlings, and barren stalk. The main deficiencies of ear are irregular row arrangement caused by an increase of number of spikelets per alveolos, inverted embryos (due to the development of the second flower), various grades of defective kernels, from defective lethal to a type which we call "light yellow soft" in accordance to the appearance of the grains; kernels with mosaic corneous defective endosperm are not rare.

In several crosses involving Colorado x "Early Yellow" (an extract of Canadian "Little Yellow" and Cateto) we found an F_2 segregation for purple aleurone, approximately in the ratio of 13:3.

In crosses of Cuarentino x Early Yellow, one third of the F_1 ears gave a segregation of about one half orange to one half purple, with shades ranging from deep to very pale.

No special references shall be made to "Amarillo" a large-grained early yellow flint of the La Plata regions which is of no great interest to us owing to its light color. A large-grained, very late and very hard white flint (Cristal) of our regions is also of little importance commercially.

B. Dent corn

It seems that all types of commercial dent corn here are derived from both yellow and white North American Dent, the former generally out-crossed to the local Cateto varieties. Most commercial dents are thus very variable, and not differentiated into regional types as the hard orange flints.

We received recently several samples of an excellent white, soft dent corn, cultivated by the Caingang Indians from Paraná and São Paulo, and which seems very promising for breeding commercial corn.

C. Soft corn

Soft corn is grown very little commercially, though it is the principal field corn of the Indian tribes.

D. Pop corn

The only native type seems to be the "Pointed Pop" with small strongly beaked kernels in straight and salient rows.

"Milho de Pinto" (translation: chicken corn) with very small grains on small cylindrical ears, each plant producing several ears, and a type of "Rice pop corn", are most probably imported varieties.

E. Sweet corn

No sweet corn has been grown formerly on any scale, except from imported seeds, but new varieties have been produced by crossing. Several types of Piracicaba sweet corn are in distribution and gave good results in the field. By planting, with ten-day intervals from early September until January, green corn may be harvested over a very long period.

2. Resistance to diseases and pests in general.

Practically no pest or disease has been so far of major importance. This is, however, not due to the absence of fungi or insects, but to a very pronounced and widely distributed resistance. Thus, planted side by side, Piracicaba Sweet Corn P-18 had at the most one earworm at the tip of the ear, while Andean corn from Bolivia was almost completely eaten from top to base, with several larvae per ear. While most strains of Cateto are not attacked by aphids, sometimes a whole inbred line shows a high degree of infestation. The same is true for rust attack, which is generally very low in local strains, but rather high in material from the tropical North of Brazil and also in several U.S.A. strains. Smut is a very minor disease, and was somewhat heavier only in segregates of the cross, corn x teosinte.

F. G. Brieger

3. Resistance against grains weevil and moth.

The studies about which we gave a short report last year are continuing, and other varieties were included in the tests. The hardness of grains have no influence on the resistance, since the most resistant types are a soft dent and some indigenous floury types. Hard pop corn and "Cristal" (hard white flint) are very susceptible.

Furthermore, the resistance so far affects only the attack of the grain weevil, while even the resistant types are susceptible to the grain moth.

N. Kobal

II. Indigenous corn and studies on the origin of corn

4. Indigenous corn.

Our collection has now been increased sufficiently to allow to draw some general conclusions. These are at variance with those of other authors, who had not been able to inspect and study extensively material from the lowland regions, east of the Andes, which in its extreme variability alters considerably the picture.

If we accept the highland region, east of the Andes between about 13° and 18° latitude, belonging partially to Bolivia and partially to Brazil (State of Matto Grosso), as the most probable region of origin, we may distinguish at least three centers of primary domestication, surrounding this center:

A. The Southern Region, formed by the Pilcomayo-

Paraguay-Paraná Basin. There are two main tribes of Indians in this region; the Tupi-Guarani and the Caingang, who cultivate quite distinct types of corn. The principal Guarani corn is a soft corn with yellow color both in the endosperm and the aleurone layer, while the main Caingang maize is a soft white dent. Both these types are very productive, with normal long heavy and cylindrical ears and regular row arrangement. There are several minor types, such as a hard white flint in the Guarani region, and a soft yellow Caingang corn, much inferior to the Guarani Yellow. Both tribes have one primitive type in common: the Pointed Pop Corn, with small hard grains of varying colors, ending in a pointed and curved beak, long glumes and very regular and salient rows. The ears are generally conical and long, ending in a tapering tip which bears mainly male flowers only, thus giving a "tripsacoid" appearance. As an additional type one may mention the large white soft corn, grown by the Chavantes-Opaie, a nearly extinct tribe on the Southern border of Matto Grosso. While generally the aleurone does not contain anthocyanine, purple and red colors are found. Black, red and variegated pericarp is quite frequent.

B. The Northern Region, formed by the southern margin of the Amazon Basin from the Andes in the West to the Araguay River in the East, approximately between 8° to 20° latitude.

In spite of the fact that the material came from several completely unrelated Indian tribes - such as the Gaviões in Acre, the Bororo and Cajabi in Matto Grosso, the Tapirape on the Araguaya - all samples belong to the same basic type: Long and thick ears, or long and slender ears with an apparently low row number, owing to the curious type of interlocking described a short time ago by Cutler, and a very pronounced tendency for thin and flexible cobs. This flexible cob is one of the main characters which we may consider as primitive, and which is not found outside the region. The strong development of the husks and the "tripsacoid" ear tip is common to both the Northern and Southern regions.

The grains are large and contain soft starch, no dent or flint corn having been found in the region. An approach to dent is shown by some "shrunken" kernels, due to some recessive endosperm factor.

The color of the aleurone may vary from brown and deep orange to pale yellow, and also to white, in the absence of some dominant factor (Bn). Black, purple or red aleurone is rather rare, except in Acre. Pericarp color shows the usual range from almost black to colorless, including variegated pericarp. The endosperm is generally yellow.

C. The Andean region of the old Chimu and Inca Empire.

The corn types of the Andean region have been considered

as "the prototype" of South American corn in numerous collections, but there cannot be much doubt that they represent only just another group of regional types, profoundly different both from the corn of the Paraguay basin or the southern margin of the Amazon basin. The material received from Dr. Cardenas on several occasions and from other sources, ranging from Peru in the North to the Argentine in the South, makes it evident that the spherical ear with irregular row arrangement, found in the highest altitudes, may be a primitive type, but is certainly not the predominant type. In general the ears, though they may be short and thick, have regular row arrangement and often salient rows. Tripsacoid ear tips have been found, however, rarely.

The Andean corn has generally soft starch, and though sometimes indented, no very pronounced dent types were encountered. The Andean pop corn, though having sometimes kernels with a sharp tip, are quite different from the pointed pop corn of the Guarani and Caingang. Andean sweet corn varies very much from ears which are practically identical with Mexican sweet corn to a type with nail-like kernels, sugary only at their tip.

D. The marginal zones

No samples have been received as yet from the west coast, outside the Andean Empire.

The material received from Caribean region (Colombia) are typical tropical flints, either large grained or small grained pop corns, equal to Anderson's "milho rebentador".

On the east coast, it seems to be very probable that the region from the Argentine up to the State of São Paulo has been the original zone of the hard orange flints, which form regional types more or less in correspondence with the latitude. The corn today in cultivation in the States from Rio de Janeiro to the mouth of the Amazon have been classified recently by Cutler as belonging to the "Tropical Flints". However, the variability and unstability of the large amount of material which I received from these Brazilian States leave little doubt that we are dealing with a recent hybrid mixture, in which entered hard orange flint, U.S.A. dent and possibly soft yellow indigenous corn. It seems to me very doubtful now if indigenous corn could still be found there, since the Indian population has been liquidated or assimilated and crossed with both white immigrants and black imported slaves.

Only two samples from the northern margin of the Amazon have been studied so far, and both came from the most extreme points; from Iauarate near the Rio Negro, almost on the border of Colombia, and the other from the Emerillon Indians (Tupi) from Amapa, north of the mouth of the Amazon and near the border of French Guiana. They are different not only between themselves, but also from the corn of

the southern Amazon margin, and from the Tropical Flints of the Caribean coast.

E. Tunicate corn was obtained only rarely, and never among the samples of indigenous lowland corn. According to the information of Dr. Cardenas it is also difficult to obtain in Bolivia where it has a "therapeutical" value. Thus it may be "tabu" with the Indians and this may perhaps explain its absence in the collections, or it may not be in cultivation any more. The four strains which were grown in our plots had always initially normal or almost normal tassels, and the special type of tunicate tassel with large glumes and many female flowers was only obtained after outcrossing to non-tunicate forms and selecting. In this connection it may be mentioned that no support could be found that the so-called "fourth type of Azana" with many grains on a tassel-like structure is some kind of tunicate, as Mangelsdorf believes. The interpretation given by Parodi seems much more probable, that Azana was referring to grain Sorghum, and as a matter of fact in the North of Brazil grain Sorghum is locally called "milho de pinto" or "chicken corn", a name generally given to small grained pop corn.

From a general point of view it is also interesting to note that the main type of ear among the indigenous material of South America is the cylindrical or somewhat conical ear with regular longitudinal paired rows, while the spherical ears of the high Andes represent an exception. Furthermore, the fact that representatives of all corn varieties exist among South American indigenous corn makes it probable that all major changes of domestication have occurred already before corn left the primary center of domestication and reached in its migrations Central and North America, though there have probably occurred new and parallel mutations, as for instance in the case of sugary. But there seems no reason to assume that southern and northern corn varieties are fundamentally different, and that any fundamental difference is due to accidental crossing of corn and Tripsacum in Central America.

5. Variation of row numbers.

Since the ear is to be considered the most striking feature of domesticated corn, a special study was made of the increase of row numbers. Accepting the hypothesis that corn had originally, as Euchlaena and Tripsacum, an ear with two pairs of rows on opposite sides, it was considered necessary to find out how an increase of the number of pairs of rows of alveoli may occur.

(a) A number of ears was studied which had two rows of alveoli in the upper half and a higher number in the lower half. If only one row of alveoli was interposed at the bottom, there was not only a twist in the transition zone, but the three-rowed part was twisted throughout. If there was an intercalation of two rows, these were placed side by side between the two original rows causing a

twist in the transition zone which makes the two original rows, become neighbors. An addition of three rows of alveoli was observed only rarely, and then there was one new row on one side, and two on the other side, and only a slight twist of the two original rows occurred in the transition zone. It may be mentioned that not all the ears inspected could be analyzed satisfactorily, since this could be done only where the pairs of rows were sufficiently salient to be identified as belonging to the same alveolus.

In Tripsacum australe an increase from two to three rows in the female part of the inflorescence was observed very rarely without causing any twisting.

(b) An increase of spikelets per alveolus, beyond the normal number of two, was found occasionally. This addition seems to be the cause for the not infrequent increase of rows at the base of many ears. In several lines, especially of Cuarentino, the increase of spikelet number was, however, not limited to the base of the ear, but affected the whole ear.

The addition of the new spikelets caused a zigzag arrangement of the kernels, and when occurring in large parts or in the whole ear, the result was the obliteration of longitudinal rows, and the appearance of a spiral arrangement of kernels belonging to neighboring alveoli. It seems quite possible that this may also be the explanation for the situation found in the spherical ears from the Andean highland.

The genetical basis of this type of increase is very complicated.

(c) A development of the second flower has been observed only as an abnormality, occurring always in a limited number of spikelets. When both flowers develop into kernels, irregularities of rows were caused. But when it was only a question of which flower develops and which degenerates, no irregularities may be observed, except the appearance of "inverted" embryos. The genetical analysis of this character in our material is difficult, owing to the irregularity of its occurrence in a sufficient number of grains. In crosses it gave the impression of a recessive condition.

(d) Finally a botanical peculiarity should be mentioned which was first observed in descendants of the cross, teosinte x corn: The terminal inflorescence of the ear branch was frequently a many rowed ear while all the lateral inflorescences of the same branch had only two pairs of rows on opposite side of the rachis. For the first time this condition was also observed in pure corn: Cusco from Bolivia.

In branched ears it was considered the rule, as in the tassel, that the central spike should be many rowed and all branches

should have only two pairs of rows on opposite side of their rachis. Exceptions were observed now in branched ears from Goyaz Pointed Pop and in Cuarentino.

(e) No indication of any fusion was ever observed, neither in pure Zea, Euchlaena, Tripsacum, nor in descendants of hybrids of the first two.

6. Zea-Euchlaena crosses.

While a full report of these experiments which have now reached the seventh generation shall be given later, one point may be mentioned. If teosinte should really be a segregate of a cross between some Tripsacum species and Zea, it seems rather astonishing that Euchlaena shows so little variability and that all existing forms have been included in a monotypic species. Selection in the descendants of several hybrids, obtained by continuous selfing after F_1, showed that many combinations of Zea and Euchlaena characters are possible and can be more or less stabilized. Those with predominantly Euchlaena characters are perfectly viable in nature and show that without prejudice for the survival rate many Zea chromosome regions could be introduced into Euchlaena. The characters of these descendants, and of those from backcrosses to either parent show beyond doubt that a genetic analysis of the species differences cannot be obtained from backcrosses to corn only, where a large part of the Euchlaena genes become obliterated and lost.

F. G. Brieger

III. Cytogenetical studies

7. Linkage testers.

With the inclusion of several new lines we have now almost completed the collection of the testers, with four or more genes in each chromosome and other combinations for special purposes. We found material from the Argentine very disappointing, and had to transfer the genes to a central-South American background. As such we use now an early commercial flint and an indigenous corn from Parana (South) top dominant for all genes for aleurone color. At the end of 1948 all testers should have been transferred and their linkage values checked. Thus a list will be given in next year's Maize Letter for the use of South American geneticists, and for subtropical zones in general.

8. Husk color.

(a) Purple husks in sun-red plants are quite common in South American material, and it seems that several genes are responsible, acting only in certain backgrounds. A_1 is always present in colored husks.

(b) Rosewood self and variegated color of husks are due to a new series of pericarp alleles at the P locus. The types found up to now are:

Pericarp	Cob	Husk
red	red	rosewood
red	red	white
variegated	variegated	variegated rosewood
white	red	dilute rosewood
white	red	only margin of each husk stained (fimbriated).

(c) Tobacco color in husk appeared last year in material from Colombia, and previous to any genetical analysis we are selfing in order to get homozygous and deeply colored strains.

The husk's color appears in ears picked when completely dry, about 40 to 50 days after pollination. Before this time, purple husk seems sun-red or very dilute purple, the rosewood color does not show at all and tobacco color is so light that it is confused with the natural yellowish shade of the husks.

N. Kobal

9. Yellow endosperm.

A detailed analysis of endosperm color became indispensable both for the breeding work and in the analysis of the indigenous corn, and thus we intensified these studies again. In order to get some order in a rather confused situation we suggest to adopt some rules about symbols, reserving the letters Y-y for basic factors of dominant yellow, the symbols Or-or for dominant orange shades and Am-am (amarello) for dominant yellow shades.

Excepting the basic factors Y_3 and Y_7 which cause also chlorophyll deficiences in the plant, there exist evidently at least two more Y factors causing separately a ratio of 3 yellow to one white, and together the ratio of 15 yellow to one white.

The shade of the endosperm color is controlled by at least three sets of factors:

(a) Dosage effects of the main factors Y

(b) Interaction of major factors for shade and of a various number of modifiers

(c) At least one plant character giving a segregation of three plants with all yellow-orange endosperm to one plant with all yellow endosperm.

The main endosperm ratios so far encountered were: 3 orange to 1 yellow; 1 orange to 3 yellow; 1 deep orange to 2 orange to 1 yellow.

A good classification is, of course, possible only in the absence of any orange to yellow aleurone color and in the presence of hard and corneous starch. Soft corns which contain, as shown by crosses, deep yellow endosperm, exhibit only a slight cream colored endosperm, owing to the optical effect of the soft starch and its air content.

F. G. Brieger
N. Kobal

10. New mutants.

Both in our commercial material and in the indigenous lines a number of mutant types appeared which shall be studied in detail and localized later. Those which permit a phenotypical classification are cited below:

Yellow striped - Identical to yellow stripe-1. The character shows from the fourth leaf until maturity. Pollen and sometimes ears are produced.

Tassel seed - Phenotypically identical to Tassel seed-5, but recessive. Ears are normal.

Brachytic - We received a pop corn with spherical small ears from Acre, and the plants proved to be homozygous for a recessive type of brachytic except for two contaminations. Height about 50 cm., internodes short, leaves more or less stiff. The plants have a normal fertile tassel, and give two to three ears. The cross with brachytic of chromosome 1 gave normal (tall) F_1 plants.

Stiff leaves - The plants are smaller than their normal sisters, with very stiff straight and narrow leaves. Pollen and normal ears produced. Recessive.

Dwarf - Not classifiable in seedling stage. The plant is higher than other dwarfs. Leaves are broad. Pollen and good ears produced.

Ramosa - Plants and tassel normal. Branched ears well filled, the branches having more than four rows, in constrast with other known ramosa. Recessive.

Crinkly - Plant dwarf, leaves strongly crinkled and sticky. Pollen and good ears produced.

Virescent - Only one was maintained because of the obviousness of the character. The virescent seedlings are white and remain white for more than a week. The majority of the plants do not change color and die. Others grow slowly and silk about 40 days later than normal sisters.

Barren stalk - From a commercial strain; tho plants are normal in all ways and strong but without sign of an ear.

Waxy - Quite common, and selected from Goyaz (Center of Brazil) and lowlands of Bolivia and Paraguay. The classification with iodine is somewhat difficult, as is the case also in Argentine waxy.

Scarred endosperm - The endosperm is scarred. In homozygous ears the scarred character can change to semi-defective types.

Shrunken - One ear of a commercial strain gave a segregation of three normal to one shrunken kernel. The phenotype is identical to shrunken-1. Incomplete types of shrunken were found in Bororo corn, and behave also as a simple recessive.

Brittle - Several ears of Caingang corn segregated clearly for a recessive endosperm character, phenotypically identical with brittle.

Defective endosperm - Found very frequently both in commercial inbred lines and in indigenous corn. The types vary from inviable defective to mosaic defective or to yellow-soft defective. Some of the latter germinate and give normal plants.

F. G. Brieger
N. Kobal

11. Knob position and knob number.

The work has been started only recently and some preliminary results were obtained. The numbers so far found in the indigenous material range from 1 to 6 per complement. The positions so far found are identical with those already reported from other material.

From these preliminary results it seems already justified to draw the conclusion that knobs had been in existence already during the primary phase of domestication and have then scattered over the whole corn area. Otherwise it would be difficult to explain that knob positions are always the same.

F. G. Brieger
W. E. Kerr

12. Sterility in Soft Paraguay Yellow. A partially sterile type, conserved during several years, has now finally come under closer inspection. Selfs, sibs or intercrosses within the sterile lines give generally poorly filled ears, with a certain amount of variation from almost empty ears to ears with one side almost normally filled. When pollinated with pollen from unrelated plants the ears are always well filled.

Studies on the germination of the pollen grains gave the following result:

	Germination
Pollen of sterile plants on silks of sterile plants:	very little
Pollen of sterile plants on silks of fertile plants:	normal
Pollen of fertile plants on silks of sterile plants:	normal
Pollen of fertile plants on silks of fertile plants:	normal.

The crosses carried out agree with these results and, for instance, by dividing the silks of an ear and selfing one half and outcrossing the other, only the latter half of the ear was well filled. F_1 hybrids of sterile x fertile gave sterile F_1s, while the reciprocal cross has not yet flowered. At meiosis the only abnormality observed was a tendency for partial asynapsis. From 95 to 100% of the pollen grains are, however, normal, though variations in size occur frequently. The tassel also shows some sporophytic sterility in its branches.

N. Kobal

13. Sterility of crosses. In several commercial hybrids tested last year, male sterility appeared. The pedigree records show that in nearly all cases one dent variety (Pelotas) was used as female parent. The sterility seems to be due to some abnormality in pollen development. Meiosis appears to be normal, but the development stops after pollen tetrads are formed. Instead of the pollen grains, mature anthers contain aborted grains or masses of cells which stick together.

F. G. Brieger
N. Kobal

Acknowledgment

A comparison of this year's report and former contributions shows a very great progress in our work which includes now also cytological studies. We are for this very much indebted to Dr. Marcus M. Rhoades who stayed in Piracicaba for a few months, from October to January, and who gave us very valuable help in the study of many problems of corn genetics. His stay was made possible by grants from the Rockefeller Foundation, and the Secretary of Agriculture in São Paulo.

III. MAIZE PUBLICATIONS -- 1947

(Including certain 1945-46 publications not previously listed and some early 1948 publications.)

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James E. Wright, Jr.

IV. SEED STOCKS PROPAGATION

In the following inventory are listed the stocks of genes and gene combinations of which a supply of viable seed is now available at Cornell. Only those stocks grown since 1942 are considered viable as indicated by our experience last summer in attempting to grow cultures from old seeds.

Thus it may be assumed that stocks for genes other than those listed have been lost or have never been incorporated into our supply. Especially is the latter true for those genes which have been reported since 1942. It would be helpful to the Coöp. therefore, if each coöperator would check his stocks against this list, and if he has any that do not appear here to forward a small supply to the Coöp. for multiplication.

Most of the propagation of material during the past summer involved the growing of cultures from old seed which were in danger of losing their viability. This included both single-gene stocks and multiple-gene linkage testers. In addition, certain weak stocks were outcrossed to adapted inbreds in order to make material available in more vigorous combinations. Reselection within previously-made hybrids of this sort was continued.

(m.s. = may segregate)

a	44-163; 45-68; 45-147; 45-151; 47-23; 47-26
a_2	45-78; 45-92; 47-44; 47-173
a_3	45-127; 47-102
ad	47-100
an	47-6; 47-13; 47-101
an_2	43-5,6,7,8 (m.s.)
ar	45-95; 47-58
at	45-94 (m.s.); 47-103
au	47-64 (m.s.)
b	43-100; 45-11; 47-171
B	43-101; 47-17
B^W	44-205
ba	45-42; 45-96
ba_2	45-97
bd	45-82; 47-49; 47-52
bk	45-98
bk_2	47-65
bm	44-76; 47-43
bm_2	45-56; 45-58; 47-4,5,8,10,11,12,13
bm_3	45-99; 45-143
Bn	47-54

bp 44-163
br 45-56; 45-57 (m.s.); 47-4,6,8,10,11,13
bt 46-107; 47-42
bt_2 43-142; 45-13
bv 45-94 (m.s.); 46-107
c 43-163; 44-174; 44-206; 47-56,59
Ch 43-11; 47-105
cl (corrugated leaf) 43-141; 47-106
cr 43-106 (m.s.); 44-159 (m.s.); 45-122 (m.s.); 45-100; 47-30,31
d 43-12; 44-75; 45-67; 45-69; 47-25,29,32; 47-107
d_2 44-154; 45-102; 47-121
d_3 44-72; 44-97; 44-146; 47-122
d_5 43-13; 44-40
da 45-88; 47-58
Dt 44-163; 45-68; 47-24
du 47-174
f 45-57; 45-150 (m.s.); 47-6,8,10,11,13
fl 45-61; 46-104; 47-20,21,67
fl_2 45-103
fs 45-104; 47-68
g 43-155; 44-90 (m.s.); 45-12 (m.s.); 45-90; 47-62,63,173
g_2 44-76 (m.s.); 47-123
g_3 43-18 (m.s.)
g_4 43-19; 44-41 (m.s.)
gl 44-159; 45-80,82,84,98,122; 47-50,51,52,53,173
gl_2 45-8,9,10; 47-14,18,19,20,21,71
gl_3 45-71,72,73; 47-36,38,39
gl_4 45-20 (m.s.); 45-51,52,89,103,106; 47-56,59
gl_5 43-23,143; 44-5,36
gl_6 45-107; 47-109
gl_7 43-24; 45-139
gl_8 44-88,89; 47-125
gl_9 43-147; 47-126
gl_{10} 45-109; 47-110
gl_x 43-142; 44-66 (m.s.)
gs 47-12,13
gs_2 45-11; 47-15,16,127
h 45-110 (m.s.); 47-128
hf 45-111 (m.s.); 47-111 (m.s.)
Hs 45-112; 47-112
I 47-82

vp_2 43-184; 44-93,141,143,144
vp_4 43-81,82,186; 44-58
w 44-27,28,29,30,59,60,61
w_2 43-87; 44-83
w_3 44-32,62
w_{11} 43-89; 44-33; 45-46
wa 43-83 (m.s.); 47-99
Wc 45-142
Wh 43-84,187,188; 47-118
wl 43-112 (m.s.); 44-86 (m.s.); 47-34,167
ws 45-89
ws_2 47-39
ws_3 45-60; 47-18,19
wx 43-163; 44-156,170,174,206; 45-88,95,141,146,148,150, 154; 47-56,58,59
y 45-68,133,149; 47-173
yg 43-190
yg_2 44-174; 45-20 (m.s.)
yg_3 45-143 (m.s.); 47-168
yp_2 43-191
zb 43-208; 44-38,73,112 (m.s.)
zb_2 43-209; 44-74 (m.s.)
zb_3 43-210; 44-39,98 (m.s.)
zb_4 43-91,92; 45-57; 44-63,104 (m.s.); 47-7,10,11
zb_6 45-144; 47-120
zg_3 43-93,192 (m.s.); 44-94 (m.s.)
zl 47-9

Linkage testers

Chromosome 1

bm_2 br P^{rr} (47-4)
br f an gs (47-6)
ms_{17} zl P^{mo} (47-9)
br f an gs bm_2 (47-13)

Chromosome 2

lg gl_2 v_4 ts	(47-14,22)
lg gs_2 v_4	(47-16)
ws_3 lg gl_2	(47-19)
lg gl_2 v_4 fl	(47-21)

Chromosome 3

Rg d	(47-25)
na ts_4	(47-28)
lg_2 d ts_4	(47-32)

Chromosome 4

su Tu gl_3	(47-36)
Ts_5 su	(47-34)

Chromosome 5

bm v_2 pr ys	(47-43)
pr v_{12}	(47-45)

Chromosome 6

Pl sm py y	(47-46)

Chromosome 7

ra v_5 gl o_2	(47-50)
gl ij bd	(47-52)
ij Tp gl ra v_5	(47-53)

Chromosome 8

j v_{16} ms_8	(47-55)

Chromosome 9

c sh wx gl_4 yg_2	(47-56)
wx da sa ar	(47-58)

Chromosome 10

g_1 l_2	(47-63)

Mangelsdorf's multiple tester:

47-173 - p bm_2 lg_1 a su Pr y gl j wx g

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